Highway Engineering

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Measurement and Back-Calculation of Effective Thermal Conductivity of Unbound Aggregates

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Abstract: The effective thermal conductivity of unbound aggregates is an important thermal property for thermal analysis in pavement engineering. In this paper, the effective thermal conductivity of unbound aggregates is studied based on laboratory measurement and model back-calculation of finite element software. The unbound aggregates specimens were prepared in the laboratory. The specimens were heated with a self-designed instrument and the temperature changes of the specimens were measured. Then the effective thermal conductivity was determined through back-calculation with the finite element software. The effective thermal conductivity obtained from the test is verified by the simulation model. The results show that the effective thermal conductivity increases and the air void decrease with the decrease of particle size. The effective thermal conductivity of the aggregates with the same particle size increases with the increase of moisture content. Compared with the samples with larger aggregate size, the samples with smaller aggregate size have smaller air void and higher effective thermal conductivity. The comparison between irregular aggregate and circular aggregate with the same particle size range shows that irregular aggregate has a smaller porosity and a larger effective thermal conductivity.

Key words: backcalculation; thermal properties; unbound aggregate

基于 DIC 技术的 OGFC 铁氧体沥青混合料自愈合研究

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摘 要：沥青混合料具有一定的自愈合能力，能够通过电磁感应加热技术和微波加热技术获得增强。然而当前为了探究混合料的自愈合效果，针对愈合前后混合料的裂缝发展的定量分析和直接监测手段较少。数字图像相关技术（Digital Image Correlation，DIC）因其能够直接测量荷载作用下物体的位移场和应变场，应用较为广泛。本文通过三点弯曲疲劳试验和三点弯曲破坏试验，以起裂时间、断裂过程区程度、水平应变等为指标，研究了微波加热时间和愈合时间对 0%和 5%铁氧体掺量的沥青混合料自愈合效果的影响以及铁氧体对试件应变发展过程的影响。另外各项指标的变化可以看出，铁氧体不仅显著提高了愈合效果，而且使得混合料的韧性显著提升。

关键词：沥青混合料；数字图像相关技术；自愈合；铁氧体

DIC Technique to Investigate Self-Healing Properties of Ferrite-Filled Open-Graded Friction Course (OGFC) Asphalt Mixture

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Abstract:

Asphalt mixture has the ability of self-healing and can be enhanced by induction heating and microwave heating technologies. However, there are few methods to quantitatively analyze and directly monitor the crack propagation of the mixture before and after healing to evaluate the self-healing efficiency. Digital Image Correlation (DIC) technique, used in this paper, is widely applied because it can directly measure the displacement field and strain field of an object under load. In this paper, the three-point bending fatigue test and the three-point bending fracture test were conducted to study the influence of microwave heating time and healing time on the self-healing of the asphalt mixture with 5% ferrite and without ferrite. The influence of ferrite on the strain development process of specimens, through the indexes of crack initiation time, fracture process zone length, dissipated energy, and horizontal strain, was discussed. It is found that the addition of ferrite can significantly delay the secondary cracking of the OGFC asphalt mixture. Based on DIC observations, there is an optimal microwave heating time for the OGFC asphalt mixture with 5% ferrite, which is heated by microwave for 80s. Meanwhile, the longer the healing time, the better the healing effect, but the influence of the healing time is less significant compared with the heating time. Besides, it can be concluded from the change of the horizontal strain when the crack develops that the ferrite not only significantly improves the healing effect, but also obviously improves the toughness of the mixture.

keywords: asphalt mixture; DIC; self-healing; ferrite powders.

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高模量沥青混凝土路面力学行为特性分析

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摘　要：高模量沥青混凝土具有模量高、抗车辙性能好等优点，能够显著提高沥青路面的抗永久变形能力并适当减薄沥青结构层厚度。本文分析了天津地区普通公路沥青混凝土路面典型结构的路面受力特点，同时利用 KENLAYER 和 ANSYS 有限元软件对路面结构的剪应力分布特点、疲劳寿命和车辙进行试验分析，结果表明将高模量沥青混凝土材料设置在上下面层结构位置，能有效降低结构内部的剪应力，改善受力情况，提高其疲劳强度和抗车辙能力，大大延长公路的使用寿命。

关键词：高模量沥青混凝土；剪应力；疲劳；车辙

Mechanical Behavior Characteristics Analysis of High Modulus Asphalt Concrete Pavement

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Abstract:

High modulus asphalt concrete has the advantages of high modulus and good rutting resistance. It can significantly improve the permanent deformation resistance of asphalt pavement and reduce the thickness of asphalt structure layer. In this paper, the Pavement Stress Characteristics of typical asphalt concrete pavement structures of ordinary highways in Tianjin are analyzed. At the same time, KENLAYER and ANSYS finite element software are used to test and analyze the distribution characteristics of shear stress, fatigue life and rutting of pavement structure. The results show that setting high modulus asphalt concrete material in the upper and lower layers can effectively reduce the shear stress in the structure, improve the stress condition, improve its fatigue strength and rutting resistance, and greatly prolong the service life of the highway.

keywords: high modulus asphalt concrete; shear stress; fatigue; rutting

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基于激光及摄像法的路面轮迹横向分布典型值研究

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摘　要：由于大型车辆的轮迹横向分布引导着路面病害发展的趋势，因此获取不同路段的轮迹横向分布典型值对路面结构设计至关重要。本文同时利用现场交通摄像法及新型的双激光测距法收集广东省内不同等级道路慢车道上的轮迹横向分布数据(两种方法收集同样的轮迹数据为验证新方法数据的精确性)，通过MEPDG（力学经验设计软件）分析，预测并对比各路段路面的病害变化，以此寻找不同路段之间是否存在轮迹横向分布的典型值。模拟结果表明：在车道宽度一致的情况下，省内二级公路之间的轮迹横向分布值、普通一级公路与一级公路（经城市快速路改造）间的轮迹横向分布值可相互借鉴，而省内一级公路（经城市快速路改造）与高等级公路的轮迹横向分布值则可相互替换。对比模拟结果还发现，车辙及疲劳裂纹相比于路面平整度，对轮迹横向分布变化的表现更为敏感，这也为道路养护单位对轮迹密集路段的早期修补和保养提供参考。

关键词：路基路面工程；轮迹横向分布；MEPDG；标准差

Laser and Visual Based Study on Typical Values of Lateral Distribution of Wheel Track

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Abstract:

Since the lateral distribution of the wheel of the cart guides the trend of road surface disease development, the typical value of the wheel track lateral distribution of different road sections is crucial to the pavement structure design. This paper collects the lateral distribution data of the wheel tracks on the slow lanes of different grades in Guangdong Province by on-site traffic camera method, and introduces MEPDG (Asphalt Pavement Mechanics Experience Design Software) to analyze and predict and compare the disease changes of the road sections of each road section. Whether there is a typical value of the lateral distribution of the wheel tracks between the sections. The simulation results show that the lateral distribution values of the wheel tracks between the secondary roads in the province and the horizontal distribution values of the common first-class roads and the first-class roads (through the urban expressway reconstruction) can be mutually For reference, the horizontal distribution values of the first-class highways (transformed by urban expressways) and high-grade highways in the province can be replaced. Comparing the simulation results, it is also found that the rutting and fatigue cracks are more sensitive to the performance of the lateral distribution of the wheel track than the road surface flatness. This also provides a reference for the early repair and maintenance of the wheel track intensive road sections by the road maintenance unit.

keywords: pavement engineering; lateral distribution of wheel tracks; MEPDG; standard deviation

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Study on Dynamic Response Characteristics of Permeable Asphalt Pavement based on Unsaturated Seepage

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Abstract: To study the dynamic response characteristics of permeable asphalt pavement under the unsaturated state and move loading, 3-D finite element models for the asphalt pavement with the coupling of water-air-force were established based on unsaturated seepage theory. The vertical stress, the transverse stress, the vertical displacement and the pore water pressure response of the asphalt pavement under moving loads were analyzed at different times. In addition, the results were compared and analyzed with the results of saturated asphalt pavement. The results shown that the maximum transverse stress of unsaturated asphalt pavement is about 150 kPa, while that of saturated asphalt pavement is about 850 kPa. It is shown that the discharge of water has a great effect on avoiding cracks in the pavement. The maximum pore water pressure of unsaturated asphalt pavement is 56.67 kPa, and that of saturated asphalt pavement decreased by 40.70 % under the same condition. The change of displacement in the area near the upper layer is more remarkable, and the maximum displacement of unsaturated asphalt pavement is less than that of the saturated asphalt pavement.

Key words: unsaturated seepage; water-air-force coupling; the vertical stress; the transverse stress; pore water pressure

Numerical Simulation of Three-Point Bending Test for Pre-Notched Asphalt Mixture Beam Using Discrete Element Method Software

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Abstract: A virtual three-point bending test method of asphalt mixture pre-notched beams is developed based on discrete element method (DEM) software PFC3D to study the macro and micro fracture characteristics and crack propagation mechanism of the material, and the effectiveness of the model is verified by comparing the peak load obtained from the simulation and the laboratory. Then, the method is used for analyzing the influence of the pre-cut location of cracks on the crack resistance of asphalt mixtures at low temperatures, and investigating the macroscopic crack morphological characteristics and crack propagation mechanism of the cracked specimen. The results indicate that the discrete fracture network (DFN) can well show the complex fracture paths of asphalt mixtures including the main fracture, the fracture branch and the fracture bending. The fracture growth patterns can be divided into three types: the I type reflection fracture pattern, the I-II complex reflection fracture pattern and the pure flexural fracture pattern. The macroscopic main crack expansion direction gradually deflects to the loading point with the increase of γ values under the condition of the I type reflection crack mode, while the angle of the main fracture toward the loading point decreases with the increase of γ values under the condition of I-II composite reflection crack mode. The virtual test method can well reflect the crack propagation mechanism of cracks at the initiation stage, rapid fracture stage and propagation stage. At the crack initiation stage, the crack resistance of the asphalt mixture beam is proportional to γ values when asphalt mixtures is cracked in the mode of I type and I-II composite reflection crack.

Key words: asphalt mixture; three point bending test; DEM; cracking mechanism

Fluid-Solid Coupling Simulation of Pavement and Near-Surface and Sensitivity Analysis on Near-Surface Temperature

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Abstract: In this paper, a three-dimensional fluid-solid coupling model of asphalt pavement and near surface is established by finite element method based on fluid-solid coupling theory. The validity of the model and the reliability of the simulation data are verified by the measured data. By controlling single variable to change the thermal parameters （thermal conductivity，specific heat，emissivity，reflectance, density and slope A of convection coefficient）of pavement surface and meteorological factors（wind speed and solar radiation）, the temperature distribution of pavement structure layer and near surface temperature during high temperature period in daytime and low temperature period in night were studied. The positive and negative correlation between the change of temperature field and the change of various factors is obtained, and the specific measures to alleviate the near-surface thermal environment, reduce the urban heat island effect and enhance the thermal comfort of pedestrians are put forward. Through orthogonal test, the sensitivity order of pavement properties to near-surface temperature and pavement temperature in daytime high temperature period is obtained （reflectivity > slope A > emissivity > conductivity > density > specific heat）. It is of great guiding significance to further improve the accuracy of predicting three-dimensional fluid-structure coupling model and to reasonably select pavement material parameters..

Key words: fluid-solid coupling; finite element method; near-surface air temperature; sensitivity analysis; orthogonal test

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Optimization Design and Experimental Investigation of Piezoelectric Energy Harvesting Devices for Pavement

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Abstract: The paper designs a compression-based pavement energy harvesting device with a group of piezoelectric transducers and investigates the selection of the component materials to enhance the electric energy output of power-generation pavements. The external dimensions of the proposed devices are optimized based on vehicle wheelpath distribution and tire trace patterns. And various device material configurations are examined by different cover plates and transducer specifications for optimal mechanic-electric response characteristics. Subsequently, the device is tested as an example and its electrical output performance is evaluated under typical road loading environments. Finally, a comparative analysis of various disclosed piezoelectric harvesting device technology were conducted and further research plan was developed. Results indicate that the modified polypropylene and aluminum plate meet the application demand of the device, and the optimum device dimensions under light and heavy traffic conditions are 150 mm×150 mm. Under the loading of 0.7 MPa-15 Hz, the 150 mm×150 mm device with nine parallel transducers achieves a maximum output power of 50.41 mW. And under the loading of 0.2 MPa-10 Hz, the device achieves a maximum output power of 2.92 mW. The performance of piezoelectric device designed in this paper excels that of many other available devices.

Key words: pavement engineering; energy-harvesting; piezoelectric device; electrical output

Preparation and Performance Research of Stacked Piezoelectric Energy-Harvesting Units for Pavements

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Abstract : The exploration and research of pavement piezoelectric energy harvesting technology provides new ideas for the collection and application of road green energy. To improve the applicability of the piezoelectric energy-harvesting units in road environment effectively, based on technical requirements of energy-harvesting units for pavements, this paper compares two processes for preparing stacked piezoelectric energy-harvesting units and evaluates their application performance in terms of electromechanical conversion performance and structural strength; and the optimal preparation process for the units is determined as well. Two detailed structure optimization schemes of U-shaped interlayer copper foil electrode structure and lateral lead electrode structure are designed, which are tested and evaluated from the three perspectives of energy output performance, working durability and material properties, and the optimal electrode structure is determined. The results indicate that at 0.7 MPa-10 Hz, the parallel connected units prepared based on the multilayer adhesive process can increase the terminal voltage by 28.0 V and the output power by 22.80 mW, which are superior than units prepared by the monolithic co-firing process. In addition, the multilayer units exhibit good structural stability and weatherability. Under the same load condition, the optimal load resistances of the units with the U-shaped interlayer copper foil electrode and the lateral lead electrode can reach 20 kΩ with comparable energy outputs. Subsequently, mechanical testing is conducted after 50,000 simulation (MTS) cyclic loading, the structural performance of the U-shaped interlayer copper foil units is relatively durable and stable: the open-circuit voltage is attenuated by 4.4 V, the output power is attenuated by 3.30 mW, and the average capacitance of a single unit is only attenuated by 3.4 nF. Finally, future research plan is discussed.

Key words: road engineering; energy-harvesting; piezoelectric; stacked piezoelectric energy-harvesting units; preparation process

两种模拟条件下透水沥青混合料渗透特性与净化能力研究

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摘 要：为研究不同模拟条件下透水沥青混合料的渗透特性和净化能力，在室内制备PAC-13型透水沥青混合料马歇尔试件，并对其在风干与不风干两种模拟条件下的渗透系数与污染物净化率进行测定，研究渗透系数与污染物净化率的变化规律，分析风干效应对透水沥青混凝土渗透系数衰变速率的影响。结果表明：合理控制空隙率，可确保透水沥青混凝土的透水性能和净化能力；风干效应增加了污染物与净化介质的接触，可促进污染物的净化。

关键词：透水沥青混凝土；风干效应；空隙率；净化能力

Study on Permeability and Purification Ability of Permeable Asphalt Mixture Under Two Simulated Conditions

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Abstract:

In order to explore the permeability and purification ability of permeable asphalt mixture under different simulated conditions, the PAC-13 permeable asphalt mixture Marshall specimens were prepared in the laboratory. Under two simulated conditions of wind-drying and non-wind-drying, the permeability coefficient and pollutant purification rate of Marshall specimens were measured. The change regulation of permeability coefficient and pollutant purification rate was analyzed. The influence of wind-drying effect on the decay rate of the permeability coefficient of permeable asphalt concrete was studied. The results show that reasonable control of void fraction can ensure the permeability and purification ability of permeable asphalt concrete, and the wind drying effect can increase the contact between pollutants and purification medium to promote the purification of pollutants.

keywords: permeable asphalt concrete; wind drying effect; void fraction; purification ability

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Preparation of CNF Modified Emulsified Asphalt and Study on High Temperature Performance

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Abstract: Carbon nanofiber exhibits excellent mechanical properties and was widely used in composite materials. CNF modified emulsified asphalt was studied in this paper. Surfactant and ultrasonication were used to disperse CNFs in water, and then modified emulsified asphalt was produced using CNFs suspension. The optimum content of surfactant and ultrasonic energy were determined through UV-vis spectra. High temperature performance of asphalt with different dosage of CNFs was compared and the optimum dosage was 0.5% weight ratio to get the best performance.

Key words: carbon nanofiber; ultrasonication; surfactant; high temperature performance

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用于彩色抗滑路面的粘结材料制备及性能研究

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摘 要：为获得兼具黏结力强、固化时间较短、柔韧耐久的彩色抗滑路面粘结材料，提出了基于力学性能的 TDI-PUP 增韧改性环氧树脂的方法。通过拉拔试验、拉伸试验、弯曲试验及冲击试验研究了 TDI-PUP-M-ER 力学强度和柔韧性能，确定了 TDI-PUP 最佳掺量，优选了固化剂。进一步通过冻融循环试验、低温轮碾试验、高温化学腐蚀试验、高温老化试验系统评价了 TDI-PUP-M-ER 粘结材料的耐久性能。结果表明：TDI-PUP 能够显著改善环氧树脂的柔韧性。TDI-PUP 的最佳掺量为 10 %，TDI-PUP-M-ER 的拉伸强度较纯环氧树脂提高了 52.8 %，断裂伸长率提高了 112 %，弯曲强度较纯环氧树脂提高了 21.6 %，弯曲变形提高了 61.1 %，优选出脂环胺和脂肪胺固化剂。TDI-PUP-M-ER 粘结材料经冻融循环后黏结强度仅衰减 2.8%，酸溶液腐蚀后，质量损失率仅为 0.69mg/g，这表明本研究制备的 TDI-PUP-M-ER 粘结材料耐久性能良好。

关键词：TDI-PUP-M-ER；粘结材料；制备；耐久性；彩色抗滑路面

Preparation and Properties of Bonding Material for Colorful Anti-Slip Pavements

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Abstract:

The performance of the bonding materials of colorful anti-slip pavements is a critical factor influencing their service life. Epoxy resins perform well as bonding materials for colorful anti-slip pavements, although they have the drawbacks of long curing time, poor flexibility, and low durability. To obtain a bonding material with a strong bonding force, fast curing rate, good flexibility, and durability based on several mechanical properties, TDI-polyether polyurethane prepolymer modified epoxy resin (TDI-PUP-M-ER) was prepared. The basic performances of TDI-PUP-M-ER were studied by pullout, tensile, bending, and impact tests. Based on the acquired results, the optimal amount of TDI-polyether polyurethane prepolymer (TDI-PUP) and preferred curing agents for the TDI-PUP-M-ER were determined. Furthermore, the durability of the TDI-PUP-M-ER bonding material was systematically evaluated by freeze-thaw cycle tests, rutting tests at low and high temperatures, chemical corrosion tests, and aging tests at a high temperature. The results showed that the flexibility and mechanical strength of the epoxy resin are considerably improved by adding TDI-PUP. When the content of TDI-PUP in epoxy resin was 10%, the comprehensive performance of TDI-PUP-M-ER was optimal. Compared with the pure epoxy resin, the tensile strength of TDI-PUP-M-ER was improved by 52.8 %, its elongation at break by 112 %, its bending strength by 21.6 %, and its bending deformation by 61.1 %. After the TDI-PUP-M-ER bonding material was frozen and thawed, its bonding strength was reduced slightly by 2.8 %. After corrosion by acidic solutions, the final mass loss rate of the resin was only 0.69 mg/g, showing that the TDI-PUP-M-

ER bonding material exhibits good durability.

keywords: TDI-PUP-M-ER; bonding material; preparation; durability; colorful anti-slip pavement

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高黏改性沥青的流变性能分析

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摘 要：为了探究高黏改性沥青与普通沥青的流变性能差异，分别从黏度、剪切模量、疲劳开裂和永久变形等方面对沥青进行流变性能试验分析，结果表明：高黏改性沥青线性黏弹性范围的剪切模量与 SBS 改性沥青接近，抗疲劳开裂能力弱于 SBS 改性沥青。从愈合性能来看，间歇时间越长，高黏改性沥青的恢复能力越强，与其他沥青的愈合效果差别也越大。其抵抗高温永久变形的能力与 SBS 改性沥青接近而远优于 70#基质沥青。

关键词：道路工程；高黏沥青；动态剪切模量；疲劳开裂；愈合能力；永久变形

Analysis of Rheological Performance of High-Viscosity Modified Asphalt Binders

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Abstract:

In order to investigate the rheological properties of high-viscosity modified asphalt binder, the rheological properties are investigated in terms of viscosity, shear modulus, fatigue cracking and permanent deformation. The results are compared with other petroleum asphalt binders. The experimental results show that the viscosity of high-viscosity modified asphalt binder is much greater than that of 70# base asphalt binder and SBS modified asphalt binder. Meanwhile, the shear modulus of linear viscoelastic stage is similar to that of SBS modified asphalt binder, and the fatigue crack resistance is worse than that of SBS modified asphalt binder. As for healing performance, the longer the rest time, the stronger the recovery ability of high-viscosity asphalt binder, which leads to the better healing effect. In addition, its ability to resist high temperature permanent deformation is close to SBS modified asphalt binder and better than 70# base asphalt binder.

keywords: road engineering; high-viscosity asphalt; dynamic shear modulus; fatigue cracking; healing ability; permanent deformation

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Study on Rheological Properties of Graphene Rubber Composite Modified Asphalt

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Abstract: In this paper, The rheological properties of graphene rubber composite modified asphalt were studied by dynamic shear rheometer (DSR). The rubber modified asphalt containing 0%, 0.2% and 0.4% graphene was prepared and analyzed. The rheological properties, including permeability, softening point and ductility, were measured under dynamic temperature and frequency loading. With the increase of temperature, graphene effectively enhances the elastic recovery performance of rubber asphalt and greatly improves the rutting resistance of rubber modified asphalt. The results confirm that the addition of graphene can effectively improve the high temperature performance of rubber modified asphalt, harden the rubber modified asphalt and weaken its low temperature tensile properties.

Key words: graphene; dynamic rheological properties; elastic recovery performance; rutting resistance; high temperature performance

磨细锶渣水泥砂浆的性能研究

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摘 要：为研究锶渣作为水泥砂浆掺合料的可行性，通过实验研究了磨细锶渣掺量对砂浆力学性能的影响，锶渣分别设为 10%，20%，30%，40%，50%等量取代水泥，强度随着锶渣掺量的增加逐渐下降，下降呈阶梯型。同时通过实验对磨细锶渣砂浆的干缩性能和水稳定性做了详细的研究。实验结果表明：常温磨细锶渣和煅烧 800℃的锶渣胶砂干缩发展趋势基本相同；锶渣的抗冻性不及水泥，因为锶渣水泥胶砂试件没有水泥胶砂试件密实，强度高。

关键词：锶渣；道路

Research on the Performance of Pulverized Strontium Slag on Properties of Cement Mortar

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Abstract:

Abstract: In order to study the feasibility of using strontium slag as cement mortar admixture, the influence of the content of ground strontium slag on the mechanical properties of cement mortar was studied experimentally. The strength of cement was replaced by 10%, 20%, 30%, 40% and 50% strontium slag respectively. The strength decreased gradually with the increase of the content of strontium slag, and the strength decreased step by step. Meanwhile, the dry shrinkage and water stability of mortar made of strontium slag are studied in detail. The results show that the development trend of dry shrinkage of fine strontium slag at room temperature is basically the same as that of calcined strontium slag mortar at 800 C. The frost resistance of strontium slag is lower than that of cement because the strontium slag cement mortar is not as compact as that of cement mortar and has high strength.

keywords: strontium slag; road engineering

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Evaluation of Mechanical Performance and Reinforcement Mechanism of Bitumen Reinforced with Recycled Glass Fiber

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Abstract: A majority of industrially produced fiber reinforced polymer (FRP) composite materials in the world is dumped as waste in landfill. Therefore, these materials are a major environmental concern. Recycling and reusing these discarded FRP composites in civil engineering remains a challenge. In this work, the high temperature property, water resistance, low temperature performance and reinforcement mechanism of bitumen reinforced with recycled glass fiber (GF). The experimental results revealed that GF can significantly improve the stiffness and rutting resistance of bitumen. Moreover, both the high temperature performance and low temperature performance of bitumen were strengthened due to the addition of GF, which makes it be suitable both for hot and cold climate regions. The optimal incorporation of GF with the diameter of 0.5-071mm, length bigger than 10mm and content is 5%.

Key words: glass fiber; bitumen; high temperature property; low temperature property; reinforcement mechanism

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Influencing Factors of Piezoelectric Response of Energy Harvesting Array for Asphalt Pavement

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Abstract: In this paper, a piezoelectric energy harvesting array is prepared to supply power for road sensors. In order to study the energy supply characteristics of piezoelectric energy harvester, the response of energy harvesting array to different conditions simulated traffic condition are studied. The influences of load, load frequency and number of cells on output voltage of energy harvesting array are analyzed by uniaxial compression test. The influences of the types of asphalt mixture and ambient temperature on output voltage are analyzed through rutting test. Energy harvesting array have different sensitivities to different loads. To quantify this sensitivity, the concept of loading utilization efficiency is proposed. The experimental results show that the output voltage and loading utilization efficiency increases gradually with the increase of load and load frequency. When the load is 4.5kN and loading frequency is 10Hz, the open circuit voltage of the piezoelectric energy harvester is stable at 10.32V, and the loading utilization efficiency is 73.07%. The output voltage and loading utilization efficiency decrease with the increase of the number of energy harvesting cells in parallel. With the number of parallel energy harvesting cells increasing from 1 to 3, the output voltage drops by 26.6% under 5Hz of load frequency, and the minimum loading utilization efficiency is 25.49%. In the rutting experiment, the AC-13 asphalt pavement has superior force transmission performance. The output voltage and the loading utilization efficiency of the harvester under the AC-13 are the largest. Output voltage and loading utilization decrease with the rise of temperature. Using polyurethane plates makes the loading utilization efficiency more than 100%. The finite element method is used to explain the cause of the phenomenon by three-dimensional modeling. The simulation results show that the addition of polyurethane plate increases the deformation of thin piezoelectric ceramics, so as to increase the piezoelectric response of the energy harvesting array.

Key words: road engineering; energy harvesting array; uniaxial compression; rutting test; finite element model

The Interlaminar Failure Process of Double Asphalt Mixture Under Tensile Failure

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Abstract In order to quantify the interlaminar failure process of double asphalt mixture under tensile failure, a 3D finite element model of cylindrical asphalt concrete in direct tensile experiments was established based on the bilinear cohesive zone model (BCZM). This model was calculated by the explicitly quasi-static method to solve the convergence problem. Meanwhile, the effect of quasi-static parameters (mesh, loading curves, mass scaling (MS) and simulated tensile rate) on computational efficiency and precision were systematically compared. It was shown that when the loading curve was a smooth line, the simulated tensile rate was 10 times that of experiment and the MS was 100, the model computational results were most consistent with the test results. Therefore, based on above-recommended parameters, this model was applied to analyze the tensile failure process. The calculation results showed that the maximum stress of interlaminar interface was concentrated in the annular area during tensile failure process. Also, according to the normal stress distribution area, the tensile failure process should be divided into three stages: the expansion stage, the stress concentration stage, and the failure stage, which could describe the failure process more accurately and clearly. Based on the three stages, initial damage displacement was proposed to evaluate the effect of experiment’s tensile rate on the interlaminar stability of double asphalt mixture.

Key words: asphalt

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Energy-Saving Potential and Eco-Friendliness of Waste Materials in Induction Heating of Asphalt Mixtures

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Abstract: In the face of the challenges of energy depletion and environmental pollution, how to effectively and environmentally use induction heating technology to achieve pavement function has become a research hotspot. This paper intends to tap the energy-saving potential and eco-friendliness of waste materials (WM) in induction heating of asphalt mixture. The waste steel shavings (WSS) were used as an internal energy-saving material (I-ESM) to modify asphalt mixture, and waste ferrites (WF) were used as an external energy-saving material (E-ESM) to prepare magnetic concentrator layer (MCL). Under the action of MCL, the induction heating experiments, ice-melting experiments and self-healing experiments of AM-WSS were conducted. Then the effect of content of I-ESM and type of E-ESM on the above experiments were evaluated simultaneously. The result shows that the presence of the MCL can greatly improve the energy efficiency of the above experiments, and it can be inferred that the gradation of the WF in the MCL is the significant factor determining its energy-saving rate (ESR). It is also found that the optimal ESR, better induction heating rate (IHR), better average melting rate (AMR), and better healing ratios (HR) can be obtained when the content of WSS is 6% in the sample. Finally, based on the experimental results, the application of the I-ESM and E-ESM in the unit pavement will save electrical energy up to 39024 kw • h and reduce CO2 emissions up to 12755 kg. The research results will provide a good reference and new idea for taping the energy-saving potential and eco-friendliness of WM in the pavement engineering.

Key words: energy-saving; waste material; asphalt pavement; induction heating; emission reduction

Induction Heating Performance of Asphalt Mixture Under the Action of the Magnetic Concentrator Layer Composed of Waste Ferrite

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Abstract: This paper aims to evaluate the effect of the magnetic concentrator layer (MCL) composed of waste ferrite (WF) on the induction heating performance (IHP) of the asphalt mixture. With this purpose, asphalt mixtures containing waste steel shavings (AM-WSS) were prepared. Four kinds of normal magnetic concentrator layer (NMCL) were prepared according to the particle size of WF. Under the action of NMCL, the induction heating experiments of AM-WSS were conducted. In the experiments, the heating rate (HR) and energy saving rate (ESR) were proposed to evaluate the effect of the WSS and NMCL on IHP. Results show that HR increases as the increase of WSS content, while ESR increased first and then decreased. Therefore, the samples with 6% of WSS were proposed as an optimal content to obtain optimal ESR and better HR. More interestingly, the existence of NMCL can significantly improve the HR and ESR of AM-WSS, and the HR and ESR increase as the decrease of the particle size of WF in NMCL. Finally, to better apply NMCL in asphalt pavement, WF was mixed into asphalt to form two kinds of asphalt magnetic concentrator layer (AMCL). The results show that the mixing of asphalt and WF reduces the improvement effect of MCL, and the improvement effect of AMCL formed by single particle size WF on IHP is better than that formed by graded WF when the mass of WF is the same. It can be concluded that MCL can improve the IHP of AM-WSS, and its gradation plays a decisive role in improvement effect.

Key words: ferrite; steel shavings; magnetic concentrator; induction heating; asphalt

基于红外光谱对基质沥青老化程度的研究

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摘 要：为了研究评价基质沥青的老化程度，基于红外光谱对压力老化（PAV）与薄膜烘箱老化（TFOT）两种老化方式的基质沥青进行研究。分析了两种老化方式下老化前后基质沥青的吸光度的变化与特征峰面积的变化，建立了评价基质沥青老化的模型。研究表明，老化后的基质沥青的吸光度会呈现一定的增加趋势；通过羰基特征峰的面积建立的模型可以用来较准确的评价基质沥青的 TFOT 老化，通过羰基与亚砜基的峰面积建立的模型可以准确地评价基质沥青的 PAV 老化。

关键词：PAV 老化；TFOT 老化；红外光谱；羰基；亚砜基

Study on Aging Degree of Matrix Asphalt Based on Infrared Spectroscopy

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Abstract:

In order to study the evaluation of the aging degree of matrix asphalt, the matrix asphalt of pressure aging (PAV) and film oven aging (TFOT) was studied based on infrared spectroscopy. In this papers, the change of absorbance and the change of characteristic peak area of matrix asphalt before and after aging were analyzed and the model for evaluating the evaluation of matrix asphalt aging was established. Studies have shown that the absorbance of matrix asphalt after aging will show a certain increase trend; the model established by the area of the characteristic peak of carbonyl can be used to more accurately evaluate the TFOT aging of matrix asphalt, which is established by the peak areas of carbonyl and sulfoxide groups, respectively. The model established by the peak areas of the carbonyl group and the sulfoxide group can accurately evaluate the PAV aging of the matrix pitch.

keywords: PAV aging; TFOT aging; infrared spectroscopy; carbonyl; sulfoxide group

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Study on Properties of Organic Montmorillonite/Polyurethane Modified Asphalt

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Abstract: This paper proposes a new method of using the organic montmorillonite (OMMT) as an environmentally friendly alternative to chemical additives (e.g. compatibilizer, stabilizer) which are commonly toxic and highly volatile, to improve storage stability of thermoplastic polyurethane (TPU) modified asphalt binder. The synergistic effect of OMMT and TPU on physical properties of asphalt was also evaluated. The results of the X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) show that the increase in OMMT content promotes the intercalation of TPU and asphalt molecules to form stable ternary composite system. Results of 25°C penetration, softening point, 5°C ductility, dynamic shear rheometer (DSR), blending beam rheometer (BBR) tests and Burger's model calculation indicate that OMMT and TPU can dramatically improve high and low temperature properties, temperature susceptibility and elastic behavior of asphalt, while it lowers viscous behavior.

Key words: asphalt; TPU; OMMT; Environmentally friendly alternative; swynergistic effect; property.

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高速公路沥青路面加铺结构层后路面功能区划分研究

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摘 要：针对高速公路改扩建工程中加铺结构层后路面结构功能区变化问题，借助有限元分析软件 ABAQUS 建立了加铺结构层后路面结构数值分析模型，分析了各力学指标随路面结构深度变化规律，对路面功能区进行了划分。结果表明：可将加铺结构层后沥青路面划分为抗低温缩裂区、抗车辙功能区、抗疲劳开裂功能区和表面功能区四个功能区，其中抗疲劳开裂功能区分为主抗疲劳开裂功能区和次抗疲劳开裂功能区，主抗疲劳开裂区为加铺沥青稳定碎石基层，次抗疲劳开裂区为原路面下面层或沥青稳定碎石基层，表面功能区位置与抗低温缩裂区重叠。

关键词：高速公路；改扩建工程；加铺结构层；路面结构；功能区

Research on the Division of Pavement Functional Zone After Overlaying Structural Layers on Highway Asphalt Pavement

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Abstract:

In view of the change of pavement structure functional zone after paving structural layer in highway reconstruction and expansion project, the numerical analysis model of pavement structure after paving structural layer was established using the finite element analysis software ABAQUS, and the variation law of various mechanical indexes with the depth of pavement structure was analyzed, and the pavement function zone was divided. Results show that the pavement after overlaying structural layers can be divided into four functional zones which are anti-low temperature shrinkage crack zone, anti-rut functional zone, anti-fatigue crack functional zone and surface functional zone. Furthermore, the anti-fatigue crack functional zone could be furtherly divided to the main anti-fatigue crack functional zone and secondary anti-fatigue crack functional zone. The main anti-fatigue crack functional zone is in the overlay asphalt stabilized macadam base, and the secondary anti-fatigue crack functional zone is in the asphalt stabilized macadam base under the original road surface. The surface functional zone overlaps with the anti-low temperature shrinkage crack zone.

keywords: highway; reconstruction and expansion project; overlay structural layer; pavement structure; functional zone

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基于预拌-增强技术的沥青混合料可行性研究

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摘 要：基于降耗、环保的需要，提出预拌-增强的技术路线，即采用高标号软质沥青对矿料进行预拌，保证沥青混合料具有良好的施工和易性，同时采用岩沥青粉末复拌改性提高沥青混合料的路用性能。为此，本文首先采用荧光显微技术观察岩沥青在 110#基质沥青中的分布，讨论天然沥青对软质沥青的改性机理及其复合效果；其次通过室内试验试验研究不同类型天然沥青和剂量对复合沥青结合料的高温、低温和抗老化性能的影响，据此选择适宜的天然岩沥青添加比例；在此基础上，进行预拌增强沥青混合料性能试验并与 SK70#热拌沥青混合料、SBS 改性沥青混合料进行对比，以评价预拌增强沥青混合料路用性能的优劣和应用推广的可行性。试验结果表明预拌增强的技术路线可以实现施工和易性与性能改善的平衡，还具有节能减排的效益；而后续环节中添加天然沥青可以吸收软质沥青的轻质组分，形成微观多相、宏观均匀稳定的分布体系，以此实现对软质沥青的改性和增强作用，研究发现天然沥青复合软质沥青可使结合料的感温性能、高温性能和老化性能得以提高，但低温性能有所降低；综上研究，预拌-增强技术不仅可以明显降低混合料的拌和温度，而且可以提高沥青混合料的高温性能、低温性能、水稳性能，甚至可以接近 SBS 改性沥青的性能水平；另外，当青川岩沥青掺量为 15%、布敦岩沥青掺量为 20%时，预拌-增强环保型沥青混合料具有良好的路用性能及环保效益。

关键词：预拌增强

Study of Premixing & Reinforced Asphalt Mixture Performance

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Abstract:

Based on the needs of reducing consumption and environmental protection, the route of premixing & reinforced(P&R) technology is put forward, that is, the high grade soft asphalt is used to premix the mineral materials to ensure that the asphalt mixture has good construction workability, while the use of rock asphalt mixing compound modified to improve pavement performance of asphalt mixture. Therefore, this paper first observed the distribution of rock asphalt in 110 # matrix asphalt by fluorescence microscopy, and discussed the modification mechanism of natural asphalt on soft asphalt and its compound effect. Secondly, indoor experiments were conducted to study the effects of different types of natural asphalt and dosage on high temperature, low temperature and anti-aging properties of composite binder, so as to select suitable proportion of natural rock asphalt. On this basis, the performance test of P&R asphalt mixture was carried out and compared with SK70 # hot asphalt mixture and SBS modified asphalt mixture to evaluate the pros and cons of the pavement performance of P&R asphalt mixture and its application feasibility. The test results show that the P&R technology enhances the balance between construction workability and performance improvement, and also has the benefits of energy saving and emission reduction. While the addition

of natural rock asphalt in the subsequent stage can absorb the light components of soft asphalt to form microcosmic, multi-phase, macroscopically uniform and stable distribution system in order to realize the modification and enhancement of soft asphalt. In addition,the results also show that the natural rock asphalt compositing soft asphalt can improve the temperature sensitivity, high temperature performance and aging performance of the binder, but the low temperature performance decreases. In summary, P&R technology not only can significantly reduce the mixing temperature of the mixture, but also can improve the high temperature performance, low temperature performance, water stability of asphalt mixture, and even close to the performance level of SBS modified asphalt. When the content of QC rock asphalt is 15%, or the content of Budon rock asphalt is 20%, the P&R asphalt mixture has good road performance and environmental protection benefits.
keywords: premixing &reinforced(P&R)

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Influence of Aging on Fatigue and Self-Healing Properties of Asphalt

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Abstract :To study the effect of aging on the fatigue self-healing properties ofmatrix asphalt、rubber powder modified asphalt and SBS modified asphalt,A dynamic shear rheometer was used to test the fatigue performance of the three asphalt before and after aging. Atomic force microscopy was used to observe surface changes of the three asphalts before and after aging.Appropriate damage parameters were set,and a rest period was added during the time-scanning process to investigate the asphalts' self-healing properties. The results show that with the deepening of aging, the fatigue life of matrix asphalt and SBS modified asphalt will increase, and the fatigue resistance will be better, which is contrary to the general law. This is because the complex shear modulus and hardness of the asphalt after aging in the stress control mode are greatly increased, so that the amount of deformation generated becomes small, and the complex shear modulus is increased by the required time. At the same time, the study found that rubber powder modified asphalt has better fatigue resistance than matrix asphalt. The matrix asphalt and SBS modified asphalt increase in surface roughness as the aging progresses. This is due to an increase in asphaltene and a decrease in light components. For rubber powder modified asphalt, as the degree of aging increases. The roughness showed a slight downward trend. This is because the interaction of the asphalt and the rubber powder particles increases the consistency of the asphalt, increases the interaction force between the molecules, and suppresses the formation of the "peak structure".gray correlation analysis showed that the degree of aging was the greatest influencing factor,followed by the damage degree time, and temperature,and using the range analysis, the effects of various levels on the healing properties of the three types of asphalt can be obtained.

Key words: self-healing capacity; rubber powder modified asphalt; matrix asphalt; SBS modified asphat; microstructure

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Influence of Micro-Texture on the Long Term Skid Resistance Performance of Aggregates

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Abstract: This article intends to study the influence of micro-texture on the long term skid resistance performance of four types of aggregates (Bauxite, Granite, Limestone and Basalt). For this purpose, profile roughness and Polished Stone Value (PSV) were tested, and the mineralogical composition, hardness and micro morphology of these aggregates were also investigated. The results showed that micro texture played a major role in the long term skid resistance performance of aggregates. Mineralogical composition affected the change of micro texture characteristics of aggregates during long term polishing process. Lots of high hardness mineral were conducive to stable micro-texture of aggregates and retard the frictional attenuation. However, a small amount of soft minerals were beneficial to the formation of new rougher micro texture. Due to the higher Vickers hardness and the hardness difference of minerals in the aggregate, bauxite had higher skid resistance during long term polishing process and it was suitable for the wearing course, especially high friction surface treatment.

Key words: wearing course; aggregates; mineralogical composition; micro-texture; vickers hardness; polished stone value

基于沥青粘弹性的弹性恢复率测量装置及试验方法研究

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摘　要：本文通过对现有 JTG E20-2011 公路工程沥青及沥青混合料试验规程 T0662-2000 沥青弹性恢复试验过程存在问题的分析，对比三种不同改性沥青的低温弹性恢复试验、极限弹性恢复试验、持载弹性恢复试验结果，提出了一种基于沥青粘弹性的改性沥青弹性恢复率测量装置及试验方法，并对本方法的准确性进行了验证，以及与现有方法进行了比较。结果表明，本方法不仅能够准确的反应改性沥青弹性恢复率，同时提高了试验结果的准确性，而且可以同时进行多组沥青试样的测量，提高了试验工作效率。

关键词：公路工程；弹性恢复率；测量装置；改性沥青；试验方法

Experimental Investigation on Measuring Device and Test Method of Elastic Recovery Rate Based on Asphalt Viscoelasticity

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Abstract:

This paper presents a measuring device and test method of elastic recovery rate of modified asphalt based on asphalt viscoelasticity. The accuracy of this method is verified and compared with the existing methods. And this is based on the analysis of the existing JTG E20-2011 highway engineering asphalt and asphalt mixture test procedures T0662-2000 asphalt elastic recovery test process problems, comparison of three kinds of modified asphalt low temperature elastic recovery test, limit elastic recovery test, load elastic recovery test results obtained. The results indicated that this method can not only accurately respond to the elastic recovery rate of modified asphalt, but also improve the accuracy of the test results, and can also be used to measure multiple sets of asphalt samples and improve the efficiency of the experiment.

keywords: highway engineering; elastic recovery rate; measuring device; modified asphalt

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各项异性渗流作用下多孔沥青路面动力响应分析

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摘　要：水与动荷载的共同反复作用是导致多孔沥青路面水损坏的主要原因，因此需深入分析多孔沥青路面在渗流与动荷载联合作用下的动力响应。本文基于多孔介质理论，通过自行设计的渗水试验装置获得排水面层的各向异性渗透系数，建立考虑渗流各向异性的多孔沥青路面三维有限元模型，获得了渗流、动荷载联合作用下饱和多孔沥青路面内超孔隙水压力、特征应力的时程变化特征；最后采用正交试验方法对面层内超孔隙水压力进行参数敏感性分析。结果表明：含水多孔沥青路面与干燥沥青路面动力响应的不同点主要集中在面层内；面层与基层交界面上受正、负超孔隙水压力循环作用的影响最大，需做好排水面层下防水处理，并保证界面粘结强度；面层超孔隙水压力敏感性分析表明排水面层内超孔隙水压力受自身材料渗透性影响最大。

关键词：道路工程；多孔沥青路面；渗流各项异性；动力响应；敏感性分析

Dynamic Response Analysis of Porous Asphalt Pavement Considering Anisotropic Seepage

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Abstract:

The repeated action of water and dynamic traffic load is the main cause of water damage of porous asphalt pavement. It is necessary to deeply analyze the dynamic response of porous asphalt pavement under the combined action of seepage and dynamic load. Based on the porous media theory, the anisotropic hydraulic conductivities of the drainage surface layer are obtained through the self-designed water seepage test device, and the three-dimensional finite element model of porous asphalt pavement considering seepage anisotropy is established. The variations of excess pore water pressure and characteristic stress of saturated asphalt pavement are obtained. Finally, the orthogonal test method is used to analyze the parameter sensitivity of the excess pore water pressure in the surface layers.

keywords: road engineering; porous asphalt pavement; anisotropic seepage; dynamic response; sensitivity analysis

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透水沥青混凝土堵塞行为与净化能力试验研究

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摘　要：透水沥青混凝土路面在长期服役过程中容易发生空隙堵塞现象。为探明其堵塞行为与净化能力的演变规律，确定合理的清理周期，对不同空隙率透水沥青混合料马歇尔试件进行了室内堵塞模拟试验，并对其渗透系数与污染物净化率进行了同步测定。试验结果表明，在模拟周期内，试件的排水能力逐渐衰减，而净化能力得到增强，渗透系数与污染物净化率呈现显著的负相关关系。基于这一规律，分别根据平衡原则、最大污染物净化率原则和排水能力优先原则提出了三种清理时间节点的确定方法。

关键词：透水沥青混合料；空隙堵塞；净化能力；风干现象；清理时间节点

Experimental Study on the Clogging Behavior and Purifying Capacity of Permeable Asphalt Concrete

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Abstract:

The void of permeable asphalt concrete (PAC) is prone to clogging during its long-term service. In order to find out the evolution law of clogging behavior and purifying capacity and determine a reasonable cleaning period, the laboratory clogging simulation test was carried out on the Marshall specimens of PAC with different void ratios. The permeability coefficient and the pollutant purification rate were measured synchronously. Results showed that during the simulation period, the drainage capacity of the specimen gradually decreased, and the purifying capacity increased. The permeability coefficients and the pollutant purification rates showed a significant negative correlation. Based on this, three principles for determining the cleaning time nodes were proposed, including the principle of balance, the principle of maximum pollutant purification rate and the priority principle of drainage capacity.

keywords: permeable asphalt mixture; void clogging; Purifying capacity; wind drying phenomenon; cleaning time nodes

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Effect of Cement and Emulsified Asphalt Contents on the Performance of Cement-Emulsified Asphalt Mixture

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Abstract: The effects of cement and emulsified asphalt contents on the performance of cement-emulsified asphalt mixture were systematically evaluated, including the indirect tensile strength, compressive strength, modulus of resilience, tensile strength ratio, dynamic stability, maximum bending strain, and Cantabro loss. In addition, the mesoscopic images and void characteristics of cement-emulsified asphalt mixtures with different material compositions were obtained, using scanning electron microscopy (SEM) and computed tomography (CT). The results indicated that at a constant cement content of 3%, when the emulsified asphalt content increased from 6% to 9%, the indirect tensile strength, compressive strength, and modulus of resilience first increased and then decreased. At a constant emulsified asphalt content of 8%, when the cement content increased from 0% to 4%, the indirect tensile strength first increased and then decreased, and the compressive strength and modulus of resilience each reached its maximum at a cement content of 3%. The addition of cement significantly improved the high-temperature stability and moisture stability of the asphalt mixture but was not conducive to its low-temperature performance. In addition, a minimum Cantabro loss was observed at a cement content between 2% and 3%. The mesoscopic void structures formed in different cement and emulsified asphalt contents also significantly affected the mechanical properties and mixture performances.

Key words: road engineering; cement-emulsified asphalt mixture; strength; mixture performance

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城市不同透水铺装结构的透水效率计算方法及数值分析

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摘　要：渗水、蓄水、排水是城市透水铺装结构设计的重要功能。本文针对不同的透水铺装结构，分析其产流机制，提出排水型路面结构排水性能评价指标，建立全透型路面储水-渗透模型和计算方法。研究结果表明，排水型路面只有在降雨强度较小时，不会产生地表径流，单向路幅宽度小于 14m，其渗流时间在 2h 以内，具有较优的排水功能；全透型路面土基渗透速度直接影响雨水的下渗能力，路面结构出现最大储水量时间滞后于最大降雨强度发生时间，在整个降雨过程期间，全透型路面结构中的最高蓄水水位为 192.9186mm，未超出级配碎石设计厚度 250mm，满足排水功能要求。

关键词：排水型路面；全透型路面；模型；评价指标；数值分析

Calculation Method and Numerical Analysis of Permeability Efficiency of Different Permeable Pavement Structures in Cities

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Abstract:

The permeable pavement structure is an environmentally friendly pavement structure which can effectively reduce urban waterlogging and noise pollution. This paper takes a two-way six-lane urban road in Nanjing as the object, analyzes the flow-producing mechanism of different permeable pavement structures, and proposes the drainage performance evaluation index of drainage type and full-transparency pavement structure, and establishes its water permeability efficiency calculation model and numerical analysis method. The research results show that when the rainfall type pavement has small rainfall intensity, surface runoff will not occur, the one-way width is less than 14m, and the seepage time is less than 2h; the permeability of soil-based permeation of the fully permeable drainage pavement directly affects the infiltration of rainwater. Capacity, the maximum water storage time of the pavement structure lags behind the maximum rainfall intensity. During the entire rainfall process, the peak water level in the pavement structure is 192.9186mm, which meets the design requirements of the pavement structural layer thickness.

keywords: drainage pavement

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融雪除冰剂微观分析及水稳定性研究

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摘　要：冬季路面积雪结冰导致路面抗滑系数下降，严重威胁人们的生产和生活。本研究对市售的 JM 融雪除冰剂进行 SEM 和 EDS、XRD、红外光谱等微观分析以及降低冰点试验、融冰性能和含 JM 沥青混合料的水稳定性能研究。研究表明：JM 融雪除冰剂具有释放除含有抗凝冰氯盐外还含有其他的有机物质，其表面的孔隙有助于抗凝冰氯盐的释放；JM 降低冰点效果明显，且融冰效果较好。通过将 JM 直接掺入到沥青混合料中进行水稳定性研究，结果表明沥青混合料水稳定性降低，但是 TSR 仍能满足规范要求。

关键词：微观分析;降低冰点试验;融冰试验;水稳定性

Microscopic Analysis and Performance Study of Snow Melting De-Lcing Agent

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Abstract:

The snowy ice in the winter road area leads to a decrease in the anti-sliding coefficient of the road surface, which seriously threatens people's production and life. In this study, the commercially available JM snow melting de-icing agent was subjected to SEM and EDS, XRD, infrared spectroscopy and other microscopic analysis, as well as to reduce the freezing point test, the melting performance and the water stability performance of the JM-containing asphalt mixture. Studies have shown that JM snow melting deicing agent has other organic substances in addition to containing anti-condensation ice chloride salt, and its surface pores contribute to the release of anti-condensation ice chloride salt; JM has obvious effect of lowering freezing point and melting ice effect better. The water stability study was carried out by directly incorporating JM into the asphalt mixture. The results show that the water stability of the asphalt mixture is reduced, but the TSR can still meet the specifications.

keywords: microscopic analysis; freezing point test; melting performance; water stability

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酸雨侵蚀作用对沥青混合料路用性能影响研究

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摘　要：化石燃料能源的过度依赖导致我国酸雨天气呈现大范围、长时间、高强度的发展态势，为研究极端酸雨气候对沥青混合料综合路用性能的影响规律，本研究室内配制 PH 值分别为 1、3、5 的酸雨溶液，并分别对三种岩性（玄武岩、辉绿岩、花岗岩）的沥青混合料开展周期性酸雨加速侵蚀试验，最后针对其高温稳定性、低温抗裂性、水稳定性和疲劳性能开展实验研究。结果表明：沥青混合料受酸雨侵蚀作用后路用性能有较大程度下降，随着酸雨 PH 值的下降和侵蚀时间的增加，下降速度也不断加快。矿料物化性质的不同使沥青混合料对酸雨的耐受度有一定差异，耐受度从大到下依次为花岗岩沥青混合料＞辉绿岩沥青混合料＞玄武岩沥青混合料。酸雨的侵蚀作用导致沥青从集料表面发生剥蚀，进而造成矿料中碱性成分流失，加速了对沥青混合料的侵蚀作用。

关键词：道路工程；酸雨侵蚀；沥青混合料；路用性能；耐受度

Study on the Erosion Effect of Acid Rain on Pavement Performance of Asphalt Mixture

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Abstract:

The over-reliance of fossil fuel energy leads to a large-scale, long-term and high-intensity development trend of acid rain in China. To study the effect of extreme acid rain climate on the comprehensive road performance of asphalt mixture, In this study, an acid rain solution with PH values of 1, 3, and 5 were prepared in the laboratory, The accelerated acid rain erosion test was conducted on asphalt mixtures of three lithologies (diabase, basalt, and moorstone), Finally, experimental studies were conducted on its high temperature stability, low temperature crack resistance, water stability and fatigue properties. The results show that the road performance of bituminous mixture is greatly reduced after acid rain erosion. With the decrease of acid rain PH value and the increase of erosion time, the decline rate is also accelerating. The difference in the material properties of the minerals makes the asphalt mixtures have a certain degree of tolerance to acid rain. The tolerability ranges from large to low is basalt asphalt mixture, diabase asphalt mixture, and moorstone asphalt mixture. The erosion of acid rain causes the bitumen to erode from the surface of the aggregate, which in turn causes the loss of alkaline components in the mineral and accelerates the erosion of the asphalt mixture.

keywords: road engineering; acid rain erosion effect; asphalt mixture; road performance; tolerance level

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基于 COMSOL 流固耦合分析的沥青路面结构动水压力研究

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摘　要：动水压力作用是沥青路面产生水损害的重要原因，不同沥青路面结构在不同荷载作用下的动水压力差异显著。本文针对密级配沥青路面和 4 种透排水沥青路面结构，采用基于多孔介质理论的 COMSOL 多物理场有限元软件，建立了动态荷载作用下的路面二维轴对称模型，研究不同沥青路面的孔隙水压力变化，并以单层排水沥青路面为例，分析了车速、轮载，混合料渗透系数等参数对沥青路面孔隙水压力的影响。研究结果表明：沥青路面饱水条件下，路表竖向位移值更小，水的存在消散了部分车辆荷载。单层排水沥青路面孔隙水压力峰值为 321.5KPa，双层排水沥青路面孔隙水压力峰值为 241.2KPa 均远小于密级配沥青路面的 429KPa。全透式沥青路面孔隙水压力峰值最小，三层排水沥青路面次之。根据孔隙水压力云图，密级配沥青路面的孔隙水压力在竖向的影响深度较大，而单层排水沥青路面的孔隙水压力在水平方向的径向影响较大。由正交模拟结果所得，影响单层排水沥青路面内部孔隙水压力的因素，参数敏感性由大到小依次为渗透系数，轮载峰值，车速。

关键词：道路工程；孔隙水压力；流固耦合；沥青路面；水损害；竖向位移

Study on Dynamic Water Pressure of Asphalt Pavement Structure Based on COMSOL Fluid-Structure Coupling

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Abstract:

Dynamic water pressure is an important cause of water damage on asphalt pavement. The dynamic water pressure of different asphalt pavement structures under different loads is significantly different. Based on the theory of porous media, the two-dimensional axisymmetric model of asphalt pavement under dynamic loading was established using COMSOL Multiphysics® finite element software. The water damage mechanism of dense-graded asphalt pavement and permeable asphalt pavement under pore water pressure was compared and analyzed. In addition, the effects of changing vehicle speed, wheel load and permeability coefficient on the pore water pressure of single-layer drainage asphalt pavement are considered. The results show that the existence of water alleviates the overall stress on the pavement structure, making the vertical displacement of the road surface smaller. The maximum pore water pressure value is 321.5KPa for single-layer drainage asphalt pavement, whereas for double-layer drainage asphalt pavement, the value is 241.2kPa. Both of them are much smaller than 429KPa for dense-graded asphalt pavement. The maximum pore water pressure value of the full-permeable asphalt pavement is the lowest, followed by the triple-layer drainage asphalt pavement. According to the pore water pressure cloud map, the pore water pressure of the dense-graded asphalt pavement has a greater influence on vertical depth, whereas the pressure in the single-layer drainage asphalt pavement has a greater influence on the horizontal direction. From the orthogonal test results, the factors affecting the pore

water pressure inside the single-layer drainage asphalt pavement, the parameter sensitivity from large to small is the permeability coefficient, wheel load peak, and vehicle speed.
keywords: road engineering; pore water pressure; multiphysics coupling; asphalt pavement; water damage; vertical displacement

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基于单轴拉伸循环加载试验的沥青混合料疲劳特性研究

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摘　要：为了揭示沥青混合料疲劳损伤特性，本文基于黏弹性连续损伤理论对 AC-20 和 SMA-13 沥青混合料进行，确定了第一加载路径伪应变和损伤变量，最终经过损伤计算获得伪劲度模量与损伤变量之间的关系。结果表明：采用峰值相位角作为疲劳损伤的判定依据可以较好地表征沥青混合料的临界损伤状态。两种沥青混合料在不同应变条件下动态模量随着相位角增加而下降，当相位角达到峰值时，动态模量大幅度减小，试件出现疲劳破坏。随着损伤程度 S 的加剧，伪劲度模量 C 先快速衰减而后逐渐进入平缓阶段。在循环荷载重复作用下，沥青混合料随着损伤能力 Sapp 增加，疲劳寿命也随之延长。

关键词：道路工程；沥青混合料；疲劳损伤；粘弹性连续损伤理论；疲劳破坏模型

Study on Fatigue Characteristics of Asphalt Mixture Based on the Uniaxial Direct Drawing Cycle Loading Fatigue Test

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Abstract:

In order to reveal the fatigue damage characteristics of asphalt mixture, AC-20 and SMA-13 asphalt mixtures are subjected to the cyclic direct tension fatigue test based on the Visco-Elastic Continuum Damage Method and the damage variable and pseudo-strain of the first loading path are determined.Finally, the relationship between the pseudo-stiffness modulus and the damage variables is obtained through damage calculation.The result shows that the peak phase angle can be used to judge the critical damage state of asphalt mixture. The dynamic modulus of the two asphalt mixtures decreased with increasing phase angle under different strain conditions. When the phase angle reached the peak value, the dynamic modulus decreased greatly and the specimens showed fatigue damage. As the degree of damage increased, the pseudo-stiffness modulus decayed rapidly and then gradually entered a gradual phase. Under the cyclic loading, the asphalt mixture increased with the damage capacity, and the fatigue life was also prolonged.

keywords: road engineering; asphalt mixture; fatigue damage; viscoelastic continuous damage theory; fatigue failure model

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“厚板+沥青混凝土层”结构层间界面特性的温度效应

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摘　要：“厚板+沥青混凝土层”结构在温度荷载作用下会在结构内部产生较大的温度应力可能导致水泥混凝土板与沥青混凝土层层间界面由黏结状态转为接触摩擦作用，从而对复合结构层间的协同作用产生影响。通过引入基于表面的内聚力模型模拟水泥混凝土板与沥青混凝土层层间黏结-脱黏-接触的复杂相互作用关系，建立复合结构层间界面特性演化三维有限元分析模型，并结合足尺推板试验结果对模型合理性进行验证。细致分析了整体温度作用下“厚板+沥青混凝土层”结构层间界面特性演化过程以及层间剪切强度、界面剪切刚度和临界断裂能等参数的影响规律。研究结果表明：初始较小温度下，层间剪切应力在水泥混凝土板伸缩缝处最大；升温 5.9℃时，水泥混凝土板伸缩缝位置处剪切应力率先达到界面剪切强度，界面微裂纹开始萌生；升温 19.2℃时，层间起始脱黏；当升温幅度达到 60℃时，界面黏结转为层间接触作用，正常使用范围内，整体升温作用下层间界面不会发生纵向剪切破坏。较小的剪切强度和过大的剪切刚度会导致层间损伤过早萌生，提高层间剪切强度和界面临界断裂能可以有效的控制层间损伤和层间脱黏的产生，有利于提高复合结构的整体协同作用性。

关键词：沥青混凝土；复合结构；界面特性；温度效应；内聚力模型

Research on Interface Characteristic Between Composite Structure of Slab and Asphalt Concrete Under Temperature Loading

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Abstract:

Interface characteristic between composite structure of slab and asphalt concrete may make change under temperature load, which will makes effects on the synergistic effect of composite structures. The complex interaction relationship between slab and asphalt concrete layer under temperature loading is kind of “bonding-debonding-contact”, which can be simulated by surface based cohesive zone model (SCZM). A three-dimensional finite element model of interface characteristic of structures was established, and the model was validated by the results of the longitudinal shear test of slab track. Evolution of interface characteristic and influence law of parameters such as shear strength and critical fracture energy were analyzed particularly. The study shows that interfacial shear stress at the expansion joint of the slab is the largest. The interfacial shear stress at the expansion joint reaches shear strength firstly, and interface damage initiates under 5.9℃ temperature rising. When the increasing extent of temperature is 19.2℃, the interfacial crack begins to expand. When the increasing extent of temperature is 60℃, the interface characteristic changes from bonding state to contact friction and longitudinal shear damage will not occur between the internal surface under the temperature loading within normal use. Small shear stress and critical

fracture energy lead to initiation of interface damage easily. Improving shear strength and critical fracture energy can effectively control interface crack and improve the synergistic effect of composite structure.

keywords: asphalt concrete; composite structure; interface characteristics; temperature; cohesive zone model

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沥青路面加铺结构中土工布夹层粘结失效时温特性研究

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摘　要：针对含土工布夹层的双层沥青混合料试件进行直剪试验，以层间抗剪强度为指标，通过方差分析和多重比较分析了温度、加载速率对土工布夹层粘结失效的影响作用，建立了含土工布夹层试件的层间抗剪强度与温度、加载速率的数学关系，基于时间-温度等效原理确定了层间抗剪强度 sigmodial 主曲线，并对其时温等效特性进行了验证。结果表明：含土工布夹层试件层间抗剪强度受温度和加载速率显著影响，随温度升高或加载速率下降其值逐渐降低；指数模型对层间抗剪强度拟合效果良好，模型预估值与试验测试值基本吻合；sigmodial 主曲线在更宽加载速率范围内表征了层间抗剪强度的变化趋势，粘层油蠕变柔量与层间抗剪强度两力学参量的移位因子一致性验证了土工布夹层粘结失效具有时温等效特性。

关键词：土工布夹层；层间抗剪强度；指数模型；时间-温度等效原理

Time-Temperature Characterization of Bond Failure for Geotextile Interlayer in Asphalt Overlay

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Abstract:

Abstract: Layer-parallel direct shear test was carried for the double-layered asphalt concrete specimens with geotextile interlayer. The influence significances of temperature and deformation rate on the bond failure behavior of geotextile interlayer in asphalt overlay were analyzed using the index of interlayer shear strength based on ANOVA and multiple comparing methods. Then the mathematical relationship between temperature, deformation rate and interlayer shear strength was derived from an exponential function. Moreover, the sigmoidal master curve of interlayer shear strength was build based on the time-temperature superposition principle (TTSP) and the equivalent character of time-temperature for interlayer shear strength was also validated. The results show that the influences of temperature and deformation rate are significant. The interlayer shear strength would be lower when the temperature increases or deformation rate decreases. Exponential model can be used to predict the interlayer shear strength in laboratory, and simulation results inosculate with experimental results very well. The change tendency of the interlayer shear strength is showed in a broader range of deformation rate by using the sigmoidal master curve. The interlayer shear strength of specimen with geotextile interlayer has equivalent character of time-temperature which is been validated by the consistency of shift factors for creep compliance and interlayer shear strength.

keywords: geotextile interlayer; interlayer shear strength; exponential model; time-temperature superposition principle

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基于遗传神经网络的再生沥青混合料性能预测研究

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摘　要：再生沥青混合料的各项性能需要通过大量室内试验得以验证，需要消耗大量的时间和精力。已有的再生沥青混合料性能预估研究很难将混合料的影响因素与混合料整体性能建立起较为精准的模型。本文以 matlab 为平台，分别应用 BP 神经网络和遗传算法优化的 BP 神经网络对再生沥青混合料的性能进行预测。以旧料掺量、油石比等 8 个影响因素作为输入层，以动稳定度、残留稳定度等 5 个性能指标作为输出层，将 28 组归一化处理后的试验数据进行神经网络的训练、验证和测试。结果表明：遗传算法优化的 BP 神经网络测表现出更加精准的预测效果。将遗传算法优化的 BP 神经网络应用于工程实践中再生沥青混合料性能预测可以大大提高试验科学性和预见性。

关键词：BP 神经网络；再生沥青混合料；路用性能；预测模型；遗传算法；matlab

Prediction of Performance of Recycled Asphalt Mixture Based on Genetic Neural Network

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Abstract:

The performance of the recycled asphalt mixture needs to be verified through a large number of laboratory tests, and it takes a lot of time and experience. It is difficult to predict the performance of the existing recycled asphalt mixture, and it is difficult to establish a more accurate model for the influence factors of the mixture and the overall performance of the mixture. In this paper, Matlab is used as a platform to predict the performance of recycled asphalt mixture using BP neural network and genetic algorithm optimized BP neural network. Eight input factors such as old material content and oil-cement ratio were used as the input layer, and five performance indicators such as dynamic stability and residual stability were taken as output layers. The 28 sets of normalized test data were used to train the neural network. , verification and testing. The results show that the BP neural network optimized by genetic algorithm shows a more accurate prediction effect. The application of the BP neural network optimized by genetic algorithm in the engineering practice to predict the performance of recycled asphalt mixture can greatly improve the scientific and predictability of the experiment.

keywords: BP neural network; recycled asphalt mixture; road performance; prediction model; genetic algorithm; matlab

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基于层位功能的沥青路面结构有限元分析

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摘　要：目的：为分析面层厚度及面层模量梯度对不同类型沥青路面结构的力学响应，方法：本文基于 2017 年《公路沥青路面设计规范》中沥青混合料动态压缩模量及沥青路面结构设计指标，以江苏交通控股京沪高速项目为依托，采用 ABAQUS 软件计算无机结合料稳定类、沥青结合料稳定类基层沥青路面这两种典型路面结构的设计指标。结果：面层厚度对于沥青路面结构中面层剪应力影响不大，而面层模量梯度对于沥青路面最大剪应力值影响较大；面层厚度和面层模量梯度对沥青混合料层层底拉应变的影响都较为显著。结论：在一定范围内，适当增加无机结合料稳定类基层沥青路面面层的厚度，可以有效地改善基层层底拉应力状况。面层模量梯度对无机结合料稳定层层底最大拉应力的影响较小；面层厚度对无机结合料稳定类基层沥青路面结构中路基顶面竖向压应变的影响大于沥青结合料稳定类基层沥青路面结构。面层模量梯度对沥青路面路基顶面竖向压应变影响较小，对我国新建和改建高速公路的路面结构设计具有较大指导意义。

关键词：力学响应

Finite Element Analysis of Asphalt Pavement Structure Based on Horizon Function

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Abstract:

Aim: In order to analyze the mechanical response of surface thickness and modulus gradient to different types of asphalt pavement structure, methods: Based on the dynamic compressive modulus of asphalt mixture and the design index of asphalt pavement structure in Highway Asphalt Pavement Design Code 2017, and relying on the Beijing-Shanghai Expressway Project of Jiangsu Traffic Holding Company, ABAQUS software was used to calculate the stability class of inorganic binder and asphalt knot. The design indexes of asphalt pavement with aggregate stabilized base course are two typical pavement structures. Result: The thickness of asphalt pavement has little effect on the shear stress of asphalt pavement structure, while the modulus gradient of asphalt pavement has great influence on the maximum shear stress value of asphalt pavement; the thickness of asphalt pavement and the modulus gradient of asphalt pavement have significant influence on the bottom tensile strain of asphalt mixture layer. Conclusion: In a certain range, increasing the thickness of inorganic binder stabilized base asphalt pavement can effectively improve the tension stress of base layer. The modulus gradient of the surface layer has little effect on the maximum tensile stress at the bottom of the stabilized layer of inorganic binder, and the thickness of the surface layer has more effect on the vertical compressive strain of the top surface of the roadbed in the stabilized base asphalt pavement structure of inorganic binder than that of the stabilized base asphalt pavement structure of the asphalt binder. The modulus gradient of asphalt pavement has little

influence on the vertical compressive strain of the top surface of asphalt pavement, which has great guiding significance for the pavement structure design of new and rebuilt expressways in China.
keywords: Mechanical response

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Numerical Simulation of Bridge Asphalt Plug Joints

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Abstract: Asphalt plug joints (APJs) provide excellent surface flatness, low costs and noise, ease of installation, but premature failures have been observed due to complexity of service behavior. A detailed finite element model using Comsol Multiphysics is established to investigate the influence of load locations on the interface between pavement and joint filling material and analyze the tensile deformation ability of joint at -10℃ and 20℃; The semi-sinusoidal uniformly distributed load is utilized to simulate the dynamic load, and the anti-rutting ability of the joint under heavy traffic at different temperatures is explored. It is found that APJs have good rutting resistance and the maximum stress is at the top of the interface between pavement and joint filling material in the process of driving. Internal stress increases as temperature decreases. Moreover, with the increase of tensile length, stress growth rate is faster.

Key words: ksphalt plug joints; surface flatness; comsol Multiphysics; anti-rutting ability

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Predict the Rheological Properties of Aged Asphalt Binders Using a Universal Kinetic Model

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Abstract: In this study, universal models were proposed to predict the aging behaviors of five different asphalt binders, where the rheological properties were emphasized on. The carbonyl content and crossover modulus of binders during oxidative aging process were predicted using the proposed universal kinetic models. The carbonyl content test using the Fourier Transform infrared spectroscopy (FTIR) technique and the frequency sweep test using a Dynamic Shear Rheometer (DSR) were performed to obtain the optimum model parameters. From the testing results, the crossover modulus of binders under oxidative aging effect showed similar growth trend to the carbonyl content that follows the two-reaction kinetics of aging. An approximately linear relation was established between the log crossover frequency and the inverse of log crossover modulus. A sufficient good agreement was achieved between the measured and predicted results of carbonyl content and crossover modulus of asphalt binders at given aging temperature and duration. However, it lost a little prediction accuracy when using the universal model parameters, compared to the specific model parameters. Moreover, based on the calculated crossover modulus and crossover frequency, the complex shear modulus and phase angle were successfully predicted based on the Christensen-Anderson model. The proposed universal model provides an effective approach of predicting the rheological properties of aged asphalt binders.

Key words: asphalt binder; aging; rheological properties; prediction; universal kinetic model

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Crumb Rubber and Trans-Polyoctenamer Rubber Asphalt Mixture (CRTAM): Gradation Design and Performance Evaluation

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Abstract: The utilization of crumb rubber (CR) in asphalt mixtures has increased in the field of road engineering in recent years. CR can also play a role in filling the aggregate while modifying the asphalt. To obtain a crumb rubber asphalt mixture (CRAM) with excellent performance, this paper combines trans-polyoctenamer rubber (TOR), CR, and other additives to prepare a new type of CR. First, the skeleton intrusion compact volume method is used to optimize the grading of coarse and fine aggregates, and the design of crumb rubber and trans-polyoctenamer rubber asphalt mixture (CRTAM) gradation is carried out by the same volume replacement grading method and unequal volume replacement grading method. Then, the road performance (i.e., high-temperature stability, low-temperature crack resistance, and water stability) is analyzed through experiments. The results show that the aggregate grading point in the tightly packed state with 4.75 mm as the cutoff coarse and fine aggregate meets the requirements, and the six gradations obtained by unequal volume replacement with 2% CR and trans-polyoctenamer rubber (TOR) comply with the requirement that VCAmix ≤ VCADLC. Both have a skeleton dense texture. CRTAM has good high- and low-temperature performance and water stability. When the substitution ratio is 1.5 and 0.5, the high-temperature performance is better, and when the substitution ratio is 0.5, the flexural strain energy density is highest and the low-temperature performance is the best. Combined with economic benefits, it is recommended that CRT content is 2% and the substitution ratio is 0.5.

Key words: gradation design; crumb rubber; TOR; road performanxe

Structural Investigation of the Snow-Melting Heated Bridge Deck Based on the Thermal Field Distribution

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Abstract: This paper aims to improve the energy utilization of the snow-melting heated bridge deck system with a thermally conductive layer (SHBD-TCL) and reduce its thermal deformation caused by the non-uniform thermal field distribution. Therefore, three structures of the SHBD-TCL were proposed, and they have thermally conductive layers and heating cables embedded in different layers. Then, the finite element models corresponding to the above structures were developed. The energy utilization and thermal deformation were analyzed, and the embedded spacing and embedded depth were set as input factors. Also, the effective energy ratio ( ) and the maximal deformation (Umax) were set as the optimization targets, and their prediction models were established based on the above input factors. Finally, to obtain the greater and less Umax, the multi-objective optimization has been applied to obtain the optimum structure and rational parameters. The optimum structure Str1 was selected to conduct the laboratory experiments, which verified the reasonability of the finite element model of SHBD-TCL. The research enriches the thermodynamic structure design theory of the snow-melting bridge system..

Key words: snow-melting heated bridge deck; energy distribution; thermal deformation; heating cables; structure optimization; prediction model

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Shear Performance of Phosphorus Slag Asphalt Mixture of Bridge Deck Pavement

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Abstract: The slippage destroy in asphalt pavement of bridge deck is a prominent early damage, therefore, this research applied the phosphorus slag in the asphalt mixture with the aim of improving slippage resistance performance in bridge structure. Firstly, the tradition pavement performance of phosphorus slag asphalt mixture is verified by rutting test, freeze-thaw splitting test and Marshall immersion test. The results show that the addition of phosphorus slag into asphalt concrete can improve the rutting resistance and water stability at high temperature. Secondly, using uniaxial penetration test as evaluation method and shear strength as evaluation index, it is verified that the shear strength of the mixture is significantly improved after phosphorus slag equally replaces all limestone aggregates and fillers of 0.075mm-4.75mm in asphalt pavement mixture. The influence of asphalt type, temperature and loading rate on the shear strength of the mixture was analyzed. Finally, using the self-designed interlayer shear test device and taking the interlayer shear strength as the evaluation index, the factors affecting the interlayer stability of bridge deck pavement structure are evaluated. The results show that phosphorus slag asphalt mixture can improve the interlayer shear resistance of bridge deck pavement; the interface treatment of bridge deck has a significant impact on interlayer shear resistance, and the exposed stone treatment of bridge deck is an effective measure to improve the interlayer shear strength of bridge deck pavement; the addition of phosphorus slag powder or anti-stripping agent into SBS modified asphalt can slightly improve the interlayer shear resistance; the interlayer shear strength increases with the normal direction. The higher the temperature, the lower the interlayer shear strength. The research results of this paper provide a basic understanding and guidance for the application of phosphorus slag in bridge deck pavement.

Key words: asphalt Mixture; bridge Pavement; shear performance; phosphorus slag

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Development and Validation of Innovative Laboratory Chip-Seal Tests

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Abstract: Although chip-seal is an economical and environmentally friendly preventive maintenance treatment on the asphalt pavements, however, its benefits may be discounted due to possible premature unbounding with asphalt pavement. Therefore, it is critical to understand the bond strength of chip-seal with asphalt pavement under varying environmental and material conditions. This study aims to develop and validate innovative laboratory chip-seal tests to characterize the bond strength of chip-seal with asphalt pavement. The laboratory approaches using interface and shear bond tests were developed in this study. The field chip-seal samples from Kalamazoo were employed to validate the developed laboratory interface and shear bond tests. This study also investigated the interface and shear bond strengths between chip-seal and asphalt pavement of several asphalt-aggregate combinations and different asphalt application rates. In addition, in order to characterize the effect of temperature and freeze-thaw cycles on the bond strength of chip-seal with asphalt pavement, as well as its moisture resistance, several test temperature, multiple freeze-thaw cycles, and various moisture-reduced cycles were applied in the developed interface and shear bond tests. The preliminary results suggest that the poor bond durability of chip-seal with asphalt pavement is in part due to the raw materials used and the severe environmental experienced. Therefore, the proposed innovative laboratory chip-seal tests were successful in functionally for the investigating of the bond strengths of chip-seal with asphalt pavement.

Key words: asphalt pavement, chip-seal, interface and shear bond strengths, freeze-thaw cycle, moisture resistance

Evaluation of Low-Speed Pavement Skid Resistance-Need for New Testing Method

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Abstract: Low speed skid resistance measurement is of great significance to analyse the actual causes of insufficient friction of pavement, and to formulate appropriate maintaining measures. At present, British Pendulum Tester (BPT) is commonly used to measure the low-speed skid resistance of pavement. However, previous studies have shown that there are operational limitations in the use of BPT. A new low speed friction tester (WFT) developed by Chang'an University was introduced in this paper. The stability, accuracy and efficiency of BPT and WFT were compared through laboratory tests and field tests. The influence of test speed on WFT test results in the range of normal walking speed was evaluated. Tests were also performed to examine the variability of WFT test results with respect to water film thickness. Results show that the stability of WFT test was better than that of BPT. BPT test results were unreliable and unsuitable for coarse surfaces or groove surfaces of pavement. The results also showed that WFT tests were independent of changes in walking speeds of operators and variations of water applied from the spray jet. WFT could generate continuous friction data and save a lot of testing time, especially in field. Therefore, WFT can be used as a practical alternative to BPT, when testing the low-speed friction of pavement in laboratory and field.

Key words: road engineering; low-speed skid resistance; british pendulum tester; walking friction tester

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改扩建工程既有路面加铺与拓宽路面后评估

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摘　要：基于某高速改扩建工程，通过对比既有路面不同加铺方案对平整度的改善效果，发现对老路精铣刨 0.5～1.0cm 后再进行加铺可以显著提高既有路面平整度状况，且该方案经济、合理，具有一定的推广价值。分别选取车辙和弯沉盆参数为指标，对拓宽路面高模量沥青混合料结构应用效果进行评估，检测表明高模量 EME-14 路面结构车辙深度仅为 2.7±2.0mm，比对比段降低 28.9%。和常规路面结构（SMA-13+SUP-20+SUP-25）相比，高模量 EME-14 路面结构可以有效减少沥青分层永久变形量，同时可以有效降低沥青层内剪应力、剪应变，从而减少压密型和流动性车辙的产生。通过对弯沉盆参数分析，高模量 EME-14 路面结构具有较好承载力，能够满足改扩建工程拓宽车道重载交通的需求。

关键词：改扩建；加铺方案；高模量沥青混合料；平整度；车辙；弯沉盆参数

Post-Assessment of Overlay on Old Asphalt Pavement and Widened Pavement Structure for Expressway Reconstruction and Expansion Project

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（Jsti）

Abstract:

The improvement of roughness was comparatively analyzed, after using different overlay schemes for old asphalt pavement on the basis of a certain expressway reconstruction and expansion project. It was found that roughness could be obviously improved when old pavement was exactly milled 0.5-1.0 centimeter before overlaying. Besides, this scheme is economic and reasonable, and worthwhile popularizing. Rutting depth and deflection basin parameters were used in this paper to evaluate the widened pavement structure, where high-modulus asphalt mixture EME-14 was applied. Pavement detection suggested that the rutting depth for high modulus EME-14 structure was 2.7±2.0mm, which was 28.9% lower than reference section. Compared with regular pavement structure, i.e., SMA-13+SUP-20+SUP-25, high modulus EME-14 pavement structure could effectively decrease the permanent deformation of each asphalt layer, and meanwhile reduce the shear stress and strain of asphalt layer. The consolidation rutting and flow rutting thus decreased. Moreover, high modulus EME-14 pavement exhibited bearing capacity via the analysis of deflection basin parameters, which was capable of meeting the requirement of heavy traffic in the widened lanes.

keywords: reconstruction and expansion project; pavement overlay; high-modulus asphalt mixture; roughness; rutting; deflection basin parameters

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沥青路面的氧气扩散系数对其老化的影响

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摘　要：沥青路面的氧气扩散系数是一个表征氧气在沥青路面中扩散能力的参数。氧气在沥青路面中扩散过程十分缓慢，而且室内测试沥青路面的氧气扩散试验十分耗时。因此，本文拟基于沥青混合料料的体积参数建立一个氧气扩散系数预测模型。拟合优度检验结果表明该模型具有良好的预测性能。也就是说，该模型可以准确地预测沥青路面的氧气扩散系数。本文中使用该预测模型对三个典型类型的沥青混合料（WC，BC，SMA）在同一孔隙率条件下，进行氧气扩散系数预测，分别为1.13×10-4cm^2/s，7.31×10-5cm^2/s，and 7.21×10-6cm^2/s。另外，通过三种沥青混合料老化后的沥青进行红外试验，试验结果表明沥青中的亚砜基和酮基的大小排序为：WC>BC>SMA。这表明沥青路面老化程度与其氧气扩散系数呈正相关关系。

关键词：沥青混合料；老化；氧气扩散系数；预测模型

Effect of Oxygen Diffusivity on the Aging of Compacted Asphalt Mixtures

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Abstract:

The oxygen diffusion coefficient of compacted asphalt mixture is an important parameter that characterizes the capacity of facilitating oxygen transport in asphalt pavements. However, the diffusion tests are pretty time-consuming for some specimens. Hence, a predictive model of oxygen diffusion coefficient for compacted asphalt mixtures was developed as a function of voids in mineral aggregate, voids filled by asphalt and air voids based on the sensitivity analysis results. The goodness-of-fit test shows that the predictive model was rated as excellent, indicating that the model has good accuracy in predicting the oxygen diffusion coefficients of compacted asphalt mixtures. The oxygen diffusion coefficients of three specimens (WC-1, BC-1, and SMA-1) for the long-term aging test were predicted to be 1.13×10-4 cm2/s, 7.31×10-5 cm2/s, and 7.21×10-6 cm2/s, respectively. The Fourier transform infrared spectroscopy (FTIR) test results show that the area ratios of sulfoxides and ketones were greatest for WC-1 followed by BC-1 and lastly SMA-1, indicating that there is a positive relationship between oxygen diffusion coefficient of compacted asphalt mixtures and aging degree of asphalt binders.

keywords: asphalt mixture; aging; oxygen diffusion coefficient; predictive model

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基于熵权-TOPSIS 方法的钢桥面防水粘结材料组合体系优选评价

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摘　要：为比较钢桥-沥青混凝土铺装结构中防水粘结材料组合体系的粘结特性，优选出钢桥铺面工程中性能优异的防水粘结材料，选择钢桥面铺装结构中常用的四种防水粘结层材料组合体系，制作含不同层间粘结材料组合体系的钢板-沥青混凝土复合试件，并在不同温度下分别测试其直接拉拔强度、直剪强度和 45° 斜剪强度。同时，在 25℃环境温度下，分别测试含不同层间粘结材料组合体系的钢板-沥青混凝土复合试件的疲劳寿命。另外，结合不同组合体系下的材料成本，运用基于熵权的逼近理想解排序（TOPSIS）方法考虑不同防水粘结材料组合体系的直接拉拔强度、直剪强度、斜剪强度、疲劳寿命、材料成本五类指标及其数值，得出最优的防水粘结材料组合体系。该方法可为钢桥面防水粘结材料组合体系的优化选择提供依据。

关键词：钢桥面铺装；防水粘结材料组合体系；熵权-TOPSIS 方法；优选评价

Evaluation and Optimum of Steel Bridge Deck Waterproof Bonding Materials Composite System Using Entropy Weight-TOPSIS Method

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Abstract:

In order to compare the bonding characteristics of waterproof bonding material combination system in steel bridge whose upper material is asphalt mixture. Optimum selection of waterproof bonding materials with excellent performance in steel bridge pavement engineering. Choosing four kinds of waterproof bonding material combination systems which used in steel bridge deck pavement structure and fabricated steel plate-asphalt concrete composite specimens, testing their direct tensile strength, direct shear strength and 45 degree skew shear strength at different temperatures (0℃,25℃,70℃). At the same time, the fatigue life of steel sheet-asphalt concrete composite specimens with four kinds of waterproof bonding material combinations was tested at 25℃. In addition, the TOPSIS method based on entropy weight is used to consider the five indexes which are direct tensile strength, direct shear strength, skew shear strength, fatigue life and material cost of different waterproof bonding material combination systems, and getting the optimal waterproof bonding material combination system. This method could provide a technical basis for the optimal evaluation of the steel deck waterproof bonding material combination systems.

keywords: Steel deck pavement; waterproof binding materials composite system; entropy weight-Topsis method; evaluation and optimum

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基于数据分析的 SMA13 配合比设计过程关键影响因素及优化决策研究

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摘　要：本文基于大量 SMA13 配合比工程案例数据，通过数理统计分析方法，提炼出配合比设计控制指标的关键影响因素，并进一步深入研究各显著性影响指标与控制指标间的相关性，将 SMA13 配合比设计过程经验进行量化，为其配合比设计提效及优化提供科学依据。

关键词：SMA13；配合比设计；影响因素

Research on Key Influencing Factors and Optimization Decision of SMA13 Mix Design Process Based on Data Analysis

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Abstract:

Based on a large number of SMA13 mix ratio engineering case data, this paper extracts the key influencing factors of the mix design control index through mathematical statistics analysis method, and further studies the correlation between each significant impact index and control index, and designs the SMA13 mix ratio. Process experience is quantified to provide a scientific basis for its mix design efficiency and optimization.

keywords: SMA13; design of mix proportion; influence factor

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沥青路面半刚性基层损坏评价方法研究

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摘　要：沥青路面半刚性基层作为路面结构的重要组成部分，其损坏状况直接影响道路整体性能，因此需要对其进行合理评价以决定其处治方式。目前实际工程中依旧以“破损类”方法判断半刚性基层损坏状况，操作流程复杂、繁琐，效率低下且成本较高。基于FWD检测弯沉盆的模量反算方法为通过“非破损”类手段评价半刚性基层损坏提供了可能，但是如何通过半刚性基层模量判断其损坏状况这一问题有待解决。针对目前研究的不足，本文系统分析路面结构层性能指标之间的相关性，在此基础之上提出半刚性基层损坏评价方法。

关键词：沥青路面；模量反算；半刚性基层；损坏评价

Damage Evaluation Method of Asphalt Pavement Semi-Rigid Base

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Abstract:

Asphalt pavement semi-rigid base as an important part of the pavement structure, the damage directly affects the overall performance of the road, it needs to be properly evaluated to determine its treatment. Currently the actual project is still to "damage" method to determine the damage of semi-rigid grass-roots level, the operation process is complex, cumbersome, inefficient and costly. The backcalculation of the deflection basin based on the FWD method provides the possibility of evaluating the damage of the semi-rigid base through the "non-destructive" method. However, how to judge the damage condition of the semi-rigid base layer modulus needs to be solved. In view of the shortcomings of the current research, this paper systematically analyzes the correlation between the performance indexes of pavement structure layer, and on this basis proposes the evaluation method of semi-rigid base damage.

keywords: asphalt pavement; modulus back-calculation; semi-rigid base; distress evaluation

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The Tire Path Shifting Road and Estimation of Pavement Performance Using Mechanistic-Empirical Model

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Abstract: Even though pavement located outside tire paths have the same structures as pavement inside paths, they are rarely used. This paper introduces the tire path shifting (TPS) road to use the entire pavement structure on highways efficiently. On the TPS road, tire paths can be shifted periodically to another pavement location directed by the shifts of pavement markings. Advantages of the TPS road design may include a much thinner asphalt concrete (AC) layer for the same design life or a significant extension of pavement life using the original pavement structure. TPS road can also reduce the frequency of overlays and maintenance because the development of AC surface longitudinal cracking is slowed down by shifting traffic to another transverse location periodically. Equation to calculate shift distance/widening distance is developed, and bi-modal that considers interaction of traffic wanders is created to check premature pavement failure between original tire paths and shifted tire paths. A case study is conducted on a typical high volume two-lane highway in Alabama for a 30-year design. As a result, the total AC layer thickness of the TPS road is 37.64% thinner than that of the traditional road. That is a 30.17% reduction in asphalt concrete usage. However, by using the traditional pavement structure, TPS road can only increase the pavement life for 1 year to 31 years. Thus, it is recommended that the best time to implement the TPS road is when roads are under new construction, reconstruction and rehabilitation.

Key words: tire path shifting road; traffic wander; wheel path; pavement design and rehabilitation; interacting traffic flow

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水泥稳定碎石耐久性增强技术研究

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摘　要：水泥稳定碎石为我国高等级公路普遍采用的半刚性基层材料类型，容易出现裂缝、唧浆等病害，影响公路的使用寿命。本文分别从提升拌和工艺、添加纤维和优化级配设计三个方面，对水泥稳定碎石混合料的无侧限抗压强度、劈裂强度和抗冲刷性开展了室内试验对比研究，分析了不同增强技术对混合料耐久性的影响。结构表明，三种增强技术可以有效提高水泥稳定碎石混合料的耐久性，其中振动拌和工艺和骨架密实型结构对抗压强度的提升最为显著，添加纤维可以有效提升混合料的抗裂性能和抗冲刷性能，从而减少裂缝和唧浆等病害的产生。

关键词：水泥稳定碎石；振动拌和；纤维；耐久性；骨架密实结构

Research on Durability Enhancement of Cement Stabilized Aggregate

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Abstract:

Cement stabilized aggregate is a kind of semi-rigid base material commonly used in China's high grade highways. Something like Cracks were easily to be found .In this paper, the unconfined compressive strength, splitting strength and scour resistance of cement stabilized crushed stone mixture were compared in laboratory tests from three aspects of lifting mixing process, adding fiber and optimizing gradation design, and the influence of different strengthening technologies on the durability of the mixture was analyzed. It shows that the three kinds of enhancement techniques can effectively improve the durability of the cement stable aggregate mixture, the vibrating mixing process and the skeleton dense type structure aggregate improve the compressive strength effectively. The fiber added in can effectively improve anti-cracking performance of mixture and erosion resistance, thereby reducing cracks and dangerous such as pumping slurry. Bridge engineering; risk assessment; operation period.

keywords: cement-stabilized aggregate; durability; vibrant mixing; fiber; dense skeleton type

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多层排水性沥青面层结构承载力评价

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摘　要：为评价多层排水性沥青路面的结构承载力，确定多层排水性沥青路面可用于何种交通等级道路，本文从理论计算和室内试验两个方面对多层排水性沥青路面进行分析与评价。首先，依据沥青路面设计规范（JTG D50-2017）对密级配沥青路面、单层排水沥青路面、双层排水沥青路面和三层排水沥青路面进行结构设计验算，计算结果表明四种路面结构可用于任何交通等级下的道路。其次，自行设计了局部三轴多级加载试验，采用直径为 80.6mm 的小压头施加荷载，由压头范围外的混合料提供与路面结构相近的围压。同时，采用与实际路面结构完全相同的全厚式面层结构试件，采用温度控制装置模拟路面结构内部的温度场分布，以及设计多应力水平的加载方式模拟实际路面车辆荷载轴载谱，以最接近实际路面状态的方式评价多层排水性沥青面层结构的高温承载力。试验结果表明，密级配沥青面层结构具有最高的高温承载力，依次为单层、双层和三层排水性沥青面层。基于局部三轴多级加载试验得到的复合流值，对单层、双层和三层排水性沥青面层结构的交通适用性进行预测。研究结果表明，单层排水性沥青面层可用于特重交通等级道路，双层和三层排水性沥青面层可用于重交通等级以下的道路。

关键词：道路工程；结构承载力；局部三轴多级加载试验；多层排水性沥青面层；多孔沥青混合料

Structure Capacity of Multilayer Porous Asphalt Courses

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Abstract:

Abstract: Multilayer porous asphalt pavement is very important to the construction of spongy road. In order to evaluate the structure capacity and determine the application of multilayer porous courses, theoretical calculation and laboratory test were used. Firstly, based on the Specifications for Design of Highway Asphalt Pavement (JTG D50-2017), traditional dense graded asphalt pavement, single-layer porous asphalt pavement, double-layer porous asphalt pavement, and triple-layer porous asphalt pavement were calculated and validated. Results indicate that four pavements can be used in any road. Secondly, a partial triaxial multiple-stress test (PTMS) was developed to evaluate the high temperature structure capacity of multilayer porous asphalt courses. A smaller loading head with diameter of 80.6mm was designed to simulate the confinement condition of field condition. Specimen used in PTMS includes surface layer, middle layer and bottom layer, which have the same materials and structures as to the field pavements. A temperature control system was used to simulate the temperature distribution in the field conditions, and multiple-stress was used in PTMS to simulate the vehicle load spectrum in the field conditions. Test conditions in the PTMS approximately are same to the field conditions. The results indicate that traditional dense graded asphalt courses have the highest high temperature structure capacity, following with single-layer,

double-layer, and triple-layer porous asphalt courses. The structure capacity of single-layer, double-layer, and triple-layer porous asphalt courses was predicted based on the multiple flow number. Based on the results, it can be concluded that the single-layer porous asphalt course can be used in extra heavy traffic roads. The double and triple-layer porous asphalt courses can be used in heavy traffic road.

keywords: road engineering; structure capacity; partial triaxial multiple-stress test; multilayer porous asphalt courses; porous asphalt mixtures

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A Long Life Asphaltic Pavement for Steel Bridge Deck

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Abstract: In view of insufficient service life of steel bridge deck pavement and the advantages of long life pavement, the concept of long life steel bridge deck pavement is presented, together with guideposts and design requirements. Then this paper proposes a long life structure: "epoxy asphalt concrete (EAC) lower layer+ stone mastic asphalt (SMA) upper layer" based on "EAC+EAC". In order to assess the structure, the performances of the pavement were investigated according to the design requirements. Firstly, the high temperature stability, crack resistance, fatigue resistance, skid resistance and the linear contraction coefficients of EAC and SMA were tested in the laboratory; secondly, composite structure tests were designed to study the overall performances of the pavement system; thirdly, numerical analysis of "EAC+EAC" and "EAC+SMA" was conducted to clarify the mechanical response and failure mechanism of pavement. The results indicate that this structure can effectively avoid through cracks and be maintained flexibly comparing with "EAC+EAC". As main bearing layer, EAC has excellent fatigue resistance to eliminate structural damage. While SMA equipped with good resistance to deformation and slip, can be used as the surface functional layer to improve driving comfort, which conforms to the concept of long life steel bridge deck pavement.

Key words: steel bridge deck pavement; long life asphaltic pavement; epoxy asphalt; SMA; structural performance

中国和法国混合料设计确定最佳沥青用量的差异和联系

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摘　要：在沥青混合料设计中，中国规范采用马歇尔配合比设计方法确定最佳沥青用量。法国采用集料级配组成、矿料密度、多年实践经验建立的丰度系数来初步确定沥青用量。两者的沥青用量均仍需进一步的混合料试验修正。本文采用中国 AC-13 和法国 BBSG-14 两种常见沥青混合料的典型级配，分别确定两种混合料在中法两国标准下的最佳沥青用量。通过对比分析两种典型混合料的沥青用量值，找到中法两国确定最佳沥青用量设计方法的差异和联系，为中国海外工程建设时不同标准的采用和转化提供资料。

关键词：沥青混合料；马歇尔方法；丰度系数；最佳沥青用量

Differences and Connections in Determining the Optimum Asphalt Content Between China and France in Mixture Design

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Abstract:

In asphalt mixture design, Marshall mixture design method is adopted to determine the optimum asphalt content in China. France uses aggregate gradation ratio, mineral density and richness module established by many years of practical experience to determine the asphalt content initially. the asphalt content of both mixtures still needs further test verification. In this paper, two representative gradations of common asphalt mixtures, AC-13 in China and BBSG-14 in France, are selected. The optimum asphalt content of the above two mixtures is determined according to the specifications of the two countries. Then by comparing and analyzing the asphalt content of the two typical mixtures above, we can study the differences and connections between China and France in determining the optimum asphalt content design methods and provide information for the adoption and conversion of different standards in overseas construction projects in China.

keywords: asphalt mixture; Marshall method; richness module; optimum asphalt content

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Research on Shallow Defect Detection of Urban Roads Based on HWD

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Abstract: The thesis is about the research result of the detection of shallow loose defects in urban roads. By using the heavy-weight deflectometer (HWD), the shallow defect mo-del of urban roads is established .Then the deflection basins data for different sizes of shallow loose defects at different buried depths are calculated through this model, so as to analyze the regulation of variation deflection basins slope, and the method of determining shallow defect by deflection basins slope is proposed . Through comparing the data of a municipal road between the one calculated by the deflection basin slope method and the data measured by round penetrating radar (GPR). The result shows that they are highly consistent, thus, it is proved that the method has a good practical value in engineering.

Key words: shallow defect; ground penetrating radar(GPR); heavy weight deflectometer (HWD); depth of influence; the slope of deflection basin

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Modal Dynamic Inversion of Pavement Structure Layer Based on Improved Support Vector Machine

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Abstract: The back analysis of the modulus of the pavement structure layer can be summarized as a complex nonlinear optimization problem, which is to fit the analysis of the deflection basin and the source data in an optimal way by appropriately selecting the data processing and optimization algorithms. According to the theory of dynamics analysis,the finite element method is used to solve the dynamic response of the pavement structure,and the firefly algorithm is used to optimize the parameters of the inversion model based on support vector machine.The calculation of the inversion results shows that using the support vector machine method to back-calculating is a simple and effective method.

Key words: structural layer modulus; dynamic response; support vector machine (SVM); firefly algorithm; modulus inversion

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湿热地区碾压混凝土基层沥青路面动力响应试验研究

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摘　要：为研究车辆荷载作用下碾压混凝土基层沥青路面的动力响应，铺筑了试验路，布设了应变、温度传感器，研究了该路面结构不同层位的动态响应特征及轴载、车速、车型、温度等因素对动态响应的影响。结果表明：实车荷载作用下，沥青面层的横向应变主要为拉应变，纵向应变呈现拉压交替的状态，横向应变大于纵向应变，而基层与底基层底纵横向均为拉应变，纵向应变大于横向应变；沥青面层内拉应变随车速的减小与轴载的增大而增大，常温条件下，货车轴重超载 100%时，上面层与下面层底的拉应变分别增加 1.7 倍和 2.2 倍，车速从 60km/h 降低到 5km/h，上面层和下面层底的拉应变分别增加 3.0 倍和 1.2 倍；高温条件下，货车低速行驶时，上、下面层底的最大拉应变分别为 1500με和 170με，与常温条件相比增加近 10 倍。

关键词：道路工程；动力响应；移动荷载；碾压混凝土基层；沥青路面

Experimental Study on Dynamic Response of Roller-Compacted Concrete-Base Asphalt Pavement in Hot and Humid Area

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Abstract:

This study aimed to investigate the dynamic response of roller-compacted concrete (RCC)-base asphalt pavement under traffic loads. Several strain and temperature sensors were embedded in a test road at different depths. The dynamic responses driven by truck passage were tested, and the effects of axle load, vehicle speed, vehicle type, and temperature on the dynamic response were investigated. The results showed that the transverse strain in asphalt surfaces was tensile, while the longitudinal strain alternated in tension and compression. The longitudinal and transverse strains in the base and subbase were in tension and compression, respectively, and the longitudinal strain was greater than the transverse strain. The tensile strain in asphalt pavement increased with decreasing vehicle speed and increasing axle load. When the axle weight of the truck was doubled, the tensile strain in the upper and lower layers of the asphalt pavement increased by 1.7 times and 2.2 times, respectively, under low temperature and low speed conditions. The tensile strain of the upper and lower layers of the asphalt pavement increased by 3.0 and 1.2 times, respectively, when the speed decreased from 60 km/h to 5 km/h. The maximum tensile strain at the bottom of the upper layer and the lower layer of the asphalt pavement was 1500 με and 170 με, respectively, when the truck was moving at low speeds under high temperature, which is nearly 10 times higher than at low temperature.

keywords: road engineering; dynamic responses; moving load; roller-compacted concrete-base; asphalt pavement

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Effects of Different Loading Conditions on Fatigue Properties of SMA

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Abstract: Based on the strain-controlled four-point bending fatigue tests, the effects of temperature, frequency, and strain value on the fatigue damage properties of SMA were studied, meanwhile, variable amplitude fatigue tests were carried out to evaluate the damage accumulation of SMA. The results show that, lower temperature, lower frequency, and higher strain level have more significant damage on the SMA in strain-controlled fatigue test. With the increase of load cycles, the phase angle becomes greater, the growth rate under high frequency or high strain level is greater than that under low one. The difference of high-low load sequence and low-high load sequence is more significant at lower temperatures than that at higher temperature. Similarly, the differ-ence of high-low load sequence and low-high load sequence is more significant at higher strain level than that at lower strain level. Load sequence has a slight effect on the cumulative dissipated energy of SMA.

Key words: asphalt mixture; loading condition; fatigue property; damage accumulation; SMA

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微波除冰效率：不同微波频率与道路结构材料差异研究

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摘　要：为在寒冷地区进行环保经济的道路除冰，弥补传统除冰方法的缺陷，提出微波加热除冰技术。本文将微波除冰效率定义为加热到0℃时混凝土表面的升温速率，基于微波除冰机理，提出采用有限元仿真模型与室内试验结合的方法对微波除冰效率进行研究，分析不同微波频率与道路结构材料对微波除冰效率的影响。结果表明，微波频率与道路结构材料对微波除冰效率影响很大。通过仿真与实验结果的一致性，验证了仿真模型的有效性。研究结果为微波除冰技术的应用提供了理论指导和实践依据。

关键词：道路工程；微波除冰；仿真模型；除冰效率

Microwave Deicing Efficiency: Study on the Difference Between Microwave Frequencies and Road Structure Materials

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Abstract:

A method of deicing using microwave heating is proposed to make economical road deicing in a cold area, and to make up for deficiencies in the existing methods for melting ice. This paper proposes to define microwave deicing efficiency as the heating rate of a concrete surface when heated to 0 ◦C. Based on the mechanism of microwave deicing, a method combining the finite element simulation model with indoor experiments was proposed to study the deicing efficiency of microwaves, and the effects of different microwave frequencies and different road structure materials on microwave deicing efficiency were analyzed. The results show that the microwave frequency and road structure materials have a great influence on microwave deicing. Through the consistency of the simulation and experimental results, the validity of the simulation model based on the finite element theory is verified. The results provide theoretical guidance and a practical basis for future applications of microwave deicing.

keywords: road engineering; microwave deicing; simulation model; deicing Efficiency

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多层式开普结构在陇东改建国道沥青路面中的应用

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摘　要：开普封层是由碎石封层和稀浆封层或微表处层构成的一种复合封层技术。具有抗反射开裂性、抗滑性、防水性和平整度均较好等优点。然而，开普封层使用效果受施工质量影响显著，层间粘结不良易造成推移、表层脱皮、剥落等病害。该技术在国道改建项目中的应用还不多见。依托陇东地区国道改建项目，以多层式开普封层结构代替沥青路面下面层，对橡胶沥青碎石封层+橡胶沥青碎石封层+改性乳化沥青微表处的三层式开普结构材料组成设计、施工工艺及层间粘结保障措施开展研究，结果可供同类地区开普封层技术应用参考。

关键词：橡胶沥青；开普封层；改建道路；沥青路面

Application of Multi-Layer Cape Seal Structure in the Asphalt Pavement of Rehabilitated Trunk Highways in East Gansu

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Abstract:

Cape seal is a composite sealing technique constituted by chip seal and slurry seal or micro surfacing, which holds plenty of advantages such as good anti reflective cracking property, enough surface texture, high imperviousity and evenness. However, the effect of Cape seal is predominantly controlled by the construction quality. Poor adhesion between layers could lead to several common distresses as shoving, stripping as well as peeling. So far, this technique has been barely used in rehabilitated trunk highways domestically. This research evaluated the feasibility of applying multi-layer asphalt rubber Cape seal structure into the surface course of asphalt pavement for reconstructed highway in the loess region of West China. Based on a typical test section, the material design and construction of asphalt rubber Cape seal and possible measures to strengthen the bond between different layers were investigated.

keywords: asphalt rubber; cape seal; reconstructed highway; asphalt pavement

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基于有限元模拟的水泥稳定基层路面拱胀破坏控制标准

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摘　要：为了更加系统的研究温度和盐结晶膨胀对路面发生拱胀病害的综合影响规律，详细研究了混合料硫酸盐含量、基层施工温度、膨胀系数和抗压回弹模量等因素对水稳基层的拱胀影响及规律。首先通过对路面结构层温度进行现场监测，得到我国西北内陆典型夏季高温期路面温度场分布规律，建立路面结构温度场预估方程；其次，根据应变等效原则将盐溶场转换成相应的温度场，得到转化关系式从而实现对基层盐膨胀的模拟；并运用 ABAQUS 建立水稳基层拱胀有限元分析模型，系统研究了不同因素作用下水稳基层的力学响应及变化规律，提出基于预防基层拱胀的各因素控制标准，从而有效防止或减轻拱胀病害的发生。

关键词：道路工程；拱胀破坏；仿真模型；控制标准

Control Criteria for Arching Expansion Construction of Cement Stabilized Base Pavement Based on Finite Element Simulation

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Abstract:

In order to study the comprehensive influence of temperature and salt crystallization expansion on pavement arch expansion more systematically, the effects of sulfate content of mixture, construction temperature of base course, expansion coefficient and modulus of compressive resilience on arch expansion of water-stabilized base course are studied in detail. Firstly, through on-site monitoring of pavement structure layer temperature, the distribution law of pavement temperature field in typical summer high temperature period in northwest of China is obtained, and the prediction equation of pavement structure temperature field is established. Then according to the principle of strain equivalence, the salt solution field is transformed into the corresponding temperature field, and the transformation formula is obtained to simulate the salt expansion of base course. Finally, ABAQUS is used to establish the finite element analysis model of arch expansion of water-stabilized base course. The mechanical response and variation law of water-stabilized base course under different factors are systematically studied. The control criteria of various factors based on prevention of arch expansion of base course are put forward, so as to effectively prevent or reduce the occurrence of arch expansion disease.

keywords: road engineering; arch expansion destruction; simulation model; control criterion

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新疆盐渍土地区水泥稳定基层拱胀变形规律及其机理研究

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摘　要：为进一步明确硫酸盐对水稳基层膨胀变形的影响规律，基于硫酸盐结晶膨胀理论，设计水泥稳定砂砾混合料盐胀试验，研究了不同硫酸盐含量和环境湿度条件下水稳基层材料的盐胀规律，揭示了水稳基层材料的盐膨胀机理，提出了水稳基层混合料中硫酸盐含量的合理控制范围，为南疆盐渍地区水稳基层盐胀变形研究提供一定有益借鉴。结果表明：当盐含量小于 1.0 %时，混合料每增加 0.25 %的盐含量，其总膨胀变形量将增大 85μm；水稳基层材料盐含量与其膨胀量存在良好的指数关系，相关系数 0.97 以上；水泥稳定砂砾混合料中硫酸盐含量宜控制在 0.136 %以内。

关键词：道路工程；水稳基层；盐胀变形；膨胀机理；硫酸盐

Sulfate Expansion Deformation Law and Mechanism of Cement Stabilized Macadam Base of Saline Areas in Xinjiang

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Abstract:

Based on the theory of sulfate crystallization expansion, the sulfate expansion deformation test of cement-stabilized gravel mixture was designed to further clarify the influence of sulfate on expansion deformation of cement stabilized macadam base. The sulfate expansion deformation law of cement stabilized macadam base material under different sulfate content and environmental humidity conditions were systematically studied. The sulfate expansion deformation mechanism of cement stabilized macadam base material was revealed. And the sulfate content in cement stabilized macadam base mixture was put forward. Reasonable control scope can provide some useful reference for the study of sulfate expansion deformation of cement stabilized macadam base in saline areas of South Xinjiang. The results show that when the sulfate content is less than 1.0 %, the total expansion deformation of the mixture increases by 85 μm with the increase of 0.25 % sulfate content. There is a good exponential relationship between sulfate content and expansion of cement stabilized macadam base materials, and the correlation coefficient is above 0.97. Sulfate content in cement stabilized macadam base mixture should be controlled within 0.136 %.

keywords: road engineering; cement stabilized macadam base; sulfate expansion deformation; expansion mechanism; sulfate

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沙漠区半刚性基层沥青路面温度场及拱胀力学分析

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摘　要：为了研究沙漠区半刚性基层沥青路面由于气候环境因素产生的拱胀破坏，在分析了拱胀成因后以拱胀病害区临近新建高速公路为依托对高温期晴朗无云条件下的沥青路面结构温度场进行了监测，根据半刚性基层温度变化规律建立了基层不同层位处的温度预估模型，并基于压杆失稳理论建立了半刚性基层在温胀作用下的力学模型，且推导了拱胀破坏临界状态下极限荷载。研究结果表明：沙漠区沥青路面温度变化与气温变化规律具有相似性，且明显滞后，表面层温度最高可达 64℃；半刚性基层温度变化幅度较小，其温度主要集中于 35-45℃；基层不同层位处的温度预估模型拟合度较好，其 R^2 值均在 0.9770 以上；当基层纵向受力大于(4π^2*EI)/L^2 +f 时，基层结构会产生拱起破坏。

关键词：道路工程；半刚性基层；温度场；预估；临界荷载

Analysis of Temperature Field and Arch Expansion Mechanics of Semi-Rigid Base Asphalt Pavement in Desert Area

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Abstract:

In order to study the arch expansion damage caused by climatic and environmental factors in the semi-rigid base asphalt pavement in desert area, the temperature field of asphalt pavement structure under the condition of cloudless in high temperature period has monitored after the cause of arch expansion had analyzed, which is based on the near new expressway in the arch expansion disease area. According to the temperature variation law of semi-rigid base, the temperature estimation model at different layers of the base is established, and the mechanical model of semi-rigid base under the action of temperature expansion is established based on the theory of pressure rod instability, and the ultimate load under the critical state of arch expansion failure is deduced. The results show that the temperature change of asphalt pavement in desert area is similar to the law of temperature change, and the temperature of surface layer can reach up to 64℃, the temperature variation of semi-rigid base is less change and the temperature is mainly concentrated in 35-45℃, and the temperature prediction model at different layers of the base is accurately, and its values of R^2 are above 0.9770; when the longitudinal force of the base is greater than (4π^2*EI)/L^2 +f, the base structure will produce arch damage.

keywords: road engineering; semi-rigid base; temperature field; estimation; critical load

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辽宁省沥青路面气候分区（温度）研究

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摘　要：本文根据近 20 年辽宁所辖 53 个区县的气象资料，开展了辽宁省沥青路面气候分区(温度)研究，提出辽宁省沥青路面道路石油沥青选用的建议，用于指导沥青路面的设计。

关键词：辽宁；沥青路面；气候分区；温度

Study on Climate Zoning (Temperature) of Asphalt Pavement in Liaoning Province

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Abstract:

Based on the meteorological data of 53 districts and counties in Liaoning Province in the past 20 years, this paper studies the climate zoning (temperature) of asphalt pavement in Liaoning Province, and puts forward some suggestions on the selection of asphalt for asphalt pavement in Liaoning Province, which can be used to guide the design of asphalt pavement.

keywords: liaoning; asphalt pavement; climate zoning; temperature

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掺配玄武岩粗集料对沥青混合料抗滑性能耐久性的影响研究

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摘　要：沥青路面的抗滑耐久性对行车安全具有重要的意义。针对沥青混合料中粗集料采用石灰岩存在路面表面抗滑耐久性不足问题，通过掺配玄武岩粗集料的方式改善沥青混合料抗滑耐久性。测试了玄武岩粗集料不同掺配比例时沥青混合料的初始构造深度和摆值，利用室内加速磨耗实验，得到了历经 0~18000 次磨耗作用后掺配有玄武岩粗集料的沥青混合料表面构造深度和摆值，分析了玄武岩粗集料掺配对沥青混合料抗滑性能衰变的影响规律。主要结论有：沥青混合料表面构造深度及摆值随着玄武岩粗集料掺配量的增加而增加；掺配玄武岩粗集料后沥青混合料表面构造深度及摆值前期衰减速度快后期衰减速度慢，当磨耗作用次数在 10000 次左右时抗滑性能指标逐渐达到衰变稳定值；为满足沥青路面抗滑性能指标耐久性要求，玄武岩粗集料掺配量应达到 60%及以上时。

关键词：沥青混合料；抗滑性能；玄武岩粗集料；掺配

Study on the Influence of Mixing Basalt Coarse Aggregate on the Anti-Skid Durability of Asphalt Pavemen

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Abstract:

The anti-skid durability of asphalt pavement is of great significance to traffic safety. Aiming at the insufficiency of anti-skid durability of limestone as coarse aggregate in asphalt mixtures, this paper improves the anti-skid durability of asphalt mixtures by mixing basalt coarse aggregate, The anti-skid durability of asphalt pavement is of great significance to traffic safety. Aiming at the problem of insufficient skid resistance of asphalt mixture using limestone as coarse aggregate, this paper improves the skid resistance durability of asphalt mixture by mixing basalt coarse aggregate. The initial texture depth(TD) and the BPN of asphalt mixtures with different proportion of basalt coarse aggregate were tested. The TD and BPN of asphalt mixtures with basalt coarse aggregate after 0-18000 wear tests were obtained. The influence of basalt coarse aggregate on the anti-skid durability of asphalt mixtures was analyzed. The main conclusions are as follows: the TD and BPN of asphalt mixture increase with the increase of basalt coarse aggregate content.When mixing basalt coarse aggregate, the declining rate of TD and BPN of asphalt mixture is fast in the early stage and slow in the late stage, when the number of abrasion action is about 10000 times, the anti-sliding performance index gradually reaches the decay stability value. Durability of anti-skid performance index requires that the content of basalt coarse aggregate should reach 60% or more.

keywords: Asphalt mixture; skid resistance performance; basalt coarse aggregate; blending ratio

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川藏公路南线西藏境病害类型分析与防治措施研究

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摘　要：川藏公路南线是西藏自治区的五大主干公路之一，具有极其重要的经济、国防意义。但公路沿线复杂的地理、地质条件，导致多种地质灾害频发，严重威胁公路的正常使用。本文在对川藏公路南线西藏段病害实地调查与分析的基础上，阐述了该公路的破坏现状及病害类型，得出了这些病害的引发原因不仅在于材料、施工等方面，更主要的是滑塌和水毁等地质灾害所造成的，并针对这些病害提出了相应的整治措施。

关键词：川藏公路南线；地质灾害；破坏现状；病害类型；整治措施

Study and Analysis on the Disease Types and Regulation Measures for the South Line of Sichuan-Tibet Highway

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Abstract:

The south line of Sichuan-Tibet Highway in Tibet territory is one of the five major trunk roads in Tibet Autonomous Region, which has an extremely important economic and defense significance. The complex geographical and geological conditions along the highway led to variety of geological disasters which is a horrible threat to the normal use of the highway. This paper based on the investigation and analysis for the south line of Sichuan-Tibet highway in Tibet territory, the destroying conduction and disease type of this highway is declared, the reason of this diseases which not only is materials and construction ,the more important is the other geological disasters like slump and water damage is concluded, and the corresponding improvement measures for this kind of disease is proposed.

keywords: south line of Sichuan-Tibet highway; geological hazards; destroy situation; disease types; regulation measures

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Road Condensate Ice Formation Mechanism and Prevention Analysis in Plateau Damp Environment

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Abstract: This paper analyzes and researches road condensation ice formation mechanism, so as to find out the effective and economical method to prevent road frozen ice and govern it. The method of prevention can be divided into passive inhibition technology and proactive inhibition technology. Passive inhibition technology cannot inhibit the formation of condensation. In the process of research of prevention condensation , early warning system for snow and ice research also should not ignore. To establish early warning systems and take it into implementation will greatly reduce the extent of the ice and snow disasters.

Key words: formation mechanism; passive inhibition; proactive inhibition; early warning

La_2O_3改性沥青的抗紫外老化性能研究

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摘　要：为了提高沥青的抗紫外老化性能，提出以稀土氧化物 La_2O_3 为改性剂，制备稀土改性沥青。采用紫外老化环境箱模拟沥青的光氧老化过程。通过对紫外老化前后的沥青进行动态剪切流变试验、弯曲梁流变试验、红外光谱试验，从宏观和微观的角度评价沥青的紫外老化程度，分析 La_2O_3 对沥青抗紫外老化性能的影响。结果表明：紫外老化后，沥青的复数模量，蠕变劲度、蠕变速率、亚砜基指数均增大。改性沥青对应的这些指标的增大幅度均比基质沥青小，说明 La_2O_3 的掺入可以改善沥青因紫外老化而造成的高低温性能劣化，当 La_2O_3 掺量为 2%时，四项指标的增大幅度最小，沥青的抗紫外老化性能提升作用最显著。

关键词：La203 改性沥青

Study on Ultraviolet Aging Properties of Rare Earth Modified Asphalt

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Abstract:

In order to improve the anti-ultraviolet aging performance of asphalt, the rare earth oxide La2O3 was used as modifier to prepare rare earth modified asphalt. Ultraviolet aging chamber was used to simulate the photooxidation aging process of asphalt. Through dynamic shear rheological test, bending beam rheological test and infrared spectrum test of asphalt before and after ultraviolet aging, the ultraviolet aging degree of asphalt was evaluated from macro and micro angles, and the effect of La_2O_3 on the ultraviolet aging resistance of asphalt was analyzed. The results show that the complex modulus, creep stiffness, creep rate and sulfoxide index of asphalt increase after ultraviolet aging. The increase range of these indexes of modified asphalt is smaller than that of base asphalt, which indicates that the addition of La_2O_3 can improve the degradation of high and low temperature performance of asphalt caused by ultraviolet aging. When the content of La_2O_3 is 2%, the increase range of the four indexes is the smallest, and the anti-ultraviolet aging performance of asphalt is the most significant.

keywords: La_2O_3 modified asphalt

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蓄盐型融雪抑冰沥青路面研究综述

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摘　要：寒冷环境下，路表积雪结冰容易导致严重的交通事故和巨大的经济损失。蓄盐沥青路面是一种具有融雪抑冰能力的功能性路面，能够在寒冷环境下保障路表抗滑和道路通行能力。本文系统综述了蓄盐沥青路面的工作机理、盐化物材料、沥青混合料及其性能与评价方法研究进展。首先按照材料形态和盐分包裹材料，对盐化物材料进行分类，对比了几种常用的融雪抑冰沥青混合料方法，从填料特性与级配干扰的角度分析了盐化物材料掺入后沥青混合料级配参数的变化规律。在综述蓄盐后沥青混合料的高温稳定性、水稳定性、低温抗裂性、抗疲劳性、耐久性以及吸湿性和抗滑性等研究结论的基础上，分析了盐化物导致沥青混合料路用性能劣化的作用机制。最后介绍了常见的融雪抑冰性能评价与测试方法。在对现状综述的基础上，针对盐化物材料设计、沥青混合料改进、路用性能劣化机理以及融雪抑冰性能评价等关键内容，展望了蓄盐沥青路面技术的未来发展方向。

关键词：融雪路面；蓄盐沥青路面；融雪抑冰能力

Review of Antifreeze Asphalt Pavements Containing Salts

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Abstract:

The snow or ice formed on pavement surfaces in cold weather results in serious traffic accidents and heavy economic losses. Asphalt pavement containing salts is a typical functional pavement to prevent the covering of ice or snow on pavement surfaces in cold weather keeping the skid resistance and the traffic capacity of roads. The current paper summarized the recent development of antifreeze asphalt concretes (AFACs) including additives, asphalt mixtures, engineering performance and evaluation. The salt-based materials are classified according to the morphology and encapsulant, after which the frequently used design methods of asphalt mixture containing salts were also compared from the view of filler characteristic and interference between aggregates. Afterwards, the rutting resistance, water stability, low temperature cracking resistance, fatigue resistance, moisture absorption, and skid resistance were reviewed and summarized followed by a functional mechanism analysis of the degradation of engineering performances caused by salts. Finally, the usually utilized evaluation of antifreeze performance and test methods were introduced. The further researches and development directions based on the literatures review of the asphalt pavement containing salts were also proposed focusing on additives design, improvement of asphalt mixtures, degradation of engineering performances, and antifreeze performance evaluation.

keywords: snow melting pavement; asphalt pavement containing salt; antifreeze performance

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Infra-Structure in Jordan and Its Effect on the Ministry of Transport Plan in 2018 from a Logistic Constructive Point of View

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Abstract: This research aims at discussing the strategies, challenges and trends presented in the 2018 plan of the Ministry of transport in Jordan. It highlights its implementation suitability based on the existing infra structure and construction in Jordan. It also shed lights on the challenges that faces the completeness of the aforementioned transport plan based on the logistic factor and the budget allocated for such projects. The paper also presents the future trends the ministry of transport wishes to accomplish and predicts the success of the establishment of such trends with regard to the infrastructure in Jordan and the logistic supplies. The methodology used in this research is descriptive and analytical. A total of 100 subjects whose specialized in the areas of engineering, finance planning and management were the targeted subjects of the study. A questionnaire was designed and handed to the subjects along with an interview form that was designed to fulfil the objectives set for the study. Subjects were chosen according to their profession engineering, finance planning and management. Findings of the current study revealed three major findings; it was found out that the national transport strategy implemented in Jordan reflects seven factors three of them are the basic of the four challenges found to face the country. Two main point were found as main trends in the area and one of which is expected to face high risk of failure in implementation according to the infrastructure and the budget allocated for the projects.

Key words: transport plan; logistics construction

Measurement and Correction of Interface Shear Stiffness Between Slab and Base for Concrete Pavement

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Abstract: In order to determine the interface contact parameter between concrete slab and base accurately, the shear tester was invented which could simulate the horizontal shear under different vertical pressure, and the bond - slip curve was determined in two stages. Then the correction of interface vertical pressure was made for average shear stiffness based on simple iterative method, and the equivalent shear stiffness of three interface treatments was recommended. The results showed that: in the first stage of the shear test, the specimen treated by emulsified asphalt required the maximum shear force, and asphalt concrete was minimum. The contact state between slab and base is significantly correlated with the interface treatments, and it has significant effect on the structural behavior of the pavement. So, the interface treatments selection needed to find a balance between flexural tensile stress and thermal stress of the slab. In the second stage, the shear resistance capacity of three kinds of interface treatments were significantly weakened and the average shear stiffness declined dramatically. It is very difference for interface shear stiffness when the pavement structure in different using stages, so the interface shear parameter selection must consistent with the using state of the pavement when analysis the concrete structure.

Key words: concrete pavement; interface shear stiffness; bond-slip curve; interface treatments

浅析混凝土路面胀缝

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摘　要：通过对混凝土路面胀缝设置后的普查，发现胀缝处的路面破坏比较严重，仅次于路面的角隅断裂，成为混凝土路面破坏的第二大主因。虽然许多国家都取消了胀缝设置，但目前还没有一篇文章来详细阐述取消混凝土路面胀缝的理由。本文在几个方面论述了取消混凝土胀缝的可行性。

关键词：混凝土路面；胀缝；取消

Initial Analysis on the Expansion Joints of Concrete Pavement

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Abstract:

It can be found that expansion joints of pavement suffer more serious damage after the general survey of concrete pavement expansion joints settings. The damage of expansion joints has already become the second biggest cause of concrete pavement damage after corner fracture. Although many countries have abolished the set of expansion joint, there is no article has elaborate on reasons for the cancellation of concrete pavement expansion joints. This paper has discussed the feasibility of the cancellation of concrete expansion joints in several ways.

keywords: concrete pavement; expansion joint; cancel

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混凝土传力杆设计缺陷

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摘　要：混凝土路面中在胀缝和缩缝处设置的传力杆，理论上是要抵消一部分车辆荷载作用后产生的剪切、弯曲和支撑压力。理论基础是铁木辛柯的著作，铁木辛柯的传力杆内力分析有些局限性和缺陷，有哪些局限性和缺陷，进行如下分析。

关键词：传力杆；设计；局限性；缺陷

Dowel Bar Concrete Design Flaws

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Abstract:

Concrete pavement in the expansion joints and joints installed at the force of the rod, theoretically to offset part of the vehicle load generated after the shear, bending and support pressure. The theoretical basis is the work of Timoshenko, his analysis of internal force has some limitations and defects, what are the real limitations and defects, as the following analysis.

keywords: rod; design; limitations; defects

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Analysis on the Influence of Installation Form of Dowel Bar on Heavy Traffic Concrete Pavement

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Abstract: Four types of axle load spectra are designed according to different design axle loads, and on this basis, four types of heavy traffic concrete pavements are designed according to related specifications together with the four designed axle load spectra. Then the four pavement structures are simulated and loaded by finite element software, i.e., Ansys, and the influence of the diameter, spacing and installation deviation of dowel bars on the mechanical response of these pavements are analyzed. The results show that the diameter, spacing and horizontal deflection of dowel bars have little influence on the load-transfer coefficient for heavy traffic concrete pavements, which can be neglected, while the vertical deviation of dowel bars has a great impact on the load-transfer coefficient.

Key words: dowel bar; concrete pavement; ansys; heavy traffic

水泥路面环氧抗滑磨耗层的接地特性研究

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摘　要：针对水泥路面环氧磨耗层抗滑性能缺乏定量分析的问题，采用有限元方法，建立轮胎与环氧磨耗层的数值模型，系统分析轮胎胎面花纹、轮胎行驶状态、轮胎行驶速度、轮胎轴重、胎压、磨耗层厚度等因素对接地压力和附着系数的影响。结果表明：无论是光面轮胎还是花纹轮胎，接地压力呈对称型马鞍形分布；花纹轮胎最大接地压力比光面轮胎大 13.27%；接地压力和附着系数均随着轮胎行驶速度的增加而逐渐减小，随着轮胎轴重的增加而增加；随着胎压的增加，接地压力逐渐增大，附着系数却逐渐减小；接地压力和附着系数均随着磨耗层厚度的增加而增大。建立轮胎接地压力和附着系数预估模型，结合室内摩擦系数试验结果，对预估模型进行验证，表明模型拟合精度较高，误差均在 5%以下。

关键词：道路工程；水泥路面；环氧树脂磨耗层；数值分析；抗滑性能

Study on Grounding Characteristics of Epoxy Wearing Coarse of Cement Pavement

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Abstract:

For the lack of quantitative analysis on the skid-resistant performance of the epoxy wearing coarse of cement concrete, the finite element method is used to establish the numerical model of tire and epoxy wearing coarse. The ground pressure and adhesion coefficient of the tire tread pattern, tire running status, tire running speed, wheel weight, tire pressure, wear layer thickness are analyzed. The results have shown that Regardless of whether it is a glossy tire or a patterned tire, the ground pressure is a symmetrical saddle-shaped distribution. The maximum ground pressure of the patterned tire is 13.27% greater than that of a smooth tire. The ground pressure decreases as the tire travel speed increases, the adhesion coefficient decreases as the tire travel speed increases. Tire ground pressure and adhesion coefficient increase with increasing axle load. The tire ground pressure increases with tire pressure, adhesion coefficient decreases with increasing tire pressure. Both the ground pressure and the adhesion coefficient of the tire increase with the thickness of epoxy wearing coarse. A prediction model for ground pressure and adhesion coefficient is established. Combined with the test results of indoor friction coefficient, the prediction model is verified. It shows that the model has high fitting precision and the error is below 5%.

keywords: road engineering; cement pavement; epoxy wearing coarse; numerical analysis; skid-resistant performance

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新型地聚合物道路路面修复材料组成设计与性能研究

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摘　要：以粉煤灰为主要原材料，矿粉为添加剂，水玻璃和氢氧化钠为复合激发剂，标准砂为细集料，制备地聚合物砂浆。运用三维图与等值线作图分析的方法，探究水胶比与胶砂比这两个组成设计参数对粉煤灰基地聚合物砂浆的流动度、抗压强度、抗折强度的影响规律。试验结果表明水胶比与胶砂比均对粉煤灰基地聚合物砂浆流动度与力学强度影响较大，水胶比在 0.4~0.42，胶砂比在 0.45~0.5 时，制备出的地聚合物砂浆工作性能和力学性能较优。基于地聚合物砂浆脆性较大的特点，应用长度为 8mm 与 12mm 的 PVA 纤维进行增韧改性。结果表明，掺量为 0.5%的 PVA 纤维对地聚合物砂浆抗压强度影响不大，但是抗折强度显著提高，延性增强，因此压折比下降，弯曲韧性增强。

关键词：道路路面；组成设计；性能

Mix Design and Performance Study on the Fly Ash Based Geopolymer Mortars for Pavement Repair

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Abstract:

Fly ash as the raw material, blast furnace slag as the additives, sodium silicate and sodium hydroxide as activators, standard sand as fine aggregate, a kind of fly ash-based geopolymer mortars was made. The effect rules of water-binder ratio and binder-sand ratio on fluidity, compressive strength and flexural strength were researched by three dimensional figure and contour mapping analysis method. Experimental results showed that both of water-binder ratio and binder-sand ratio for fly ash based geopolymer mortars had a great influence on the fluidity and mechanical strength. The manufacture of geopolymer mortars had a better working and engineering performance when water-binder ratio was varied from 0.4 to 0.42 and binder-sand ratio was varied from 0.45~0.5. Based on the great brittleness of geopolymer mortars, 8 mm and 12 mm length PVA fiber were used in toughness modification. Results showed that the dosage of 0.5% PVA fiber had a little influence on the compressive strength of geopolymer mortars, but flexural strength and ductility significantly enhanced, resulting in the drop of compressive strength to flexural strength and the enhancement of flexural toughness.

keywords: pavement; mix design; performance

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货车超限超载运输非现场综合执法系统路面改造设计研究

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摘 要：公路运输超限超载导致桥梁、公路使用寿命锐减。为了加强对违法超限超载运输行为的治理，江苏省着手货车超限超载运输非现场综合执法系统工程的建设，通过科技手段，整合路政、公安交管部门执法力量，推进路政、公安交管部门联合执法长效化、常态化，最终实现货车超限超载运输非现场综合执法。根据动态称重检测系统的使用要求，需将点位处路面结构设置为水泥混凝土路面。本文对拟选取部分站点对路面改造方案进行方案研究，以选取适用的路面结构形式，保证动态称重系统的良好运行。

关键词：货车；超限超载；非现场执法；路面改造

Research on Road Surface Reconstruction Design of Off-Site Comprehensive Law Enforcement System for Freight Vehicle Overloading and Overloading Transportation

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Abstract:

Overloading of highway transportation leads to a sharp decrease in the service life of bridges and highways. In order to strengthen the control of illegal and overloaded transport, Jiangsu Province has started the construction of the off-site comprehensive law enforcement system for overloaded and overloaded transport of trucks. Through scientific and technological means, the law enforcement forces of road and public security traffic control departments are integrated, and the joint law enforcement of road and public security traffic control departments is promoted to be long-term and normalized, so as to realize the off-site comprehensive law enforcement of overloaded and overloaded transport of trucks. According to the application requirements of dynamic weighing detection system, the pavement structure at the point should be set as cement concrete pavement. In order to select the suitable pavement structure form and ensure the good operation of dynamic weighing system, this paper chooses some stations to study the pavement reconstruction scheme.

keywords: trucks; overloading; off-site law enforcement; road improvement

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基于损伤塑性模型的混凝土双 K 断裂参数确定

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摘 要：基于混凝土损伤塑性模型，对混凝土三点弯曲梁（TPB beam）损伤-断裂过程进行数值模拟；基于构建的数值模型，由损伤起始临界时刻定义起裂荷载，由峰值荷载时刻损伤因子的分布确定裂缝失稳扩展时刻的临界等效有效裂缝长度，提出了一种确定混凝土起裂断裂韧度、失稳断裂韧度的新方法。研究结果表明：基于损伤塑性模型的混凝土三点弯曲梁数值模型能较准确的预测单次荷载作用下混凝土三点弯曲梁的荷载-位移曲线，模拟混凝土的准脆性断裂破坏过程，即裂缝起裂、稳定扩展、失稳扩展三个阶段；采用本文提出的数值模拟方法确定的起裂断裂韧度和失稳断裂韧度和原有方法确定起裂断裂韧度、失稳断裂韧度的结果吻合良好，误差均在 10%以内，满足工程规范要求。新方法简单、实用，有助于推动双 K 断裂模型在混凝土结构裂缝稳定性分析和安全性评价中的应用。

关键词：三点弯曲梁；损伤塑性模型；双 K 断裂模型；起裂断裂韧度；失稳断裂韧度

Determination of Double-K Fracture Parameters of Concrete Based on Damage Plasticity Model

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Abstract:

Based on the concrete damaged plasticity model, the damage-fracture process of three-point bending concrete beam (TPB beam) was numerically simulated. Based on the numerical model, the initial cracking load was determined by the load corresponding to the damage initiation critical point, and the critical equivalent effective crack length to calculate unstable fracture toughness was determined from the distribution of damage factor at the peak load point, a new method was proposed to determine the initial fracture toughness and unstable fracture toughness. The results show that the numerical model of TPB beam based on damage plasticity model can accurately predict the load-displacement curve and simulate the quasi-brittle fracture process of TPB beam under monotonic load, including, crack initiation, stable crack propagation and unstable crack propagation. The results of initial fracture toughness and unstable fracture toughness obtained from the proposed method are in good agreement with the results determined from common methods, the relative errors are all less than 10%, which meets the requirements of engineering specifications. The proposed method is relatively simple and practical, which can contribute to promote the application of double-K fracture model in crack stability analysis and safety evaluation of concrete structures.

keywords: three-point bending beam; damage plasticity model; double-K fracture model; initiation fracture toughness; unstable fracture toughness

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Prestress Loss in Concrete Structures Calculated with Domestic and Foreign Codes

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Abstract : Creep is an inherent property of concrete materials. In prestressed concrete structures, the creep of concrete will redistribute the internal forces of the concrete and tendons, affecting the bearing capacity of structures. Accurate prediction of the prestress caused by creep is critical to design a prestressed concrete structure. The comparison of codes or specifications of different countries on concrete structures was performed in this study. A basic model of prestress loss caused by creep was first deduced from a simple engineering model, and then by comparing the calculation formulas given by each code with the derived model, it was found that the overall fundamentals of different codes were similar and the considerations were basically the same; Among these codes, the formulas given by the Chinese Codes, the European Code (DD ENV 1992-1-1), and the AASHTO Code (AASHTO LRFDUS-5-M) were similar to the concrete aging formula; while the ACI Code (ACI 209R-92), the Australian Code (ACI 209R-92), and the Canadian Code (CSA-S6-06) depended more on empirical coefficients from experiments. In the calculation example, the value of creep coefficient directly affected the calculating result of prestress loss. By comparing of the creep models adopted in "Specifications for Design of Concrete Structures", the European Code (DD ENV 1992-1-1), the ACI Code (ACI 209R-92) and the Railway Code (TB10002.3-2005), the effects of input parameters on calculation of creep coefficient were discussed in details This study revealed the appropriate conditions using different codes.

Key words: prestressed structure; concrete creep; prestress loss; codes comparison; creep coefficient

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Nonlinear Strain Distribution in a Field-Instrumented Concrete Pavement Slab

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Abstract: It is well known that temperature along the depth of concrete pavement slabs is highly nonlinearly distributed. Utilizing appropriate methods is crucial for quantifying equivalent temperature gradient and the associated curling and stress calculations. The existing methods to obtain temperature gradient are either simply by subtracting the bottom surface temperature from the top surface temperature or by converting the nonlinear temperature distribution to an equivalent temperature difference based on the measured temperature distribution. None of the above methods are based on the strain which is the direct cause of slab curling. This study measures the strain development at different depths of field instrumented concrete pavement slabs. The nonlinear distribution characteristics of the temperature and strain along slab depth are evaluated for locations of slab corner and at slab centre. According to the measurements, both temperature and strain can be nonlinearly distributed along slab depth. The nonlinear distribution is more severe at slab corner than slab centre, especially for strain distribution. A new strain-based quantification method for equivalent temperature gradient is developed based on the field strain measurements. Its validity is verified by the field measured slab curling data. The newly developed strain-based method provides an alternative way for the temperature-associated performance evaluation of concrete pavement slab.

Key words: instrumented concrete pavement slab; nonlinear strain distribution; nonlinear temperature distribution; strain measurement

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机场道面与公路水泥混凝土路面施工工艺对比研究

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摘 要：经过对机场道面铺筑施工工艺及公路水泥混凝土路面施工工艺现场考察，发现两者在施工工艺及施工组织方面存在一定差异，铺筑结果互有优劣。公路水泥混凝土路面铺筑多使用一体化施工机械，施工效率高、进度快，缺点是铺筑出的路面平整度差、抗滑耐久性差，施工工艺粗糙；机场道面铺筑多采用较为灵活的人工滚筒进行提浆收面，道面纹理丰富，抗滑性能优越，缺点是施工机械老旧，且不使用混凝土外加剂，道面表面结构功能层易起砂、扬尘。现将两种水泥混凝土构筑物的铺筑形式及其铺筑结果进行对比分析，方便施工者参考，进行取长补短。

关键词：公路水泥混凝土路面；机场道面；铺装工艺；刻槽工艺；施工质量

Comparative Study on Construction Technology of Airport Road Surface and Cement Concrete Pavement

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Abstract:

After on-site inspection of airport pavement construction technology and cement concrete pavement construction technology, it is found that there are some differences in construction technology and construction organization, and the paving results have advantages and disadvantages. Cement concrete pavement construction uses multi-purpose construction machinery, which has high construction efficiency and fast progress. The disadvantage is that the paved pavement has poor flatness, poor anti-sliding durability and rough construction process. The pavement of the airport pavement is more flexible. The roller is used for the surface of the slurry, the surface texture is rich, and the anti-sliding performance is superior. The disadvantage is that the construction machinery is old, and the concrete admixture is not used, and The functional layer of the surface structure of the pavement is easy to sand and dust. The paving forms and paving results of the two cement concrete structures are compared and analyzed, which is convenient for the builders to refer to and learn from each other.

keywords: cement concrete pavement; airport pavement; paving process; grooving process; construction quality

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半柔性复合路面在季冻区服务区水泥混凝土路面 维修中的应用

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摘 要：本文结合沈阳过境绕城高速公路古城子服务区水泥混凝土路面维修工程半柔性复合路面的应用，介绍了半柔性复合路面的原材料、配合比设计及施工工艺以及施工注意事项，通过对完工路面的检测，验证了半柔性复合路面的路用性能，为其进一步推广应用奠定了基础。

关键词：半柔性复合路面；高速公路；服务区；水泥混凝土路面；维修

Application in Maintenance to Cement Concrete Pavement in Service Area in Seasonal Frozen Area on Semi-Flexible Composite Road Surface

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Abstract:

Based on the application of semi-flexible composite pavement for cement concrete pavement maintenance project in the Guchengzi service area of Shenyang transit expressway, this paper introduces the raw materials, matching design and construction technology of semi-flexible composite pavement as well as the construction precautions. The pavement performance of semi-flexible composite pavement is verified passed the test of the completed road surface, which lays a foundation for its further application.

keywords: Semi-flexible composite pavement; Expressway; Service area; Cement concrete pavement; Maintenance

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水泥混凝土路面破碎加铺技术的应用研究

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摘 要：水泥混凝土路面在我国低等级道路中占有的比重很高，对损坏严重的水泥混凝土路面进行破碎加铺，不仅有利于降低公路改造的投资成本，同时对于保证行驶质量和提高资源利用效率也有着重要的影响。通过对旧水泥混凝土路面碎石化的基层模量进行反演，发现水泥混凝土碎石化基层与传统意义上的柔性、刚性基层结构不同，等厚度的碎石化基层与级配碎石基层相比，其承载能力更强，总结了应用有限元法静力学反演碎石化基层模量和计算加铺结构弯沉的方法。经过试验路验证的加铺设计方法适用于水泥混凝土路面升级改造工程。

关键词：水泥混凝土路面；碎石化；有限元；加铺结构设计；静力学分析

Study on the Technology of Rubblization and Paving of Cement Concrete Pavement

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Abstract:

Hardened pavement in our country occupies an important part in low grade road. Breaking and paving badly damaged cement concrete pavement not only helps to reduce the investment cost of highway reconstruction, but also has an important impact on ensuring driving quality and improving resource utilization efficiency. Through the inversion of modulus of crushed cement concrete base, it is found that the crushed cement concrete base is different from the traditional flexible and rigid base structure, and the crushed cement concrete base of equal thickness has stronger bearing capacity than the graded gravel base. The steps of inverting the modulus of crushed cement concrete base and calculating the deflection of overlay structure are summarized. The pavement design method verified by the test road is suitable for upgrading and upgrading of low-grade cement concrete pavement.

keywords: cement concrete pavement; rubblization; finite element; overlay structure design; static analysis

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水泥路面水性环氧稀浆下封层与半刚性基层间的粘结性能研究

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摘 要：为了增强水泥路面中水性环氧稀浆下封层与半刚性基层二者的结构整体性，以利于车辆荷载作用下路面结构的受力。试验首先通过原材料的选取和混合料配合比设计，成型了组合试验试件。在此基础上，借助具有竖向荷载的直接剪切试验，对比分析了不同稀浆封层结合料条件下的封层级配、封层后期养生温度、封层成型温度和半刚性基层表面污染程度对稀浆封层和半刚性基层层间粘结性能的影响，并提出了保证二者层间粘结性能的措施。试验结果表明：相比于基质乳化沥青和 SBR 改性乳化沥青，水性环氧-SBR 改性乳化沥青稀浆封层与半刚性基层间的粘结性能明显较优；各因素对不同结合料的封层与半刚性基层间的粘结性能影响程度一致，均表现出封层级配、成型温度和污染程度对层间粘结性能影响较大，而后期养生温度对层间粘结性能影响较小的特点；建议采用细粒式封层，在 20℃的成型温度下铺筑封层且在铺筑前清扫半刚性基层下承层的措施，以保证层间的粘结性能。

关键词：水泥混凝土路面；水性环氧-SBR 改性乳化沥青；稀浆下封层；粘结性能

Research on Bonding Performance Between Waterborne Epoxy Slurry Under-Sealed Layer and Semi-Rigid Base in Cement Pavement

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Abstract:

In order to enhance the structural integrity of waterborne epoxy slurry under-sealed layer and semi-rigid base in cement pavement, and to be beneficial to the stress of pavement structure under the vehicle load. Firstly, the composite test specimens were formed based on the selection of raw materials and the mix proportion design. On this basis, by means of direct shear test with vertical load, the effects of seal coat’s gradation, curing temperature at the late stage, forming temperature and surface contamination degree of semi-rigid base on the bonding performance between slurry seal and semi-rigid base under the condition of different slurry seal binder were compared and analyzed, and the measures to ensure the bonding property between slurry seal and semi-rigid base were put forward. The experimental results show that compared with the matrix emulsified asphalt and SBR modified emulsified asphalt, the bonding performance between the waterborne epoxy-SBR modified emulsified asphalt slurry seal layer and the semi-rigid base is obviously better; each factor has the same effect on the bonding performance between the sealing layer of different binders and the semi-rigid base, and both of them show that the gradation of seal coat, forming temperature and contaminating level have great influence on the bonding performance between the two layers, while the curing temperature at the late stage has less impact on the interlayer bonding performance; it is recommended to select the fine-grained sealing layer, lay the sealing layer at a forming temperature of 20℃ and clean the semi-rigid base before laying to guarantee the bonding performance between the slurry under-sealed layer and semi-rigid base.

keywords: cement concrete pavement; waterborne epoxy-SBR modified emulsified asphalt; slurry lower seal coat; bonding performance

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Monitoring of Macrotexture Deterioration for Micro-Milled Tunnel Concrete Pavement Using 3D Line Laser Data

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Abstract: Facing pavement preservation challenges as a result of funding shortages in China, the Sichuan Department of Transportation (SDOT) have attempted to use micro-milling method to cost-effectively improve the tunnels concrete pavement surface texture, to extend skid resistance performance. To monitor the short-term and long-term performance of the micro-milling operation, the macrotexture was characterized and quantified using the Mean Texture Depth (MTD) indicator. This paper verifies the feasibility of using 3D line laser technology to develop a full-lane evaluation method that can measure MTD and explore the short (6 months) and long-term (24 months) MTD deterioration statistical characteristics and degradation. A filed test was first conducted to validate accuracy of the proposed method by comparing to the electric sand patch method. Results show that the correlation coefficient of the two methods can reach 0.88~0.93. At 6th months, the mean MTD of micro-milled surfaces were decreased from 0.91mm to 0.83 mm. At 24th months was decreased to 0.67 mm. After 6 months, the lowest value of MTD has a 100-200mm offset to the middle of the road, This is due to the wheel trajectory offset caused by the driver keeping a distance from the side wall of the tunnel during driving. Based on specification in China, In the 24th month after milling, the area where the texture deteriorated to an MTD value of 0.35 mm or less accounted for 13% of the entire unit and 25% of the wheel track.

Key words: tunnel; concrete cement pavement; micro-milled macrotexture; deterioration; mean texture depth; 3d line laser

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Research and Application of Geopolymer Material in Reinforcement of Trenchless Structure of Cement Pavement

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Abstract: Under the repeated action of vehicle load and water penetrating into the pavement structure layer, the foundation under the cement concrete pavement slab produces plastic deformation and mud, which causes the void between the cement concrete slab and the base, the base and the base or the base and the cushion. However, after cracking, subsidence, pit and other diseases of the old pavement, excavation-type repair is usually used in the local location, that is, all the surface and foundation are removed, new pavement is built after the subgrade is treated and repaired, or pavement structural layer is directly added after the surface and foundation are regenerated in situ or in situ, resulting in large amount of maintenance or reconstruction works, high maintenance costs, and repair time. The length of pavement has great influence on traffic, but it fails to achieve the goal of long service life of pavement.

On the basis of cement grouting reinforcement and expansive polyurethane polymer grouting waterproofing, DJZ geopolymer grouting material is studied. Compared with traditional cement grouting material, geopolymer grouting material has the advantages of super high fluidity and permeability, strong water erosion resistance, activating inert material in base or subgrade filling, and improving road bearing capacity. Through the study on the application of polymer grouting in the treatment of cement pavement void, i.e. Yingkeng Highway S253 of Yingde Provincial Highway, Putian Provincial Highway S202, Minqing Provincial Highway S202 of cement pavement void, it can be seen from the deflection detection after grouting and the excavation results of exploratory pit that the bearing capacity and resilience modulus of pavement structure have been significantly improved. The bearing capacity of the structure exceeds the design requirements. The geopolymer grouting reinforcement technology is successful. DJZ geopolymer grouting material can be effectively used to treat the void of cement pavement.

Geopolymer grouting reinforcement technology does not need to excavate the road surface, reduces the construction time, reduces the impact of road maintenance on traffic, and ensures the short-term recovery of traffic. It has obvious social significance and economic benefits for highway maintenance with large traffic volume. It is an effective road reinforcement treatment method.

Key words: cement concrete pavement, void, detection, DJZ geopolymer, grouting, quality, deflection value

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露石混凝土路面缓凝剂作用机理研究

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摘 要：通过不同浓度梯度露石剂试验；并设置不同温度梯度的混凝土养生环境对比试验；结合德国 TONI 水泥混凝土水化热试验设备，设置基准组与添加露石剂的对照组进行混凝土水化热试验。结果表明：露石清扫时间和露石深度随着露石剂浓度的增加呈现增加的趋势，但超过一定浓度值后清扫时间和清扫后的露石深度均不再增加。混凝土成型后，表面水膜消失速率随养生环境温度的升高逐渐加快，露石剂喷洒时间随之缩短。基准和添加露石剂的水泥混凝土随着恒温养生时间的增加，放热速率曲线均呈现先增加再降低的趋势，但添加露石剂的对照组放热速率最大值、最大放热速率、混凝土 1400min 的放热量均有所减小和推迟。

关键词：道路工程；对比试验；水泥水化；露石剂

Study on the Mechanism of Action of EACCP

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Abstract:

The experiment was carried out by using different concentration gradient of the aggregate exposing solvent test, and set up the concrete health environment with different temperature gradient , The concrete hydration heat test was carried out with the control group of TONI cement concrete hydration test set and the control group with the addition of aggregate exposing solvent. The results show that the cleaning time and the depth of EACCP is increasing with the increase of the concentration of aggregate exposing solvent, but they are not increased.,after the certain concrete , the disappearance rate of the surface water film increases with the increase of the temperature of the health environment, and the spraying time of the terring agent is shortened. The hydration heat release rate of the cement concrete of the add aggregate exposing solvent groups and unadded groups increased with the increase of the constant temperature , and the exothermic rate curves show a tendency to increase first and then decrease. However, the maximum exothermic rate, the maximum exothermic rate and the heat release rate of concrete 1400min were reduced and delayed of the add aggregate exposing solvent groups.

keywords: road engineering; comparative test; cement hydration; aggregate exposing pavement

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露石混凝土路面清扫刷洗一体化工艺改进研究

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摘 要：通过对 EACCP 实际施工中出现问题进行分析，结合城市道路清扫车的类型和对其清扫原理研究，提出露石清扫的扫刷触地压力、颗粒起动条件、颗粒收集效率等参数，寻找 EACCP 大里程施工中清扫效率提升的方法。从现有技术理论论证实际施工中可以通过控制城市道路清扫车的触地压力，根据体积和质量相互反推出露石清扫量，再根据清扫量合理的搭配盘刷转速和清扫车速来提高 EACCP 的清扫效率，使大里程施工耗时更短。

关键词：EACCP；道路清扫机；清扫量；清扫效率

Study on Improvement of Integrated Cleaning Process of Exposed-Aggregate Concrete Pavement

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Abstract:

Based on the analysis of the problems in EACCP construction and the study of the type of road sweeper and its cleaning principle, the parameters such as the contact pressure, particle start-up condition and particle collection efficiency of sweeping brush are found. Method of improving cleaning efficiency during construction. Demonstrating the actual construction of the existing technology can be used to control the contact pressure of the urban road sweeper by controlling the contact pressure of urban road sweeper, the volume of cleaned rock can be deduced according to the volume and quality, and then the cleaning efficiency is improved according to the reasonable brushing speed and sweeping speed. Less time-consuming.

keywords: EACCP；road sweeper；Amount of cleaning；cleaning efficiency

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Development and Test of Super-Early-Strength Concrete with a Sealed Wetting-Heating Curing System

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Abstract: In order to realize super-early-strength concrete, a new enclosed wetting-heating curing system suitable for use in the laboratory is designed for this study. According to this system, a concrete specimen is sealed in a covered heating mold, which is then placed in a heat-preservation box with adjustable temperature. The concrete produced by this curing system is subjected to strength testing and 60%-80% of the concrete's design strength is attained within 12 h, thereby showing this system's feasibility for producing super-early-strength concrete.

Key words: super-early strength; enclosed wetting; curing system; heating mold; heat-preservation box

不同纤维对超高性能混凝土强度的影响

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摘 要：为了研究不同纤维种类及掺量对超高性能混凝土强度的影响，分别选用形状和长径比相同的聚丙烯纤维、玄武岩纤维和镀铜钢纤维，通过改变纤维掺量（0kg、12.5kg、25kg、37.5kg、50kg、62.5kg、75kg）研究了单一纤维与混杂纤维对超高性能混凝土不同龄期（3d、7d 和 28d）抗压强度的影响。结果表明：单掺聚丙烯纤维、玄武岩纤维和钢纤维均可提高水泥混凝土的抗压强度，其中单掺玄武岩纤维对混凝土强度提升最明显，试件 28d 抗压强度 115MPa，玄武岩纤维掺量为 12.5kg/m3；混杂三种纤维掺入也可提升混凝土抗压强度，其中混杂玄武岩纤维、钢纤维组合效果最好，28d 抗压强度 130MPa，混杂纤维掺量为 50kg/m3。

关键词：超高性能混凝土；聚丙烯纤维；玄武岩纤维；镀铜钢纤维；抗压强度

Effect of Different Fibers on the Strength of Ultra High Performance Concrete

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Abstract:

In order to study the influence of different fibers on the strength of ultra-high performance concrete (UHPC), polypropylene fibers, basalt fibers and copper-plated steel fibers with the same shape and length-diameter ratio were selected. By changing the fiber content (0kg, 12.5kg, 25kg, 37.5kg, 50kg, 62.5kg, 75kg), the effects of single fiber and the mixed fibers on compressive strength (3d, 7d and 28d) of the UHPC were conducted respectively. The test results show that the strength of concrete can be improved by adding only polypropylene fiber, basalt fiber and steel fiber, among which the strength of concrete can be improved most obviously is adding basalt fibers alone. The compressive strength of the specimen 28d is 115MPa. Basalt fiber content is 12.5kg / m. Mixed three kinds of fibers can also improve the compressive strength of concrete. The combination of basalt fibers and steel fibers has the best effect. The 28d compressive strength is 130MPa. The content of mixed fiber is 50kg/m.

keywords: ultra-high performance concrete；polypropylene fibers; basalt fibers; copper-plated steel fibers; compressive strength

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考虑邻板高程差的装配式水泥路面行驶舒适性研究

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摘 要：配式路面板的预制与安装误差会导致板块间存在高程差，为研究此类不平整对行驶舒适性的影响，以座椅加权加速度均方根值作为评价指标，建立五自由度 1/2 车模型，采用 Newmark-β 法对该模型进行求解，获得小客车驶过不同邻板高程差时的加速度时程，进而对装配式水泥路面的行驶舒适性进行评价。结果表明：邻板高程差引起的装配式水泥路面不平整对行驶舒适性影响显著，且影响程度与车型、行驶速度、邻板高程差大小、板长等因素有关；在驶过单个接缝时，座椅竖向加速度最大值会随着车速和邻板高程差的增加而增加；在驶过多个接缝时，加权加速度均方根值会随邻板高程差的增加而增加、随板长的增加而减少；接缝影响距离随车速呈现整体上升趋势，但其大小会根据车型和车速产生规律性的变化；使用加权加速度均方根值对行驶舒适性进行评价，可为装配式水泥路面的设计与施工提供参考。

关键词：装配式水泥路面；行驶舒适性；邻板高程差；加权加速度均方根；接缝影响距离

The Driving Comfort of Precast Concrete Pavement Considering the Joint Faulting

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Abstract:

The fabrication and installation error of precast concrete pavement (PCP) panels results in the joint faulting. To study the effect of this unevenness on the driving comfort, the weighted root-mean－square acceleration (WRMSA) on driver’s seat is selected as the evaluation index. A five-degree-of-freedom half-vehicle model is introduced to simulate a standard car. The Newmark-β method is applied to solve the acceleration on driver’s seat that induced by the joint faulting. Calculation result indicates that: Driving comfort is significantly affected by the joint faulting, and the degree of its influence depends on vehicle type, driving velocity, height of joint faulting, panel length. When passing a single joint, the maximum vertical acceleration increases with the increase of driving velocity and height of joint faulting. When passing multiple joints, the WRMSA increases with the increase of height of joint faulting and decreases with the increase of panel length. The joint influence distance shows an upward tendency with vehicle speed. While its value will change according to the vehicle type and driving speed. This study can provide a scientific reference for precast concrete pavement design and construction quality control.

keywords: precast concrete pavement; driving comfort; joint faulting; weighted root-mean-square acceleration; joint influence distance

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基于实测点云的装配式水泥混凝土铺面虚拟装配技术

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摘 要：装配式水泥混凝土铺面在施工过程中可能会由于装配空间的不匹配造成装配失败。本文借助三维扫描设备，提出了一种基于实测点云的装配式水泥混凝土铺面虚拟装配技术。该技术首先通过对点云数据的压缩、降噪、拼接等处理，实现了装配式铺面板与其装配空间的三维重构。随后，在 CATIA 软件中通过虚拟装配检测板块安装时可能发生的装配干涉，并通过干涉查询表给出相应的解决方案，从而有效地保障装配式水泥混凝土铺面装配的顺利进行。

关键词：装配式水泥混凝土铺面；三维扫描；点云处理；三维重构；虚拟装配

Virtual Assemble Technology for Precast Concrete Pavement Based on On-Site Point Cloud Data

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Abstract:

The mismatch between precast concrete pavement slab and assemble space may cause difficulty of construction and cost of rework. This paper proposed a virtual assemble technology for precast concrete pavement, the on-site point cloud data is acquired by TLS. Firstly, the point cloud data is preprocessed, including simplification, denoising and registration. Then the precast slab and the assemble space are reconstructed into 3D models by using processed point cloud data. The virtual assemble procedure is operated in the DMU environment of CATIA. A
confliction table is proposed to provide construction solution when confliction of different models are detected. By using this virtual assemble technology., construction accuracy and efficiency of precast concrete pavement can be improved.

keywords: precast concrete pavement; 3D scanning; point cloud data; 3D reconstruction; virtual assemble

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The Effect of Nano-$CaCO_3$/Styrene Butadiene Rubber (SBR) on Fundamental Characteristic of Hot Mix Asphalt

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Abstract : This study investigates the performance characteristics of nano-$CaCO_3$/SBR modified asphalt mixture. SBR modified asphalt was mixed with nano-$CaCO_3$ particles at concentration of 3%，4%，5%，6% and 7% by weight of asphalt binder. Wheel track test was used to determine the proper dosage of nano compound modifiers which is comparable to SBS modified asphalt mixture in terms of deformation performance at high temperature. Asphalt mixture performance tests such as static creep test, overlay test and three-point beam bending test were conducted for nano modified asphalt mixture and SBS modified asphalt mixture. The micro topography and micromechanical property of modified bitumen are evaluated by Atomic Force Microscopy to study the modification mechanism of nano modifiers. Results show that 5%$CaCO_3$/4%SBR modified asphalt mixture have superior rutting resistance and creep characteristics at high temperature in terms of wheel track test and static creep test. However, reflection cracking resistance and flexural deformation stability of 5%$CaCO_3$/SBR modified asphalt mixture at low temperature are slightly worse than SBS modified asphalt mixture. Despite this, ANOVA result indicates that the difference between two kinds of asphalt mixture is not significant. AFM test result reveals that 5%$CaCO_3$/SBR modifier can well dispersed in bitumen and evidently increase the micromechanical properties of bitumen such as adhesion and dissipated energy while it has negative effect on DMT modulus. In general, 5%nano-$CaCO_3$/4%SBR modifier has the desirable potential to comprehensively improve the performance of hot mix asphalt and is promised to be applied in warm area.

Key words: Nano-$CaCO_3$; styrene-butadiene-styrene; styrene-butadiene-rubber; atomic force microscopy; static creep test; texas overlay test

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Study on Evaluation Method of Mud-Pumping of Cement Concrete Bridge Deck Pavement

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Abstract: Mud-pumping is one of major distresses of concrete bridge deck pavement, which not only influences theriding comfort of vehicles but also affects the appearance of bridge pavement and endangers the whole bridge structure. Although many methods have been used to assess the mud-pumping distress, most of them remain in the qualitative assessment. Relevant researches about testing methods and quantitative assessment approaches are seldom studied. In this paper, Initial Surface Absorption Test (ISAT), X-ray CT technology, and fractal theory are adopted to assess mud-pumping pavement and study the effect of capillary force on the mud-pumping distress. In addition, the influences of voids distribution characteristics on the capillary water absorption capability are discussed. The ISAT result shows that three significant parameters of mud-pumping cores, such as the capillary water absorption mass, the capillary water absorption coefficient, and the ratio of capillary voids to air voids, are markedly different from those of the non-pumped cores. The mud-pumping cores had a relatively higher void ratio of distress are recommended by this paper.

Key words: bridge deck pavement; mud-pumping distress; capillary force; fractal theory

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基于 DIC 技术的沥青混凝土开裂特征量化研究

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摘 要：沥青混凝土是黏弹性材料，其断裂过程伴随不可忽略地蠕变变形。通常使用位移传感器获取沥青混凝土的开裂特征指标，该方法具有精度高、使用简单等优点，但同时具有测点的位置固定且数量有限、位移传感器需与试件接触等局限性。数字图像相关（DIC）技术是全场式、非接触式位移测量方法，在不接触试件的条件下，可全场跟踪试件位移变化情况，捕获裂缝尖端断裂过程，可为断裂研究提供更多参数指标。本文基于 DIC 技术应用半圆弯曲试验研究沥青混凝土的断裂特性，测量了如下断裂指标：裂缝开口位移(CMOD)、裂尖开口位移(CTOD)和δ25。提出了更为全面的开口位移矩阵作为开裂特征量化指标，用以评价沥青混凝土断裂过程中裂缝尖端复杂的断裂特性。研究发现：裂缝尖端内聚力区域不一定唯一，且具有不规则、不连续等特点。位移开口矩阵为重新定义裂缝以及量化蠕变特性提供了新依据。

关键词：数字图像相关技术；沥青混凝土；断裂研究；开口位移矩阵

Quantitative Research on Cracking Characteristics of Asphalt Concrete Based on DIC Technology

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Abstract:

Asphalt concrete is viscoelastic material and its fracture process is accompanied by creep deformation which cannot be ignored. Generally, displacement sensors are used to obtain fracture characteristic indexes of asphalt concrete. This method has the advantages of high accuracy and simple use, but at the same time, it has limitations such as limited and fixed measuring points, contact between displacement sensors and specimens and so on .Digital image correlation (DIC) technology is full-field and non-contact displacement measurement method can track the displacement change of the specimen in full field under the condition of not contacting the specimen, capture the fracture process at the crack tip, and provide more parameter indexes for fracture research. In this paper, DIC technology is used to study the fracture characteristics of Asphalt concrete using semicircular bending test, and the following fracture indicators are measured: Crack Opening Displacement (CMOD), Crack Tip Opening Displacement (CTOD) and δ 25.A more comprehensive open displacement matrix is proposed as the quantitative index of cracking characteristics to evaluate the complex fracture characteristics of crack tip in asphalt concrete fracture process. The results show that the cohesive zone is not unique, irregular and discontinuous before crack tip. The displacement opening matrix provides a new basis for redefining fracture and quantifying creep characteristics.

keywords: digital image correlation technology; asphalt concrete; fracture research; opening displacement matrix

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不同方法设计 AC-16 沥青混合料性能评价

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摘 要：为了评价设计方法对沥青混合料性能的影响，分别采用垂直振动成型设计法（VTM）、马歇尔设计法（Marshall）和旋转压实法（GTM）对 AC-16 沥青混合料进行了配合比设计，并研究了这三种沥青混合料路用性能。结果表明：VTM 法与 GTM 法设计的 AC-16 混合料密度基本相当，约为 Marshall 的 1.02 倍；与 Marshall 设计法相比，VTM 法与 GTM 法设计的 AC-16 油石比降低了 9.0%，力学性能、动稳定度、抗弯拉强度至少分别提高了 30%、34%、17%，水稳性略有提升；密度增大 1.8%，动稳定度、抗弯拉强度可分别提高 17%、11.7%；油石比降低 9%，动稳定度、抗弯拉强度可分别提高 17.2%、5.6%。可见，VTM 设计 AC-16 沥青混合料与 GTM 设计的具有相同路用性能。

关键词：道路工程；沥青混合料；垂直振动成型方法；马歇尔方法；旋转压实法

Performance Evaluation of AC-16 Asphalt Mixture Designed by Different Methods

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Abstract:

To evaluate the influence of design methods on the performance of asphalt mixture, the vertical vibration design method (VTM), Marshall design method (Marshall) and rotary compaction design method (GTM) were used to design AC-16 asphalt mixture, then performances of these three asphalt mixtures were studied. The results show that the density of AC-16 mixture designed by VTM method and GTM method is basically the same, about 1.02 times that of Marshall method. Compared with Marshall design method, the asphalt-aggregate ratio of AC-16 mixture designed by VTM method and GTM method is reduced by 9.0%. The mechanical properties, dynamic stability, and flexural strength are increased by at least 30%, 34%, and 17%, respectively, and the water stability is slightly improved. The dynamic stability and bending strength can be increased by 17% and 11.7%, respectively, with the density increased by 1.8%. The dynamic stability and bending strength can be increased by 17.2% and 5.6%, respectively, with the asphalt-aggregate ratio reduced by 9%. It can be seen that the VTM design AC-16 asphalt mixture has the same road performance as the GTM design.

keywords: road engineering; asphalt mixture; vertical vibration compaction method; Marshall compaction method; rotary compaction method

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Heat Conduction Effect of Conductive Gussasphalt Concrete Pavement

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Abstract: The snow- and ice-melting effect and energy usage of steel bridge deck pavement are affected by the heat-transfer rate and temperature change in the middle of the combination structure when using conductive gussasphalt concrete (CGA). To determine the heat conduction effect and the snow melting time of conductive gussasphalt concrete pavement, the heat conduction estimation method and a theoretical equation of the CGA combination structure are derived. A CGA combination structure with spreading carbon fiber in the middle of the CGA layer is prepared. The accuracy of the theoretical equation is checked and verified. Then, the heat conduction effect and the time required to reach and maintain the temperature above 0℃ of different CGA combination structures are evaluated. According to the estimation results and weather conditions, the power will be turned on or shut off ahead of time to improve the deicing efficiency and save energy. The results show that the theoretically obtained estimation values are close to the test values. The theoretical equation can estimate the heat conduction effect of the CGA combination structure.

Key words: road engineering; conductive gussasphalt concrete; heat conduction effect; deicing and snow melting; estimation

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有机坡缕石改性沥青制备及性能研究

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摘 要：为改善沥青高温性能及改性沥青储存稳定性，基于坡缕石的物理化学特性，经有机化处理，对沥青进行改性，制备有机坡缕石改性沥青，并通过沥青基本物理性能试验研究其物理指标变化，借助动态剪切流变试验（DSR）、Brookfield 旋转粘度试验，分析有机坡缕石改性沥青的高温流变性能及粘温特性，通过离析试验，分析有机坡缕石改性沥青储存稳定性。结果表明，掺加了有机坡缕石的改性沥青软化点明显升高，针入度和延度有所降低，说明其对高温性能改善明显，对低温性能存在一定不利影响。坡缕石经有机化处理，可提高改性沥青的高温粘度。随有机坡缕石掺量的增加，改性沥青抗车辙因子逐渐增大，当有机坡缕石掺量超过 3%后，其掺量的增多对沥青高温性能进一步提升效果并不显著。对坡缕石进行有机化处理可以提高改性沥青储存稳定性。

关键词：改性沥青；有机坡缕石；物理性能；流变性能；储存稳定性

Preparation and Properties of Organic Palygorskite Modified Asphalt

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Abstract:

In order to improve the high temperature performance of asphalt and the storage stability of modified asphalt, the organic palygorskite was prepared to modify the asphalt based on the physical and chemical properties of palygorskite. The basic physical properties of organic palygorskite modified asphalt were test and its high temperature rheological properties and viscosity-temperature characteristics were analyzed by the means of dynamic shear rheological test (DSR) and Brookfield rotational viscosity test. And its storage stability was analyzed by the separation test. The results show that the softening point of modified asphalt with organic palygorskite is obviously increased, while the penetration and ductility are reduced. It can be found that the organic palygorskite has an obvious improvement on high temperature performance and an adverse effects on low temperature performance of the modified asphalt. The high temperature viscosity of the modified asphalt could be increased after the palygorskite was treated organically. The anti-rutting factor of modified asphalt gradually increased with the increase of content of organic palygorskite. However, the increase in amount of organic palygorskite has no significant effect on the high temperature performance after its amount exceeds 3%. What’s more, the organic treatment of palygorskite could improve the storage stability of modified asphalt.

keywords: modified asphalt; organic palygorskite; physical properties; rheological properties; storage stability

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聚氨酯与稻壳灰对沥青流变性能的影响

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摘 要：农林废弃物引发的环境问题日益突出。为实现副产品再利用，本文选用稻壳灰(RHA)热塑性聚氨酯弹性体(TUPE)复合对沥青进行改性，以获取性能优异的改性沥青。通过短期老化前后沥青试样的荧光显微镜、三大指标试验、动态剪切流变试验（DSR)、多应力蠕变恢复试验（MSCR）研究改性剂对沥青高低温和流变行为的影响。结果显示：TUPE 的加入改善了 RHA 在沥青中的分散性。TUPE-RHA 复配改性对沥青的高温、低温和温度敏感性均有明显提升。改性剂的加入提高了沥青的弹性性质，降低了粘性性质。老化前后复配改性沥青拥有最好的抗永久变形的能力。

关键词：改性

Effect of Polyurethane and Rice Husk Ash on the Rheological Propertes of Asphalt Binder

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Abstract:

Nowadays, environmental problems caused by agricultural and forestry waste have been increasingly prominent. In order to reuse the by-products, this paper selects the rice husk ash (RHA) and thermoplastic polyurethane elastomer (PUTE) composite to modify the asphalt to obtain the modified asphalt with excellent performance. The effects of modifiers on the high and low temperature and rheological behavior of asphalt were studied by three major index tests, dynamic shear rheological test (DSR) and multi-stress creep recovery test (MSCR) of asphalt samples before and after short-term aging. The results of fluorescence microscopy show that the addition of TUPE improves the dispersion of RHA in the asphalt. The TUPE-RHA compound modification is capable of significantly improving the high temperature, low temperature and temperature sensitivity of asphalt. The addition of the modifier increases the elastic properties of the asphalt and reduces the viscous properties. The modified asphalt before and after aging has the best resistance to permanent deformation.

keywords: modification

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响应曲面法优化 CSW 与聚酯纤维复改沥青生产工艺参数研究

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摘 要：为研究生产工艺参数对 CSW（硫酸钙晶须）与聚酯纤维复改沥青性能的影响，采用响应曲面法进行实验设计，以搅拌时间、搅拌温度和发育温度为实验因素，以软化点、10℃延度和 25℃锥入度为响应值，利用 Design-Expert 8.05b 软件建立实验因素与响应值间的多元二次回归模型，进行各实验因素交互作用对响应值的影响分析。结果表明：所建三个多元二次响应回归模型拟合效果好，可用于生产工艺参数分析与预测；CSW/聚酯纤维复配改性沥青最优生产工艺参数为搅拌时间 31min、搅拌温度 175℃、发育温度 175℃，此时改性沥青的软化点、10℃延度和 25℃锥入度分别为 49.4℃、14.1cm 和 58.4mm，偏差率均小于 3%，表明采用响应曲面法进行 CSW 与聚酯纤维复改沥青生产工艺参数优化设计结果可靠、方法可行。

关键词：响应曲面法；CSW/聚酯纤维复改沥青；工艺参数；设计优化

Optimization on Process Parameters for CSW/Polyester Fiber Modified Asphalt Using Response Surface Methodology

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Abstract:

In order to study the effect of process parameters on the performance of calcium sulfate whisker/polyester fiber modified asphalt, the relevant experiment was carried out with response surface methodology by selecting the stirring time, stirring temperature and development temperature as the experimental factors, the softening point, 10℃ductility and 25℃cone penetration as the response values. Design-Expert 8.05b was used to establish the multivariate quadratic regression model, and the optimal production process parameters were obtained by analyzing the influence of interaction of experimental factors on the response values. The results showed that the three multivariate quadratic response regression models were significant and the lacks of fit were not significant, indicating the established model could be used for process parameter analysis and prediction. The optimal process parameters were stirring time of 31 min, stirring temperature of 175℃ and development temperature of 175℃. Under these conditions , the softening point,10℃ ductility and 25℃ cone penetration were 49.4℃、14.1cm and 58.4mm, and the deviation rate were less than 3%. Result indicated that the response surface methodology was feasible to optimize the design process parameters of CSW/ polyester fiber modified asphalt.

keywords: response surface methodology; CSW/polyester fiber modified asphalt; process parameters; design optimization

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纳米 ZnO/SBS 改性沥青及沥青混合料性能研究

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摘 要：为改善 SBS 改性剂在基质沥青中的分散效果，进一步提高 SBS 改性沥青的性能，本文首先根据常规性能试验在不同纳米 ZnO 掺量条件下优选出最佳掺量，然后通过 DSR 试验、BBR 试验、荧光显微等手段对 SBS 改性沥青、优选的纳米 ZnO/SBS 改性沥青进行分析，并对上述两种沥青混合料进行路用性能测试。结果表明：随着纳米 ZnO 掺量的增加，纳米 ZnO/SBS 改性沥青的针入度、软化点逐渐减小，延度逐渐增大；高温性能较 SBS 改性沥青混合料有小幅下降，但抗弯拉强度和最大弯拉应变分别增长了 13.4%、16.4%，残留稳定度、冻融劈裂强度比分别增长了 4.3%和 4.8%，低温性能和水稳定性能得到一定程度的改善。

关键词：纳米 ZnO；SBS 改性沥青；改性机理；路用性能

Study on Properties of Nano-ZnO/SBS Modified Asphalt and Asphalt Mixture

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Abstract:

In order to improve the dispersion effect of SBS modifier in matrix asphalt and further improve the performance of SBS modified asphalt, this paper firstly optimizes the optimum dosage according to the conventional performance test under different nano-ZnO dosage conditions, and then passes the DSR test, the BBS test, fluorescence microscopy and other means to analyze the SBS modified asphalt with the preferred nano ZnO/SBS modified asphalt, and the road performance test of the above two asphalt mixtures. The results show that with the increase of nano-ZnO content, the penetration and softening point of nano-ZnO/SBS modified asphalt are gradually decreased, and the ductility is gradually increased. The high-temperature performance is slightly lower than that of SBS modified asphalt mixture, but the flexural strength and maximum bending strain increased by 13.4% and 16.4%, the residual stability and freeze-thaw splitting strength ratio increased by 4.3% and 4.8%, the low temperature performance and water stability were improved to some extent.

keywords: nano-ZnO; SBS modified asphalt; modification mechanism; road performance

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阿尔巴尼亚岩沥青改性沥青流变特性研究

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摘 要：选用 DSR、BBR 和 Brookfild 旋转粘度仪测试了阿尔巴尼亚岩沥 青（ARA）改性的 70#沥青的各项性能,分析不同掺量 ARA 改性对于基质沥青流变特性的影响。试验结果表明：加入 ARA 后，沥青结合料的粘度和 PG 高温等级增加，相位角减小，抗车辙因子增大，沥青的温度敏感性降低，高温稳定性大大提高,；低温条件下蠕变劲度模量增大，低温性能略有下降，但仍符合我国规范的要求，可用于非极端低温的环境。

关键词：道路工程；阿尔巴尼亚岩沥青；动态剪切流变仪；流变性能

Study on Rheological Properties of Albanian Modified Asphalt

Wan Dong，Gao Wenze
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Abstract:

The dynamic shear rheometer (DSR), low temperature bending rheometer (BBR) and Brookfild rotational viscometer were used to test and analyze the 70# asphalt modified by Albanian rock asphalt (ARA). The effect on the rheological properties of the matrix asphalt. The results show that: after adding ARA, the PG high temperature grade and viscosity of the asphalt binder increase, the anti-rutting factor increases, the phase angle decreases, the high temperature stability of the asphalt is greatly improved, the temperature sensitivity is lowered, and the dosage is increased. The increase of the increase is increased; the creep stiffness modulus increases under low temperature conditions, and the low temperature performance decreases slightly, but the low temperature performance of the asphalt binder still meets the requirements of China's specifications and can be used in non-extremely low temperature environments.

keywords: road engineering; albania rock asphalt; dynamic shear rheomete; rheological property

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Exploring the Harding Mechanism of Asphalt Binder During Aging Process

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Abstract: The asphalt binder in pavement mixtures frequently exposed to oxygen and undergoes daily temperature cycles. This results in oxidation of its chemical composition, leading to the aging of the asphalt binder. The aging process of asphalt binder directly affects the pavement's service life and therefore has been subject to intense research regarding the chemical composition. However, the microscopic reasons for these changes are not yet clear. A molecular dynamics (MD) simulation is employed to investigate the hardening mechanism of asphalt binder during aging process from a microscale perspective. Six molecular models for six asphalt binders at different aging states are created based on the ratio of saturates, aromatics, resin and asphaltene (SARA) as well as carbonyl and sulfoxide indexes to investigate the hardening mechanism of asphalt binder. The results explain the mechanism for hardening of asphalt binder during aging process.

Key words: hardening mechanism; molecular dynamics (md) simulation; asphalt binder; aging

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废机油对老化沥青再生的效果研究

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摘 要：为研究废机油对老化沥青的再生效果，本文基于原材料性质分析，确认了废机油作为再生剂的可行性。采用旋转薄膜烘箱加热试验模拟沥青老化，并测定其老化后的性能变化特征。通过调整废机油再生剂比例，研究废机油再生剂对老化沥青的再生效果。研究表明：原样沥青经老化处理后变硬，三大指标均出现不同程度的劣化，且粘度增加，其劣化程度和粘度增加幅度随老化时间的延长而增大。老化 85min 的沥青在再生剂掺量为 3%老化沥青的再生效果最佳，恢复原样沥青性能。经过 170min 和 255min 老化后，基质沥青分子结构发生破坏，废机油不适宜作为其再生剂。

关键词：沥青老化；沥青再生；废机油；再生剂

Study the Effect of Waste Engine Oil on the Regeneration of Aged Asphalt

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Abstract:

In order to study the regeneration effect of waste engine oil on aged asphalt, this paper confirms the feasibility of using waste engine oil as regenerant based on the analysis of raw material properties. The aging of the asphalt was simulated by a rotating film oven heating test, and the characteristics of the performance change after aging were measured. By adjusting the proportion of waste oil regenerant, the regeneration effect of waste oil regenerant on aged asphalt was studied. The research shows that the original asphalt becomes hard after aging treatment, and the penetration, softening point and ductility all have different degrees of deterioration, and the viscosity increases, the degree of deterioration and the increase in viscosity increase with the aging time; The optimum dosage of 85min aged asphalt regenerant is 3%,170min and 255min aging destroyed the molecular structure of asphalt, and waste engine oil is not suitable as its regenerant.

keywords: aging asphalt; asphalt regeneration; waste oil; regeneration agents

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Research on the Molecular Weight Distribution Characteristics and Rheological Properties of Bitumen During the Short-Term Aging

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Abstract: Recent years, due to its advantages of safe, smooth and durable, the asphalt pavement has been used worldwide. However, the age of bitumen during its service period is inevitable, and thus the performance of asphalt pavement will decline. Since the aging mechanism of bitumen is complex and has not been investigated in great detail, the anti-aging materials and rejuvenators are designed mostly based on empirical experiments. Thus, there is a need to investigate the aging mechanism systematically to offer a new way of illustrating the changes during the aging process, and the investigation of the short-term aging mechanism could be the first step. This study explored the variations of rheological properties and characteristics of molecular weight distribution during the short-term aging process, and the data got by the gel permeation chromatography (GPC) was further analyzed by the principal component analysis (PCA). The experimental designed in this research include preparing aged bitumen samples under five aging temperatures and six aging durations, and then the tests were performed by the dynamic shear rheometer (DSR), the bending beam rheometer (BBR), and the GPC. The results indicated that the aging would increase the complex modules (G*), the creep stiffness (S), and the fatigue resistance index (Nf), but would decrease the phase angle (δ) and the m-value. In addition, the transformation from middle molecular size (MMS) to large molecular size (LMS) was found the most significant phenomenon during the aging process. Moreover, among all the molecular weight distribution indexes, the polydispersity index (PDI) was found having the best correlation with rheological properties of asphalt during the aging process.

Key words: asphalt short-term aging; rheological properties; gel permeation chromatography; principal component analysis

Model Analysis of Precipitation Rate of Active Ingredients in Self-Melting Snow Salinized Particles

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Abstract: According to the particle composition of the salinized material of the self-melting snow pavement, a spatial three-dimensional model was established, the precipitation process of the effective constituents of the particles of the salinized material was numerically simulated, and the influence of the material properties of the active ingredients on the diffusion rate was analysed. The equation of relationship between the precipitation rate of the active ingredients and the amount of each component is obtained by regression of the existing data, and use the existing data to verify the accuracy of the equation. The results are of great significance for the composition design of the self-melting snow salinized material, which makes the mixture of salt particles in the micro-forms have good snow melting effect, and provide experimental basis for the promotion and application of salt particles.

Key words: self-melting snow pavement; salinized particles; numerical model; regression analysis; engineering verification

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玄武岩纤维沥青混合料水损伤衰变规律分析

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摘 要：为分析高温—水浴耦合作用下，玄武岩纤维对沥青混合料抗车辙形变能力和抗水损伤衰变性能的影响。采用 PMW 汉堡车辙试验，改变水浴温度和车轮行驶速度等试验条件对掺加和不掺玄武岩纤维的沥青混合料板块试件在浸水环境下的水稳定性和抗车辙性能进行评价。试验结果表明，玄武岩纤维可以提高沥青混合料在高温—水浴耦合作用下的水稳定性能和抗车辙性能。通过灵敏度分析得到随着水浴温度的波动，玄武岩纤维沥青混合料的抗车辙变形能力衰减最大。

关键词：玄武岩纤维沥青混合料；试验条件；汉堡车辙试验；水损伤

Analysis the Decay Principle During Water Damage Process of Basalt Fibre Asphalt Mixture

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Abstract:

In order to analyse the influence of the high temperature-water bath coupling effect of basalt fibre on the anti-rutting deformation ability of asphalt mixture and the decay performance of water damage. Adopt PMW Hamburg Wheel-track Device Test to change the test conditions of water bath temperature and wheel speed to evaluate the water stability and rutting performance of asphalt mixture plates with adding and without basalt fibre in a submerged environment. Test results show that basalt fibre can improve the water stability and rutting performance of asphalt mixture under high temperature-water bath coupling. The anti-rutting deformation ability of basalt fibre asphalt mixture is the most attenuated with the fluctuation of water bath temperature by sensitivity analysis.

keywords: basalt fibre asphalt mixture; test condition; hamburg wheel-track device test; water damage

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路用热阻集料表面处理优化研究

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摘 要：为提高热阻集料在沥青混合料中的适用性，优选了有机硅树脂和硅丙乳液两种处理剂，系统研究了页岩陶粒、多孔火山岩和耐火碎石三种常用热阻集料的表面处理工艺。全面评价了表面处理后热阻集料的基本性能，确定了两种处理剂处理不同集料的最佳工艺；基于电镜扫描试验，对比分析了热阻集料表面封装效果；系统研究了表面处理后热阻集料路用性能，确定了不同热阻集料的最佳表面处理剂。研究结果表明：有机硅树脂处理页岩陶粒、多孔火山岩和耐火碎石的最佳浓度分别为 25%、25%和 15 %；硅丙乳液处理以上三种集料的最佳浓度分别为 35%、25%和 15%，助剂含量为 3%，成膜温度为 30 ℃；其中有机硅树脂处理的三种热阻集料表面封装效果较好，而硅丙乳液处理的热阻集料表面可观察到明显孔隙；两种处理剂均能不同程度提高热阻集料的路用性能；推荐使用有机硅树脂处理页岩陶粒和多孔火山岩，使用硅丙乳液处理耐火碎石。

关键词：道路材料；有机处理剂；热阻集料；表面处理；性能评价

Surface Treatment Optimization of Thermal-Resistant Aggregate for Road Pavement

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Abstract:

To render thermal-resistant aggregates more suitable in asphalt mixtures, the optimal process for treating three typical thermal-resistant aggregates, shale ceramsite (SC), porous volcanic rock (PVR), and refractory gravel (RG), with two organic treatment agents, silicone resin (SR) and silicone–acrylic (SA) emulsion, was determined according to the basic properties test. Further, the best agent for different aggregates was recommended according to a scanning electron microscopy and road performance. The results indicate that the optimum concentrations of SR for SC, PVR, and RG are 25%, 25%, and 15%, respectively, while the optimum concentrations of the SA are 35%, 25%, and 15%, respectively, the additive content is 3%, and the film formation temperature is 30 °C. Furthermore, the surface package effect of SR–treated aggregates is better than that of the SA–treated aggregates. Both agents can improve the road performance of thermal-resistant aggregates. Finally, it is recommended to use SR to treat SCs and PVRs, and to treat RGs with an SA emulsion.

keywords: road material; organic treatment agent; thermal-resistant aggregate; surface treat; performance evaluation

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应力控制模式下沥青混合料疲劳损伤力学性能研究

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摘 要：为提高沥青混合料在不同的交通环境条件下的疲劳性能，研究以 SMA-13、Sup-20 和 Sup-25 三种不同级配沥青混合料为试验对象，分别添加不同种类的沥青和纤维，制备成七种不同类型沥青混合料车辙模板。在 0.7、1.0 和 1.5 的应力比下对不同沥青混合料小梁进行四点弯曲疲劳试验，在试验结果基础上对七种不同沥青混合料的劲度模量和累积耗散能进行全面分析，并将沥青混合料的应力水平和对应的疲劳寿命建立双对数坐标的疲劳曲线。结果表明：在同种类型沥青混合料条件下，应力水平越小，试件的耗散能疲劳曲线斜率越小，而累积耗散能越大；在 3 个应力水平循环荷载作用下的弯劲度模量的变化都可以分成三阶段；另外，在双对数坐标下沥青混合料的疲劳寿命与应力水平存在很好的线性关系。

关键词：沥青混合料；疲劳性能；四点弯曲小梁试验；玄武岩纤维；应力控制模式

Research on Mechanical Properties of Asphalt Mixture Fatigue Damage Under Stress Control Mode

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Abstract:

In order to improve the fatigue performance of asphalt mixture under different traffic conditions,The study useed SMA-13, Sup-20 and Sup-25 three different grades of asphalt mixture as test objects, and different types of asphalt and fiber were added to prepare seven different types of asphalt mixture rutting templates. Four-point bending fatigue test on different asphalt mixture girders at stress ratios of 0.7, 1.0 and 1.5, based on the test results, a comprehensive analysis of the stiffness modulus and cumulative dissipation energy of seven different asphalt mixtures was carried out. Then, the fatigue curve of the double logarithmic coordinates is established by the stress level of the asphalt mixture and the corresponding fatigue life. It was turned out that under the same type of asphalt mixture, the smaller the stress level, the smaller the slope of the fatigue curve of the dissipative energy of the test piece, and the greater the cumulative dissipation energy;the change of the bending stiffness modulus under the cyclic stress of three stress levels can be divided into three stages; and there is a good linear relationship between fatigue life and stress level of asphalt mixture under double logarithmic coordinates.

keywords: asphalt mixture; fatigue performance; four-point bending beam test; basalt fiber; stress control mode

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基于幂律方程的多聚磷酸（PPA）改性沥青蠕变特性分析

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摘 要：多聚磷酸（Polyphosphoric Acid，PPA）改性沥青具有优异的高温性能和储存稳定性，被越来越广泛地用作路面胶结材料。为探究 PPA 改性沥青的蠕变特性，制备了 3 种不同 PPA 掺量的改性沥青，并测试、分析了其基本物理性能；在 3 个温度水平下进行了恒应力蠕变-恢复试验，并基于幂律方程对其蠕变阶段进行了分析。结果表明：PPA 能够显著改善沥青的高温性能，但对低温变形能力存在不利影响；幂律方程 ε(t)=〖σ_0〗^m•t^n 能够较为准确地表征 PPA 改性沥青的蠕变行为，模型参数与温度和 PPA 掺量之间分别存在稳定的正相关关系和负相关关系，其中，n 几乎不随应力水平的改变而变化；温度升高和 PPA 掺量的增加对沥青蠕变行为具有相反的作用效果，可以通过增加 PPA 掺量来改善沥青的高温抗变形性能。

关键词：多聚磷酸（PPA）改性沥青；蠕变特性；幂律方程；高温性能

Creep Characteristics Analysis of Polyphosphoric Acid (PPA) Modified Asphalt Based on Power Law Equation

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Abstract:

Polyphosphoric acid (PPA) modified asphalt is widely used as pavement material due to its excellent high temperature performance and storage stability. To analyze the creep properties of PPA modified asphalt, three kinds of modified asphalts with different PPA content were prepared, and the basic physical properties were tested and analyzed. The constant stress creep-recovery test was carried out at three temperature levels, and the creep stage was analyzed based on the power law equation. The results show that PPA can significantly improve the high temperature performance of asphalt, but it has a negative impact on the low temperature deformation capacity. The power law equation, ε(t)=〖σ_0〗^m·t^n can accurately characterize the creep behavior of PPA modified asphalt. The model parameters exhibit a stable positive and a negative correlation with temperature and PPA content respectively, and n is almost unaffected by force level; The addition of PPA can weaken the adverse effect of temperature rise on the creep behavior, thus improving the high temperature deformation resistance of asphalt.

keywords: polyphosphoric acid (ppa) modified asphalt; creep characteristics; power law equation; high-temperature performance

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沥青再生过程中新旧混合沥青力学性能研究

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摘 要：随着我国的公路建设事业进入建养并重阶段，热再生技术作为一种重要的沥青路面养护技术受到工程界广泛关注。本文通过实验方法测试了沥青路面再生过程中新旧沥青融合后的混合沥青的高温粘度和服役温度区间内的粘弹性指标，并对实验结果进行数值拟合，得到混合沥青高温粘度的预测方程，可以指导再生沥青混合料的配合比设计及工程应用，从而完善沥青路面热再生技术体系。

关键词：道路工程；沥青；再生；粘度；剪切模量

Study on Mechanical Properties of Mixed Asphalt for Recycled Asphalt Pavement

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(Chongqing Jiaotong University)

Abstract:

Recycling asphalt pavement is an important maintenance technology of asphalt pavement that has been widely concerned by the engineers. In this study, the high temperature viscosity of mixed asphalt prepared by aged and virgin asphalts were tested by experimental method, and the results were numerically fitted to obtain the prediction equation of the high temperature viscosities of the mixed asphalt. The equation can guide the mix design and engineering application of the recycled asphalt pavement.

keywords: pavement engineering; asphalt; recycling technology; viscosity; shear modulus

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基于粒料表面处理的彩色防滑路面耐久性研究

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摘 要：为提高彩色防滑路面中粒料的基本性能，进而增强彩色防滑路面的耐久性，采用有机硅树脂对防滑粒料进行表面处理，对比分析了处理前后粒料的基本性能，从耐磨耗性及色彩耐久性两个方面提出了不同工况条件下彩色防滑路面材料耐久性评价指标及方法，对比分析了不同工况下经有机硅树脂处理过和未处理的彩色防滑路面的耐久性。研究结果表明：经有机硅树脂处理后，防滑粒料的吸水率、磨耗值、压碎值、磨耗脱落质量等各项基本性能分别提高了 54%、29%、44%、34%；经有机硅树脂处理后的试件，在磨耗前期，最大磨耗脱落质量损失率、摆值衰减率、构造深度衰减率分别为 37%、9.5%、14.0%，未处理试件的三个指标分别为 39%、11.4%、15.5%，两种试件磨耗后粘结强度分别下降了 0.08 MPa、0.12 MPa；基于汽油腐蚀单一工况及高温汽油腐蚀复合工况条件下，经处理试件的色彩鲜艳度系数分别下降了 2.81%、3.30%，未处理试件的色彩鲜艳度系数分别下降了 3.30%、5.54%；基于紫外线辐射单一工况及高温紫外辐射复合工况条件下，经处理试件的色彩鲜艳度系数衰变率分别为为 0.34%、1.21%，未处理试件的色彩鲜艳度衰减速率分别为 0.48%、8.52%。

关键词：彩色防滑路面；粒料；表面处理；耐久性

Durability of Color Anti-Skid Pavement Based on Granular Surface Treatment

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(Chang'an University)

Abstract:

In order to improve the basic performance of particles in color anti-skid pavement, and enhance the durability of color anti-skid pavement. The silicone resin was used to treat the surface of anti-skid particles. The basic properties of the particles before and after treatment were compared and analyzed. The durability evaluation indexes and methods of color anti-skid pavement under different working conditions were put forward from two aspects of abrasion resistance and color durability. The durability of treated and untreated color anti-skid pavements with silicone resin under different working conditions were compared and analyzed. The results show that the water absorption, weared stone value, crushed stone value, and mass abrasion shedding rate of the anti-skid particles are increased by 54%, 29%, 44%, and 34%, respectively, after treatment with silicone resin. In the early stage of abrasion test, for the specimens treated with silicone resin, the maximum abrasion mass loss rate, the maximum British pendulum number attenuation rate and the maximum texture depth attenuation rate are 37%, 9.5%, and 14%, respectively. While the 3 indexes of untreated specimens are 39%, 11.4%, and 15.5%, respectively. After abrasion, the bonds strength of the two specimens decrease by 0.08 MPa and 0.12 MPa, respectively. Based on two working conditions of gasoline corrosion and combined high-temperature gasoline corrosion, the color brightness coefficients of treated specimens decrease by 2.81% and 3.30%, respectively, and that of untreated

specimens decrease by 3.30% and 5.54%, respectively. Based on two working conditions of ultraviolet radiation and the combined high temperature and ultraviolet radiation, the color brightness coefficient attenuation rates of treated specimens are 0.34% and 1.21%, respectively. And those of untreated specimens are 0.48% and 8.52%, respectively.
keywords: color anti-skid pavement; anti-skid particles; surface treatment; durability

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原材料对沥青混合料抗疲劳性能影响的试验研究

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摘 要：原材料的性能及组成是影响沥青混合料抗疲劳性能的主要因素之一。本次研究将从有无抗车辙剂、沥青种类与集料的最大公称粒径三个方面研究它们对沥青混合料抗疲劳性能的影响。在间接拉伸疲劳试验中，采用控制变量的方法，通过对比，确定上述三种因素各自对沥青混合料抗疲劳性能的影响。试验结果表明：在较小应力水平下，添加抗车辙剂可以提升沥青混合料的劈裂强度并相应的降低劈裂强度所对应的位移值，抗车辙剂可以有效的增强沥青混合料的抗疲劳性能；改性沥青混合料具有较高的强度同时具有良好的形变能力，改性沥青混合料的抗疲劳性能优于基质沥青；最大公称粒径对沥青混合料抗疲劳性能的影响则需要具体考虑应力环境水平进行评估。

关键词：沥青混合料；疲劳性能；抗车辙剂；改性沥青；公称粒径

Experimental Study on Influence of Raw Material to the Fatigue Performance of Asphalt Mixture

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Abstract:

The performance and composition of raw materials are one of the main factors affecting the fatigue performance of asphalt mixtures. In this study, the fatigue performance of asphalt mixture was studied from three aspects: whether anti-rutting agent exists, asphalt type and maximum nominal size of aggregate. In the indirect tensile fatigue test, the method of controlling variables is used to determine the influence of the above three factors on the fatigue performance of asphalt mixture through comparison. The test results show that, the addition of anti-rutting agent can improve the splitting strength of asphalt mixture and reduce the displacement corresponding to the splitting strength at a lower stress level, and the anti-rutting agent can effectively enhance the fatigue performance of asphalt mixture; the modified asphalt mixture has high strength and good deformation capacity, and the fatigue performance of modified asphalt mixture is better than that of base asphalt mixture. The influence of maximum nominal particle size on fatigue performance of asphalt mixture needs to be assessed with specific consideration of stress environment level.

keywords: asphalt mixture; fatigue performance; anti-rutting agent; modified asphalt; nominal particle size

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钢桥面铺装增强型浇筑式沥青混合料性能研究

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摘 要：结合港珠澳大桥钢桥面铺装实体工程，本文首先对浇筑式沥青混合料的配合比进行设计，然后对比浇筑式沥青混合料，对格栅增强浇筑式沥青混合料、组合结构（38 mmSBS 改性沥青 SMA+30mmGMA）的高温抗车辙、弯曲抗裂、抗剪及疲劳性能进行评价。结果表明：GMA10 浇筑式沥青最佳拌和温度为 210~230℃；格栅能够增强浇筑式沥青混合料高温抗车辙性能，玻纤格栅增强效果比碳纤维格栅要好；增加 SMA 沥青混合料上面层的组合结构，整体的高温性能良好，格栅进一步增强其抗变形能力；玻纤格栅沥青混合料的抗拉强度随温度的增而急剧减小，弯拉应变快速增加，在 50℃高温下仍具有较好的抗裂性能；纤格玻栅增强混合料间的抗剪效果在中低温环境下不明显，在高温下添加玻纤格栅的强度比不加格栅的浇筑式沥青混合料试件增加了 25%左右，添加玻纤格栅的试件疲劳寿命高于不加格栅的，但不如 SBS 改性 SMA13 的。

关键词：浇注式沥青混合料

Study on Performance of Reinforced Casting Asphalt Mixture for Steel Bridge Deck Pavement

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Abstract:

Combining with the steel bridge deck pavement solid project of hong kong-zhuhai-macao bridge, this paper first designs the mix proportion of pouring asphalt mixture, and then compares the pouring asphalt mixture to evaluate the high temperature rutting resistance, bending crack resistance, shear resistance and fatigue resistance of grille reinforced pouring asphalt mixture and composite structure (38 mm SBS modified asphalt SMA + 30 mm GMA). The results show that the optimum mixing temperature of GM a10 pouring asphalt is 210 ~ 230 ℃; The grid can enhance the high temperature rutting resistance of the pouring asphalt mixture, and the glass fiber grid has better reinforcing effect than the carbon fiber grid. Increasing the composite structure of the upper layer of SMA asphalt mixture has good overall high temperature performance, and the grille further enhances its deformation resistance. The tensile strength of glass fiber grid asphalt mixture decreases sharply with the increase of temperature, the flexural tensile strain increases rapidly, and it still has good crack resistance at 50 ℃ high temperature. The shear resistance between glass fiber grating reinforced mixtures is not obvious in the medium and low temperature environment. the strength of the specimens with glass fiber grating added at high temperature is about 25 % higher than that of the specimens with pouring asphalt mixture without grating. the fatigue life of the specimens with glass fiber grating added is higher than that without grating, but sm a13 is not modified by SBS.

keywords: pouring asphalt mixture

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Application of Compressible Packing Model for Optimization of Large Stone Porous Asphalt Mixes Gradation

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Abstract:The gradation is a key factor affecting the performance of asphalt mixtures. The design requirements vary with different climates and traffic conditions. The optimization design of the Large Stone Porous asphalt Mixes (LSPM) gradation is carried out using the Compressible Packing Model(CPM) to improve the performance in this paper. The virtual packing density is used to characterize the compactness of particles in the CPM system, and the CPM can realize the packing state of particles by comparing the laboratory test and theoretical calculation. Furthermore, the gradation of LSPM was determined by the combination analysis of particles in multi-component system. The dynamic stability, freeze-thaw splitting strength ratio, low temperature strength and fatigue life were tested to characterize and analyze the performance of LSPM in laboratory, and the results were compared with that of existing gradation to verify the superiority of the proposed gradation. Results showed that CPM model can better simulate the packing state of particles, and a new gradation curves were proposed by the virtual packing of multi-component particles. Laboratory tests results also depicted the designed mixture could meet the performance requirements of LSPM mixture, and the fatigue performance of the mixture has been improved significantly.

Key words: compressible packing model, large stone porous asphalt mixes, gradation design, packing density, performance

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基于分子动力学模拟的 SDBS 及其异构体/集料表面体系传质的影响

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摘 要：采用分子动力学模拟方法研究了阴离子表面活性剂十二烷基苯磺酸钠（SDBS）及其 4 种异构体在集料主要化学成分 CaCO3 固体表面的吸附并观察其固液界面的吸附过程。模拟发现十二烷基苯磺酸钠及其异构体能在短时间内吸附到 CaCO3 表面，并在吸附过程中逐渐形成聚集结构；计算得到的界面相互作用能表明在 CaCO3 表面的吸附性能和聚集程度与乳化剂分子的支化度及空间位阻有关;乳化剂中亲油基与亲水基均对其在溶液中的扩散起促进作用。模拟表明，分子动力学模拟方法可以作为实验的一种补充，为实验提供必要的微观信息及理论依据。

关键词：固-液界面；阴离子乳化剂；分子动力学模拟

Molecular Dynamics Simulation to Investigate the Influence on the Mass Transfer of SDBS and Its Isomer/ Aggregate Surface System

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Abstract:
The adsorption of anionic surfactant sodium dodecyl benzene sulfonate (SDBS) and its four isomers on the solid surface of CaCO3, the main chemical component of aggregates, was studied by molecular dynamics method. process. It was found that sodium dodecylbenzene sulfonate and its isomers can adsorb to the surface of CaCO3 in a short time and gradually form an aggregate structure during the adsorption process. The calculated interfacial interaction energy indicates the adsorption performance and aggregation on the surface of CaCO3. The degree is related to the degree of branching and steric hindrance of the emulsifier molecule; both the lipophilic group and the hydrophilic group in the system promote the diffusion of the emulsifier in the solution. The simulation shows that the molecular dynamics simulation method can be used as a supplement to the experiment, providing the necessary micro information and theoretical basis for the experiment.
keywords: solid-liquid interface; anionic emulsifier; molecular dynamics simulation

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改性沥青疲劳破坏判定指标适用性研究

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摘 要：为研究不同种类改性沥青的疲劳破坏演化规律和疲劳失效指标的适用性，采用动态剪切流变仪(DSR),在应力/应变两种控制模式下对90#基质沥青(OB)、SBS改性沥青(SBS)、岩沥青改性沥青（RA)、胶粉改性沥青（CR)、岩沥青/SBS复合改性沥青（RA/SBS）和岩沥青/胶粉复合改性沥青（RA/CR）进行了时间扫描疲劳试验，确定了5种不同疲劳失效定义方式下的疲劳寿命（Nf50、Nfm、Nδ、NR和Np20)，并将统计学分析方法应用于疲劳寿命的适用性评价。研究结果表明：Nf50不受荷载控制模式和沥青种类的影响；Nfm仅适用于应力控制模式的疲劳寿命判断；Nδ和Np20受沥青种类和荷载控制模式影响显著，且不具备普适性；NR受沥青种类影响较小，在忽略荷载控制和应变控制模式下，对本研究所有试验沥青具有较好的疲劳寿命评价效果。统计分析结果进一步表明，应力/应变控制模式下的Nf50和NR具有等效的试验沥青疲劳寿命排序结果，由于其计算简单、定义明确，因此推荐作为时间扫描疲劳试验中检测沥青疲劳失效的判定标准。采用Nf50和NR对本研究所有试验沥青的疲劳寿命进行排序，得到添加2%SBS和5%岩沥青的RA/SBS是应力控制模式下的最佳掺配，添加18%胶粉和5%岩沥青的CR/RA是应变控制模式下的最佳掺配。

关键词：道路工程；DSR；岩沥青复合改性沥青；疲劳性能；加载模式

Research on the Applicability of Fatigue Damage Criterion of Modified Asphalt

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Abstract:

In order to investigate the fatigue failure evolution and the suitability of fatigue failure criteria of different modified asphalts, Dynamic Shear Rheometer is used to conduct the time scanning fatigue test on 90# base asphalt (OB), SBS modified asphalt (SBS), rock asphalt modified asphalt (RA), crumb rubber modified asphalt (CR), rock asphalt/SBS composite modified asphalt (RA/SBS) and rock asphalt/crumb rubber composite modified asphalt (RA/CR) under controlled-stress and controlled-strain modes. The corresponding fatigue life was determined according to 5 fatigue failure definitions, and the statistical analysis method is applied to evaluate the suitability of fatigue life indexes. The research results show that Nf50 is not affected by load control modes and asphalt types, Nfm is only suitable for fatigue life judgment of stress control mode, Nδ and Np20 are significantly affected by asphalt types and load control modes, and are not universal. NR is less affected by the types of asphalt, and it exhibits a preferable fatigue life evaluation effect ignoring the load and strain control modes. The statistical analysis results indicate that Nf50 and NR have equivalent fatigue life ranking results under the stress/strain control mode. Besides, because of its simple calculation and distinct definition, it is recommended to be used as the determination standard for testing asphalt fatigue failure in time scanning fatigue test. According to the fatigue

failure criteria Nf50 and NR, the fatigue life of all asphalts tested in this study was ranked. It was found that RA/SBS with 2%SBS and 5% rock asphalt performed the best fatigue resistance under the stress control mode, and CR/RA with 18% rubber powder and 5% rock asphalt performed the best fatigue resistance under the strain control mode.
keywords: road engineering; dynamic shear rheometer; rock asphalt composite modified asphalt; fatigue performance; loading mode

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Microscopic Analysis of Asphalt Mixture Uniaxial Penetration Test Based on the Discrete Element Method

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Abstract: In order to study the shear strength of asphalt mixture from the mesoscopic aspect and reveal the rutting mechanism of asphalt pavement, the study investigated the effects of different working conditions and rutting depth on shear strength of asphalt mixture based on laboratory tests and discrete element method. The uniaxial penetration test piece was reconstructed by PFC2D longitudinal profile image based on the asphalt mixture core sample and the uniaxial penetration virtual test was carried out. According to the analysis of the internal state of mesoscopic mechanics of asphalt mixture, it is shown that the distribution of the tensile and compressive stress within the specimen, property and morphological character of coarse aggregates, adhesion property of asphalt and aggregate are the influence factors of shear performance of asphalt mixture. With the increase of rutting depth, the displacement angle of coarse particles under load is gradually reduced, and the internal structure tends to be stable, resulting in the increase of shear strength at the rutting slot due to the increase of compaction degree of asphalt mixture at the rutting slot.

Key words: asphalt mixture; mesoscopic behavior; uniaxial penetration test; discrete element method

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Improved Methodology for Identifying Prony Series Coefficients Based on Continuous Relaxation Spectrum Method

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Abstract: The Prony series models have been widely utilized in characterizing the linear viscoelastic (LVE) properties of asphalt mixtures. However, as a crucial step in identifying the coefficients in Prony series, the determination of the time coefficients is based on empirical adjustments and time-consuming selections and lacks an effective unified method. In order to overcome the drawbacks of existing methods, this study proposed a method for determining the optimal relaxation time range (ORTR) based on the continuous relaxation spectrum method, which was then utilized to identify Prony series coefficients. There are four consecutive steps in the procedure: (1) establishing the continuous relaxation spectrum by applying the inverse Stieltjes transform to the storage modulus model, (2) setting trial groups of the relaxation time range on the basis of the relaxation time corresponding to the peak value of the continuous relaxation spectrum, (3) identifying the ORTR through the comparison of the characteristic numbers of terms of the trial groups, (4) determining the coefficients in Prony series based on the relationship between the relaxation strength and the relaxation time. The method was validated by using complex modulus data of two types of asphalt mixtures at four test temperatures and six test frequencies. The results show that: (1) the center of the ORTR was near the relaxation time corresponding to the peak point of the continuous relaxation spectrum; (2) the total numbers of terms in the Prony series models developed from the optimal relaxation distribution were less than 35 and the model errors were less than 3.18%.

Key words: Prony series; optimal relaxation time range; asphalt mixture; complex modulus; relaxation spectrum

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不同官能团对 SBS 改性沥青蠕变特性的影响

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摘 要：文章选择较为常见的羟基（-OH）和氨基（-NH2），以 HPT、EBS、HPT-R 为试验材料，与 SBS 复合进行改性，利用动态剪切流变仪（DSR），借助多应力重复蠕变恢复试验（MSCR）和温度扫描试验，研究不同官能团对 SBS 改性沥青高温蠕变特性的影响；利用弯曲梁流变仪（BBR），借助低温弯曲流变试验，研究不同官能团对 SBS 改性沥青低温蠕变特性的影响。结论表明：在高温条件下，羟基与氨基共同存在时，在一定程度上对 SBS 改性沥青的抗变形能力有提高的作用，但改善效果并不明显；氨基和羟基单独作用时，对 SBS 改性沥青的抗变形能力影响较大，基于累计应变、R、Jnr 和δ，氨基均使得 SBS 改性沥青的高温抗变形能力较大程度地减弱。在低温条件下，氨基的存在使得 SBS 改性沥青的低温性能减弱，但减弱的程度很小，当羟基单独存在时，基于蠕变劲度 S、蠕变劲度变化率 m 及 m/S 比，使得 SBS 改性沥青的低温性能增强。

关键词：改性沥青；官能团；蠕变特性

Effect of Different Functional Groups on Creep Characteristics of SBS Modified Asphalt

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Abstract:

With selecting common hydroxyl (-OH) and amino (-NH2), HPT, EBS and HPT-R were used as test materials to modify with SBS. By dynamic shear rheometer (DSR) ,the Multiple Stress Creep Recovery Test (MSCR) and Temperature Scanning Test were carried out to study the effects of SBS modified asphalt with different functional groups on the high temperature creep properties. Using banding beam rheometer(BBR), low temperature bending rheological test was used to study the the effects of SBS modified asphalt with different functional groups on the low temperature creep properties. The results show that under high temperature conditions, the deformation resistance of SBS modified asphalt can be improved to a certen extent when the hydroxyl group and amino group co-exist, but the improvement effect is not obvious. Based on the cumulative strain, R, Jnr and δ, the amino group or the hydroxyl group makes the high-temperature anti-deformation ability of SBS modified asphalt greatly weakened. Under low temperature conditions, when the amino group exist, the low temperature performance of the SBS modified asphalt is weakened, but it’s not obvious. When the hydroxyl group exist alone, the low temperature performance of SBS modified asphalt enhanced based on the creep stiffness S and the rate of creep stiffness m and m/S ratio makes.

keywords: modified asphalt; functional groups; creep characteristics

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基于高温性能和数理统计方法的改性沥青适用性研究

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摘 要：为了寻求经济且环保的改性沥青结合料，以克服或减轻高温地区沥青路面的车辙病害，本文选用废胶粉（GTR），多聚磷酸（PPA）和 SBS 高聚物作为 SK90#基质沥青的改性剂，以广东某高速公路为依托工程，在充分考虑当地施工环境的前提下，基于室内试验对不同改性沥青结合料的高温性能进行研究，并基于数理统计方法和沥青结合料的性能对各改性沥青在不同老化状态和不同温度条件下进行分组，从而研究 GTR 改性沥青和 PPA 改性沥青在高温地区的适用性。研究结果表明，与基质沥青相比，SBS，GTR 和 PPA 三种改性剂对未老化和 RTFO 老化后的改性沥青高温性能均有显著影响；对于 PPA 改性沥青，相位角相对于温度呈线性趋势，而 SBS 和 GTR 沥青的相位角则表现出非线性趋势;掺加 0.7%PPA（1.2%PPA）和 3%SBS（5%SBS）的改性沥青可以在高温地区互换使用，PPA 和 SBS 对沥青结合料的流变性能的影响存在线性关系； SBS，GTR 和 PPA 三种改性剂的掺加对经 PAV 老化后的改性沥青在中温区间时（22℃~31℃）的抗车辙性能不会造成显著影响。

关键词：沥青路面；改性沥青；数理统计方法；高温性能；适用性

Study on the Applicability of Modified Asphalt Based on High-Temperature Properties and Mathematical Statistics Method

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Abstract:

In order to seek economical and environmentally friendly modified asphalt binders to overcome or mitigate the rutting and cracking of asphalt pavement, this paper selects waste rubber powder (GTR), polyphosphoric acid (PPA) and SBS polymer as SK90#. The modifier of matrix asphalt is based on a highway in Guangdong Province. Based on the consideration of the local construction environment, the high and low temperature performance of different modified asphalt binders is studied based on laboratory tests, and based on mathematical statistics and asphalt. The properties of the binder were grouped under different aging conditions and different temperature conditions to study the applicability of GTR modified asphalt and PPA modified asphalt in Hebei. The results show that compared with the matrix asphalt, the three modifiers SBS, GTR and PPA have significant effects on the high temperature properties of the modified asphalt with unaged and RTFO aging. For PPA modified asphalt, the phase Angle shows a linear trend relative to temperature, while the phase Angle of SBS and GTR asphalt shows a nonlinear trend. Modified asphalt mixed with 0.7% PPA (1.2% PPA) and 3% SBS (5% SBS) can be used interchangeably in high temperature areas. The effect of PPA and SBS on the rheological property of asphalt binder is linear. SBS, GTR and PPA mixed with three kinds of modified agent on the PAV modified asphalt after aging at medium temperature range (22℃ ~ 31℃) of anti-rutting performance does not have a significant impact.

keywords: asphalt pavement; modified asphalt; mathematical statistics method; high-temperature performance; applicability

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水性环氧树脂/聚氨酯/乳化沥青材料：制备和路用性能

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摘 要：为获得兼具高温高粘结强度、低温高柔韧性等优异性能的桥面铺装层间防水粘结材料，制备了可冷态便捷施工、常温快速固化的水性环氧树脂/聚氨酯/乳化沥青（WEPEA）；基于拉伸强度和断裂伸长率确定了 WEPEA 组成配比；基于高温粘结性能、低温柔韧性能、黏附性能、防水性能和耐老化性能试验系统测试了 WEPEA 路用性能，并与 SBS 改性沥青和胶粉改性沥青防水粘结材料各项性能进行对比分析；进一步的研究了 WEPEA 在不同温度下的黏度随时间变化规律；采用荧光显微镜揭示了 WEPEA 微观形貌，验证了各组分配伍性及稳定性。结果表明：水性聚氨酯能有效改善高掺量水性环氧树脂改性乳化沥青的柔韧性，水性环氧树脂/聚氨酯掺量分别为 50%和 30%的条件下，WEPEA 拉伸强度可达 1.6 MPa，断裂伸长率可达 150%；采用以上掺量作为基础配比，WEPEA 防水粘结料具有优异的高温粘结强度、低温抗裂和抗冲击性能、与集料的黏附性和水稳定性，且以上性能均明显优于 SBS 改性沥青和胶粉改性沥青；同时所制得的 WEPEA 各组分分散均匀，具有良好的配伍性和稳定性。

关键词：道路材料；改性乳化沥青；水性环氧树脂；水性聚氨酯；路用性能

Waterborne Epoxy Resin/Polyurethane/Emulsified Asphalt: Preparation and Road Performance

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Abstract:

To obtain a waterproof binding material for bridge decks with excellent properties of high bonding strength at high temperatures and high flexibility at low temperatures, a waterborne epoxy resin/ polyurethane/ emulsified asphalt (WEPEA) was prepared, which could be constructed in a cold state and cured rapidly at room temperature. The composition of WEPEA was determined based on the tensile strength and elongation at breaking. The road performance of WEPEA was systematically investigated based on its high-temperature bonding properties, low-temperature flexibility, adhesion, waterproofing performance, and aging resistance. In addition, the performance of WEPEA was compared with that of SBS-modified asphalt and rubber asphalt. The viscosity variation and micro-morphology of WEPEA were investigated, and the compatibility and stability of each component were verified. The results show that waterborne polyurethane can effectively improve the flexibility of emulsified asphalt with a high content of waterborne epoxy resin. WEPEA exhibited excellent bonding strength, crack resistance and anti-impact properties, adhesion to aggregates, and water stability. These properties of WEPEA were all superior to those of the SBS-modified asphalt and rubber asphalt.

keywords: road material; modified emulsified asphalt; waterborne epoxy resin; waterborne polyurethane; road performance

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高黏改性沥青流变性能研究

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摘 要：本研究以基质沥青、基于基质沥青制备的高黏改性沥青和成品高黏改性沥青为研究对象，通过动态剪切流变试验的温度扫描、频率扫描、MSCR 和弯曲梁蠕变试验，对比研究了不同沥青的流变性能。结果表明，高黏改性沥青具有较高的车辙因子，且成品高黏改性沥青的车辙因子最高；不同温度条件下沥青的复数模量主曲线形态相似，加载频率增大，复数模量增大，高频范围内，基质沥青与基于基质沥青制备的高黏改性沥青模量水平相似；多应力重复蠕变试验反映了沥青抵抗永久变形的能力，表明成品高黏改性沥青的抗永久变形能力最强；高黏改性沥青的低温流变性能明显高于基质沥青的，蠕变劲度、蠕变速率与温度条件呈指数关系。

关键词：道路工程；流变性能；高黏改性沥青

Study on Rheological Properties of High Viscosity Modified Asphalt

Yuan Dongdong, Jiang Wei, Xiao Jingjing, Ye Wanli, Shan Jinhuan
(Chang'an University)

Abstract:
In this study, base asphalt, high-viscosity modified asphalt based on base asphalt and finished high-viscosity modified asphalt were studied. Temperature scanning, frequency scanning, MSCR using dynamic shear rheometer and bending beam creep were tested. The rheological properties of different asphalts were tested and compared. The results show that the high-viscosity modified asphalt has higher rutting factor, and the finished high-viscosity modified asphalt has the highest rutting factor; the morphologies of complex modulus of the three modified asphalts are similar, and the complex modulus increases with the increase of loading frequency. In the high frequency range, the base asphalt is similar to the high viscosity modified asphalt modulus based on the base asphalt. The results of the multi-stress repeated creep tests can reflect the permanent anti-deformation ability of asphalts. The permanent anti-deformation ability of the finished high-viscosity modified asphalt is better than the others. The low-temperature rheological properties of the high-viscosity modified asphalt are significantly higher than that of the base asphalt, and the creep stiffness and creep rate are exponentially related to temperature conditions, respectively.
keywords: road engineering; rheological properties; high-viscosity modified asphalt

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废弃机油残留物对不同沥青物理化学和流变性能的影响分析

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摘 要：本文从物理化学和流变学角度探究了废弃机油残留物（WEOB）对不同沥青性能的影响。将WEOB按照沥青质量的2%、4%和6%分别掺加到两种不同沥青中。采用气相色谱质谱（GC-MS）分析了WEOB中的化学组分，通过傅里叶变换红外光谱（FTIR）对WEOB改性沥青的官能团进行研究，采用旋转粘度（RV）和动态剪切流变（DSR）试验对WEOB改性沥青的流变性能进行表征。试验结果表明：WEOB中含有芳香族溶剂，石蜡油和聚烯烃油，且具有和沥青相似的官能团。WEOB的添加较大程度降低了沥青的粘度和铺筑温度。但WEOB将会减弱沥青的抗车辙性能和抗开裂能力。

关键词：废弃机油残留物；改性沥青；化学组分；FTIR；流变性能

Effects of Waste Engine Oil Bottom on Physicochemical and Rheological Properties of Different Asphalts

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Abstract:

The objective of this research is to explore the influence of waste engine oil bottom(WEOB) on asphalt binders in term of physical、chemical and rheological properties. Two sources of asphalt were modified with WEOB at 2wt%、4wt% and 6wt% concentrations. Gas chromatography-mass spectrometry (GC–MS) was used to reveal the main chemical components of WEOB. Fourier transform infrared (FTIR) spectroscopy were used to investigate the changes in the functional groups of WEOB-modified asphalt. Rotational viscosity (RV) and dynamic shear rheometry (DSR) tests were used to characterize the rheological properties of WEOB-modified asphalt. Results indicate that WEOB mainly consists of aromatic solvents, paraffin oil, and polyolefin oil and has similar functional groups as asphalt. Meanwhile, WEOB significantly decrease the viscosity of binders and reduces construction temperatures. However, WEOB has a negative effect on rutting resistance performance of asphalt and fatigue behavior.

keywords: waste engine oil bottom; modified asphalt; chemical component; ftir; rheological properties

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Flame Resistance of Asphalt Mixtures with Flame Retardants Through a Comprehensive Testing Program

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Abstract: As more and longer tunnels are constructed, fire safety in tunnels has become a major issue in the world. The objective of this study is to investigate the flame resistance of warm mix asphalt mixtures with flame retardants through a comprehensive testing program. In this study, a compound flame retardant (FR) was added to the asphalt and warm-mix asphalt. The comprehensive testing program included the flash point test and oxygen index test of the asphalt binder, combustion test of loose and compacted mixtures, and cone calorimeter test of asphalt mixtures in order to understand the flame resistance of the asphalt and mixtures. The asphalt binder results indicate that FR has no significant effect on the flash point but has an obvious effect on the fire point, and FR asphalt requires the introduction of more oxygen because the FR prevents it from burning. During various combustion tests, the FR reduces the flame, lessens the smoke, and lowers the temperature but noticeably increases the burning time. The structural integrity of the burned FR mixture samples is preferable. The cone calorimeter test shows that the ignition time is extended, both the heat release and smoke for the FR mixtures are noticeably decreased; and the CO and CO^2 emissions are both reduced. This means FR mixtures have better flame resistance and will have less potential for environmental pollution. Moreover, the results also show that Sasobit has little effect on the flash point, fire point or oxygen index of the asphalt. It also has little effect on the burning time and the flame height of loose mixtures. Since Sasobit aids combustion, it decreases the maximum temperature and mass loss of the compacted mixtures during the firing process. It also shortens the ignition time, decreases the released heat, the total smoke, and the release of CO and CO^2. Thus, the flame resistance of warm mix asphalt with FR is the best due to the combined effect of the FR and Sasobit, which means that it is the most preferable for asphalt pavement in tunnels.

Key words: warm-mix asphalt; WMA; flame retardant; flame resistance; limiting oxygen index; burning time; heat release rate; smoke

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基于 CT 的盐-水条件下沥青混合料计算空隙率修正方法

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摘 要：为解决因盐-水与沥青 CT 值相近导致“容积效应”进而出现由阈值法求得沥青混合料空隙率准确度欠佳的问题，采用 CT 技术对经 0%，5%，10%，15%，20%，25%浓度氯盐溶液浸泡作用前后 AC-13 与 OGFC-13 马歇尔试件进行 CT 横断面扫描，在应用指针扫描和二维最大熵算法对 CT 图像进行处理的基础上，基于 sobel 边缘检测提出了“有效厚度”概念，对清水和氯盐浸泡条件下沥青混合料空隙率计算值分别进行修正及 t 检验。结果表明：该修正方法适用于不同类型沥青混合料，且得到的计算空隙率精度较高，可替代真实空隙率值；CT 差值与有效厚度呈 y=a*x^b 的关系，且拟合相关性高达 0.957。为今后采用 CT 研究不同浓度盐水浸泡后沥青混合料计算空隙率提供了较精确的方法，亦为盐蚀条件下沥青混合料耐久性评价及预估提供新思路。

关键词：道路工程；沥青混合料；盐分；CT；空隙率修正；边缘检测

Correction Method for Calculated Air Voids of Asphalt Mixture Based on CT Technology Under Salt-Water Condition Heating

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Abstract:

In order to solve the volume effect caused by the similarity of the salt-water and asphalt CT values, the problem of the accuracy of the void ratio of the asphalt mixture obtained by the threshold method is unsatisfactory. CT cross-section scanning of AC-13 and OGFC-13 Marshall specimens before and after soaking with 0%, 5%, 10%, 15%, 20%, 25% concentrated chloride solution by CT technique, using pointer scanning and based on the two-dimensional maximum entropy algorithm for processing CT images, the concept of effective thickness was proposed based on sobel edge detection. The calculated void fractions of asphalt mixture under water and chloride salt immersion conditions were corrected and t test. The results show that this correction method is suitable for different types of asphalt mixture, and the calculated air voids accuracy is higher after correction. It can be considered as a substitute for the true air voids value after t test. The relationship between the CT difference and the effective thickness is y=a*x^b, and its fitting correlation is as high as 0.957. In order to calculate the air voids of asphalt mixture after soaking with different concentrations of salt water in the future, it provides a more accurate method, and provides a new idea for the durability evaluation and estimation of asphalt mixture under salt erosion conditions.

keywords: oad engineering; asphalt mixture; salt; CT; air voids correction; edge detection

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基于乳化沥青残留物胶浆路用性能的填料性质评价

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摘 要：为了研究矿物填料各项理化指标对乳化沥青残留物胶浆路用性能影响的特点及与流变指标的关联度，本文对粉胶比为 1.0 条件下的六种类型乳化沥青残留物胶浆利用动态剪切流变仪、弯曲梁流变仪以及压力老化仪，通过多应力重复蠕变试验、弯曲梁流变试验以及疲劳加载评价其高低温及疲劳性能，并对表征路用性能的流变指标与矿粉理化指标进行灰色关联分析。结果表明：不同类型的残留物胶浆的平均变形恢复率均表现出较高的应力敏感性，而不可恢复蠕变柔量的应力敏感性在不同类型残留物胶浆之间差别较大；矿粉的密度、亲水系数以及表征较小粒径指标（P20、D10）与残留物胶浆路用性能有着较高的关联度，在工程实践中建议上述指标作为乳化沥青混合料所用矿粉质量控制指标。

关键词：乳化沥青残留物胶浆；理化指标；流变指标；灰色关联分析

Evaluation of Mineral Fillers Properties Based on the Pavement Performance of Emusified Residues

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Abstract:

In order to study the effect of the physical-chemical indexes of mineral powder on the performance of emulsified bituminous residue mortar and the correlation between the physical-chemical indexes of mineral powder and rheological indexes, In this paper, the high and low temperature properties, fatigue performance of the six types of emulsified residues mortar with the ratio of filler bitumen at 1.0 was studied through MSCR, fatigue test, BBR test in DSR and BBR. The rheological indexes of road performance and the physical-chemical indexes of mineral powder was analyzed by using grey relational analysis method. The experiment results show that: the Rdiff among different types of emulsified bituminous residue appears to be more higher, while the difference of the Jnr-diff in those emulsified bituminous residue is obvious. The density, hydrophilic coefficient and small particle size indexes (P20、D10) shows a higher degree of association with the road performance of emulsified bituminous residue, The above indexes is advised as the key indicators to control the quality of mineral powder used for emulsified asphalt mixture in engineering practice.

keywords: emulsified bituminous residue mortar; the physical-chemical indexes; rheological indexes; grey relational analysis

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基于抗车辙性能提升的复合高模量沥青混合料研究

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摘 要：为提高高速公路沥青路面抗车辙性能，采用复合型硬质沥青添加剂和级配设 HEME-14,对比分析了该复合高模量沥青混合料EME-14和普通高模量沥青混合料EME-14、SUP-20、改性AC-20沥青混合料的高低温性能的差异，并运用动态模量主曲线进行预测分析。研究结果表明:采用复合型硬质沥青添加剂制备的复合高模量沥青混合料EME-14动稳定度达11059次/mm,约是普通高模量沥青混合料EME-14动稳定度的1.4倍、SUP-20动稳定度的1.6倍、改性AC-20动稳定度的1.8倍；主线模拟结果显示，相比普通EME-14和改性AC-20，复合EME-14在高温下具有更好的高温稳定性。

关键词：沥青混合料；高模量；复合型添加剂；高温稳定性；动态模量

Study on Performance of High Modulus Asphalt Mixture with Improvement of Rutting Resistance

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（江苏中路工程技术研究有限公司）

Abstract:

In order to improve the rutting resistance of expressway asphalt pavement, the hard asphalt additive compound was used to prepare the high modulus asphalt mixture EME-14 Through the rutting test and dynamic modulus test at different temperature, the high and low temperature properties of the EME-14 and common high modulus asphalt mixtures EME-14, SUP-20 and SBS modified AC-20 asphalt mixtures were compared and analyzed. The predictive analysis was carried out by using the dynamic modulus main curves. The results showed that the dynamic stability of high modulus asphalt mixture EME-14 prepared by hard pitch additive compound was 11059times/mm, which was about 1.4 times of EME-14 dynamic stability of common high modulus asphalt mixture, 1.6 times of SUP-20 dynamic stability, and 1.8 times of modified AC-20. Compared with traditional middle-layer asphalt mixture, it has excellent rutting resistance performance at high temperatures.

keywords: asphalt mixture; high modulus; compound additive; thermal stability; dynamic modulus

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高性能超薄铺装沥青混合料设计和性能研究

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摘 要：为减少高速公路车辙和裂缝路段的养护铣刨深度同时提高养护加铺层的使用寿命，设计和研究了一种高性能超薄铺装沥青混合料 U-PAVE10。通过采用 P 类型低熔点聚烯烃和 SBS 复合改性技术制备具有 135℃黏度低、60℃黏度高、弹性恢复性能好的复合改性沥青，采用动稳定度试验和不同温度下的动态模量试验研究了该沥青混合料的路用性能，并运用动态模量主曲线进行预测分析。结果表明：采用复合改性技术制备的沥青制备的超薄沥青混合料动稳定度超过 10000 次/mm，分别是 SMA-13 和改性 AC-13 混合料动稳定度的 1.6 倍和 1.9 倍；相比 SMA-13 沥青混合料具有低温模量更低、高温模量更高的特点，具有更好的低温下抗裂、高温下抗车辙的综合路用性能。

关键词：改性沥青混合料；超薄铺装；低熔点聚烯烃改性剂；高温稳定性

Study on Design and Performance of High Performance Ultra-Thin Paving Asphalt Mixture

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（江苏中路工程技术研究有限公司）

Abstract:

In order to reduce the maintenance milling depth of expressway section with rutting and crack and improve the service life of the maintenance overlay, a high performance ultrathin paving asphalt mixture U-PAVE10 was studied. By using P-type low melting point polyolefin and SBS compound modification technology, the composite modified asphalt was prepared, which had lower viscosity at 135℃, higher viscosity at 60℃ and good elasticity recovery performance. The road performances of the ultra-thin asphalt mixture were studied by dynamic stability test and dynamical modulus test at different temperatures. The high and low temperature properties of the ultra-thin asphalt mixture were prognosticated and analyzed with the dynamic modulus main curves. The results showed that, the dynamic stability of ultra-thin asphalt mixture prepared by composite modified asphalt was more than 10000 times/mm, which was 1.6 times of SMA-13 mixture and 1.9 times of AC-13 mixture. Compared with SMA-13 modified asphalt mixture, the ultra-thin asphalt mixture had the characteristics of lower modulus under low-temperature, higher modulus under high temperature, good performance in crack resistance under low-temperature and rutting resistance under high temperature.

keywords: modified asphalt; ultrathin paving ,low melting point polyolefin modifier; high temperature stability

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PPA/SBR 复合改性沥青紫外老化性能研究

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摘 要：为了研究紫外老化对 PPA/SBR 复合改性沥青的性能影响，首先采用动态剪切流变试验对沥青不同老化程度的流变性能进行分析，其次通过四组分与红外光谱试验得出紫外老化前后沥青组分变化与特征峰官能团结构指数，运用各组分胶体指数差值与官能团结构指数分析各组沥青紫外老化速率与机理。结果表明：PPA 的添加有效改善了沥青的高温流变性能；相比于基质沥青与 PPA、SBR 改性沥青，复合改性沥青的流变性能、组分转化和特征官能团的变化受紫外老化影响较小，经过室内模拟紫外老化，PPA 改性沥青的抗车辙因子、相位角变化幅度较低，PPA 与复合改性沥青紫外老化前后的胶体指数差值较小；光氧化导致羧基与亚砜基指数增加，丁二烯基指数减小，由官能团结构指数变化得出复合改性沥青抗紫外老化能力较强。PPA 改性沥青具有较好的高温流变性能与抗紫外老化性能， PPA/SBR 复合改性沥青可使抗紫外老化效果更加明显。

关键词：道路工程；多聚磷酸；紫外老化；四组分；流变性能；红外光谱

Research on Ultraviolet Aging Properties of PPA/SBR Composite Modified Asphalt

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Abstract:

In order to research the effect of ultraviolet aging on the performance of PPA/SBR composite modified asphalt. Firstly, the rheological properties of asphalt with different aging degrees were analyzed by dynamic shear rheological test. Secondly, the change of asphalt composition and characteristic peak functional group structure index before and after ultraviolet aging were obtained by four-component and infrared spectroscopy tests. The ultraviolet aging rate and mechanism of each asphalt group were analyzed by colloid index difference and functional group structure index. The results show that the addition of PPA can effectively improve the rheological properties of asphalt at high temperature. Compared with base asphalt, PPA and SBR modified asphalt, the rheological properties, component transformation and characteristic functional groups of composite modified asphalt are less affected by ultraviolet aging. After indoor simulated ultraviolet aging, the rutting resistance factor and phase angle of PPA modified asphalt changed slightly. The colloid index difference between PPA and composite modified asphalt before and after ultraviolet aging is small. Photooxidation results in the increase of carboxyl and sulfoxide index and the decrease of butadiene index. Therefore, the composite modified asphalt has stronger anti-ultraviolet aging ability from the change of functional group structure index. PPA modified asphalt has better rheological properties at high temperature and anti-ultraviolet aging performance. PPA/SBR modified asphalt can make anti-ultraviolet aging effect more obvious.

keywords: road engineering; polyphosphoric acid; ultraviolet aging; four components; rheological

properties; infrared spectroscopy

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高粘改性沥青的制备与性能研究

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摘 要：为了获得一种经济、适用的高粘改性沥青，提升我国多孔沥青路面耐久性，本文选用 5 类热塑性弹性体，研究其对基质沥青三大指标、动力粘度、粘韧性及韧性的影响，初步确定满足日本排水路面用高粘改性沥青基本性质的弹性体种类；其次，针对筛选的两类弹性体，选择合适的增粘剂与增塑剂，分别进行三因素三水平正交试验设计，结合极差分析方法探讨不同物质及掺量对沥青试样上述性质的影响规律，选出满足要求的改性组合；采用 DSR 对 RTFO 老化前、后的改性组合进行温度扫描和重复应力蠕变回复测试，评价其感温性能、抗老化和永久变形的能力，最终优选出两组性能优异的高粘改性沥青。

关键词：高粘改性沥青；多孔沥青混合料；道路工程

Preparation and Properties of High Viscosity Modified Asphalt

Luan Bo，Zhang Zhengwei，Liu Xiang
(Chang'an University)

Abstract:

In order to obtain an economical and applicable high-viscosity modified asphalt and improve the durability of China's porous asphalt pavement, this paper selects 5 types of thermoplastic elastomers to study its influence on the three major indexes of matrix asphalt, dynamic viscosity, visco-toughness and toughness, and initially determines the types of elastomers that meet the basic properties of high-viscosity modified asphalt for Japanese drainage roads. Secondly, According to the two types of elastomers selected, the appropriate tackifiers and plasticizers were selected, and the three-factor and three-level orthogonal test design were carried out respectively. The influence of different substances and dosages on the above properties of asphalt samples was studied by using the range analysis method. Selecting the modified combination that meets the requirements; using DSR to perform temperature scanning and repeated stress creep recovery tests on the modified combination before and after RTFO aging, evaluate its temperature sensing performance, anti-aging and permanent deformation ability, and finally, two sets of high-viscosity modified asphalt with excellent properties are preferred.

keywords: high viscosity modified asphalt; porous asphalt mixture; highway engineering

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泡沫沥青冷再生混合料关键技术指标及工程应用研究

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摘 要：本文结合甘肃省公路养护现状，在室内外试验的基础上，针对泡沫沥青冷再生混合料关键技术指标开展研究，分析了其在甘肃省的适用性。通过室内沥青发泡实验，研究了发泡原理及其发泡评价指标;对于泡沫沥青混合料,着重分析了水泥掺量对混合料性能的影响，并分析了现有成型方式、养生温度存在的问题以及对混合料性能的影响；针对现有规范设计评价指标单一问题，提出了基于振动成型的三轴试验残余粘聚力指标评价抗水损害能力；同时，现场试验段的铺筑对泡沫沥青冷再生技术在甘肃省的应用推广奠定了基础。

关键词：泡沫沥青；发泡原理；泡沫沥青混合料；水稳定性；工程应用

Study on Key Technical Indexes and Engineering Application of Foamed Asphalt Cold Recycling Mixture

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Abstract:

Based on the current situation of highway maintenance in Gansu Province, based on indoor and outdoor tests, the paper studies the key technical indexes of foamed asphalt cold recycled mixture and analyzes its applicability in Gansu province. Through indoor asphalt foaming experiment, the foaming characteristics and influencing factors were studied. For the foamed asphalt mixture, the existing molding methods and the problems of curing temperature were emphatically analyzed. In view of the existing standard design evaluation index single problem, the physical properties, mechanical properties, water stability and high temperature stability of the foamed asphalt mixture were studied in depth. The residual cohesion index of vibration forming three axis test is used to evaluate the ability of water damage resistance. At the same time, the laying of field test section lays a foundation for the application and popularization of cold recycling technology of foamed asphalt in Gansu province.

keywords: foamed asphalt; foaming principle; foamed asphalt mixture; water stability; engineering application

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环氧沥青和聚合物环氧改性沥青的相分离微观形貌研究

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摘 要：本文利用激光共聚焦显微镜(LSCM)研究了环氧沥青(EA)和环氧 SBS 改性沥青(ESBA)的相分离结构。研究表明，环氧沥青结合料和粘结料的相分离都是以旋节线分解（SD）机理形成的。随着沥青含量的增加，在环氧树脂连续相中沥青的粒径逐渐变大。当沥青含量达到 60 wt%时，热拌环氧沥青结合料相分离发生反转。随着基质沥青针入度的增加，环氧沥青粘结料中沥青颗粒的粒径变小。ESBA 存在双相分离结构：沥青与 SBS 间的相分离和 SBS 改性沥青（SBA）与环氧树脂间的相分离。当工业 SBA 含量达到 60 wt%时，SBA 仍然是分散相，并没有像 EA 那样发生相反转。随着 SBS 含量的增加，ESBA 中 SBS 颗粒增加变大。

关键词：环氧沥青；聚合物改性环氧沥青；SBS 改性环氧沥青；相分离；微观形貌；激光扫描共聚焦显微镜（LSCM）；共聚焦激光扫描显微镜（CLSM）；相反转

Investigation on Phase-Separated Microstructures of Epoxy Asphalts and Polymer Modified Epoxy Asphalts

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Abstract:

Phase-separated microstructures of epoxy asphalt (EA) and epoxy SBS modified asphalt (ESBA) were investigated using laser scanning confocal microscopy (LSCM). The phase separations of EA binder and bond coat form via spinodal decomposition (SD) mechanism. The size of asphalt particles in the epoxy phase increased with the increase of asphalt contents. Phase inversion occurred when base asphalt content was 60 wt% in hot-mix EA binder (HEAB). The size of asphalt particles in the EA bond coat (EABC) decreased with the increase of the asphalt penetration grades. ESBA contained a double phase-separated morphology: phase separations between asphalt and SBS and SBS modified asphalt (SBA) and epoxy. Unlike the HEAB, SBA was still the dispersed phase and no phase inversion occurred when industrial SBA content reached 60 wt%. The size of SBS in the ESBA increased with the increase of SBS contents.

keywords: epoxy asphalt; polymer modified epoxy asphalt; SBS modified asphalt; phase separation; microstructure; laser scanning confocal microscopy (LSCM); confocal laser scanning microscopy (CLSM); phase inversion

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基于红外光谱法对于 SBS 改性沥青掺量的分析

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摘 要：为了评价傅里叶变换红外光谱测定 SBS 改性剂含量技术在公路工程中的应用意义，以科学合理的表征改性沥青性能，本文通过对三种道路石油沥青和一种 SBS 改性剂在不同掺量条件下进行改性沥青标准样品制备，并利用 TENSORⅡ红外光谱分析仪对三种改性沥青进行分子结构信息分析，并对实验室标样和工厂化产品分别依照标准曲线进行标定分析。结果表明：特征吸收峰的绝对峰高和峰面积没有明显的规律性，而特定条件下沥青谱图中各特征吸收峰的相对值存在一定的规律性；工厂化成品与室内制作的标准样品相比，红外光谱检测 SBS 改性剂掺量存在±0.2%以内的误差；为保证改性沥青在工程中的优良路用性能，建议综合考虑常规物理技术指标检测方法和红外光谱检测技术。

关键词：改性沥青；SBS 改性剂含量；红外光谱检测技术；路用性能

Analysis of the Content of SBS Modifier in Modified Asphalt Based on Infrared Spectroscopy

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Abstract:

In order to evaluate the application significance of Fourier transform infrared spectroscopy (ftir) in determining the content of SBS modifier in highway engineering, to meet requirement of evaluating the properties of modified asphalt scientifically and reasonably. In this paper, Standard samples of modified asphalt were prepared with three kinds of paving asphalt asphalt and one kind of SBS modifier in different dosage conditions, it's molecular structure information was was analyzed by using TENSOR II infrared spectrum analyzer, Laboratory samples and factory products were respectively calibrated and analyzed according to the standard curve. The experiment results show that: The absolute peak height and peak area of characteristic absorption peak have no obvious regularity, while the relative value of each characteristic absorption peak in asphalt spectrogram has certain regularity under certain conditions; Compared with the standard samples made in the laboratory and factory, there is an error within ±0.2% in the content of SBS modifier detected by infrared spectroscopy; In order to ensure the excellent pavement performance of modified asphalt in engineering, it is suggested to using the conventional physical specifications test method and Infrared spectrum detection technology in combination.

keywords: modified asphalt; the content of SBS modifier; Infrared spectrum detection technology; the pavement performance

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Performance Comparison of Emulsified Asphalt Residues Prepared by Two Methods

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Abstract: Emulsified asphalt has become increasingly popular in preventive maintenance because of its widely use and economic benefit. The objective of this research was to study the performance of emulsified asphalt residues which obtained by using two different methods. The residues from SBS or SBR modified emulsified asphalt were obtained by direct heating evaporation method and low temperature evaporation method, respectively. The residues were then investigated based on softening point test and elastic recovery test. The dynamic shear rheological (DSR) test and multiple stress creep and recovery (MSCR) test have been performed on the residues. The complex shear modulus (G*) and phase angle (δ) as well as rutting parameter (G*/sinδ) were investigated using the DSR test, while non-recoverable creep compliance (Jnr) and percent recovery were evaluated through the MSCR test. It has been shown that the low temperature evaporation increased the softening point and enhanced the elastic recovery of SBS modified emulsion residues, but the results were opposite to SBR modified emulsion residues. All the residues obtained by low temperature had higher complex shear modulus values (G*) than that by direct heating evaporation method. Comparing with the direct heating evaporation method, SBS modified residues obtained by low temperature had higher deformation resistance and elastic properties, but the results of SBR modified residues are reverse. The properties of residues varied with the different obtaining methods, and the obtaining method should be improved in Chinese standard.

Key words: emulsified asphalt; residue; obtaining method; evaporation model; performance comparison

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几种生物油改性沥青混合料力学性能比较研究

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摘 要：文本旨在评估三种废木生物油(原样生物油、脱水生物油和聚合物改性生物油)以不同比例(比例分别为 5%和 10%)添加入传统沥青中对沥青混合料性能的影响。分别采用沥青路面分析仪(APA)试验、四点弯曲梁疲劳试验和间接拉伸(IDT)强度试验评估沥青混合料的抗车辙、抗疲劳和拉伸强度。试验结果表明，添加生物油可显著提高沥青混合料的疲劳性能，而对车辙性能并没有显著的影响，此外对拉伸强度略有影响。同时，聚合物改性生物油与其他两种改性沥青混合料相比具有更优的性能。室内试验结果的统计分析结果与上述结论一致。研究结果表明，废木生物油可以用为路面石油沥青胶结料的一种改性剂。

关键词：生物油；车辙性能；间接拉伸强度；疲劳性能；统计分析

Comparison Research of Mechanical Performance of Several Kinds of Bio-Asphalt Modified Asphalt Mixtures

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Abstract:

This study aims to evaluate the effect of bio-oils on asphalt mixture performance after blending bio-oil (5% and 10% by weight, respectively) into the traditional asphalt binder. Three types of bio-oils are used – the original bio-oil, dewatered bio-oil and polymer-modified bio-oil. The asphalt pavement analyzer (APA) test, four-point beam fatigue test and indirect tensile (IDT) strength test were conducted to evaluate the rutting resistance, fatigue performance and tensile strength, respectively. The test results showed that the addition of bio-oils significantly improves the asphalt mixture fatigue performance, has no significant effect on the rutting performance, but slightly impacted the tensile strength. In addition, polymer in the bio-oil was observed to improve the asphalt mixture performance as the PMB modified asphalt mixtures performed better than the two other mixtures. Further, statistical analysis on the laboratory test results are conducted and found to be consistent with the findings above. The study shows that the bio-oils derived from waste wood resources can be a good extender and modifier for petroleum asphalt binders in the pavement industry.

keywords: bio-oil; rutting performance; indirect tensile strength; fatigue performance; statistical analysis

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Design and Performance of Economical Epoxy Asphalt SMA Mixture

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Abstract: In order to apply epoxy asphalt stone matrix asphalt (SMA) to asphalt pavement with long and/or steep longitudinal slope, epoxy asphalt with different epoxy content was prepared. The microstructure of epoxy asphalt was observed through a fluorescence microscope to analyze the compatibility of epoxy resin with matrix asphalt. Dynamic shear rheological test at different high temperature and bending creep test at different low temperature were conducted on them to evaluate their high temperature performance and low temperature performance. Epoxy asphalt SMA with different epoxy system dosage were prepared. The water stability, high temperature stability, shear resistance and low temperature crack resistance of epoxy asphalt SMA were tested through water immersion Marshall test, freeze-thaw split test, rutting test, shear test and low temperature bending test. The results showed that the cured epoxy resin was evenly distributed in the matrix asphalt, and the two had good compatibility. With the increase of the amount of epoxy system, the high temperature performance and shear resistance of epoxy asphalt were greatly improved, but it had an adverse effect on its low temperature crack resistance. With the increase of the epoxy resin content, the high temperature performance, water stability and shear resistance of epoxy asphalt SMA were also improved, but the low temperature performance was also reduced. Finally, according to the performance test results of epoxy asphalt SMA, the suitable epoxy system dosage of epoxy asphalt SMA under different technical requirements were recommended, which can be used as reference for similar projects.

Key words: asphalt pavement; long longitudinal slope; steep longitudinal slope; epoxy asphalt; stone matrix asphalt (SMA); high temperature stability; low temperature stability; water stability; design index

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基于非菲克模型的沥青砂浆中气态水扩散特性研究

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摘 要：在干旱少雨地区的沥青路面除受到降水等液态水的影响，还有受到气态水的影响。水气受到温度梯度和湿度梯度的驱动，在路面结构中扩散传输，使沥青路面的湿度呈现动态变化，水气的传输会破坏沥青路面的原有结构并影响沥青路面的路用性能。因此，为了探究水分子在沥青砂浆中的扩散特性，本文将采用积聚型试验，首先测量在恒温恒湿条件下沥青砂浆不同时刻的质量变化，之后运用 Langmuir 方程和时变方程分析水气在扩散过程中的相态变化和时变特征，并且分析了不同影响因素对于水分子不同扩散特性的影响。试验表明：沥青砂浆中的水气扩散受到沥青、集料、温湿度的影响，不同因素对不同扩散特性的影响程度不同；温度升高可以促进水气在沥青砂浆中的扩散并且促进自由水向结合水转化，湿度上升会抑制水气扩散并且抑制自由水向结合水转化。

关键词：沥青砂浆

Study on Diffusion Characteristics of Gaseous Water in Asphalt Mortar Based on Non-Fick Model

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Abstract:

In the dry areas,the asphalt pavement is affected by liquid water,such as precipitation,and is also affected by gaseous water.The water vapor is driven by the temperature gradient and the humidity gradient, and spreads in the pavement structure, so that the humidity of the asphalt pavement changes dynamically.The transmission of moisture will destroy the original structure of the asphalt pavement and affect the pavement performance of the asphalt pavement.Therefore,in order to explore the diffusion characteristics of water molecules in asphalt mortar,this paper will use the accumulation type test to first measure the mass change of asphalt mortar at different times under constant temperature and humidity conditions.Then the Langmuir equation and time-varying equation are used to analyze the phase change and time-varying characteristics of water vapor during the diffusion process, and the effects of different influencing factors on the different diffusion characteristics of water molecules are analyzed. The test shows that the water vapor diffusion in the asphalt mortar is affected by the asphalt,aggregate,temperature and humidity,and the influence of different factors on different diffusion characteristics is different. The increase in temperature promotes the diffusion of moisture in the asphalt mortar and promotes the conversion of free water to the combined water. An increase in humidity inhibits the diffusion of moisture and inhibits the conversion of free water to bound water.

keywords: asphalt mortar

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沥青稳定碎石疲劳性能影响因素的灰熵分析

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摘 要：为了得到影响沥青稳定基层疲劳性能的关键因素，基于 ATB25 与 ATB30 两种密级配碎石混合料，选择 9 种集料级配、3 种沥青，以 13 种沥青稳定碎石混合料试件的各类试验数据为灰熵分析的参考列，以沥青稳定碎石疲劳方程中的 K 值与 N 值为比较列，进行影响沥青稳定碎石疲劳性能的灰熵分析，得到不同参数对沥青稳定碎石疲劳性能影响的显著程度。研究表明，沥青饱和度、混合料空隙率、沥青针入度、油石比四种因素是影响沥青碎石稳定基层疲劳性能的关键因素。

关键词：沥青稳定基层；疲劳性能；灰熵分析；道路工程

Grey Entropy Analysis of the Factors Influencing the Fatigue Performance of Asphalt Stabilized Gravel

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Abstract:

In order to get the key factors affecting the fatigue test performance of the asphalt stabilized subbase, two categories based on ATB25 and ATB30 macadam mixture, 9 kinds of aggregate gradation, three kinds of asphalt, with 13 kinds of asphalt stabilized macadam mixture specimens of all kinds of test data for grey entropy analysis reference column, with fatigue equation of asphalt stabilized macadam K value compared with the value of N for columns, to influence the fatigue performance of asphalt stabilized macadam grey entropy analysis, get on the impact of different parameters on fatigue performance of asphalt stabilized macadam level significantly. The study shows that four factors, namely asphalt saturation, void fraction of mixture, asphalt penetration and asphalt ratio, are the key factors affecting the fatigue performance of asphalt macadam stabilized base course.

keywords: asphalt stabilized base; fatigue performance; grey entropy analysis; highway engineering

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Development of Australian Performance-Based Specification for Bituminous Binders

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Abstract: Australia purchases about US$600m of bituminous binders annually to maintain and construct its road network. To ensure value for money in this major procurement area, Australia has developed performance-based specifications for these materials. Unmodified bitumens are specified in Australian Standard AS 2008 which classifies the materials based on their dynamic viscosity at 60°C. The specified properties of polymer modified binders (PMBs) are included in the Austroads specification framework for PMBs (AGPT/T190). Two new performance-based test methods have been recently developed for PMBs, namely the consistency 6% at 60°C test (to evaluate rutting performance at high road temperatures) and the stress ratio at 10°C test (to evaluate cracking performance at low road temperatures). Consistency 6% at 60°C tests are conducted using an Australian test device known as the elastometer while stress ratio at 10°C tests are conducted using the internationally used Dynamic Shear Rheometer (DSR). This paper provides information on these key specification tests and their relationships with road performance. A plan for further development is also briefly discussed.

Key words: bitumen specification; australian standard; pavement performance; polymer modified binders; viscosity; performance indicators; test method; dynamic shear rheometer

Nonlinear Rheological Behaviour of SBS Modified Asphalt Binders Under LAOS

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Abstract: The binders in pavement could support the loading in either linear regime or nonlinear regime. The linear viscoelasticity of asphalt binders was well established, however, a few of researches focused on nonlinear viscoelasticity of asphalt binders. Here the nonlinear rheological behavior of one kind of neat asphalt binder and the corresponding SBS modified asphalt binders under large amplitude oscillatory shear stress (LAOS stress) are analyzed by FT-rheology and strain decomposition methods. We find that the relative nonlinearity of asphalt binders increases with increase in stress and decrease in frequency; the relationship between I3/I1 and stress amplitude can obey the sigmoidal function; the intrinsic nonlinearity Q0 decreases with increase in frequency. Both the FT analysis results and decomposition results show that the nonlinearity of SBS modified asphalt binder is much more significant than asphalt binder. SBS could increase the nonlinearity and the elastic proportion of asphalt binder and decrease the fluidity of it. All the studied binders exhibit stress softening and stress thinning under all the studied test conditions.

Key words: asphalt binder; nonlinear rheological behavior; laos stress; sbs polymer; ft-rheology; strain decomposition

酸性集料与沥青的粘附机理研究

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摘 要：本文针对沥青与酸性集料的粘附性差的问题开展研究。对表面处理剂处理后酸性集料与沥青的粘附性能进行研究，结果表明酸性集料经过表面处理之后与沥青粘附性能显著提升。运用分子动力学对表面处理剂与集料、沥青的界面进行模拟分析，研究表面处理剂的粘附机理，结果表明表面处理剂的加入增大了沥青与酸性集料界面相互作用能，其中相较于范德华相互作用能，库仑相互能的变化较大，并在界面相互吸附过程中占主导地位。本研究有效提高了沥青与酸性集料的粘附性，成功改善了酸性集料的水稳定性，这将为酸性集料的广泛应用提供依据。

关键词：酸性集料；表面处理剂；粘附性；粘附机理；分子动力学

Study on the Adhesive Mechanism of Acid Aggregate and Asphalt

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Abstract:

The adhesion of acid aggregate treated with surface treatment agent and asphalt was studied. The results showed that the adhesion of acid aggregate to asphalt improved significantly after surface treatment. Molecular dynamics was used to simulate and analyze the interface of surface treatment agent with aggregate and asphalt. The results showed that the interface interaction energy between asphalt and acid aggregate increased with the addition of surface treatment agent. Compared with van der Waals interaction energy, coulomb interaction energy changed greatly, and played a dominant role in the process of interface adsorption. This study effectively improved the adhesion between asphalt and acid aggregate, and successfully improved the water stability of acid aggregate, which will provide a basis for the wide application of acid aggregate.

keywords: Acid aggregate; Surface treating agent; Adhesion; Adhesion mechanism; key words: Molecular dynamics

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Fatigue Performance of Fibre-Reinforced Asphalt Treated Permeable Base

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Abstract: In order to study the effect of lignin fiber on fatigue performance of asphalt treated permeable base (ATPB), semi-open graded ATPB was designed, and fiber reinforced ATPB (FATPB-25) beam specimens with different fiber contents were fabricated. Four - point bending fatigue tests were conducted under different stress ratios, and the fatigue life of FATPB-25 with 0.3% fiber was contrasted with those of ordinary AC-25 and ATB-25. The influence of fiber dosage and stress ratio on FATPB-25 fatigue performance were obtained, and its fatigue equation coupling fiber content was established. The fatigue lives were statistical analyzed based on Weibull distribution, and the fatigue equation with failure probability was established. Fatigue resistance of FATPB-25 with 0.3% fiber was much better than that of AC-25 and ATB -25, so it can be used as durable drainage binder course or flexible base course.

Key words: pavement engineering; asphalt treated permeable base; fatigue; fiber reinforced; weibull distribution

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High Temperature Rheological Characteristics of Plasma-Treated Crumb Rubber Modified Binders

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Abstract: Crumb rubber modified asphalt has gained growing interest as a kind of environmentally friendly binder in the past few decades. The aim of this study was to investigate the impact of plasma surface treatment of crumb rubbers on the high temperature performances of their modified binders at unaged and RTFO-aged states, which were produced with two base asphalts and three crumb rubber sizes. According to the performances tests and statistical analyses, plasma treatment technology on crumb rubber significantly enhanced the high temperature performances as well as storage stability, regardless of base asphalt source, crumb rubber size and aging state. The effect of base asphalt source was mainly reflected in playing a key role in determining the high temperature performances of RTFO-aged binders. Oversized and undersized crumb rubbers tended to perform poorly and plasma-treated binders produced with crumb rubber of 40 mesh were considered the most desirable. In addition, a RTFO aging caused an enhancement in elasticity and viscosity of plasma-treated rubberized binders as expected. In addition, the coupling effects in gray relational analysis indicated that plasma surface treatment on crumb rubber of 40 mesh and base asphalt A was the most effective.

Key words: plasma surface treatment; rubberized binder; high temperature performance; coupling effect; statistical analysis; plasma surface treatment; rubberized binder; high temperature performance; coupling effect; statistical analysisplasma surface treatment; rubberized binder; high temperature performance; coupling effect; statistical analysis

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Micro-Morphologies Characteristics of Polymer-Carbon Nanotubes Modified Asphalt Through Molecular Dynamics Simulation and Experiments: Role of the Strengthened Interfacial Interactions

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Abstract: Polymer modifiers have long been used to improve the performance of asphalt binder in pavement engineering. The modification effect of polymer on asphalt is largely depended on the morphologies characteristics of polymer modified asphalt. The morphologies of polymer modified asphalt are composed of polymer-rich phase, asphaltene-rich phase and interphase between the two phases. The interfacial interactions played a significantly important role on the morphologies, yet it was commonly overlooked. In this study, Carbon Nanotubes (CNTs) were selected to improve the interfacial interactions of polymer modified asphalt. Fluorescence Microscope (FM), Scanning Electron Microscope (SEM), Micro Raman Spectra (MRS) and Molecular Dynamics simulation (MD) were used to capture the interphase and polymer-rich phase characteristics of polymer–CNTs modified asphalt. Results from SEM indicated that CNTs enhanced the mechanical anchorage between polymer and asphalt component, exhibiting a prominent cage construction of polymer-rich phases. FM images manifested that CNTs induced the increase of the swelling degree of polymer-rich phase, owing to CNTs served as a tunnel to transport saturates, aromatics, and small resin molecules in MD. Raman peak and MD draw out that the C=C of CNTs had interaction with alkanes and aromatic hydrocarbons of asphalt. SBS entwined or surrounded with CNTs through the π-π conjugation of benzene ring belonging to CNTs and SBS. Thus, SBS and CNTs had synergistic effect to enhance the intermolecular interaction. Obviously, CNTs played a positive role on the interfacial interactions, pull-out behaviors alleviated interfacial failure and improved the road performance. This work here revealed the important role of interphase on the micro-morphologies of polymer modified asphalt.

Key words: Polymer modified asphalt;Carbon nanotubes;Interfacial interactions;Molecular dynamics simulations;Micro Raman spectra;Scanning electron microscope

玄武岩纤维沥青稳定碎石抗开裂性能试验研究

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摘　要：为延缓或者防止反射裂缝在沥青路面结构中的发展，本文首先选用沥青稳定碎石常用的 ATB-25 级配，对普通沥青稳定碎石、玄武岩纤维沥青稳定碎石、SBS 改性沥青稳定碎石以及玄武岩纤维改性沥青稳定碎石四种沥青稳定碎石进行组成设计，其次，通过不同应变条件下的四点弯曲疲劳寿命试验以及不同温度条件下的弯曲试验、J 积分试验对四种沥青稳定碎石的抗裂性能进行系统的评价，结果表明玄武岩纤维在改性沥青稳定碎石具有更好的抗裂性能；对比添加玄武岩纤维前后沥青稳定碎石的抗裂性能，可以得到玄武岩纤维能够显著提高沥青稳定碎石的抗裂性能，玄武岩纤维在 SBS 改性沥青中对于沥青稳定碎石抗裂提升效果远大于在基质沥青中。

关键词：玄武岩纤维；沥青稳定碎石；抗裂性能

Experimental Study on Crack Resistance of Basalt Fiber Asphalt Stabilized Macadam

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Abstract:

In order to delay or prevent the development of reflective cracks in asphalt pavement structure, ATB-25 gradation, commonly used in asphalt stabilized macadam, is selected to design the composition of four kinds of asphalt stabilized macadam: ordinary asphalt stabilized macadam, basalt fiber asphalt stabilized macadam, SBS modified asphalt stabilized macadam and basalt fiber modified asphalt stabilized macadam. Secondly, under different strain conditions. Four-point bending fatigue life test, bending test at different temperatures and J-integral test were used to systematically evaluate the crack resistance of four kinds of asphalt stabilized macadam. The results show that basalt fibers have better crack resistance in modified asphalt stabilized macadam. Compared with the crack resistance of asphalt stabilized macadam before and after adding basalt fibers, basalt fibers can be obtained significantly. In order to improve the crack resistance of asphalt stabilized macadam, basalt fibers in SBS modified asphalt can improve the crack resistance of asphalt stabilized macadam much better than in base asphalt.

Keywords: Basalt fiber;asphalt stabilized macadam; crack resistance

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Preparation and Characterization of Microcapsules Containing Light Oil for Application in Self-Healing Asphalt

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Abstract: In this study, microcapsules containing light oil as rejuvenator were synthetised and characterized to enhance the self-healing ability of asphalt materials. Rejuvenator was encapsuled by in-situ polymerization method. Optimal surfactant and dosage was chosen by comparing emulsification effect (relative emulsification volume, REV). Effect of emulsifying speed and core shell ratio on synthesis of microcapsules were analyzed. Chemical structure, thermal stability, and micro morphology of microcapsules were described by Fourier Transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), and scanning electron microscope (SEM). Self-healing effect of asphalt samples was captured through fatigue-healing test. Results shows that combined SDS (Sodium dodecyl sulfate) + Span-60 (mass ratio is 2/8) shows higher emulsion efficiency for o/w emulsion and 1.5 wt% of combined surfactant presents the best emulsion effect. Particle size distribution of micorcapsules are more concentrated under the emulsifying speed of 800 r/min, 1000 r/min, and 1200 r/min. The average particle size are around 5 μm~10 μm. Encapsulation efficiency value increases with the rise of emulsifying speed under the same core/shell ratio, and microcapsules fabricated with same emulsifying speed have larger encapsulation with the growth of shell material utilization. Characterization peaks in FTIR spectra of microcapsules and core material indicate the complete encapsulation of microcapsules in fabrication. TG and DTG curves of microcapsules show that mass of sample keeps almost unchanging from 0℃ to 180 ℃, and over 80% mass loss can be found from 200 ℃ to 400 ℃. Microcapsules are spherical and intact with agglomerated layers, and its surface is relatively rough and full of undulating and folding structures. Addition of microcapsules stiffens asphalt binder and accelerates the self-healing of asphalt with respect to complex modulus and fatigue life.

Key words: Microcapsules; In situ polymerization; Asphalt; Characterization;Self-healing

不同外掺剂对除臭型橡胶改性沥青高低温性能的影响

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摘　要：随着经济的发展，我国每年都产生大量的废旧塑料和废旧橡胶。如果将废旧橡胶和废旧塑料回收加工后加入到沥青中来提高沥青的使用性能，既能有效地解决废旧轮胎及塑料带来的污染问题，又能改善沥青材料的路用性能，从而带来显著的经济和社会效益。但常用的橡胶改性沥青臭味较大，对人体健康伤害严重，因此除臭型橡胶改性沥青应运而生。本文通过不同的试验指标，分析三种具有类似除味效果的外掺剂制备的除臭型橡胶改性沥青的高低温性能变化。

关键词：橡胶改性沥青；除臭；高低温性能

Effect of Different External Admixtures on High and Low Temperature Performance of Deodorized Rubber Modified Asphalt

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Abstract:

With the development of the economy, China produces a large amount of waste plastics and waste rubber every year. If the waste rubber and waste plastics are recycled into the asphalt to improve the performance of the asphalt, the pollution problem caused by the waste tires and plastics can be effectively solved, and the road performance of the asphalt materials can be improved, thereby bringing significant Economic and social benefits. However, the commonly used rubber modified asphalt has a large odor and is seriously harmful to human health, so deodorant rubber modified asphalt has emerged. In this paper, the high and low temperature performance changes of deodorant rubber modified asphalt prepared by three external additives with similar deodorizing effects were analyzed by different test indexes.

keywords: Rubber modified asphalt;deodorization;high and low temperature performance

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基于数字图像区域划分下的沥青混合料表面集料均匀性评价

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摘　要：为了能客观、高效的对沥青路表集料进行均匀性评价，采用数码相机采集沥青混合料表面图像并结合 MATLAB 软件对图像进行数字化处理。以集料面积百分数的变异系数作为评价路表集料均匀性时，数字图像的区域划分是关键的一步，而现有的区域划分方法存在着准确度较低的缺陷。针对该缺陷，本文提出一种名为“8 等分均值法”的划分方法以提高路表集料均匀性评价的准确度。采用现有方法和 8 等分均值法对相同车辙板均匀性的评价作对比后发现：（1）区域划分越精细，变异系数越大；（2）8 等分均值法优于现有方法。

关键词：区域划分；数字图像处理技术；沥青混合料；表面集料

The Surface Aggregate Uniformity Evaluation of Asphalt Mixture Based on Digital Image Region Division

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Abstract:

In order to objectively and efficiently evaluate the uniformity of asphalt pavement aggregate, digital camera was used to collect the surface image of asphalt mixture and carry out digital processing of the image with MATLAB software.When the variation coefficient of aggregate area percentage is used to evaluate the aggregate uniformity of road surface, the region division of digital image is a key step.in view of this defect, this paper proposes a division method called "8 equally divided mean method" to improve the accuracy of road surface aggregate uniformity evaluation.After comparing the evaluation of the uniformity of the same rut board with the existing method and the 8 equally divided mean method, it is found that :the finer the regional division, the greater the coefficient of variation;the 8 equally divided mean method is better than the existing method.

Keywords: regional division; digital image processing technology; asphalt mixture; the surface of the aggregate

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基于 MSCR 试验的温拌沥青高温性能研究

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摘　要：为了研究温拌沥青的高温性能，选择 Evotherm3G 和 EC120 两种温拌剂加入基质和 SBS 改性沥青中配制温拌沥青，采用多重应力蠕变恢复试验（MSCR）对短期老化前后温拌沥青的高温性能进行评价，研究结果表明：两种温拌剂对沥青的高温性能的影响表现出明显的差异性，Evotherm3G 温拌剂增加了沥青的应变，降低了沥青的蠕变恢复率，提高了沥青不可恢复蠕变柔量；EC120 温拌剂降低了沥青的应变，提高了沥青的蠕变恢复率，降低了沥青不可恢复蠕变柔量；Evotherm3G 温拌剂降低了沥青的高温性能而 EC120 温拌剂提升了沥青的高温性能，但两种温拌剂均能不同程度的提高沥青的应力敏感性。

关键词：温拌沥青；高温性能；多重应力蠕变试验

Study on High Temperature Performance of Warm Mixed Asphalt Based on MSCR Test

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Abstract：

In order to study the high temperature performance of warm mix asphalt, Evotherm3G and EC120 were selected to be added into the matrix and SBS modified asphalt to prepare warm mix asphalt. Multi-stress creep recovery test were used to evaluate the high temperature performance of warm mix asphalt before and after short-term aging. The results show that:the effects of two warm mixtures on high temperature performance of asphalt show obvious differences..Evotherm3G warm mixing agent increases the strain of asphalt, reduces the creep recovery rate of asphalt, and improves the non-recoverable creep compliance of asphalt. EC120 warm mixing agent reduces the strain of asphalt, improves the creep recovery rate of asphalt and reduces the non-recoverable creep compliance of asphalt. Evotherm 3G warm mixing agent reduces the high temperature performance of asphalt while EC120 warm mixing agent improves the high temperature performance of asphalt, but both warm mixing agents can improve the stress sensitivity of asphalt in varying degrees.

keywords: warm mix asphalt; high temperature performance; MSCR

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废旧油脂/塑料共混改性沥青及沥青混合料的性能研究

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摘　要：为了在减少沥青用量的前提下提升基质沥青的性能，同时也为了提高我们对生活中常见废弃物的利用率，提高沥青的路用性能，对废旧油脂和废旧塑料共混对沥青进行改性，制备改性沥青并研究其性能的变化。通过软化点、 针入度和延度测试评价改性沥青的物理性能，废旧油脂使沥青针入度增加，软化点下降，延度上升；废旧塑料使沥青针入度减小，软化点增大，延度下降。二者对沥青的影响存在互补关系，当两种材料共混时，对性能的影响各有偏差。改性沥青混合料高温性能的研究表明，两种材料共混时沥青混合料的稳定度上升，塑性变形减小，受到水损害后的抗剥落能力加强，高温稳定性增加。改性沥青混合料的水稳定性能测试的实验结果表明，两种材料共混时水稳定性下降，但冻融劈裂抗拉强度整体提高。

关键词：沥青；废旧油脂；废旧塑料；改性

Investigation of Properties of Asphalt and Asphalt Mixture Modified by Waste Oil / Plastic Blend

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Abstract：

In order to reduce the amount of asphalt under the premise of improving the performance of matrix asphalt, but also to improve our living in the common waste utilization, improve the road performance of asphalt, waste oil and waste plastic blends on the asphalt modification, Preparation of modified asphalt and study of its performance changes. The physical properties of the modified asphalt were evaluated by the softening point, the penetration degree and the ductility test. The waste oil increased the pitch of the asphalt, the softening point decreased and the ductility increased. The waste plastic reduced the penetration of the asphalt and increased the softening point , The decline in decline. The two effects on the asphalt there is a complementary relationship, when the two materials blending, the impact on the performance of each deviation. The study on the high temperature performance of the modified asphalt mixture shows that the stability of the asphalt mixture increases when the two materials blend, the plastic deformation decreases, the anti - flaking ability after the water damage, and the high temperature stability increases. The experimental results show that the water stability of the two kinds of materials is decreased, but the tensile strength of freeze - thawing is improved.

keywords: Asphalt; Waste grease; Waste plastic; Modified

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基于双控法的 SBS 改性沥青现场快速测试技术

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摘　要：SBS 改性是我国高速公路沥青路面混合料的首选改性形式，长期以来，如何在现场快速准确确定 SBS 改性剂掺量与加工效果一直是大家关注的焦点。课题组经过多年研究，采用的“SBS 质量双控手段（即电位滴定测试改性剂掺量，结合荧光测试确定加工效果的方式）”在高速公路开展现场质量控制，实现了定性与定量分析手段相结合。实践证明，受控改性沥青性能稳定，该方法弥补了现有质量控制体系的不足，具有广泛的推广价值和现实意义。

关键词：改性沥青；SBS 质量双控手段；电位滴定；荧光测试

Rapid Field Test Technology of SBS Modified Asphalt Based on Double Control Method

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Abstract：

SBS modification is the preferred form of asphalt pavement mixture in China, for a long time, how to quickly and accurately determine the amount and processing effect of SBS modifier in the field has been the focus of attention. After years of research, the "SBS quality double control method (potentiometric titration test the amount of modifier, combined with fluorescence test to determine the quality of processing effect) " used by the research team in the highway field quality control, achieved a combination of qualitative and quantitative analysis methods. Practice has proved that the performance of controlled modified asphalt is stable, this method makes up for the shortcomings of the existing quality control system, and has a wide range of promotional value and practical significance.

keywords: modified asphalt; SBS quality double control method; potentiometric titration; fluorescence test

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Atomic Force Microscope Study of the Aging/Rejuvenating Effect on Asphalt Morphology and Adhesion Performance

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Abstract: Asphalt aging is one of the most severe threats to the asphalt pavement durability and rejuvenation with cooking oil can help to resolve this issue. Currently, the influence of aging/rejuvenation on the bonding performance of asphalt binder has not been fully understood. This study aims to unveil the influence of aging/rejuvenation on the adhesionperformance under bothmicro and macro scale tests. Three type asphalt binders were examined in this study, including the original, aged and rejuvenated samples. The atomic force microscope (AFM) was first applied to examine the surface morphology and adhesion performance of the three type asphalt samples. It is found that the aging effect can increase the adhesion between asphalt binder and silica particles and the adhesion force can be further enhanced through rejuvenation. Then the three-point bending was further conducted to examine adhesion performance at the macroscale, and the obtained results are in accordance with those obtained at the microscale. However, the slant shear test indicated the shear bond strength can be reduced due to the rejuvenation with vegetable oil, which can be generated due to the lubrication effect of the oil. The results in this study can help to better understand the influence of aging and rejuvenation on the bond performance between asphalt binder and mineral aggregate.

Key words: Asphalt binder; Cooking oil; Rejuvenation; Atomic Force Microscopy (AFM); Flexural bond strength; Shear bond strength

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Evaluation of the Effect of Bio-Oil on the High-Temperature Performance of Rubber Modified Asphalt

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Abstract: The main objective of this study is to investigate the effect of bio-oil on the high-temperature performance of crumb rubber modified asphalt. Two types of crumb rubber powder produced from waste tire, 80-mesh and 20-mesh, were used to prepare the crumb rubber modified asphalt. Four weight ratios of bio-oil to rubber asphalt, 0%, 5%, 10%, and 15%, were chosen to prepare the composite modified asphalt binder in this study. Temperature sweep test and multiple stress creep recovery (MSCR) test were conducted to evaluate the high-temperature performance of the composite modified asphalt. The results showed that the viscosities of asphalts modified by 20-mesh crumb rubber were greater than that modified by 80-mesh ones. With the addition of bio-oil into crumb rubber asphalt, the viscosities of the composite modified asphalts first increased then decreased. Bio-oil can enhance the high-temperature performance of crumb rubber modified asphalt due to the physical and chemical interactions in a heated asphalt. The short-term aging process may improve the degree of blending between crumb rubber and bio-oil in the heated asphalt dispersion system and enhance the elastic property of crumb rubber modified asphalt.

Key words:rubber modified asphalt; bio-oil; high-temperature performance;temperature sweep; MSCR

高原地区多因素耦合作用下橡胶沥青性能评价

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摘　要：为提高沥青路面在高原地区多因素耦合作用下的服役寿命，以橡胶沥青为主要试验原料，将实地采集的青海格尔木地区气象数据应用于自主研发的可程式恒温恒湿阳光试验机中模拟高原地区多因素耦合作用下沥青结合料劣化过程。以针入度、软化点、延度、弹性恢复、布氏黏度（180℃）、抗剪强度（25℃）和弯曲梁流变特性（BBR）等指标研究沥青性能随多因素耦合作用龄期的变化规律；在此基础上，借助荧光显微镜（FM）、扫描电镜（SEM）和傅里叶红外光谱（FTIR）等手段，进一步探究高原地区多因素耦合作用下橡胶沥青性能演化机理。研究结果表明：高原地区多因素耦合作用持续劣化沥青胶结料性能；与基质沥青相比，橡胶沥青在高寒地区的适用性及使用效果具有明显优越性；掺入 TOR 连接剂形成的交联结构更利于提高橡胶沥青的稳定性及耐久性。

关键词：道路工程；橡胶沥青；性能评价；高原环境模拟；多因素耦合

Evaluation on the Performance of Rubber Asphalt Exposed to Multi-Factor Coupling in Plateau Area

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（Chang'an University）

Abstract:

In order to improve the service life of asphalt pavement under multi-factor coupling in the Plateau area, rubber asphalt was used as the main experimental material, and the meteorological data collected in the field of Qinghai Golmud was applied to the self-developed programmable constant temperature and humidity test machine in the simulated plateau area. Degradation process of asphalt binder under multi-factor coupling. The penetration, softening point, ductility, elastic recovery, brinell viscosity (180 °C), shear strength (25 °C) and bending beam rheological properties (BBR) were used to study the variation of asphalt performance with multi-factor coupling age. On this basis, the fluorescence microscope was used. (FM), scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR) were used to further explore the mechanism of rubber asphalt performance evolution under multi-factor coupling in the plateau. The results show that the multi-factor coupling effect in the plateau region continues to degrade the performance of asphalt binder; compared with the matrix asphalt, the applicability and use effect of rubber asphalt in the alpine region is obviously superior; the crosslinked structure formed by the incorporation of TOR binder is beneficial to improve the stability and durability of rubber asphalt.

keywords: Road engineering;rubber asphalt;performance evaluation;plateau environment simulation;multi-factor coupling

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基于感应加热的钢丝绒纤维沥青混合料除冰性能评价

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摘　要：为有效解决冬季冰雪覆盖对沥青路面行车安全的困扰，采用电磁感应加热的方式，研究了钢丝绒纤维长度、掺量对沥青混合料除冰效果与路用性能的影响，并探讨了钢丝绒纤维沥青混合料电磁感应加热除冰机理。结果表明：钢丝绒纤维沥青混合料电磁感应加热除冰效果显著，钢丝绒纤维长度、掺量与感应加热平均融冰速率呈正相关趋势；掺量6%的5mm钢丝绒纤维沥青混合料平均融冰速率最快，达0.47℃·s-1；掺入钢丝绒纤维后，沥青混合料高温稳定性与低温抗裂性均得到改善；4%掺量的5mm钢丝绒纤维沥青混合料路用性能达到最佳；综合考虑，推荐掺入4%的5mm钢丝绒纤维为沥青混合料电磁感应加热除冰最佳方案。

关键词：道路工程；沥青混合料；路面除冰；钢丝绒纤维；感应加热

Evaluation of Deicing Performance of Steel Wool Fiber Asphalt Mixture Based on Induction Heating

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Abstract:

In order to effectively solve the traffic safety problem caused by the snow and ice cover pavement in winter. The effect of the length and content of steel wool fiber on the deicing effect and road performance of asphalt mixture was studied by means of electromagnetic induction heating, and the deicing mechanism of steel wool fiber asphalt mixture by electromagnetic induction heating was discussed. The results show that the steel wool fiber asphalt mixture heated by electromagnetic induction obtained satisfactory result according to engineering test, and the length and content of steel wool fiber are positively correlated with the average melting rate of induction heating. The average melting rate of asphalt mixture containing 6% steel wool fiber with length of 5 mm is the highest, 0.47 ℃·s-1. By adding steel wool fiber of different lengths, performance of asphalt mixture is greatly improved in both high-temperature stability and low-temperature cracking resistance. Asphalt mixture containing4% steel wool fiber with length of 5 mm has achieved the best road performance. Comprehensive consideration, it is recommended that steel wool fiber containing 4% with length of 5 mm is the best solution for the deicing of asphalt mixture by electromagnetic induction heating.

keywords: road engineering; asphalt mixture; road deicing; steel wool fiber; induction heating

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微表处乳化剂的制备与性能评价

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摘　要：采用甲醛、多乙烯多胺、3-十五烷基苯酚为原料，合成了酚基多胺类微表处沥青乳化剂，并对其进行性能评价。结果表明：合成的乳化剂具有高表面活性，低临界胶束浓度和表面张力的特点，用该乳化剂制备的乳化沥青粒度小、颗粒均匀、贮存稳定性好。对比不同结构的多乙烯多胺制备的乳化剂的乳化效果不同，其乳化效果最好的是以三乙烯四胺为原料制备的 R34 乳化剂。利用 R34 乳化剂制备微表处乳化沥青的最佳工艺为，pH 值 2.5-3.0，SBR 胶乳掺量为 3%，乳化剂掺量为 1%。通过对微表处路用性能测试，结果表明：合成的 R34 乳化剂制备的微表处混合料路用性能优异，但 6d 湿轮磨耗值偏大。采用合成的 R34 乳化剂与进口产品 RH 复配制备的微表处混合料，各项性能指标均满足微表处混合料的技术要求，其中 R34/RH=3/1 作微表处复配乳化剂具有最佳性价比。

关键词：多乙烯多胺，微表处，乳化剂，湿轮磨耗

Preparation and Performance Evaluation of Micro-Surfactant Emulsifier

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Abstract：

The Phenolic polyamine micro-surfactant asphalt emulsifier was synthesized from formaldehyde, polyethylene polyamine and 3-pentadecylphenol, and its performance was evaluated. The results show that the synthesized emulsifier has high surface activity, low critical micelle concentration and surface tension. The prepared emulsified asphalt has small particle size, uniform particle size and good storage stability. The emulsifying effect of emulsifiers prepared from different structures of polyethylene polyamine was compared. The best emulsifying effect was R34 emulsifier prepared from triethylenetetramine. The optimum process for preparing micro-surfactant emulsified asphalt with R34 emulsifier was pH 2.5-3.0, SBR latex 3% and emulsifier 1%. The pavement performance of Micro-surfacing was tested. The results show that the micro-surfacing mixture prepared by synthetic R34 emulsifier has excellent pavement performance, but the wear value of 6D wet wheel is on the high side. The performance indexes of Micro-surfacing mixtures prepared by mixing synthetic R34 emulsifier with imported RH meet the technical requirements of Micro-surfacing mixtures, and R34/RH=3/1 as micro-surfacing emulsifier has the best cost performance ratio.

keywords: Polyethylene Polyamine; Micro-surfacing; Emulsifier;Wet Wheel Abrasion

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基于 SHRP 净吸附试验的沥青—集料黏附性研究

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摘　要：为准确量化集料与沥青之间的黏附性，采用能够定量评价沥青与集料黏附性的 SHRP 净吸附法进行沥青与集料黏附性评价。试验选用 50#基质沥青、90#基质沥青、SBS 改性沥青、高黏沥青以及角闪岩与中山玄武岩，测得单位质量集料吸附沥青后的集料被水分子置换后剥落的沥青质量。SHRP 净吸附法结果显示角闪岩与 4 种沥青之间的黏附性排序为：90#沥青<50#沥青#<SBS 改性沥青<高黏沥青；中山玄武岩与 4 种沥青之间的黏附性排序为：50#沥青<90#沥青#<SBS 改性沥青<高黏沥青。同时提出判定沥青与集料黏附性能的新沥青与集料匹配性指标 RL：当 RL 大于 0.455 时，匹配性较差；当 RL 介于 0.305 与 0.455 之间时，匹配性一般；当 RL 小于 0.305 时，匹配性较好。

关键词：SHRP 净吸附法；水煮法；黏附性；沥青与集料匹配性指标 RL

Study on Asphalt-Aggregate Adhesion Based on SHRP Net Adsorption Test

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Abstract：

In order to accurately quantify the adhesion between aggregate and asphalt, the adhesion of asphalt and aggregate was evaluated by SHRP net adsorption method which can quantitatively evaluate the adhesion of asphalt and aggregate. The test selected 50# matrix asphalt, 90# matrix asphalt, SBS modified asphalt, high-viscosity asphalt and amphibolite and Zhongshan basalt, and measured the mass of the asphalt which was exfoliated by the water after the aggregate was absorbed by the unit mass aggregate. The SHRP net adsorption method showed that the adhesion order between amphibolite and four kinds of asphalt was: 90# asphalt <50# asphalt #<SBS modified asphalt <high-viscosity asphalt; adhesion between Zhongshan basalt and four kinds of asphalt Sorted as: 50# asphalt <90# asphalt #<SBS modified asphalt <high viscosity asphalt. At the same time, the new asphalt and aggregate matching index RL for determining the adhesion performance of asphalt and aggregate is proposed. When RL is greater than 0.455, the matching is poor. When RL is between 0.305 and 0.455, the matching is general; when RL is less than 0.305 When the match is good.

keywords: SHRP net adsorption method; boiling method; adhesion; Asphalt and aggregate matching index RL

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基于 MSCR 试验的沥青恢复率修正算法研究

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摘　要：多重应力蠕变恢复（MSCR）试验作为评价沥青高温性能的规范试验方法已得到了广泛认可。然而在对基质沥青进行 MSCR 试验时，恢复率计算值可能出现负值，恢复率为负显然不符合基本的黏弹性理论和黏塑性理论。本文的研究目的是提出一种修正的恢复率计算方法，保证沥青的恢复率计算值始终为正。在采用动态剪切流变仪对三种基质沥青和两种改性沥青进行 MSCR 试验后，参考 AASHTO T 350－14 中的方法计算出每种沥青的恢复率，计算结果表明三种基质沥青的恢复率均在某一应力水平下出现了负值。分析基质沥青恢复率出现负值的原因发现，仪器的实际卸载时间相对于设定卸载时间出现了一定程度的时间延迟，沥青试样实际加载结束时间处于第 1s 和第 1.1s 之间。据此，本文提出了一种沥青恢复率的改进计算方法，该计算方法分为两步，第一步是确定延迟时间，第二步是根据延迟时间计算加载结束时的应变并进一步计算恢复率。采用本文提出的方法计算得到的基质沥青的恢复率均为正值，从而验证了修正方法的可行性。

关键词：多重应力蠕变恢复试验

An Improved Calculation Method for Percent Recovery of Asphalt Binders Based on the MSCR Tests

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Abstract：

The multiple stress creep and recovery (MSCR) test has been widely recognized as a routine test method for evaluating the high temperature performance of asphalt binders. However, the calculated percent recovery may be negative when the MSCR test is performed on unmodified asphalt binders. A negative value for percent recovery is apparently at variance with the fundamental viscoelastic and viscoplastic theory. The objective of this study is to propose an improved calculation method for percent recovery, which can ensure the calculated values are always positive. The Dynamic Shear Rheometer (DSR) was employed to perform the MSCR tests on three types of unmodified asphalt binders and two types of modified asphalt binders. The percent recovery of five asphalt binders at each stress level was computed in accordance with the method documented in AASHTO T 350–14. The calculation results indicated that the percent recovery was negative at a certain stress level for the three unmodified asphalt binders. It was observed that there was a time lag between the theoretical end of the creep portion and the actual end of the creep portion. This time lag resulted in the negative percent recovery of unmodified asphalt binders. The actual end time of the creep portion was between 1s and 1.1s. Based on this observation, an improved calculation method was developed for percent recovery. This improved method consisted of two steps. The first step was to calculate the time lag. The second step was to determine the strain corresponding to the actual end of the creep portion based on the calculated time lag, and to further

determine the percent recovery. After using the improved method, the calculated percent recovery of unmodified asphalt binders became positive; this fact demonstrated the feasibility of the proposed method.

keywords: multiple stress creep and recovery test

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基于煤液化残渣资源化的改性沥青材料研究

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摘　要：煤炭资源的大量使用和洁净煤技术的使用产生了大量的煤液化残渣，由此带来了煤液化残渣的处理问题，同时道路沥青的原料来源受限。在这种背景下，本文简要介绍了煤液化残渣利用的国内外研究现状，分析了煤液化残渣的组成特性，简单说明了实验的方法。探究通过在基质沥青中掺加煤液化残渣和适量的塑化剂如环氧大豆油来改善基质沥青的性能指标，一定程度上缓解道路沥青原料来源受限压力，提高道路沥青的经济性，也为解决煤液化残渣的去处提供了新思路。

关键词：煤液化残渣；路用性能；废物利用

Research on Modified Asphalt Materials Based on Recycling of Coal Liquefaction Residues

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Abstract：

A large amount of coal liquefaction residues was produced by the use of coal resources and clean coal technology,from this it brings the processing of coal liquefaction residue problems,besides,road asphalt source of raw materials was limited at the same time. Under this background, this paper briefly introduces the use of coal liquefaction residue at home and broad , it analyzes the characteristics of coal liquefaction residues and gives a brief description of the experimental method. This study was explored by adding coal liquefaction residue and the right amount of plasticizer, such as epoxy soybean oil in the matrix asphalt to improve the performance,it eases the pressure on the sources of road asphalt sources to a certain extent, and improves the economic efficiency of the road asphalt, new ideas are also provided for the solution of coal liquefaction residue.

keywords: Coal Liquefaction Residue; Recycling

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图像处理在沥青表面能参数测试中的应用

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摘　要：静滴法采用测量试剂液滴与沥青之间的接触角来计算沥青的表面能参数。但是静滴法在测量过程中存在一定的局限：（1）沥青表面基线的定位不准确；（2）试剂液滴的轮廓拟合存在较大误差。针对上述局限，本文从液滴镜面对称性角度提出了动态确定基线的方法，明确了基线位置确定的标准。利用 MATLAB 图像处理功能对图像进行预处理并对液滴轮廓进行分段拟合。准确得到试剂液滴与沥青接触面的基线，准确计算接触角值。选取谷竹 70#基质沥青和 SBS 改性沥青进行试验，并基于上述处理手段对基线和液滴轮廓进行处理。试验证明，改进后的静滴法测得的接触角更符合事实依据，稳定性更佳，能够获得更加准确的表面能参数。

关键词：静滴法；图像处理；轮廓拟合；接触角

Application of Image Processing in Testing Surface Energy Parameters of Asphalt

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Abstract:

The static drop method uses the contact angle between the measuring reagent droplet and the asphalt to calculate the surface energy parameter of the asphalt. However, the static drop method has certain limitations in the measurement process: (1) The positioning of the asphalt surface baseline is not accurate; (2) There is a large error in the contour fitting of the reagent droplets. In view of the above limitations, this paper proposes a method for dynamically determining the baseline from the perspective of mirror symmetry, and clarifies the criteria for determining the baseline position. The MATLAB image processing function is used to preprocess the image and segmentally fit the droplet contour. The baseline of the contact surface of the reagent droplet with the asphalt is accurately obtained, and the contact angle value is accurately calculated. The Guzhu 70# matrix asphalt and SBS modified asphalt were selected for testing, and the baseline and droplet contours were processed based on the above treatment methods. Tests have shown that the contact angle measured by the improved static drop method is more in line with the facts, better stability, and can obtain more accurate surface energy parameters.

keywords: static drop method; image processing; contour fitting; contact angle

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超弹改性沥青裂缝阻断层混合料路用性能研究

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摘　要：为减少裂缝等病害对在役高速公路路面加铺排水沥青面层使用效果的影响，采用SBS改性沥青和超弹改性剂，并结合混合料级配设计方法，设计和研究了一种超弹改性沥青裂缝阻断层混合料 AC-5。通过四点弯曲疲劳试验、动稳定度试验、小梁低温弯曲试验对其抗疲劳性能、高温性能和低温性能进行了评价分析。结果表明：在20℃、1000με的应变控制模式下，超弹改性沥青裂缝阻断层混合料疲劳寿命超过了200000次，动稳定度能够达到5522次/mm，小梁低温弯曲应变7599με，相比常规改性沥青混合料，具有抗疲劳性能优异以及较好的高温稳定性和低温抗裂性。最后，确定了裂缝阻断层的施工工艺，铺筑了479m的试验路，并对其经济性进行分析，可知：缝阻断层单价比Strata应力吸收层降低了44%，比橡胶沥青应力吸收层降低了16%，具有较好的经济性。

关键词：排水路面；裂缝阻断层；应力吸收层；超弹改性沥青；疲劳寿命；高低温性能

Study on Road Performance of Super Elastic Modified Asphalt Crack Resistance Fault Mixture

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Abstract:

In order to reduce the influence of cracks and other diseases on the use effect of drainage asphalt overlay on existing expressway pavement, A superelastic modified asphalt crack resistance fault mixture AC-5 was designed and studied by using SBS modified asphalt and superelastic modifier combined with mix gradation design method. Through four-point bending fatigue test, dynamic stability test and low temperature bending test of trabecula, its fatigue resistance, high temperature performance and low temperature performance were evaluated and analyzed. The results show that the fatigue life of super elastic modified asphalt crack resistance fault mixture exceeds 200 000 times under the strain control mode of 20, 1000. The dynamic stability can reach 5522 times/mm. The bending strain of trabecular beam at low temperature is 7599. Compared with conventional modified asphalt mixture, it has excellent fatigue resistance, better high temperature stability and low temperature crack resistance. Finally, the construction technology of crack resistance fault is determined, and 479 m test road is paved. And its economy is analyzed，the unit price of fracture resistance faults is 44% lower than that of Strata stress absorbing layer and 16% lower than that of rubber asphalt stress absorbing layer.

keywords: Drainage Pavement; Crack Resistance Fault; Stress Absorption Layer; Super Elastic Modified Asphalt; Fatigue Life; High and Low Temperature Performance

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基于遗传算法和符号回归对沥青流变-化学性质联系的探讨

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摘　要：在沥青路面的长期老化过程中，氧化引起的沥青化学性质衍变是驱动沥青物理硬化和失去耐久性的主要原因。沥青流变性质和化学性质的现象学关联是分析沥青老化机理和预测沥青工程性质重要的手段。本研究基于六种共五十六个沥青样品，利用遗传算法和符号回归，探索了沥青主曲线的特征参数 R 值及交叉频率和三类（官能团、四组分、相对分子含量）共十个化学因子的相关关系。结果表明，R 值及交叉频率可以和两类及以上的化学性质进行回归拟合，关联模型得到的拟合结果相关系数分别可以达到 0.85 和 0.91。本研究解决了传统沥青物理-化学性质关联模型不具有普适性的问题，同时本研究方法可以推广到其他沥青材料和沥青路面工程里难以建议函数关系的问题研究中。

关键词：沥青；遗传算法；符号回归；流变性质；化学性质

The Use of Genetic Algorithm and Symbolic Regression to Connect the Rheological and Chemical Properties of Asphalt Binders

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Abstract:

The change in oxygen-containing functional groups, asphalt fractions and molecular distributions is the driving factor for the rheological evolution of asphalt binder during oxidative aging. This paper investigated the phenomenological connections between the rheological properties and chemical properties of asphalt binder based on the genetic algorithm and symbolic regression method. Results show that the characteristic rheological parameter R value and crossover frequency can be well related with two or three chemical properties, which is regardless of the asphalt binder type and aging state. The method used in this study provides a convenient way to solve the problem that is hard to establish function relationship in asphalt pavement engineering.

Keywords:genetic algorithm;symbolic regression;rheological model;chemical property;connection

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A Multi-Aspect Understanding of Self-Healing Behavior in Asphalt Materials

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Abstract: A comprehensive understanding of the healing characteristics of asphalt materials allows the optimal usage of asphalt mixtures. In this paper, a multi-aspect experimental approach was used to gain more insight into the healing behavior of asphalt materials. Both the results from the Binder Bond Strength (BBS) test and CT-Scan test indicated that styrene–butadiene–styrene (SBS) has a negative effect on the adhesive healing property of asphalt binder. However, when it comes to the mixture level, SBS modified asphalt shows its superior healing potential measured by Four-Point Beam 4PB (4PB) test. In addition, it was found that both the cohesive and adhesive healing of the binder can affect the fatigue performance of the mixture. By comparison, the cohesive healing plays a more significant role than adhesive healing in the fatigue behavior of asphalt mixture. This finding explains the different healing performances of SBS modified asphalt measured from two scales: the binder test and the mixture test. Finally, a new index was put forward to predict the mixture's fatigue performance in Overlay Test (OT) using the adhesive healing and cohesive healing properties of the asphalt binder.

Key words: asphalt materials; self-healing; puff-off test; Overlay Test; fatigue performance

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松香树脂对 SBS 改性沥青的性能影响研究

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摘　要：为了研究松香树脂对 SBS 改性沥青的性能影响，本文采用室内旋转薄膜烘箱试验模拟 SBS 改性沥青的老化过程，研究了不同含量的松香树脂对 SBS 改性沥青的抗老化性能影响；通过动态剪切流变仪中的多重应力蠕变恢复（MSCR）试验，研究了松香树脂对 SBS 改性沥青抵抗永久变形能力的影响；运用表面能的方法计算了沥青与集料之间的结合能，分析了松香树脂对 SBS 改性沥青和集料黏附性的影响。研究结果表明：松香树脂能提高 SBS 改性沥青的抗老化性能，增大了 SBS 改性沥青的抵抗永久变形的能力，同时也提高了 SBS 改性沥青与集料的黏附性。

关键词：松香树脂

Research on Properties of SBS Modified Asphalt by Rosin Resin

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Abstract:

In order to study the effect of rosin resin on the properties of SBS modified asphalt, the aging process of SBS modified asphalt was simulated by indoor rotating film oven test. The effects of rosin resin with different content on the aging resistance of SBS modified asphalt were studied.The effect of rosin resin on the permanent deformation resistance of SBS modified asphalt was studied by multi-stress creep recovery (MSCR) test in dynamic shear rheometer.The binding energy between asphalt and aggregate was calculated by using the method of surface energy, and the influence of rosin resin on the adhesion of SBS modified asphalt and aggregate was analyzed.The results show that rosin resin can improve the anti-aging performance of SBS modified asphalt, increase the ability of SBS modified asphalt to resist permanent deformation, and also improve the adhesion of SBS modified asphalt and aggregate.

keywords: Rosin resin

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不同集料表观特性对沥青-集料黏附性能的影响

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摘　要：为了探究集料表观特性对沥青—集料黏附性能的影响，选取集料图像测试系统测试集料的表观特性，采用磁悬浮重量平衡系统测试精细化加工工艺加工的玄武岩和辉绿岩、常规加工工艺加工的玄武岩和辉绿岩等四种集料的表面能参数，使用表面张力仪测试国创 70#基质沥青、克拉玛依沥青两种沥青的表面能参数。通过 Young—Dupre 方程计算沥青—集料黏附能并与集料表观特性建立联系。试验结果表明，精细化加工比常规加工的玄武岩棱角性增加 203.3，表面纹理增加 18.20，与克拉玛依沥青的黏附能增加 34.16 erg/cm2，与国创 70#基质沥青的黏附能增加 20.8 erg/cm2；常规加工比精细化加工的辉绿岩棱角性增加 432.8，表面纹理增加 10.7，与克拉玛依沥青的黏附能增加 12.69erg/cm2，与国创 70#基质沥青的黏附能增加 3.59 erg/cm2。

关键词：表观特性；集料；黏附性；表面能

Effect of Apparent Characteristics of Different Aggregates on Adhesive Properties of Asphalt-Aggregate

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Abstract:

In order to investigate the influence of the apparent characteristics of aggregate on the adhesion performance of asphalt-aggregate, the aggregate image test system was selected to test the apparent characteristics of the aggregate, and the basalt and diabase were processed by the magnetic suspension weight balance system. The surface energy parameters of four kinds of aggregates, such as basalt and diabase, processed by processing, the surface energy parameters of Guochuang 70# matrix asphalt and Karamay asphalt were tested by surface tension meter. The asphalt-aggregate adhesion energy was calculated by the Young-Dupre equation and correlated with the apparent characteristics of the aggregate. The experimental results show that the sharpening of the basalt is 203.3, the surface texture is increased by 18.20, the adhesion with Karamay pitch is increased by 34.16 erg/cm2, and the adhesion with Guochuang 70# matrix asphalt is increased by 20.8 erg/cm2. Conventional processing has an angular increase of 432.8 compared with the refined processing of diabase, the surface texture increased by 10.7, the adhesion with Karamay pitch increased by 12.69 erg/cm2, and the adhesion with Guochuang 70# matrix asphalt increased by 3.59 erg/cm2.

keywords: apparent properties; aggregate; adhesion; surface energy

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湿度对沥青混合料黏弹性性质的影响

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摘　要：为研究湿度对沥青混合料黏弹性性质的影响，对两种沥青混合料试件进行 0%、50%、80%及 100%四种湿度水平下的单轴拉伸动态模量试验，绘制不同湿度水平下动态模量和相位角的主曲线并汇总，通过动态模量比、损失模量比及存储模量比分析沥青混合料黏弹性性质的变化情况。研究表明：当湿度增加到 100%时沥青混合料的动态模量有所下降，当车速在 60~120km/h 时，类型 1 混合料模量下降约 21%，类型 2 混合料模量下降约 35%；存储模量比先增大后减小，损失模量比逐渐减小，表明湿度的增加使得沥青混合料黏性增强，弹性减弱。但当湿度过高，由于沥青黏附性减弱造成沥青混合料整体黏弹性均有所减弱。

关键词：沥青混合料；湿度；黏弹性性质；动态模量比；损失模量比；存储模量比

Effect of Humidity on Viscoelastic Properties of Asphalt Mixture

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Abstract:

In order to study the effect of humidity on the viscoelastic properties of asphalt mixture, the uniaxial tensile dynamic modulus tests were carried out on the two types of asphalt mixture specimens at 0%, 50%, 80% and 100% relative humidity. The master curves of dynamic modulus and phase angle were summarized at different humidity levels, and the changes of viscoelastic properties of asphalt mixture were analyzed by dynamic modulus ratio, loss modulus ratio and storage modulus ratio. The research shows that when the humidity is increased to 100%, the dynamic modulus of asphalt mixture decreases with the increase of humidity. When the vehicle speed is 60~120km/h, the modulus of type 1 mixture decreases by about 21%, and the modulus of type 2 mixture decreases by about 35%; the storage modulus increases first and then decreases, and the loss modulus ratio decreases gradually, indicating that the increase of humidity makes the asphalt mixture more viscous and less elastic. However, the higher relative humidity makes viscoelasticity of all asphalt mixture pale due to the weakening of asphalt adhesion.

keywords: asphalt mxture; moisture; viscoelastic properties; dynamic modulus ratio; stroage modulus ratio; loss modulus ratio

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Laboratory Investigation of Aggregate Morphological Properties on Performance of Warm Mix Asphalt Containing RAP

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Abstract: The properties of the asphalt and aggregate in the warm mix asphalt (WMA) containing reclaimed asphalt pavement (RAP) are critical to the performance of the mixture. This study quantified the effects of the physical properties of WMA containing RAP through the grey relational theory. The asphalt and aggregate properties involved in this study included the RAP percentage, the two-dimensional morphological properties of recycled aggregate, the three-dimensional angularity of recycled aggregate, and the surface energy of recycled asphalt. The high-temperature performance represented by the dynamic stability, low-temperature indicated by the maximum bending strain; and the moisture susceptibility characterized by the tensile strength ratio were used as the target. Variables for evaluating the impacts of different properties. The results showed that the RAP content had the strongest influence on the high-temperature performance, followed by the surface energy of asphalt and the spherical degree of aggregates. The shape factor that indicates the irregularity of the aggregate particle significantly affected the low-temperature performance. The surface energy of the asphalt considerably influenced the moisture susceptibility. Higher surface energy in the asphalt contributed to better moisture damage resistance.

Key words: Warm mix asphalt; RAP; Grey Relational Analysis; Influential Factors; Aggregate Morphology

Effect of SBS Modifier Dosage on the Properties of SBS Modified Asphalt and its FTIR Characterization

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Abstract： In order to study the effect of SBS content on the elas-plastic properties and durability of asphalt, the change in spatial interaction network of the SBS modified asphalt was explored. The modified asphalt with SBS dosages of 2.5%, 3.0%, 4.0% were prepared and the elastic-plastic properties were tested. The changes of the functional groups were also investigated through the FTIR test. The findings showed that with a change of SBS content, the softening point, penetration index, ductility, and viscosity-toughness did not exhibit an obvious trend, indicating these indexes are not sensitive to SBS content. After the short-term aging, all the indexes showed a continuous trend, indicating the asphalt after short-term aging is more suitable to evaluate the performance variance. The addition of SBS introduced new functional groups into the matrix. However, the increase of SBS content can only bring the increase in functional groups, but does not change the spatial network.

Key words: SBS modified asphalt; dosage; elas-plastic properties;durability; FTIR characterization

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十年重载运营下环氧沥青钢桥面铺装耐久性评估研究

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摘　要：苏通大桥2008年通车运营后，截至2017年10月环氧沥青混凝土铺装层已出现多种病害类型。然而，目前国内外针对运营期内钢桥面铺装的耐久性评估几乎处于空白状态。因此，课题组调查并检测了苏通大桥钢箱梁环氧沥青混凝土桥面铺装的使用状况，结果表明：重车道不同位置处的强度均有不同程度上的衰减，其中上坡段桥面铺装层受损最为严重；环氧沥青混合料的抗裂性能受外界条件的影响较小；复合梁中在受力复杂桥段且病害威胁处的混合料抗弯拉强度有明显下降，变形性能有先增大后减小的趋势；单层梁中凡存在脱空病害且受力复杂的桥面铺装层处其铺装下层混合料低温性能均不如铺装上层；环氧沥青混合料的水稳定性较好。

关键词：苏通大桥；钢桥面铺装；环氧沥青混凝土；在役桥梁；耐久性评估

Study on Durability Evaluation of Epoxy Asphalt Steel Bridge Deck Pavement Under Heavy Load Operation for Ten Years

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Abstract：

After the Sutong Bridge was opened to traffic in 2008, as of October 2017, a variety of disease types have appeared in the epoxy asphalt concrete pavement. However, as of now, the durability evaluation of steel bridge deck pavement during the operation period is almost blank. Therefore, the research team investigated and tested the use condition of the epoxy asphalt concrete pavement for steel box girder of Sutong Bridge. The results show that the strengths of different positions in the heavy lane have different degrees of attenuation, and the pavement layer of the uphill section is the most damaged. The crack resistance of the epoxy asphalt mixture is less affected by external conditions. The bending strength of the double-layer beam in the complicated force bridge section and the threat of disease is obviously decreased, and the deformation performance first increases and then decreases. In the single-layer beam, there is a bridge surface pavement with disengaging disease and complicated forces. The low temperature performance of the lower layer of the pavement is not as good as that of the upper layer of the pavement. The epoxy asphalt mixture has good water stability.

keywords: Sutong bridge; steel deck pavement; epoxy asphalt concrete; existing bridge; urability evaluation

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Compatibility Between Aged and Unaged Binders in Bituminous Mixtures

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Abstract: Asphalt binders in bituminous mixtures with reclaimed asphalt pavement (RAP) comprise fractions of both aged and unaged binders, existing as a single entity. The degree of blending between the aged and virgin binder dictates the extent of homogeneity of the binder in the mix and consequently its mixture performance. However, their mechanism of interaction is still not well understood. In this study, a fundamental measure of compatibility between aged binders and unaged binders was evaluated exercising an extension of the Hansen Solubility Parameter (HSP) model of solubility. Nine binders consisting of unaged binder, field aged binders and artificially aged binders were tested using a method of turbidimetric titrations, to identify the internal stability of the binders and relative extents of different intermolecular interactions in terms of dispersive forces, hydrogen bonding and polar interactions. The results show that some aged and unaged binders noticeably differ in terms of polar interactions, which in dominance may lead to low dispersibility of molecules and increased molecular associations. These findings were further corroborated by chemical composition analysis based on saturates, aromatics, resins and asphaltene (SARA) fractionation which implied that the content of the highest polar fraction, i.e., asphaltene, was significantly higher in the aged binders. Overall, the study indicated that there are noteworthy differences in internal stability and composition between aged and unaged binders. Consequently, mixing of certain virgin-aged binder pairs could be more compatible than others based on their solubility parameters. To attain a homogenous blend while incorporating RAP, a more careful and detail-oriented approach that considers chemistries and inter-solubility of these components is recommended.

Key words:RAP; Compatibility; RAP mixing; Bitumen Ageing; Solubility

铁路沥青混凝土 I-II 复合型裂纹扩展研究

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摘　要：与传统的水泥混凝土轨下基础相比，铁路沥青混凝土轨下基础在防水损、防冻裂等方面具有较为优异的表现，但是，高频荷载的作用也许会加快该结构出现疲劳损伤的进程。本文基于细观力学和断裂力学理论，结合离散元模拟，分析讨论含微裂纹沥青混合在常荷载作用下，I-II 复合型裂纹的扩展规律。首先，基于 Eshelby 等效夹杂理论，建立沥青混合料中微裂纹演化模型。随后，根据断裂力学等理论中控制裂纹扩展的 3 个基本方程，考虑裂纹的偏转角对裂纹扩展的影响，建立沥青混合料 I-II 复合型裂纹扩展模型。最后，采用离散元数值模拟，建立含有不同偏转角微裂纹的沥青混合料虚拟试件，进行间接拉伸（IDT）试验，分析初始裂纹偏转角在二维平面内对裂纹扩展的影响。研究结果表明：（1）在裂纹孕育时间内，其能量释放率 G 与裂纹张开位移随时间缓慢增大，然而沥青混合料有效模量随时间减小。（2）在常外力作用下，微裂纹偏转角 β 的增大，使微裂纹由稳定状态转向非稳定状态，致使微裂纹孕育时间缩短，从而导致沥青混合料失稳破坏进程加快。（3）在常外力作用下，沥青混合料微裂纹数量随着偏转角 β 的增大而逐渐减小。

关键词：铁道工程；铁路沥青混凝土；I-II 复合型裂纹；Eshellby 等效夹杂；IDT 虚拟试验

Study on I-II Composite Crack Propagation of Railway Asphalt Concrete

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Abstract：

For the Under-Rail Foundation, the asphalt concrete has better performance in waterproof damage and anti-frozen, compared with the traditional cement concrete. However, the high-frequency load may accelerate the fatigue damage process for asphalt concrete. In this paper, based on the Micromechanics and Fracture Mechanics Theory, the expansion law of I-II composite crack under the action of fixed load with microcrack asphalt mixture is analyzed by combined with discrete element simulation. Firstly, based on Eshelby Equivalent Inclusion Theory, microcrack evolution model in asphalt mixture is established. Then, according to the three basic equations of crack propagation in Fracture Mechanics Theory, the I-II composite crack propagation model is established with considering the influence of the deflection angle of crack. Finally, using the discrete element numerical simulation, the asphalt mixture visual simple with different deflection angle microcrack is established and the indirect tensile(IDT) test is carried out to analyze the influence of the initial crack deflection angle on crack propagation in a two-dimensional plane. It is found that the energy release rate G and the crack opening displacement increase slowly over time, while the effective modulus of the asphalt mixture decreases during the crack incubation time. The simulation results data suggest that under ordinary external force, the deflection angle β of microcracks is

increased, so that microcracks unsteady state by the stable state of the steering, causing microcracks incubation time is shortened, resulting in instability and failure asphalt accelerated and the number of microcracks in asphalt mixture decreases with the increase of deflection angle β.

keywords: Railway Engineering; Railway Asphalt Concrete; I-II Composite Crack; Eshellby Equivalent Inclusion; IDT Virtual Test

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沥青路面温拌抗车辙添加剂的性能评价研究

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摘 要：本研究开发制备了两种外掺型沥青路面温拌抗车辙复合添加剂，并将之用于不同的沥青材料（基质沥青、改性沥青）和 SUP20 沥青混合料，对其高低温性能、抗水损害性能及降温压实性能等路用性能进行了分析研究，结果表明：掺加温拌抗车辙剂后，一方面可显著提升沥青材料的 60℃黏度，提升其 PG 高温等级，显著提高沥青混合料的高温抗车辙能力，另一方面，可降低沥青材料的 135℃黏度，从而降低沥青混合料的降温压实比，实现沥青路面的绿色施工。

关键词：沥青路面；温拌；抗车辙；复合添加剂；性能评价

Performance Evaluation of Warm Mixing Anti-Rutting Additive for Asphalt Pavement

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Abstract：

Two kinds of composite additives for warm mixing and rutting resistance of asphalt pavement are prepared and used in different asphalt materials (base asphalt, modified asphalt) and Sup-20 asphalt mixture. The pavement performance, including high and low temperature performance, water damage resistance and cooling compaction performance, are analyzed. The results show that, adding warm mixing anti-rutting agent can significantly improve 60°C viscosity of asphalt material and enhance its PG high temperature grade, which significantly improving the high temperature anti-rutting ability of asphalt mixture. On the other hand, 135°C viscosity is reduced, which reducing the temperature-reducing compaction ratio of asphalt mixture and realizing the green construction of asphalt pavement.

Keywords:asphalt pavement; warm mix; rutting resistance; compound additives; performance evaluation

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Physical, Rheological and Chemical Evaluation of Asphalt Rubber Binder Modified with Heavy Bio Oil

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Abstract: Asphalt rubber (AR) is a sustainable paving material with merits including waste tire consumption, low traffic noise and enhanced mechanical performance. However, the poor workability and storage stability limited its further application. This study attempted to alleviate these two concerns of AR simultaneously by incorporating heavy bio oil (HBO). To achieve this goal, bio-AR binders with three different mixing sequences were prepared. A series of rheological and chemical tests were conducted. Test results proven that the bio-AR binders exhibited superior rutting and fatigue resistance compared to AR binder. The viscosity values of bio-ARs were closed to AR modified with commercial warm mix additive, indicating enhancement in workability. Due to the relatively high density of HBO, the density difference between asphalt liquid phase and crumb rubber in bio-AR system was narrowed, bringing improved storage stability. Among bio-ARs prepared with different mixing sequences, the direct mixing one (ARB) had the most satisfied overall performance. The early incorporation of HBO had limited negative influence on binder performance, but allows for more energy saving during the bio-AR binder production process. Future study will be conducted on performance of bio-AR mixtures and quantitative estimation of its energy saving during blending and compacting process.

Key words: Asphalt rubber; Bio-Asphalt; Mixing Sequence; Workability; Storage stability

旋转蒸发器法回收沥青试验改进方法研究

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摘　要：为解决回收沥青中残留三氯乙烯影响沥青性质的问题，对《公路工程沥青及沥青混合料试验规程》（JTJ E20-2011）中旋转蒸发器法回收沥青的方法与步骤进行改进，将整个过程分为常温、中温和高温三段进行，提出常温阶段控制回收沥青的量是决定后续阶段蒸馏时长的主要因素，回收沥青试验结果证明改进方法更加合理、准确。

关键词：旋转蒸发器法；三氯乙烯；回收沥青

Research on Improved Test Method of Recovery of Asphalt by Rotary Evaporator

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Abstract:

In order to solve the problem that the residual trichloroethylene in the recycled asphalt affects the properties of asphalt, the method and steps of the rotary evaporator method for recovering asphalt in the《Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering》(JTJ E20-2011) will be improved. The whole process is divided into three stages: normal temperature, medium temperature and high temperature. It is proposed that the amount of asphalt recovered in the normal temperature stage is the main factor determining the length of distillation in the subsequent stage. The test results of recycled asphalt prove that the improved method is more reasonable and accurate.

keywords: rotary evaporator method; trichloroethylene; recycled asphalt

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Gradation Evaluation of Recycled Asphalt Pavement Materials Based on Variability

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Abstract: The thermal regeneration technology of asphalt pavement can make full use of recycled asphalt pavement material (RAP), save resources and protect the environment. RAP is increasingly wide-used in the maintenance of asphalt pavement.In this paper, the principle of variability of used materials was studied, the key indexes of variability were analyzed, and the recycled materials were graded and evaluated by orthogonal test. This study founded that the content and the properties of asphalt and the change of gradation had an effect on the performance of the reclaimed material, and the grading variation with the fineness modulus had a great influence on the reclaimed materials.

Key words:recycled materials; orthogonal tests; variability; regeneration

混合料细观结构特性的旋转压实成型仿真研究

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摘　要：沥青混合料的压实特性影响道路的使用性能，目前国内外对于混合料压实的研究一直停留在表象、宏观的层次，针对混合料压实过程中的细观结构特性开展更深入、更科学的研究工作意义重大。数值仿真技术可以直观地反映混合料的内部细观结构，为从细观层次研究混合料旋转压实成型的规律并定量地分析集料颗粒运动、受力等细观结构特性提供了可行性。首先利用 CT 扫描技术与 MATLAB 软件获得真实集料颗粒的轮廓模型，并导入离散元软件 PFC3D 5.0 进行填充得到虚拟集料颗粒；其次，在 PFC 软件内生成了特定空间，并逐级填充集料颗粒，生成特定级配的虚拟混合料试样；最后，开发了虚拟旋转压实平台并搭建了恒压伺服控制系统，成功模拟了混合料的旋转压实，并以矿料间隙率为指标进行了实验室旋转压实验证试验。结果表明：基于离散元软件在细观层次定量分析混合料旋转压实成型的规律是可行的，研究混合料的压实细观结构特性更有助于设计混合料，以及更好的评价混合料的路用性能。

关键词：混合料；仿真；旋转压实；细观结构；动态变化

Simulation Study on Rotational Compaction for Microstructure Characteristics of Mixtures

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Abstract：

The compaction characteristics of asphalt mixture affect the performance of roads. At present, the research on the compaction of mixed materials has been at the level of appearance and macroscopic level. It is of great significance to carry out more in-depth and scientific research on the micro-structural characteristics of the compaction process of asphalt mixtures. The numerical simulation technology can directly reflect the internal mesostructure of the mixture, and it is feasible to study the law of the rotary compaction of the mixture from the mesoscopic level and quantitatively analyze the mesostructure characteristics such as the motion and force of the aggregate. Firstly, the CT model and MATLAB software are used to obtain the contour model of real aggregate particles, and the discrete element software PFC3D 5.0 is used to fill the virtual aggregate particles. Secondly, a specific space is generated in the PFC software, and the aggregate particles are filled step by step. The virtual mix sample with specific grading is generated. Finally, the virtual rotary compaction platform is developed and the constant pressure servo control system is built. The rotary compaction of the mixture is successfully simulated, and the gap ratio of the mineral material is used as an indicator. Laboratory rotary compaction verification test. The results show that it is feasible to quantitatively analyze the law of rotary compaction of the mixture based on discrete element software. It is more helpful to study the compacted and meso-structural characteristics of the mixture to design the mixture and better evaluating the road performance of

the mixture.

keywords: mixture; simulation; rotary compaction; mesostructured; dynamic changes

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Influence of Ultraviolet Aging on Physical and Rheological Properties of Warm Mix Asphalt Binders

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Abstract: The influence of ultraviolet (UV) aging on properties of warm mix asphalt (WMA) binders is not known in great detail. The object of this study was to investigate the physical and rheological properties of WMA binders after the rolling thin film oven (RTFO)and artificially UV aging procedures in the laboratory. Two WMA binders and one control hot mix asphalt (HMA) binder were adopted. The conventional physical properties tests, dynamic shear rheometer (DSR), repeated creep recovery and bending beam rheometer (BBR) tests were performed according to SuperpaveTM test protocols, and various aging parameters were compared.In general, the test results indicated that, the warm mix asphalt binders'penetration and ductility decreased,the softening point and 135℃ viscosity increased after UV aging. The G*/sinδ and the stiffness of asphalt binders increased, whereas m-value decreased.In addition, repeated creep recovery tests found that the WMA binder has a better UV aging resistance compared with HMA binder, the SBS modified WMA binder exhibits the best UV aging resistance.

Key words: warm mix asphalt; ultraviolet aging; physical and rheological properties; DSR; BBR

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助剂和制备工艺对 SBS 改性沥青 RTFOT 老化性能的影响

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摘　要：采用常规指标试验、傅里叶变换红外光谱试验（FTIR）、荧光显微镜分析了在 5%改性剂掺量下，不同助剂含量和剪切时间的 SBS 改性沥青在不同老化时间的性能指标、化学组成和微观分布的变化规律。结果表明：随着老化时间延长，软化点均出现先降后升的两阶段老化；加入助剂或者适当延长剪切时间，均能够提高 SBS 改性沥青的 5 ℃延度；微观结构分析进一步证实 SBS 改性沥青在老化过程中软化点出现了两阶段老化。

关键词：助剂；制备工艺；SBS 改性沥青；RTFOT；老化性能

Effect of Additives and Preparation on RTFOT Aging Properties of SBS Modified Asphalt

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Abstract：

The performance indexes, chemical composition and microdistribution variations of SBS modified asphalt with 5% modifier content at different aging time were analyzed by conventional index test, Fourier transform infrared spectroscopy (FTIR), and fluorescence microscope using different additive content and shear time. The results showed that softening point appeared two distinct aging phases with the aging time, which droped at first stage and then rised up. The 5℃ ductility of SBS modified asphalt are improved by the addition of additive or appropriate shear time. Moreover, two distinct aging phases of the softening point of SBS modified asphalt was further confirmed through microstructure analysis.

keywords: Additive; Preparation; SBS Modified Asphalt; RTFOT; Aging Performances

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Feasibility Study on Transition from Marshall Mix Design to Superpave Mix Design in Pakistan

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Abstract: Roads in Pakistan are usually built based on the Marshall mix design (MMD) approach. In past years Pakistan roads are facing premature failure which may be a result of the use of an old age conventional method of road construction using the Marshall approach of designing mix. Superpave is a new method for mix design based on a more experimental approach. Marshall and Superpave mix design approaches are here compared to determine the procedure that gives relatively economical and better performing flexible pavements. The comparison here is based on the strength parameters like Marshall stability and indirect tensile strength and optimum binder content. For MMD, optimum binder content was determined by calculating the percentage of binder for maximum bulk density, maximum stability, and 4 percent air voids. For Superpave samples, optimum binder content was determined for Ndes gyrations on the curves potted between a number of gyrations and corrected densities and indirect tensile strength test was conducted on each sample. The samples compacted through Superpave gyratory compactor gave lesser OBC and more density at lower binder percentage as compared to marshal mix design procedure. Lower asphalt content obtained from Superpave mix design (SMD) suggests that pavements prepared from Superpave approach would be less susceptible to rutting and bleeding.

Key words: Marshall Superpave;Gyratory compactor;Indirect tensile strength Rutting

Potential Utilization of Cement-Treated Recycled Tire Rubber in Place of Mineral Aggregate in Stone Matrix Asphalt Mixture

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Abstract: The objective of this study is to explore the potential utilization of cement-treated recycled tire rubber to replace part of mineral aggregates in stone matrix asphalt (SMA) mixtures. First, the #8 and #16 recycled tire rubber particles were treated by Portland Type I cement. Second, along with a Control group, twelve testing groups were conducted considering different combinations of rubber sizes and proportions. Finally, the performances of SMA mixtures were investigated through indict tensile (IDT) strength, Hamburg wheel track (HWT), four-point bending beam fatigue and environmental scanning electron microscope (ESEM) tests. The results showed that SMA mixtures with cement-treated rubber had better moisture resistance, anti-stripping resistance, fatigue cracking resistance and rubber-asphalt bonding than that of mixtures with untreated rubber. Results also clearly indicated that the SMA mixtures with 50% of #16 mineral aggregates replaced by cement-treated tire rubber showed the satisfied performances; while, with a further increase in replaced size or proportion, the satisfied performances of SMA mixtures would be degenerated.

Key words: Potential Utilization; Mineral Aggregate; Cement-treated Recycled Tire Rubber; Stone Matrix Asphalt; Performances

Investigation on the Properties of Asphalt Mortar with Different Types of Fine Solid Waste

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Abstract: The self-healing of asphalt materials has been a hot topic recently. Most of the previous studies have focused on the healing modifier, mechanism and modeling. Limited work has been accomplished to fully understand the healing performance of asphalt mortar with different filler types and ratios. Nowadays, plenty of fine solid waste with extremely different physical and chemical properties have been used as alternative filler to limestone powder. This study aims to analyze the effects of different filler types and varied ratios on self-healing capability of the asphalt mortar. Firstly, seven types of filler (limestone, flyash, diatomite and four types of red mud) were mixed to prepare thirty-five groups of asphalt mortar with different filler-bitumen ratios by volume. Secondly, the rheological properties of asphalt mortar were investigated through Brookfield Viscosity and Multiple Stress Creep Recovery. Thirdly, this study examined the effect of each filler type and its ratio on the adhesion and self-healing performance. Lastly, Hamburg Wheel Tracking Test (HWTT) was performed to evaluate the moisture damage and rutting resistance of asphalt mixture with different types of filler. The results indicate that pull-off tensile strength after the first failure-healing cycle in water condition has a good linear relationship with the dynamic stability of asphalt mixture in HWTT. Moreover, Chemical components of filler play a crucial role on the performance of asphalt mortar and mixture. Finally, Red mud can be used as a promising alternative filler to limestone powder, while its chemical components need to be carefully selected.

Key words: Fine solid waste; Red mud; Asphalt mortar; Rheological properties; Self-healing

ATB-30 骨架密实级配与性能验证

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摘　要：为了提出 ATB-30 混合料骨架密实级配，分别采用马歇尔成型方法与垂直振动成型方法成型试件，基于 i 法，以 i 值对应沥青砂浆劈裂强度、抗剪强度最优为原则提出细集料级配，根据课题组已有成果提出粗集料级配、粗细比，拟定 5 组级配，通过力学强度与抗离析性能验证提出级配。结果表明：i 为 0.75 时细集料级配最佳；粗细集料比例为 67:33、70:30、73:27 时 ATB-30 混合料马歇尔稳定度、劈裂强度、抗剪强度分别为规范级配中值的 1.20-1.27 倍、1.06-1.13 倍和 1.18-1.31 倍。经试验段芯样的检测表明振动法与现场的相关性更高，建议采用振动法成型试件以评价大粒径沥青混合料的路用性能。在力学强度与抗离析性能均满足条件的基础上，提出 ATB-30 混合料骨架密实级配。

关键词：大粒径沥青混合料；成型方法；骨架密实级配；力学强度；离析

ATB-30 Dense Skeleton Gradation and Performance Verification

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Abstract:

In order to propose ATB-30 dense skeleton gradation, we using Marshall compaction method and vertical vibration compaction method to form specimens. Based on the I method, as I value corresponding to asphalt mortar cleavage strength and shear strength principle for optimal for fine aggregate gradation. According to the results of the research group, the coarse aggregate gradation and thickness ratio are proposed, then we propose five gradations. Through the mechanical strength and anti-segregation performance verification ,the dense skeleton gradation is proposed. The results shows that: when the I value is 0.75, the mechanical properties of fine aggregate gradation is the best. The Marshall stability、splitting strength and shear strength of ATB-30 mixture are 1.20-1.27 times、1.06-1.13 times and 1.18-1.31 times, respectively. When the ratio of coarse and fine aggregate is 67:33, 70:30 and 73:27, respectively, it is suggested to use vertical vibration method to form specimens to evaluate the road performance of large-stone asphalt mixtures. On the basis of satisfying the mechanical strength and anti-segregation performance, the ATB-30 mixture skeleton dense gradation is proposed.

keywords: Large stone asphalt mixtures;Compaction method;dense skeleton gradation; mechanical properties;segregation

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Effect of Microwave-Activated Crumb Rubber on the Reaction Mechanism, Rheological Properties, Thermal Stability, and Released Volatiles of Asphalt Binder

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Abstract: This study aims to investigate the reaction mechanism, high-temperature properties, thermal stability, and released volatiles of crumb rubber modified asphalt (CRMA) activated using microwaves (i.e. ACRMA). The chemical characteristics determined from Fourier-transform infrared (FTIR) spectroscopy reveal mainly physical reactions in CRMA before and after activation; however, the swelling reaction in ACRMA is more efficient than that of CRMA. These results can be confirmed through atomic force microscopy (AFM) testing. According to the stress creep and recovery (MSCR) results, the high-temperature performance of ACRMA is slightly better than that of CRMA. Microwave activation can decrease the stress sensitivity of rubber asphalt. According to the obtained thermogravimetry TG curves, microwave activation reduces the decomposition temperature of rubber asphalt. Moreover, the total released volatiles of the base asphalt are distinctly higher than those of rubber asphalts, indicating that the CR can suppress the released volatile gases of asphalt. In the initial pyrolysis of rubber asphalts, microwave treatment can reduce the generation of toxic gases. However, in the later stages of this process, the introduction of rubber particles rubber particles before and after activation have little effect on the released volatiles.

Key words: Crumb rubber asphalt; microwave activation; reaction mechanism; rheological properties; thermal stability; volatiles

极端气候对沥青路面使用性能影响研究

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摘　要：通过对全国极端气候状况以路面性能状况进行调查统计，分析了极端气候形式（极端高温、极端低温、强降雨等）与路面破坏形式的关联，研究了极端气候对沥青路面使用性能的影响机理和影响程度。为在沥青路面设计、养护过程中充分考虑极端气候的影响提供了参考依据。

关键词：道路工程；极端气候；沥青路面

Study on the Effect of Extreme Climate on Asphalt Pavement Performance

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Abstract:

Through the investigation and statistics of the extreme climate condition in China and pavement performance, the correlation between extreme climate forms (extreme high temperature, extreme low temperature, strong rainfall, etc.) and pavement failure forms was analyzed, and the influence mechanism and degree of extreme climate on asphalt pavement performance were studied. It provides reference basis for fully considering the influence of extreme climate in the design and maintenance of asphalt pavement.

keywords: Road engineering; extreme climate; asphalt pavement

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沥青老化性能评价指标相关性研究

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摘　要：选用了七种不同产地的沥青（SK-70、SL-70、QP-70、PJ-90、TH-90、SK-90、TY-90），分别对其进行了薄膜烘箱试验和紫外光老化试验，分别采用常规试验方法（针入度、软化点、延度和黏度）和动态剪切流变仪（DSR）研究了不同沥青的老化性能，通过线性拟合的方法，建立了不同老化性能评价指标（残留针入度比、延度保留率、软化点增量、黏度老化指数）之间的相关性。结果表明，黏度老化指数与复数剪切模量老化指数之间呈现正相关关系、而与相位角指数之间为负相关关系。残留针入度比、延度保留率、软化点增量与复数剪切模量老化指数、相位角指数之间的线性相关性较差。

关键词：沥青；老化性能；流变性能；相关性

Study on the Correlation of Evaluation Index of Asphalt Aging Performance

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Abstract:

Seven kinds of bitumen (SK-70, SL-70, QP-70, PJ-90, TH-90, SK-90, TY-90) were selected, and the film oven test and ultraviolet light aging test were carried out respectively, using conventional test methods (needle entry, softening point, Elongation and viscosity) and dynamic shear Rheometer (DSR) The aging properties of different bitumen were studied, and the correlation between different aging performance evaluation indexes (residual needle degree ratio, elongation retention rate, softening point increment and viscosity aging index) was established by linear fitting method. The results show that there is a positive correlation between the viscosity aging index and the complex shear modulus aging index, and a negative correlation with the phase angle index. The linear correlation between residual needle intake ratio, elongation retention rate, softening point increment and plural shear modulus aging index and phase angle index is poor.

keywords: Asphalt;Aging Performance;Rheological performance;Correlation

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大空隙超薄磨耗层在高速公路养护中的应用

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摘　要：江苏交通控股系统内高速公路新建项目采用排水沥青路面累计里程约59.5km，高速公路养护项目采用排水沥青路面累计里程约135.5km，总里程达195km。排水沥青路面成套修筑技术体系已经基本成熟。目前，PAC-13型排水沥青路较多地使用在江苏省高速公路大修工程中，如果能在高速公路预防性养护中加铺一种具有类似特性，但厚度较薄的大空隙功能层，既可实现排水、降噪、抗滑等功能，也可节约成本并有效减少后期养护;实现这样的方案需解决空隙结构稳定性、抗剪要求提高等方面的挑战。本文介绍一种大空隙超薄磨耗层材料的设计以及对现场试验段早期观测中的一些技术指标，可供同行设计同类薄层空隙材料参考。

关键词：超薄磨耗层；大空隙；现场试验；排水沥青

Application of Ultra-Thin Wearing Course in Expressway

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Abstract：

In expressways under the management of Jiangsu Communication holding Co.,Ltd., porous asphalt pavement is used in new expressway projects with a cumulative mileage of 59.5 km, while used in expressway maintenance projects with a cumulative mileage of 135.5 km. At present, PAC-13 porous asphalt road is widely used in Jiangsu's Expressway rehabilitation projects. If a functional layer with similar characteristics but thinner thickness is used, it can not only fulfill drainage, noise reduction, anti-skidding and other functions, but also save costs and effectively reduce later maintenance costs. In order to achieve this , the challenges such as the stability of void structure and the higher demand of shear resistance need to be solved. This paper mainly introduces the material design used in a type of ultra-thin wearing course with large air content as well as some test results collected from the field test section, which can be used as a reference for the design of similar materials used in thin layers.

keywords: ultra-thin wearing course; large air content; field test; porous asphalt

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沥青混合料动态模量比对试验研究

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摘　要：文章采用 ASTM-E691 法和稳健统计法对动态模量比对试验结果进行了处理和分析，为了探索实验结果差异性产生的原因，对各实验室成型试件的空隙率进行了分析研究，结果表明空隙率的大小、离散程度直接影响动态模量的试验结果的准确性。

关键词：沥青混合料；动态模量；比对试验；空隙率

Research on the Comparison Test of Asphalt Mixture Dynamic Modulus

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Abstract：

The results of dynamic modulus comparison test are processed and analyzed by using ASTM-E691 and robust statistical method. In order to explore the reasons for the differences of experimental results, the void ratio of the specimens is analyzed and compared. The results show that the size and dispersion of void ratio directly affect the accuracy of the dynamic modulus test results.

keywords: asphalt mixture; dynamic modulus; comparison test; void ratio

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TBS 改性沥青混合料性能试验研究

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摘　要：为了发挥橡胶沥青和 SBS 改性沥青的性能优势，以橡胶沥青在特殊条件下加入 SBS 改性剂生产橡胶复合改性沥青（以下简称 TBS 改性沥青），通过测试分析掺加不同改性剂下 TBS 改性沥青的性能，以及通过室内对比分析 TBS 改性沥青和 I-C 型 SBS 改性沥青成型的 AC-13、SMA-13、SUP-13 型混合料的高低温性能和水稳性能。结果表明：TBS 改性沥青在软化点上与 SBS 改性沥青类似，5℃低温延度和残留延度优于 SBS 改性沥青。在沥青混合料性能上，TBS 改性沥青在不同混合料中的性能均满足规范要求，且 TBS 改性沥青具有更好的抗水损害能力和低温性能，综合性能和使用耐久性更好。

关键词：粘度橡胶复合改性沥青

Experimental Study on Properties of TBS Modified Asphalt Mixture

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Abstract：

In order to make full use of its advantages in the performance of rubber asphalt and SBS modified asphalt, with rubber asphalt adding SBS modifier under special conditions in the production of rubber compound modified asphalt (hereinafter referred to as the modified asphalt by TBS), mixed with TBS under different modifier by test and analysis the performance of modified asphalt, and through the comparison and analysis in laboratory TBS modified asphalt and I - C type of SBS modified asphalt forming AC - 13, SMA - 13, SUP - 13 mixture of high and low temperature performance and water stability performance. The results show that the modified asphalt by TBS is similar to the SBS modified asphalt on the softening point, 5 ℃ low temperature ductility and residual ductility is better than that of SBS modified asphalt. In terms of the performance of asphalt mixture, the performance of TBS modified asphalt in different mixtures all meet the requirements of the specification, and TBS modified asphalt has better water damage resistance and low temperature performance, and better comprehensive performance and service durability.

keywords: Low viscosity rubber compound modified asphalt

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Nano-Leveled Mechanism of Recycling Reclaimed Asphalt Pavement by Different Rejuvenating Agents

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Abstract: Recycling of reclaimed asphalt pavement (RAP) is now a major process in most of asphalt mix plants as a green and sustainable production. Both a virgin asphalt binder and a rejuvenator are commonly used as a rejuvenating agent. This study is to understand the difference in the multi-scaled mechanism of recycling aged asphalt binders by a virgin asphalt and a rejuvenator. To this end, aged asphalt binders were prepared in a lab by using a SHRP aging process of Rotating Thin Film Oven Test (RTFOT) and Pressure Aging Vessel Tester (PAV) on a virgin asphalt binder. Both macro- and microscopic properties of these samples were studied by dynamic shear rheometer (DSR) and atomic force microscopy (AFM). The test results showed that as the dose of a rejuvenating agent increased, 1) smaller and denser "bee-structure" appeared on 2D and 3D topography images of the blends of aged asphalt binder with a rejuvenating agent, and nano-sized quantitative indexes of image surface area difference(SAD), Ra, Rq, Rmax decreased obviously for the blends; 2) Young's modulus, reduced modulus, threshold height and particle size decreased for the blends; 3) the phase angle increased and complex modulus decreased for the blends; 4) the efficiency of the recovering micro- and macro properties was highly dependent on the type of the rejuvenating agent used in the study.

Key words: Particle analysis; Reduced modulus; Atomic force microscopy; Micro-mechanics; Reclaimed asphalt pavement; Flow properties

PPA 应用于沥青中典型污染物溶出分析

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摘　要：本文通过设定一系列不同温度、盐度、pH 值条件模拟使用环境，对沥青及多聚磷酸（PPA）改性沥青混合料试件进行浸泡实验，测定不同因素对各种典型重金属污染物的浸出浓度、酸值及 pH 值影响。结果表明：浸泡温度对浸出液中污染物浓度未见明显影响，盐度增加、浸泡溶液 pH 值低至 2 时会增加沥青中的重金属溶出；与基质沥青相比，经 PPA 改性之后的沥青浸出液酸值及 pH 值没有明显变化，说明 PPA 的加入发生了化学反应后并无酸性离子浸出；与基质沥青相比，PPA 改性之后的沥青浸出液部分重金属浓度降低；因此，PPA 改性沥青的使用并不会对周围地表水体和土壤产生影响。

关键词：PPA；典型污染物；沥青

Dissolved Pollutant Analysis of PPA Applying in Asphalt

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Abstract：

This paper carried on soaking tests of asphalt and PPA Modified Asphalt Mixture Specimens to simulate the use environment by setting a series of different temperature, salinity and pH conditions. Different factors influences were studied on leaching concentration, acid value and pH value of typical heavy metal pollutants. The result shows that the soaking temperature has no obvious effect on the concentration of pollutants in leaching solution, the leaching of heavy metals from asphalt increases with the increase of salinity and the decrease of pH value of soaking solution to 2. Compared with base asphalt, the acid value and pH value of asphalt leaching solution modified by PPA have no obvious change, it shows there was no acid ion leaching after chemical reaction of PPA addition. Compared with base asphalt, the concentration of heavy metals in the asphalt leachate after PPA modification is lower than that of base asphalt. Therefore, the use of PPA modified asphalt will not affect the surrounding surface water and soil.

keywords: PPA; contaminants; asphalt

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Effects of Accelerators and Pre-Curing Time on the Strength of Portland Cement Mortar Under Lower Temperature (5 °C)

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Abstract: Chemical accelerators are often added into cement concrete to improve its earlier strength in winter concreting. To investigate the effect of chemical accelerators, e.g., CaCl2, NaNO2, Na2CO3, and Na2SO4, and pre-curing treatment on the performance of cement mortar under lower temperature (5 °C), the mechanical behaviors, setting time, hydration heat, and microstructure were measured. Results indicated that CaCl2 had better early strength effect on cement mortar with the curing temperature of 5 °C, meanwhile, NaNO2 slightly increased the mechanical behavior, but K2CO3 and Na2SO4 decreased the overall strength， on the contrary. Additionally, setting time and scanning electron microscopy (SEM) proved the prolonging of pre-curing time was not always beneficial to the cement mortar strength development. Proper lower temperatures could reduce micro cracking from cement hydration, which was also conducive to later strength development.

Key words: Lower temperature; Cement mortar; Accelerators; Pre-curing treatment; Winter concreting

Material Characterization to Assess Effectiveness of Surface Treatment to Prevent Joint Deterioration from Oxychloride Formation Mechanism

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Abstract: Joints in a rigid pavement can act as local reservoirs trapping deicing salts and moisture. Such a harsh micro-environment impacts the durability of concrete in cut joint surfaces, resulting in premature distress even in cases where the bulk of pavement exhibits proper durability against frost action and chemical attack by deicing salts. A comprehensive experimental program was undertaken in this study to elucidate the mechanisms of deterioration of concrete exposed to de-icing salts. Plain cement paste samples cast with water-to-cement ratio of 0.40 were exposed to salt solutions prepared with 4% and 20% concentrations of CaCl2 and MgCl2 at 4°C. A second series of paste specimens, treated with a wide range of sealers representing various generic types, were also exposed to the aforementioned salt solutions. Mechanisms of deterioration and formation of chemical compositions and phases were monitored at different exposure periods using X-ray diffraction (XRD), differential scanning calorimetry (DSC), and low-temperature differential scanning calorimetry (LT-DSC). Moreover, concrete specimens were cast and treated with the same sealers to expand the fundamental observations from paste to concrete phase.

Data obtained from plain cement paste specimens indicated no sign of calcium or magnesium oxychloride formation when exposed to 4% concentration of salt solutions, while oxychloride was detected at 20% concentrations. Potential for calcium oxychloride formation in sealed samples correlated well with paste expansion and visual concrete deterioration rates. Results indicated that an expansion threshold of 0.20 mm corresponded to the recommended threshold of oxychloride formation potential of 0.15 gOXY/gPaste.

Key words: Concrete sealer; Joint deterioration; Oxychloride; Rigid pavement

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纤维网格布表层强化混凝土抗冻性能的研究

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摘 要：为了解决寒冷地区机场混凝土道面在长期冻融循环作用下出现的表层开裂、起皮和脱落等问题，本文提出通过在砂浆层中铺设玄武岩纤维网格布和抗碱玻璃纤维网格布来增强机场道面抗冻性能，研究了尾焰喷蚀（烧蚀）、氯盐侵蚀（浸盐）和紫外线照射（紫外）三种环境因素单独和组合作用对纤维网格布强化混凝土抗冻性能的影响规律。对不同种纤维网格布强化混凝土开展了不同环境影响因素作用下的单面冻融试验，并利用 SPSS 软件对试验结果进行了定量分析。结果表明：在复合因素作用下，纤维网格布可以有效增强混凝土抗冻性能，其中玄武岩纤维网格布效果更好；三种因素同时作用对混凝土抗冻性能影响均最大；两种因素同时作用对不同混凝土抗冻性能的影响不同，玄武岩纤维网格布强化混凝土为烧蚀浸盐＞紫外浸盐＞烧蚀紫外，抗碱玻璃纤维网格布强化混凝土和素混凝为烧蚀浸盐＞烧蚀紫外＞紫外浸盐；单因素作用对混凝土抗冻性能的影响次序均为浸盐＞烧蚀＞紫外。

关键词：机场工程；抗冻性能；单面冻融试验

Study on Frost Resistance of Surface Reinforced Concrete with Fiber Mesh

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Abstract:

In order to solve surface cracking, peeling and spalling of airport concrete pavement under long-term freeze-thaw cycle in cold area, this paper proposes to lay basalt fiber mesh and alkali-resistant glass fiber mesh in mortar layer to enhance the frost resistance of the airport pavement. Effect of three environmental factors ,which are tail flame erosion (ablative), chloride salt erosion (chloride corrosion) and ultraviolet radiation (ultraviolet), on the frost resistance of fiber mesh reinforced concrete is studied, in which factors are applied by separate and combined means.Single-side freeze-thaw tests are carried out on different kinds of fiber mesh reinforced concrete under different environmental factors, and the test results are quantitatively analyzed by spss.The result shows that the fiber mesh can effectively enhance the frost resistance of concrete under the effect of composite factors, and the basalt fiber mesh is better; That the three factors are applied simultaneously has the greatest effect on the concrete frost resistance; That the two factors are applied simultaneously has different effects on frost resistance of different concrete.The degree of effect for basalt fiber mesh reinforced concrete is ablation and chloride corrosion> ultraviolet and chloride corrosion >ablation and ultraviolet, and for alkali-resistant glass fiber mesh reinforced concrete is ablation and chloride corrosion> ablation and ultraviolet > ultraviolet and chloride corrosion;the degree of effecte for single factor is chloride corrosion> ablation> ultraviolet.

keywords: Airport engineering, frost resistance, single-side freeze-thaw test

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Evaluation of Early Stage Concrete by Multiple Non-Destructive Methods

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Abstract: Seismic methods are useful tools to non-destructively assess the behaviors of fresh concrete. They have also been applied to characterize the properties of curing concrete to provide information for construction decision. This paper shows that freezing of concrete significantly affects the engineering properties of concrete. In the experimental program, ultrasonic tests were conducted on curing concrete subjected to different freezing process. The results indicate while there exists linear correlation between low strain seismic wave velocity and concrete strength under normal curing conditions, such relationships do not hold if the concrete is subjected to freezing process. A correction accounting for the effects of ice on the bulk strength needs to be applied. This correction was found to have linear relationship with water content. Procedures to correct the effects of freezing are proposed, which include the use of Time Domain Reflectometry to measure the water content. Finally, the strength of concrete in frozen status can be estimated. This information could be incorporated to determine the magnitude of Winter Load Increase in cold regions for government agencies.

Key words: Time Domain Reflectometry (TDR); Early Stage Concrete; Freeze-thaw

Investigation of Multi-Functional Admixtures on the Mechanical Properties of Pervious Concrete Based on Optimum Design of Gradation and Cement-Aggregate Ratio

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Abstract: The performance properties of pervious cement concrete (PCC) could be notably enhanced through adding multi-functional admixtures. This study was to exam the multi-modified effects of different types of admixtures based on optimum design of gradation and cement-aggregate ratio (C/A). The influence of gradation and C/A on the compressive strength and the porosity of PCC were firstly studied. Then a further optimum C/A for a control gradation of aggregates with adhesion admixtures including the water-reducing agent (WA) and reinforcing agent (RA) was conducted. More types of admixtures were further added to enhance the compressive strength. In addition, single-functional admixtures added into the graded PCC were also comparatively explored. The results revealed that 1) there existed a linear regression between the compressive strength and porosity of PCC without admixture; 2) The adhesion admixtures of WA and RA would wrap more cement without the phenomenon of cement segregation, which would result in a bigger optimum C/A and many surplus cement filler; 3) The multi-modified effect by physical fibers on the compressive strength of PCC with adhesion admixtures of WA and RA were all excellent than those of the fine solid wastes; 4) There existed a fairly good relationship between the apparent density and compressive strength of the graded PCC with multiple-functional admixtures.

Key words:pervious concrete;multi-functional admixtures; cement-aggregate ratio; gradation; mechanical strength

含软夹层砂浆冲击破坏特性及能量传递分析

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摘　要：西南山区雨季滚石给山区铁路、公路的防护提出更高要求，滚石冲击作用下不同砌筑材料的动态响应亟待研究。通过 SHPB 冲击试验，对含软夹层的砂浆试件在不同速度下的动态响应、能量传递规律和损伤破坏特性展开研究，研究表明：软夹层延缓了层状材料动态抗压强度的增长速率，将其抗冲击的速度从 3.75m/s 提高到了 5.0m/s；冲击速度大于 5.0 m/s 时，反射、透射能量逐渐减少，耗散能及耗散比的上升速率明显增大；3.31m/s~6.15m/s 的冲击速度范围内，损伤变量满足“公式”，试件破坏时的损伤值约为 0.57。研究结果为山区铁路、公路等设施的防护结构设计提供参考。

关键词：冲击荷载；夹层砂浆；分离式霍普金森压杆；能耗比；损伤变量

Damage Characteristics and Energy Transfer Rules Analysis of Sandwich Mortar Material Under Impact Loading

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Abstract:

In the rainy season of southwest mountainous areas, the rolling stones put forward higher requirements for the protection of railway and highway, and the dynamic response of different masonry materials needs to be studied urgently under the impact of rolling stone. SHPB impact test was conducted to study the dynamic response, energy transfer law and damage characteristics of mortar specimens with soft interlayer at different speeds. The research shows that the soft interlayer slows down the growth rate of the dynamic compressive strength of laminated materials, and increases the impact resistance rate from 3.75m/s to 5.0m/s. When the impact velocity is greater than 5.0m/s, the reflected and transmitted energy decrease gradually, while the rise rate of dissipation energy and dissipation ratio increase obviously. Within the impact velocity range of 3.31m/s~6.15m/s, the damage variable is satisfied the damage value of the sandwich specimen is about 0.57. The results provide reference for the design of protective structure of railway and highway in mountainous area.

keywords: low-speed impact; sandwich mortar;Split Hopkinson Pressure Bar(SHPB);energy consumption ratio;damage variable

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Parametric and Sensitive Analysis of I-II Mixed Mode Fracture of Three Point Bending Beam

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Abstract: In the paper, the I-II mixed mode fracture of a single-edge notch in a three-point bending beam is simulated using the cohesive crack model combining with extended finite element method. An experimental program is performed to validate the accuracy of the numerical model. Based on the numerical model, the impacts of various parameters on the mixed mode fracture behavior of TPB beam are analyzed. The most sensitive parameter to affect the mode I and mode II crack propagation is determined using a Tornado diagram method. The results show that the simulation results match reasonably well with the experimental results, which confirms the accuracy of the numerical model. The parameters discussed in the paper affect the mode I crack propagation characteristic and mode II crack propagation characteristic in varying degrees, for example, the mode I crack propagation is comparatively hindered and the mode II crack propagation is accelerated with increased, however, the mode II crack propagation is relatively restricted and the mode I crack propagation is more evident with increased. Under the I-II mixed cracking mode, the elastic modulus is the most sensitive parameter for mode I component, followed by initial crack length and ultimate tensile strength, while, for mode II cracking, the initial crack length is the most sensitive parameter, followed by elastic modulus and offset position of initial crack.

Key words: Mixed mode fracture;Cohesive crack model;Mixed mode fracture;Cohesive crack model;XFEM;Parametric analysis;Sensitive analysis

Shrinkage Performance and Cracking Resistance of Internal Curing Concrete with Basalt Fiber-Lightweight Aggregate

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Abstract: In order to improve the shrinkage performance and cracking resistance of cement concrete pavement, basalt fiber (BF) and lightweight aggregate (LWA) were added in concrete to investigate the effects of LWA volume replacement rate and different volume of BF combined with optimal LWA on the dry shrinkage of concrete. Then based on the flat crack test, the resistance effect of two factors (LWA volume replacement rate and BF content) on the early crack development of concrete was studied. Finally, the synthetic enhancement mechanism of BF and LWA on shrinkage and cracking resistance of the concrete was revealed. The results show that LWA with appropriate replacement rate is beneficial to reduce the concrete shrinkage rate, and the optimal replacement rate is about 40%; the added BF reduces the maximum crack width and number of cracks in the aggregate concrete, and the effect is significant when BF content is 0.1%; The added LWA promotes the full hydration of the cement in the concrete, especially the hydration products enter the pore structure of LWA and are closely bonded with the LWA, which dramatically improves the compactness of the concrete. The addition of BF limits the cracking development and greatly enhances the toughness of the concrete.

Key words: lightweight aggregate; basaltfiber; Shrinkageperformance; crackingresistance; enhancement mechanism

Influence of Superabsorbent Polymers on the Mechanical Properties and Shrinkage of Pavement Concrete

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Abstract: This paper examines the effect of superabsorbent polymers (SAPs) with varied particle sizes and contents on the mechanical strength and shrinkage of cement concretes. SEM measurements were performed to identify the mechanisms of internal curing. It was shown that the incorporation of SAPs generally increased the compressive strength and shrinkage resistance capability of specimens, especially the relatively small particle sizes. A large number of hydration products were generated and grouped around the remained pores of SAP, which could enhance the hydration degree and improve the compactness of cement concretes, as well as the performance growth.

Key words: Superabsorbent polymer;Internal curing;Mechanical strength;Shrinkage; Mechanisms

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Effect of Vibratory Mixing on Properties of High Strength Concrete and Mixing Process

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Abstract: High Strength Concrete (HSC) has been widely used in various filed, such as highway, construction and railway. It is of great significance in construction practice to study the performances of HSC during different periods, including the mixing process, the stage of fresh concrete, and the stage of harden concrete. The vibratory mixing is a effective technology to improve the mixing process. Vibratory mixing and conventional compulsory mixing were compared, and tests between traditional mixing method, sand enveloped with cement(S.E.C), aggregate enveloped with cement(A.E.C) were carried out, as was the HSC employed. The workability and durability of HSC and the effect of power consumption in mixing process were analysized, also the mixing technique was optimized on the basis of vibratory mixing. Remarkable improvement on the performances of HSC with the vibratory mixing, compared to the ordinary compulsory mixing. It is shown a decline of the plastic viscosity and yield stress, an enhancement of fluidity, a better workability of HSC, an increase of gas content and the compressive strength, and the improvement microstructure in HSC. During the mixing process, the power consumption of HSC and the peak of cohesion point are reduced, the flow point time is advanced, and efficiency of mixing is improved with the technology of vibratory mixing.

Key words:vibratory mixing; HSC; mixing technology; workability; durability; mixing process

水泥稳定碎石的温缩抗裂性能影响因素分析

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摘　要：水泥稳定碎石材料在降温过程中会产生收缩变形，为了研究影响其温缩抗裂性能各因素的显著性，采用 MATLAB 程序生成二维数字试件，并基于内聚力模型和降温过程中系统内部蓄积的应变能，通过有限元软件 ABAQUS 模拟分析了粗集料特性、粗集料-砂浆界面特性对水泥稳定碎石温缩抗裂性能的影响。结果发现影响水泥稳定碎石温缩抗裂性能的因素显著性依次为：粗集料-砂浆界面粘结强度>粗集料-砂浆界面断裂能>粗集料面积占比>粗集料最大粒径>粗集料级配类型>粗集料-砂浆刚度比。因此，适当减少水泥用量和粗集料面积占比，选用适宜的粗集料最大粒径和级配并充分压实水泥稳定碎石可有效提高材料温缩抗裂性能。

关键词：水泥稳定碎石；温缩；抗裂性能；ABAQUS；内聚力模型

Analysis of Factors Affecting Crack Resistance in Temperature Shrinkage of Cement Stabilized Macadam

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Abstract：

Shrinkage deformation will occur in cement stabilized macadam during decreasing process of temperature. In order to study the significance of various factors affecting the crack resistance in temperature shrinkage of cement stabilized macadam, two-dimensional digital specimens are generated by MATLAB algorithm. Based on cohesive zone model and strain energy accumulated during cooling process, the effects of coarse aggregate characteristics and interface characteristics of coarse aggregate and mortar on the crack resistance in temperature shrinkage of cement stabilized macadam were simulated and analyzed in ABAQUS. According to the results, the significance of factors affecting the crack resistance in temperature shrinkage of cement stabilized macadam are as follows: adhesive strength of coarse aggregate-mortar interface > fracture energy of coarse aggregate-mortar interface > proportion of coarse aggregate area > maximum particle size of coarse aggregate > gradation type of coarse aggregate > stiffness ratio of coarse aggregate to mortar. Therefore, appropriate reduction of cement content and proportion of coarse aggregate area, selection of appropriate maximum size and gradation of coarse aggregate and full compaction of cement stabilized macadam can effectively improve the crack resistance in temperature shrinkage of the materials.

keywords:cement stabilized macadam;temperature shrinkage;crack resistance;ABAQUS; cohesive zone model;strain energy

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Analysis of Arch Cracking on Cement Stabilized Macadam Base Asphalt Pavement by Using ANSYS Method

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Abstract: The different degrees of arch cracking has occurred in the cement stabilized macadam base asphalt pavement in the desert and Gobi areas like Inner Mongolia and other places. The temperature of pavement structure layer has been monitored through analyzing the field investigation and excavation, which illustrated that the arch cracking of asphalt pavement is relevant to the arch swell of the cement stabilized base at a high temperature in summer. According to the asphalt pavement design and the temperature distribution of pavement structure, the ANSYS finite element model has been applied in order to analysis the influence of temperature and expansion joints spacing of base on the arch cracking of pavement under the temperature filed. The results demonstrated that the temperature and expansion joints spacing of base have significant impact on the arch cracking of pavement. The conclusion has been driven that setting a swell joint at the cement stabilized macadam base every 200m apart might be an effective approach to avoid the arc cracking of the asphalt pavement in these areas.

Key words: Desert and Gobi areas;Cement stabilized macadam base;Asphalt pavement;Arch cracking;ANSYS finite element

The Independent Characterization and Experimental Study of Coarse Aggregate Angularity

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Abstract: The morphological parameters of coarse aggregates, including the angularity, flat and elongated (FE) and particle size, strongly influence the performance of asphalt concrete. At present, the measurement of the angularity of the coarse aggregate is affected by the particle size and the FE, in order to achieve independent characterization of angularity, compression method is used to eliminate the influence of FE on angularity; In this paper, the angularity index is calculated by fitting ellipse method, which can eliminate the influence of aggregate particle size on the angularity of coarse aggregate. The research results show that the independent characterization of the angularity of coarse aggregates can improve the measurement accuracy of the angularity of coarse aggregates.

Key words: angularity;flat and elongated;particle size;independent characterization; compression method

矿粉表面能与其所含化学成分表面能关系模型

孔令云
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摘　要：为探究矿粉表面能与其组成化学成分间的内在关系，通过灰色关联法与主成分分析法，以矿粉的化学成分质量含量为媒介，对采用毛细管上升法测得的 5 种矿粉、5 种化学成分表面能之间的关系模型进行了量化分析。结果表明：矿粉的表面能实测值与通过其化学成分表面能计算的计算值之间存在良好的关联度；提出了变化的“矿粉表面能”、“化学成分质量含量”与不变的“化学成分表面能”之间定量关系模型，通过该模型可对不同岩石加工的矿粉，在测得其化学成分质量含量后，直接计算得到矿粉的表面能，可为矿粉表面能在道路工程中应用的深入研究提供理论指导。

关键词：沥青路面；关系模型；主成分分析法；矿粉；化学成分；表面能

Relationship Model of Surface Energy Between Mineral Filler and Its Chemical Compositions

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Abstract:

To investigate the relationship of surface energy between mineral filler and its chemical compositions, the grey correlation method and principal component analysis method were employed to quantitatively analyze the relationship model measured by capillary rise method. Results showed that measured surface energy parameters of mineral filler agreed with the value calculated on the basis of chemical composition surface energy parameters. A quantitative model related to the changing "mineral filler surface energy parameter", "chemical composition content" and the unchanging "chemical composition surface energy parameter" was proposed. The surface energy of mineral filler can be determined by this model when the chemical compositions are given. All of the results can provide theoretical direction to further study on mineral filler surface energy for road engineering.

keywords: asphalt pavement; relationship model; principal component analysis method; mineral filler; chemical composition; surface energy

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稳定粉砂土在路基中应用的经济社会效益分析

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摘　要：粉砂土分布广泛，但作为筑路材料来说工程性质较差，因此需通过物理化学措施对其进行稳定。本文通过对各类稳定粉砂土物理化学特性的研究分析，详细阐述了其在路基工程中的应用及其产生的经济社会效益，对推动绿色公路建设，实现公路建设健康可持续发展具有重要意义。

关键词：稳定粉砂土；路基；经济社会效益；绿色公路

Economic and Social Benefits Analysis of Stabilized Silty Soil Applied to Roadbed

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Abstract：

The silt soil is widely distributed, but as a road-building material, it is poor in engineering properties and needs to be stabilized by physical and chemical measures. Through the study and analysis of the physical and chemical properties of all kinds of stabilized silt soil, this paper expounds its application in subgrade engineering and its economic and social benefits. It is of great significance for promoting the construction of green road and realizing the healthy and sustainable development of highway construction.

keywords: Stabilized silt soil; Subgrade; Economic and social benefits; Green Road

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水泥稳定碎石基层材料抗裂耐久性能试验研究

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摘　要：为研究适用于特重、极重交通等级强度要求的水泥稳定碎石基层材料的路用及耐久性能，采用相关试验方法，分析了水泥稳定碎石基层设计强度、级配组成、水泥用量等关键设计指标对压缩模量、抗弯拉、抗冲刷、抗温缩干缩、抗冻融循环、抗疲劳等性能的影响。结果表明：水泥用量是影响水泥稳定碎石路用性能的主要因素；悬浮密实型级配 C-B-1 具有更好的强度、抗裂、抗疲劳性能；骨架密实型级配 C-B-3，具有更好的抗温缩、干缩性能。研究成果可为今后辽宁省乃至东北地区根据气候、交通条件进行水泥稳定级配碎石基层设计提供技术支持。

关键词：水泥稳定材料

Research of Anti-Cracking and Durability Performance of Cement Stabilized Crushed Stone Pavement Base Materials

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Abstract:

Studying on the pavement performance and durability test of cement stabilized crushed stone pavement base materials were researched by being carried out suitable for the strength requirements of special heavy traffic and extremely heavy traffic grade. The cement stabilized crushed stone pavement base design strength, gradation composition and cement content were analyzed by tests of compression modulus, anti-flexural, anti-fatigue, the temperature shrinkage and dry shrinkage performance, anti-erosion performance and anti-freeze-thaw cycles by using correlation method. The trial results show that road performance of cement stabilized crushed stone pavement are influenced serious by cement content. Performances of compressive strength, anti-crack and anti-fatigue of skeleton-dense structure are better than other. Performances of temperature shrinkage and dry shrinkage of suspended-dense structure are better than other. It will provide technical support for the design of cement stabilized crushed stone pavement base in Liaoning province and even northeast China according to the climate and traffic conditions.

keywords:cement stabilized material

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Abrasion Decay Laws of Coarse Aggregates Based on Three-Dimensional Morphology Characterization

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Abstract: In order to quantitatively evaluate morphological characteristics and abrasion decay laws of coarse aggregate so that make an accurate performance evaluation for aggregates, flat-elongated index, sphericity index and specific surface area are proposed to characterize the shape properties of coarse aggregate. Limestone aggregate particles ranging in size scale of 4.75–9.5 mm, 9.5-13.2mm, 19-26.5mm were worn by the Los Angeles Abrasion tester respectively. Three-dimensional (3-D) laser scanner was used to obtain three-dimensional points cloud data of aggregate particles experienced 0, 500, 1000 and 2000 abrasion cycles. Afterwards, the data was processed by the software of reverse engineering based on morphology evaluation indexes, and the minimum bounding box algorithm was developed to calculate flat-elongated index, illustrating the morphological characteristics of coarse aggregate particles with different size and abrasion cycles. Test results show that: aggregates with small size have bigger quantity proportion of elongated particle; the greater the angularity of aggregates was, the faster the angular decay rate of the aggregates was; aggregate particles with small size has richer surface texture but easier to lost in abrasion process. Sphericity index increased, while specific surface area and flat-elongated index presented a downward trend as the particle size became bigger for different abrasion cycles. However, the flat-elongated index of aggregate particles with different size increased abnormally when abrasion cycles increased at 2000 abrasion cycles as the result of aggregate crushing. Besides, the SI and SSA of some 4.75 mm aggregate under 500 abrasion cycles showed an abnormal increasing compared to its 1000 abrasion cycles, which caused by inadequate abrasion under low abrasion cycles. Therefore, the indexes proposed in the study are able to characterize different aspects of coarse aggregates morphological property, and it is beneficial for the evaluation and selection of aggregates used in engineering construction.

Key words: Roadengineering;Coarse aggregate;LosAngeles Abrasiontest;Three-Dimensional Morphology characterization; Abrasion decay law

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基于振动法的砂岩质水泥稳定碎石力学性能研究

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摘　要：为揭示砂岩水泥稳定碎石力学特性，基于垂直振动原理成型试件，研究砂岩类型、水泥掺量、养生龄期对的抗压强度及劈裂强度的影响，采用软化系数指标，研究了砂岩水泥稳定碎石的水稳定性影响因素。结果表明：砂岩产地及水泥掺量影响水泥稳定碎石基层力学特性；4.0%的水泥掺量是无侧限抗压强度随养生龄期变化曲线的转折点；软化系数与砂岩水泥稳定碎石的养生龄期前期正相关，达到峰值后软化系数呈现下降趋势。不同产地的砂岩水泥稳定碎石力学性能符合规范要求，可进行基层施工。

关键词：道路工程；砂岩；水泥稳定碎石；振动成型；力学性能

Study on Mechanical Properties of Vibration Formed Sandstone Cement Stabilized

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Abstract:

In order to reveal the mechanical properties of sandstone cement stabilized macadam, the specimens were formed based on the principle of vertical vibration, and the effects of sandstone type, cement content, compressive strength and splitting strength of the ageing period were studied. The softening coefficient index was used to study the sandstone cement. Factors affecting the stability of the water stability of the crushed stone. The results show that the sandstone production area and cement content affect the mechanical properties of the cement stabilized macadam base; 4.0% of the cement content is the turning point of the unconfined compressive strength with the health-age curve; the softening coefficient is positively correlated with the pre-incidence period of sandstone cement stabilized macadam, and softens after peaking. The coefficient shows a downward trend. The mechanical properties of sandstone cement stabilized macadams from different producing areas meet the requirements of the code and can be applied to the base layer.

keywords: road engineering; sandstone; cement stabilized macadam; vibration forming; mechanical properties

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陕北地区砂岩特性及技术性能研究

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摘　要：针对陕北地区黄延高速公路沿线优质石灰岩匮乏、施工成本增大等问题，本文从陕北地区普遍分布的砂岩矿藏出发，采用 X 衍射试验，分析陕北地区的砂岩成岩过程及矿物组成；进行石灰岩与陕北地区砂岩的物理指标、力学指标的差异性研究。结果表明：砂岩的矿质组成直接影响力学性能，与石灰岩相比，陕北地区砂岩存在孔隙高、强度较低；吸水率更高，抗冻性不佳等特点；砂岩软化系数受自身孔隙率显著影响。

关键词：陕北地区；砂岩；矿物组成；技术性能

Characteristics and Technical Indexes of Sandstone in Northern Shaanxi

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Abstract:

In view of the shortage of high-quality limestone and the increase of construction cost in northern Shaanxi, this paper starts from the sandstone deposits generally distributed in northern Shaanxi, and uses X-ray diffraction test to analyze the diagenesis process and mineral composition of sandstone in northern Shaanxi; carry out limestone and northern Shaanxi. Research on the difference between physical and mechanical indexes of sandstone in the region. The results show that the mineral composition of sandstone directly affects the mechanical properties.

keywords: Northern Shaanxi; sandstone; mineral composition; mechanical index

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Three-Dimensional Modelling for Irregular Aggregate and Asphalt Mixture Considering Shape and Size Distribution

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Abstract: Aggregate occupies at least three-quarters of the volume of asphalt mixture and can significantly affect the performance of pavement. The geometrical morphology influences the slippage and interlock among aggregates for resisting and distributing applied loads. In recent years, the discrete element method (DEM) has been employed for simulation of asphalt mixture structure. This paper introduces an approach for simulation of aggregate and asphalt mixture using parameterized shape and size gradation. Both plane geometry factor (PGF) and section aspect ratio (SAR) were employed to describe the 3D geometric characteristics of aggregates. A numerical technique of aggregate models was implemented with probabilistic parameters depending on statistical results of PGFs and SARs. Therefore, the 3D numerical model of asphalt mixtures was assembled with three different components, which is validated by uniaxial compression test via comparison with that of the laboratory result. It was found that the PGF and SAR are appropriate to describe the three-dimensional features of aggregate shapes, due to the fact that a simplified space object can be described by a 2D graphical projection and a vector scalar corresponding to the space vector. Probability distribution curves of PGFs and SARs between coarse aggregates are in concordance with the Gauss-type function, since their correlation coefficients are all greater than 95%. It was verified that the developed clumping algorithm of aggregates was reasonable with the shapes and size gradation. Based on the parallel-bond model and the Burger's model, the results of virtual tests are in good agreement with those of laboratory uniaxial tests. It is shown that the angularity (PGF) of aggregates has a beneficial effect on the strength and stability while the flat-elongated feature (SAR) has a negative effect on those of asphalt mixtures.

Key words: asphalt mixtures; irregular aggregates; three-dimensional simulation; discrete element method; parameterized shape

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透水路面无细料开级配碎石基层材料力学性能研究

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摘　要：透水路面开级配碎石基层具有储水和透水功能，需要一定的孔隙率、抗水损坏和抗变形能力。选择不含细集料的不同粒径范围的级配碎石和单一粒径碎石为研究对象，测试其在不同围压和偏应力状态下的回弹模量，回归出各个级配的回弹模量力学模型，并和密级配碎石作对比分析。探究干湿两种状态各个级配在荷载逐级加载重复作用下的永久变形特性，以及应力水平剪切应力/强度比 SSR 对永久变形性能的影响。

关键词：级配碎石；透水路面；基层；级配

Investigate on the Mechanical Properties of Open Graded Aggregate Base Materials Without Fine Aggregate for Permeable Pavement

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Abstract：

The permeable pavement base layer has the functions of water storage and water permeability, and requires high porosity and water damage resistance. The open graded crushed stone and single-size aggregate with different particle size range without fine aggregate were selected as the research objects. The resilience modulus under different confining pressure and deviatoric stress state was tested, and the models of each gradations were developed. And the resilience modulus model is compared with the dense graded aggregate. The permanent deformation characteristics of each gradations of both dry and wet states under repeated loading and the effect of stress level using shear stress-strength ratio (SSR) on permanent deformation performance were investigated.

keywords: Aggregate gradation; Permeable pavement;base materials;resilience modulus; permanent deformation;shear stress-strength ratio

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Analysing Fill Surcharge Preloading Consolidation of Highway and Railway Foundation Using Finite Element Method

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Abstract: Geotechnical failures of highway and railway soft foundation soils are common problems in many parts of the world. This paper discusses preloading consolidation of soft railway and highway foundation soil using fill surcharge to minimize post-construction failures. To study preloading consolidation, a finite element method of sequential construction of embankment on top of soft clay layer was made using ABAQUS software. The permeability of clay, initial void ratio and thickness of clay layer were considered as variable parameters for the analysis. The finite element solution indicated that, during the consolidation period, vertical settlement and effective stress of clay increased while pore water pressure and void ratio decreased proportionally. However, the rate of consolidation depends on permeability of clay and drainage path length. Preloading is a good technic to minimize post construction settlement of railway and highway foundation soils.

Key words: Soft soil;Embankment;Consolidation;pore pressure;finite element method

基于两阶段设计的水泥稳定碎石 ITZ 性能研究

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摘　要：本文通过对水泥稳定碎石收缩开裂机理和组成结构分析，得到了水泥稳定碎石的理想界面状态，进而提出基于均匀性的两阶段分层次设计方法。并采用 SEM/EDS 和显微硬度对采用不同拌和工艺和设计方法得到的水泥稳定碎石界面过渡区（ITZ）性能进行研究。结果表明，采用两阶段设计（简称设计）较规范设计方法得到的水泥稳定碎石 ITZ 性能得到改善，微观结构相对致密，缺陷较少，过渡区厚度减小 25%-29%，平均显微硬度提高了 13.8%，揭示了通过均匀性设计改善水泥稳定碎石性能的微观机理。

关键词：水泥稳定碎石；组成结构；界面过渡区；显微硬度；SEM

Study on ITZ Performance of Cement Stabilized Macadam Based on Two-Stage Design

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Abstract：

Based on the analysis of shrinkage cracking mechanism and composition structure of cement stabilized macadam, the ideal interface state of cement stabilized macadam is obtained, and a two-stage hierarchical design method based on homogeneity is proposed. The interface transition zone (ITZ) properties of cement stabilized macadam obtained by different mixing processes and design methods were studied by means of SEM/EDS and microhardness. The results show that the ITZ performance of cement macadam obtained by two-stage design method is better than that by standard design method. The microstructure of cement stabilized macadam is relatively compact, the defect is less, the thickness of transition zone is reduced by 25%-29%, and the average microhardness is increased by 13.8%. The microscopic mechanism of improving the performance of cement stabilized macadam by uniformity design is revealed.

keywords: cement stabilized macadam; composition structure;interface transition zone; microhardness; SEM

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基于均匀性的水泥稳定碎石设计及抗裂性能研究

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摘　要：为改善水泥稳定碎石基层的抗裂性能，本研究通过对其组成结构和收缩开裂机理分析，提出了基于均匀性设计的两阶段分层次设计方法，并得到富余系数 K1 和 K2 取值分别为 1.2 和 1.45。同时对比研究采用不同拌和工艺和设计方法得到的水泥稳定碎石的抗裂性能，并采用 SEM 研究其界面过渡区的微观结构特征以揭示抗裂性改善的微观机理。结果表明，采用均匀性设计较常规方法得到的水稳碎石综合开裂系数降低 19.9%，微观结构相对致密，缺陷较少，界面过渡区减小 30%左右。

关键词：水泥稳定碎石；收缩开裂机理；富余系数；抗裂性能；界面过渡区

Design and Crack Resistance Performance Research of Cement Stabilized Macadam Based on Uniformity

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Abstract：

In order to improve the crack resistance of cement stabilized macadam (CSM) base, based on its composition and shrinkage cracking mechanism analysis, and a two-stage design method based on homogeneity design is proposed. The coefficients of rich K1 and K2 were 1.2 and 1.45. Comparing the comprehensive crack resistance of CSM obtained by different mixing processes and design methods. The microstructure of the interfacial transition zone (ITZ) was studied by SEM to reveal the microscopic mechanism of crack resistance improvement. The results show that the comprehensive crack coefficient of CSM obtained by homogeneity design is 19.9% lower than that by standard design, the microstructure is relatively dense, the defects are less, the thickness of ITZ is reduced by about 30%.

keywords: Cement stabilized macadam; Mechanism of shrinkage and cracking; Coefficient of rich; Crack resistance; Interface transition zone

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基于分形理论的骨料二维形状仿真

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摘　要：为了能获得表征真实骨料轮廓形状的二维数值骨料，本文提出一种采用分形维数指标的骨料重构方法。对真实试件剖面图像进行处理，提取独立的骨料轮廓形状并识别其分形盒维数，采用中点位移法重构出规则分形和非规则分形二维数值骨料。将弹性骨料参数和粘弹性沥青砂浆参数作为模拟参数，对圆形、方形、规则分形和非规则分形四种骨料的数值试件分别进行拉伸和压缩数值试验。结果表明数值试件的力学特性受骨料轮廓形状的影响较大。非规则分形二维数值骨料与真实骨料轮廓具有很好的相似性，并具有更合理的力学特性。

关键词：骨料；数字图像处理；分形维数；数值模拟

Simulation of 2D Aggregate Shape Based on Fractal Theory

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Abstract:

In order to obtain the two-dimensional numerical aggregate characterizing real aggregate profiles, a new method of aggregate reconstruction, which uses fractal dimension index, is proposed in this paper. After processing a cut plane of the real specimen, various independent aggregate profiles, whose fractal dimensions were recognized individually, were extracted. Regular fractal and irregular fractal numerical aggregate profiles were reconstructed using the mid-point displacement method. Numerical specimens containing round, square, regular fractal and irregular fractal aggregates, which adopt elastic parameters of aggregate and viscoelastic parameters of asphaltic sand, are separately analyzed respectively in tension and compression numerical simulation tests. Results show that mechanical behaviors of numerical specimens are influenced by aggregate profiles. Irregular fractal numerical aggregates, which perform the most reasonable mechanical behaviors, are similar to real aggregates.

keywords: aggregate; digital image processing; fractal dimension; numerical simulation

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Low Temperature Characteristics of Treated Crumb Rubber Modified Asphalt After a Long Term Aging Procedure

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Abstract: Crumb rubber modified asphalt has been widely applied in highway construction fields for its environmentally friendly characteristics and also to satisfy the demand of asphalt pavement at different application conditions. Rubberized binders achieve the recycling of scrap tires, reduce the consumption of raw materials and act as an economically beneficial construction material to asphalt pavement. However, long term aging adversely affects the low temperature performance characteristics of rubberized binders. In order to improve the aging resistance of asphalt rubberized binder, a surface treatment was applied on three crumb rubbers. In addition, two binder sources were used to produce the treated crumb rubber modified asphalts to explore their aged performances. In this research, stiffness values and m-values of pressure-aged vessel (PAV) aged rubberized asphalts were obtained from bending beam rheometer (BBR) test at -6℃, -12℃ and -18℃ to determine their minimum low temperatures and to evaluate their cracking resistances. Additionally, Thermal gravity (TG) and Differential Scanning Calorimeter (DSC) test were conducted on all rubbers to explore their thermal stabilities and determine their glass transition temperatures. The results showed that rubbers had good thermal stability at the mixing temperature and the treatment on rubbers promoted the low temperature performance for most rubbers. In addition, positive influences on low temperature properties were observed on the binders produced with medium size rubber in this study. Meanwhile, as expected, binders produced with softer virgin asphalt generally had better cracking resistances regardless of rubber type.

Key words: Rubber treatment; Long term aging;eam rheometer; Low temperature; Grey relational analysis

Experimental Analysis of Aggregate Densities and Deflections for Light Weight Deflectometer Applications

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Abstract: Nuclear gauge has been widely used to determine the in-place dry densities of pavement layers in compaction quality control. However, there is a trend for transportation agencies to use light weight deflectometer (LWD) to measure compaction sufficiency of pavement construction. LWD measurement is capable of providing the in-situ modulus of geomaterials that is one of the key parameters used to characterize the properties of pavement structural layers. Since the measurements of nuclear gauge (density) and LWD (deflection) are different, it is necessary to analyze their relationships with compaction properties, such as moisture content, layer thickness, and construction condition. This study performed intensive laboratory experiments on the aggregate materials to evaluate the effects. Extensive experiments were also performed in the test pits with LWD to determine the effect of aggregate layers on pavement structure. Proctor tests were conducted on selected pavement base materials to establish the moisture-density relationships. Material deflections were also measured on the compacted materials in the Proctor molds to reveal the moisture-deflection relationships. Through the test pits experiments, the contribution of each aggregate layer to the pavement structure capacity was analyzed and quantitated. It was concluded that moisture content has a significant effect on LWD deflection or modulus. Aggregates compacted near the optimum moisture are capable of providing a stable deflection value. After compaction, LWD measured deflection decreases as the moisture content decreases.

Key words: LWD; compaction; moisture contents; dry density; deflection

集料几何特性对颗粒间摩擦效应的影响分析

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摘 要：为研究集料的粒径、棱角性、表面纹理及球度等几何特征对颗粒间摩擦效应的影响，本文使用集料图像采集系统对两种不同岩性、四种不同粒径集料颗粒的几何特征进行表征，采用集料接触装置测试其颗粒间的摩擦效应，通过灰色关联分析法研究了集料不同几何特性对的摩擦效应的影响程度。结果表明，玄武岩集料的棱角性、表面纹理及球度等几何特性均强于石灰岩，因此也表现出较好的摩擦效应。随着粒径的增大，集料间的摩擦效应显著增加。通过灰色关联度对比发现，集料粒径对颗粒间摩擦效应的影响最大，尤其是玄武岩；棱角性及表面纹理对颗粒间摩擦效应的影响程度因集料岩性不同而不同；球度对集料间的摩擦效应影响相对最小。

关键词：集料；几何特性；摩擦效应；灰色关联分析

Analysis of the Influence of Aggregate Geometric Characteristics on Friction Action Between Particles

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Abstract:

To investigate the effect of geometric characteristics, including particle size, angularity, surface texture and sphericity, on friction action between particles, two types of aggregates with different lithology, which had four kinds of particle sizes for each type of aggregate were conducted in this study. Geometric characteristics of aggregates were evaluated using Aggregate Imaging System, and their friction actions were estimated by Aggregate Contact Device. Then influence level of geometric characteristics on friction action were analyzed using grey relational analysis method. Results indicate that geometric characteristics of basalt aggregate, including particle size, angularity, surface texture and sphericity, are stronger than limestone. Hence, it displays a better friction action as well. Friction action obviously increases with the increase of particle size. Compared to grey correlation degrees, particle size has a significant influence on friction action between aggregates, especially for basalt. Influence degrees of angularity and surface texture on friction action between aggregates are different ascribed to the different lithology of aggregate. The effect of sphericity on friction action is relatively small.

keywords: aggregate; geometric characteristics; friction action; grey relational analysis

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一种用于颗粒材料的非连续变形数字图像变形分析方法

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摘 要：为进一步研究颗粒材料发生非连续变形时内部颗粒胶结处的位移情况，对数字图像相关法（DIC）进行了改进，提出一种可以分析已知非连续面附近位移的方法，DDIC。以三维打印试件为试验材料，进行恒定拉伸速率试验，通过分析得到非连续面附近的位移信息，对比实际拉伸速率可发现，在误差允许范围内，相较于传统的分析方法，DDIC 能更准确的反映非连续面附近的位移情况。

关键词：DIC；非连续；位移；数字图像；颗粒材料

Digital Image Deformation Analysis Method for Discontinuous Deformation of Granular Materials

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Abstract:

In order to further study the displacement of the internal particle cementation during the discontinuous deformation of the granular material, the digital image correlation method (DIC) was improved, and a method for analyzing the displacement near the known discontinuous surface is proposed as DDIC . The three-dimensional printing test piece was used as the test material, and the constant tensile rate test was carried out. The displacement information near the discontinuous surface was obtained by analysis. Compared with the actual tensile rate, it can be found that DDIC is compared with the traditional analytical method within the error tolerance range. It can more accurately reflect the displacement near the discontinuous surface.

keywords: DIC; non-continuous; displacement; digital imaged; granular material

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Stochastic Numerical Model of Stone-Based Materials with Realistic Stone-Inclusion Features

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Abstract: This paper presents a systematic approach for generating a stochastic model with realistic stone-inclusion features for the numerical simulation of stone-based materials. First, the inverse discrete Fourier transform method is employed to randomly generate realistic stones with predetermined particle shape features. Then, an overlapping detection algorithm is proposed to facilitate random and quick allocation of irregularly shaped stones, considering the stone contents, stone size distributions and stone orientations. Finally, several examples are provided to show that the proposed approach can generate stone-based materials with prescribed stone features in a rapid and precise manner.

Key words:stone-based material；Stone inclusion；Stochastic model；Particle shape；Inverse discrete Fourier transform； Overlapping detection

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基于随机骨料模型的水稳碎石材料开裂行为细观数值模拟研究

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摘　要：我国沥青路面半刚性基层以水稳碎石材料为主要形式，在长期服役条件下有必要对其损伤开裂行为进行研究，目前研究主要以宏观尺度的性能试验为主，很少涉及材料不均匀特性以及非线性微观研究。本文基于 ABAQUS 二次开发，建立由骨料、砂浆、初始缺陷以及界面过渡区四相组成的二维随机骨料细观有限元模型，利用 MATLAB 预先嵌入符合分离-牵引定律的零厚度四节点内聚力单元以模拟数值试件损伤以及细观开裂行为。研究水稳碎石材料微观开裂机理，分析初始缺陷对开裂行为的影响。研究表明：初始缺陷对水稳碎石材料的开裂行为有着重要影响，数值试件的强度和刚度随着孔隙率的提高而降低。

关键词：随机骨料；细观模型；初始缺陷；有限元(FE)；裂纹扩展

Meso-Scale Simulation of Cement Based Materials Crack Behavior Based on Randomized Aggregates Model

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Abstract:

Abstract: Cement Based material has been widely used in Semi-Rigid base layer in China, which makes it a necessity to study the damage mechanism and cracking behavior with the condition of long-term service. At present, the research mainly focuses on the performance test at the macro scale, and rather limited attention has been paid to the study of inhomogeneous properties and nonlinearity of materials. In this paper, a two-dimensional (2D) mesoscale randomized aggregates model assumed as a 4-phase material composed of aggregate, cement mortar, initial defect and interface transitional zones (ITZ) was developed through Finite Element method (FEM) based on ABAQUS secondary development. The zero-thickness 4-nodes cohesive elements with traction-separation laws were inserted to simulate the damage and mesoscale cracking behavior with the help of a MATLAB program. It was found that the effect of initial defect on the cracking behavior of cement based materials can not be ignored and the strength of numerical specimen decrease with the increase of porosity.

keywords:randomized aggregates; mesoscale model; initial defect; finite element(FE); crack propagation

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Improving Compressive Strength of Cement Stabilized Macadam by Using Vibration Mixing Technology

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Abstract: The technology of vibration mixing has been applied to improve the compressive strength of cement stabilized macadam(CSM). Exerting vibration by mixing shafts and mixing blades, the unconfined compressive strengths of CSM under various conditions were studied, including different maximum vibration accelerations of mixing shafts in the mixing trough(0,1g, 2g, 3.5g), and four cement dosages(2.0%,3.0%,4.0%,5.0%). It is shown that the unconfined compressive strengths of CSM are enhanced by the vibration mixing technology, compared to the ordinary compulsory mixing method. And the 7-day unconfined compressive strengths can increase by 20.0% to 80.5%. Moreover, the percentage of strength improvement depends on the cement dosage and the vibration acceleration. The more the cement dosages are, the higher the compressive strengths can be obtained. As acceleration increases, CSM strength rises in all cases of cement dosages, while the compressive strength decreases gradually. Additionally, the strength variable coefficient of CSM at any acceleration dropped to only 10% or smaller, and the variable coefficient tended to decline with the increase of acceleration. Furthermore, the maximum vibration acceleration of the mixing shaft is recommended to about 2g, considering the machinery reliability and the usual cement dosage in construction practice. Meanwhile, the vibration mixing can reduce the original cement dosage by over 1.6% with the qualified the unconfined compressive strength, also the higher the strength requirement is, the more the cement dosages can be saved.

Key words: vibration mixing; cement stabilized macadam (CSM); unconfined compressive strength

水化硅酸镁（M-S-H）凝胶的制备与影响因素研究

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摘 要：为深入了解水化硅酸镁凝胶（M-S-H）的性质，本文以MgO、H_2O，硅灰和稻壳灰为原材料，制备MgO-SF和MgO-RHA浆体，在室内合成M-S-H凝胶产物。通过X射线衍射(XRD)，热重（TG）分析，差示扫描量热(DSC)等方法，研究了MgO-SF和MgO-RHA浆体在不同的养护温度、养护周期和SiO_2掺量情况下，对水化生成M-S-H凝胶的影响。研究表明：随着养护温度和养护周期的增长，M-S-H凝胶的生成量逐渐增多。试验表明，养护温度为40℃，养护周期为28d时，生成的M-S-H凝胶最多。硅灰和稻壳灰均可作为水泥基原材料制备M-S-H凝胶。当MgO与SiO_2掺量的摩尔比为1:1.5时，两者可以完全反应，比两者摩尔比为1:1时生成的M-S-H凝胶多。相同条件下，MgO-RHA浆体中的M-S-H凝胶含量比MgO-SF浆体中略少。

关键词：水化硅酸镁凝胶；XRD；TGA；DSC

Magnesium Silicate Hydrate (M-S-H) Synthesis and Effects Study

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Abstract:

To understand the basic properties of hydrated magnesium silicate (M-S-H) gel, MgO, H2O, silica fume (SF) and rice husk ash (RHA) to produce MgO-SF and MgO-RHA pastes. Magnesium silicate hydrated (M-S-H) gel was synthesized in laboratory. MgO-SF and MgO-RHA pastes were produced under different curing temperatures, curing time, and SiO2 dosage. The hydrated M-S-H was researched by X-ray diffraction (XRD), thermogravimetry analysis (TGA), and differential scanning calorimetry (DSC) etc. Results indicated that the M-S-H gel amount was gradually increased by long curing time and higher curing temperature. The M-S-H gel reached the highest peak with a curing temperature of 40℃ at 28d. Study shows that rice husk ash could be used as raw materials to prepare M-S-H gel as well as the silica fume. Compared to the paste with $MgO:SiO_2$ = 1:1 by molar, the one with $MgO:SiO_2$ = 1:1.5 achieved more M-S-H gel. And also, under the same condition, the past with SF produce more M-S-H gel than that with RHA.

keywords:magnesium silicate hydrate (M-S-H) gel ; XRD；TGA；DSC

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软硬复配温拌再生沥青混合料机理及性能

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摘 要：软-硬复配温拌再生沥青混合料是先采用高标号基质沥青对再生混合料预拌、后采用硬质天然沥青复拌而开发的温拌再生混合料。通过微观机理分析，揭示了沥青老化及软-硬复配再生机理；开展了不同 RAP 掺量温拌再生沥青混合料与 70#热拌沥青混合料、SBS 改性沥青混合料的高温性能、低温性能、水稳定性以及疲劳性能的对比研究。结果表明：软-硬复配温拌再生技术可行，110#基质沥青：TLA 湖沥青=7:3 温拌再生沥青混合料路用性能良好，20%RAP 掺量为最佳；相比于 70#热拌沥青混合料和 SBS 改性沥青混合料，温度可分别降低 15℃、30℃-35℃。

关键词：道路工程；温拌再生；软-硬复配温拌再生；RAP；路用性能

Mechanism and Performance of Warm Recycling Mixture of Soft and Rock Asphalt Compound

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Abstract:

Soft and rock compound with warm mix renewable technology,which is to get warm mix recycled mixture through high grade matrix asphalt mixture, again through the rock natural asphalt mixture of mixing. Microscopic mechanism analysis reveals the mechanism of asphalt aging and regeneration. and by comparative studying on high temperature performance, low temperature resistance, water stability and fatigue performance of different RAP content warm regenerative asphalt mixture with hot mix asphalt mixture (HMA), SBS modified asphalt mixture.Test and analysis result indicated that soft and rock compound regeneration technology is feasibility;the performance of warm mix recycled mixture with the 7:3 ratio of 110 # asphalt matrix and TLA lake asphalt is better;the best dosage of RAP is 20%;compared with HMA and SBS modified asphalt mixture, temperature can reduce 15℃ and 30℃to 35℃ respectively.

keywords: roadengineering; warm recycling; soft and rock asphalt compound; RAP; road performance

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Effect of Asphalt on Curing Behavior of Cold-Mixed Epoxy Asphalt

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Abstract: The cold-mixed epoxy asphalt (CEA) was eco-friendly material for steel bridge deck pavements. The effects of asphalt on curing behavior and mechanical performances of CEA were studied. The curing characteristics, and curing kinetics of CEA blends were investigated by rotational viscosity test, dynamic shear rheological analysis, and fluorescence microscopy. It turned out that the curing reaction between epoxy resin and curing agent was restrained by asphalt. According to FTIR and DSC, the curing degree of CEAs was decreased with asphalt content.

Key words: cold-mixed epoxy asphalt; curing behavior; micro morphology

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悬浮密实型 SRX 聚合物稳定碎石的路用性能

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摘 要：为了探讨 SRX 聚合物稳定碎石的路用性能，通过室内成型试验方法，研究了悬浮密实型 SRX 聚合物稳定碎石的力学强度、水稳性、渗水特性、抗永久变形特性等。结果表明：悬浮密实型 SRX 聚合物稳定碎石的最佳 SRX 掺量为 0.5%；悬浮密实型 SRX 聚合物稳定碎石的强度 CBR 值随着养生时间的增加逐级增大，增幅越来越低。50℃烘箱养生下悬浮密实型 SRX 聚合物稳定碎石的 CBR 值明显高于自然养生的。50℃烘箱养生下悬浮密实型 SRX 聚合物稳定碎石的 CBR 值大致是自然养生的 1.12 倍；随着浸水时间的延长，悬浮密实型 SRX 聚合物稳定碎石的 CBR 值的减幅较小，且最大不超过 4.2%；悬浮密实型 SRX 聚合物稳定碎石的 DS 远远大于沥青稳定碎石基层的；悬浮密实型 SRX 聚合物稳定碎石具有较高的力学强度、渗水系数、抗车辙能力以及较好的水稳定性，表明悬浮密实型 SRX 聚合物稳定碎石可以在基层中推广与使用。

关键词：道路工程；SRX 聚合物；悬浮密实型级配；路用性能

Road Performance of Spended Dense SRX Polymer Stabilized Macadam

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Abstract:

In order to study the road performance of SRX polymer stabilized macadam, the indoor molding test method was used. The mechanical properties，water stability，water seepage and resistance to permanent deformation of SRX polymer stabilized suspended crushed stones were studied. The results show that the optimum SRX content of suspended dense SRX polymer stabilized macadam is 0.5%. The strength of suspended dense SRX polymer stabilized macadam increases step by step with the increase of curing time, and the increasing rate of CBR is lower and lower. The CBR value of suspension dense SRX polymer stabilized crushed stone was obviously higher than that of natural curing under the condition of 50℃ oven curing. The CBR value of suspended dense SRX polymer stabilized macadam under 50℃ oven curing is about 1.12 times of natural curing. Under the conditions of different immersion time and SRX polymer content, The decrease of CBR value of suspended dense SRX polymer stabilized macadam is relatively small. the maximum value is no more than 4.2; The water permeability coefficient and DS of suspended dense SRX polymer stabilized macadam are much larger than those of asphalt stabilized crushed stone base. suspended dense SRX polymer stabilized macadam has high mechanical strength, water permeability coefficient, rutting resistance and better water stability. The results show that suspended dense SRX polymer stabilized macadam can be popularized and used in the base course.

keywords:road engineering; SRX polymer; suspended dense gradation; road performance

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g-C_3N_4/TiO_2复合材料制备工艺优化及光降解NO性能研究

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摘 要：以三聚氰胺和商用二氧化钛（TiO_2）为原材料，采用超声辅助一步固相法制得 g-C_3N_4/TiO_2复合光催化材料。在单因素控制变量法下研究掺量配比、煅烧温度和煅烧时间对 g-C_3N_4/TiO_2光催化剂性能的影响；根据单因素实验结果设计正交试验，优化其制备工艺。通过 XRD、SEM、FT-IR、UV-vis 和 PL 等测试手段对最佳制备工艺条件下的复合材料和两种单体材料的结构和性能进行表征，结果分析表明，g-C_3N_4和 TiO_2成功复合成了 g-C_3N_4/TiO_2，TiO_2以球状颗粒的形式覆盖在 g- C_3N_4片层结构上，复合催化剂实现了从紫外光区到可见光区的覆盖吸收，电子和空穴分离效率提高，g-C_3N_4/TiO_2的催化活性增强。

关键词：三聚氰胺；TiO_2；g-C_3N_4/TiO_2；NO 降解

Preparation Process Optimization and Photo-NO Degradation Performance of g-C_3N_4/TiO_2 Composite

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Abstract:

Melamine and commercial titanium dioxide（TiO_2）were used as raw materials to prepare g-C_3N_4/TiO_2 composite. The influence of weight ratio, calcination temperature and time on performance of the g-C_3N_4/TiO_2 were studied by single factor controlled variable method, and then orthogonal experiments were designed based on which to optimize preparation process. XRD, SEM, FT-IR, UV-vis and PL were used to characterize the structure and properties of the g-C_3N_4/TiO_2 and two monomer materials. The results showed that g-C_3N_4 and TiO_2 were successfully compounded as g-C_3N_4/TiO_2. TiO_2 with spherical particle were coated on lamellar structure of g-C_3N_4, and the composite achieved the coverage and absorption from ultraviolet to visible region. The separation efficiency of electron and hole was improved, and photocatalytic activity of TiO_2 was enhanced.

keywords:melamine; TiO2; g-C_3N_4/TiO_2; NO degradation

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Fe 掺杂 g-C_3N_4光催化剂的制备及光催化性能

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摘 要：以硝酸铁九水化合物为掺杂源，与三聚氰胺水溶共混，煅烧后制备得到掺铁 g-C_3N_4材料。X 射线衍射（XRD）和傅里叶变换红外（FT-IR）光谱结果表明 Fe 掺杂并未改变 g-C_3N_4晶体结构，紫外-可见（UV-Vis）光谱和荧光发射（PL）光谱结果表明 Fe 掺杂改变了 g-C_3N_4能带结构，降低了带隙能，提高了可见光的利用率。利用扫描电镜（SEM）观察到 Fe 掺入改善了 g-C_3N_4的团聚情况，细化晶粒尺寸，从而增大了比表面积。以 NO 气体降解率为评价指标研究了不同 Fe 掺杂量对 g-C_3N_4在可见光下催化性能的影响，结果表明当 Fe 掺杂量为 1%时制备的样品对 NO 气体降解率为 75.43%，显著高于 g-C_3N_4（50.78%）。

关键词：光催化剂

Preparation and Photocatalytic Properties of Fe-Doped g-C_3N_4 Photocatalyst

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Abstract:

$Fe(NO_3)3 \cdot 9H_2O$ was selected as the doping source and was mixed with melamine in aqueous solution。The Fe doped g- C_3N_4 photocatalyst was prepared by pyrolysis. The spectra of XRD and FT-IR show that Fe doping does not change the crystal structure of g-C_3N_4。The spectra of UV-Vis and PL show that Fe doping does change the band structure of g-C_3N_4, reduces the band gap energy and improves the utilization of visible light。The SEM images shows that Fe doping improves the agglomeration of g- C_3N_4 and fines the grain size, which increases the specific surface area。The NO degradation rate as an index to studies the effect of Fe doping on the catalytic performance of g- C_3N_4 under visible light，The experimental results of NO photocatalytic degradation showed that the degradation efficiency of photocatalyst with 1% Fe doping was 75.43%，Significantly higher than the degradation efficiency of photocatalyst of g- C_3N_4（50.78%）.

keywords: photocatalysis

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改性环氧树脂薄层在道路抗滑养护中的应用研究

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摘 要：我国高速公路快速发展的同时，交通安全事故数量逐年增加，为解决现有路面抗滑性能下降问题，自主研发了改性环氧树脂薄层铺装材料，并对施工项目的粘结强度、摩擦系数、构造深度及交通事故统计进行 5 年的跟踪研究。结果表明：其粘结强度为“先下降后稳定”的趋势，最终稳定在 1.10 MPa 左右，且破坏形式均为混凝土破坏；通车 5 年后，改性环氧树脂薄层罩面的构造深度稳定在 1.00 mm 左右，干燥和潮湿状态下摆值分别在 70、60 左右，仍然满足摩擦系数在潮湿状态大于 45。此外，采用改性环氧树脂薄层改造后的隧道，路面抗滑性能得到明显提高，交通事故率明显下降，为通行安全提供了安全保障，具有良好的社会意义及社会价值。

关键词：改性树脂薄层；粘结强度；罩面抗滑；交通事故

Research on the Application of Modified Epoxy Resin Thin Layer in Road Anti-Skid Curing

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Abstract:

With the rapid development of expressway in China, the number of traffic safety accidents increases year by year. In order to solve the problem of declining anti-skid performance of existing pavement, modified epoxy resin thin layer pavement materials are independently developed. In addition, 5 years of tracking research is conducted on the bonding strength, friction coefficient, structure depth and traffic accident statistics of construction projects.The results show that the bond strength tends to decrease first and then stabilize, and finally stabilizes around 1.10Mpa, and the failure forms are all concrete failure.After5years of operation, the structure depth of the modified epoxy resin thin coating surface was stable at about 1.00mm, and the pendulum value of the dry and wet state was around 70 and 60 respectively, and the friction coefficient was still greater than 45 in the wet state.In addition, the tunnel modified with thin layer of modified epoxy resin has significantly improved the skid resistance of the road surface and significantly reduced the traffic accident rate, which provides a safety guarantee for traffic safety and has good social significance and social value.

keywords: Modified resin thin layer; bond property; Anti-slip of overlay; traffic accident

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聚氨酯复合改性沥青的流变特性与改性机理

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摘 要：为改善聚氨酯改性沥青的流变性能，将聚氨酯（PU）和岩沥青（RA）按照自定的室内工艺流程制备得到聚氨酯复合改性沥青，采用针入度、软化点、延度和黏度常规指标试验优化了聚氨酯和岩沥青掺配方案，基于胶体理论分析了聚氨酯复合改性沥青的温度敏感性，利用动态剪切流变（DSR）试验、弯曲梁蠕变（BBR）试验研究了聚氨酯复合改性沥青的高低温流变特性，其中应用多应力重复蠕变（MSCR）试验评价了聚氨酯复合改性沥青的抗永久变形能力，确定了聚氨酯复合改性沥青的 PG 分级温度，借助扫描电镜（SEM）观测了不同聚氨酯和岩沥青掺配比例下的聚氨酯复合改性沥青微观结构，通过红外光谱（FTIR）试验分析了聚氨酯复合改性沥青的改性机理。结果表明：相同岩沥青掺量时，随着聚氨酯掺量的增加，聚氨酯复合改性沥青的针入度和延度均有所提高，软化点变化不明显；当聚氨酯掺量相同时，随着岩沥青掺量的增加，聚氨酯复合改性沥青的软化点增大，但针入度和延度则有所下降；添加 3%聚氨酯和 15%岩沥青，以及 5%聚氨酯和 15%岩沥青的聚氨酯复合改性沥青表现出相同的最高 PG 高温等级温度，添加 5%聚氨酯和 5%岩沥青的聚氨酯复合改性沥青的 PG 低温等级温度最低；基质沥青、聚氨酯和岩沥青之间相容性良好，且聚氨酯与沥青能形成交联网状结构，有助于改善沥青的流变性能。综合考虑经济因素、常规指标试验、微观形貌与流变性能试验的结果，确定了聚氨酯复合改性沥青的最优掺配比是添加 5%聚氨酯和 5%岩沥青；在聚氨酯复合改性沥青的内部，异氰酸根分别与沥青中的酚、羧酸发生了化学反应，聚氨酯中的不饱和键与沥青中的 S-S 键发生了交联反应。

关键词：道路工程；聚氨酯；流变特性；改性机理；岩沥青

Rheological Properties and Modification Mechanism of Polyurethane Composite Modified Asphalt

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Abstract:

The objective of this study is to improve the rheological properties of polyurethane modified asphalt, the polyurethane modified asphalt was prepared using matrix asphalt, polyurethane and rock asphalt through a self-determined laboratory process. The composition of polyurethane and rock asphalt was optimized by penetration, softening point, ductility and rotational viscosity tests. The temperature sensitivity of polyurethane composite modified asphalt was based on the colloid theory. The rheological properties of the modified asphalt were investigated by dynamic shear rheology (DSR) and bending beam rheology (BBR) tests, in which, the multiple stress creep recovery (MSCR) test was performed to evaluate the resistance to permanent deformation of polyurethane composite modified asphalt， and the PG grade temperature of the composite modified asphalt was determined. Scanning electron microscopy (SEM) was used to observe the internal microstructure of the polyurethane composite modified asphalt with different dosage of the

polyurethane and rock asphalt. The modification mechanism of the polyurethane composite modified asphalt was studied by infrared spectroscopy (FTIR) test analysis. The results showed that the penetration and ductility of the polyurethane composite modified asphalt were improved with the increase in the content of polyurethane, when the identical amount of rock asphalt was used, but the softening point exhibited a slight variation. The softening point of composite modified asphalt with the same amount of polyurethane increased with the increasing content of rock asphalt. whereas the penetration and ductility decreased. The polyurethane composite modified asphalt with 5% polyurethane and 15% rock asphalt, and 3% polyurethane and 15% rock asphalt performed the best PG high temperature grade. The polyurethane composite modified asphalt with 5% polyurethane and 5% rock asphalt performed the lowest PG temperature grade. The base asphalt, polyurethane and rock asphalt indicated preferable compatibility. The polyurethane could form a crosslinked and networked structure with asphalt, which was helpful to improve the rheological properties of asphalt, based on the comprehensive results of economic factors, conventional indices, microstructure and rheological property tests, it was found that the optimal composition was the composite asphalt added into 5% polyurethane and 5% rock asphalt. In the interior of the composite modified asphalt, the isocyanate respectively reacted with the phenol and carboxylic acid in the asphalt, and the unsaturated bond in polyurethane crosslinked with the S-S bond in asphalt.

keywords: road engineering; polyurethane; rheological properties; modification mechanism; rock asphalt

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基于秸秆液化的生物沥青制备工艺及其性能分析

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摘 要：为促进废弃秸秆的资源化利用和可持续道路材料的开发，基于稻草秸秆液化制备生物沥青。通过正交试验分析了制备温度、制备时间、固液比、液化剂比例和催化剂用量对秸秆液化率的影响，并确定了最佳液化工艺；进一步将液化产物掺入到基质沥青中制备生物沥青，通过针入度、软化点、延度和黏度等指标对生物沥青进行了性能分析。结果表明：催化剂用量对秸秆液化率的影响最为显著，固液比次之，其次分别为反应温度、液化剂比例，反应时间对其影响最小。在 160℃、180min、固液比为 1:3.5、液化剂比例为 3:2、催化剂用量为 10%时，液化效果最好。利用最佳工艺条件下液化产物制备的生物沥青，各项性能指标良好，且有效改善了基质沥青的低温性能。

关键词：秸秆；液化工艺；生物沥青；性能分析

Preparation Process of Bio-Asphalt by Straw Liquefaction and Performance Analysis

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Abstract:

To promote the resource utilization of waste straw and the sustainable development of road materials. Bio-asphalt was prepared by liquefied straw. The effects of preparation temperature, preparation time, solid-liquid ratio, liquefier ration and catalyst amount on the liquefaction rate were analyzed by orthogonal test, and the best liquefaction process was determined. Then the liquefied product was made into the bio-asphalt, and the performance of bio-asphalt was analyzed by penetration, softening point, ductility and viscosity. The results showed that the effect of catalyst on liquefaction rate is most significant, followed by solid-liquid ratio, and the others were reaction temperature and liquefier ration, and the reaction time had the least influence. When the preparation temperature was 160° C, the preparation time was180 min, solid-liquid ratio was1:3.5, liquefier ration was 3:2, and catalyst amount was 10%, the liquefaction rate of bio-asphalt is best. The bio-asphalt prepared by using the liquefied product under the optimal process has good performance indexes, the low-temperature performance can be effectively improved.

keywords:straw; liquefaction process; bio-asphalt; performance analysis

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水泥路面共振碎石化注浆补强方案与效果评价

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摘 要：建筑在软弱结构上的水泥路面，实施共振碎石化后，往往出现结构强度不足的情形，在标高受限制时注浆是一种有效的方式。注浆是一种隐蔽技术手段，实施应进行基层、路基、基层和路基联合注浆多方案比选。对于路基处于饱和状态的情况，路基注浆应结合有效的降排水措施。针对一次注浆仍不满足要求点，需进行二次注浆补强。

关键词：共振碎石化

Evaluation of Grouting Project and Effect for Cement Pavement After Resonant Breaking

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Abstract:

The strength of the residual structure is always insufficient after resonant rubblization of cement pavement on weak structure. Grouting is an effective method when elevation is limited. Grouting is a kind of concealed engineering method. Project selection is indispensable, including base, subgrade, both base and subgrade grouting projects. For saturated subgrade, grouting should be combined with effective drainage measures. In view of the fact that the primary grouting still does not meet the requirements, the secondary grouting reinforcement is needed.

keywords: resonant rubblization

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光伏路面的发展与展望

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摘 要：本文简单介绍了光伏路面的国内与国外的发展现况，整理了光伏路面的技术问题以及人们现有的解决方法，并对光伏路面未来的前景展开了设想。最后，针对设想，分析了需要在未来攻克的技术瓶颈，重点评述了纳米光电材料的概念、优势，以及未来应用于路面领域的可行性。

关键词：光伏路面

Development and Prospect of Photovoltaic Pavement

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Abstract:

This paper briefly introduces the current development of photovoltaic pavement at home and abroad, sorts out the technical problems of photovoltaic pavement and the existing solutions, and proposes the future prospects of photovoltaic pavement. Finally, aiming at the idea, it analyzes the technical bottlenecks that need to be overcome in the future, and re-evaluates the concept and advantages of nano-optoelectronic materials and the feasibility of applying them to the pavement field in the future.

key words:photovoltaic paveme

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基于盐冻环境下聚丙烯纤维对铁尾矿砂水泥混凝土性能的影响研究

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（长安大学）

摘 要：将铁尾矿砂应用到水泥混凝土中可以为基础设施建设提供足够的原材料，然而在冻融循环及硫酸盐侵蚀作用下的铁尾矿砂混凝土性能并不是非常优越，为了改善铁尾矿砂混凝土在低温及盐渍土地区适应能力，将铁尾矿砂、聚丙烯纤维掺入到水泥混凝土中，设计了 3 组配合比，然后经历 140d 冻融循环及 5%硫酸钠盐侵蚀，分析其抗压强度、抗弯拉强度、质量损失率、膨胀率、硫酸根离子分布与扩散系数变化规律。结果表明：聚丙烯纤维可以使得铁尾矿砂混凝土抗压强度及抗弯拉强度衰减缓慢；0——140d，纤维含量在 0.3%时混凝土质量减少的幅度有所缓和；当铁尾矿砂含量为 30%时，0.3%聚丙烯纤维的混凝土膨胀率为 0.0352%，而 0 聚丙烯纤维的混凝土膨胀率为 0.0612%；含 0.3%聚丙烯纤维可以抑制酸根离子在混凝土中的扩散速度；随着冻融循环及硫酸钠盐侵蚀的不断进行，硫酸根离子扩散系数都在减小，且最终都趋于均匀，硫酸根离子扩散系数在同一时期与距侵蚀面的距离成反比。

关键词：冻融循环；硫酸盐侵蚀；聚丙烯纤维；铁尾矿砂；切片试验；扩散系数

Study on the Effect of Polypropylene Fiber on the Performance of Cement Concrete with Iron Tailings Sand in Salt-frozen Environment

Tang Ke , Mao Xuesong
（Chang'an University）

Abstract:

The application of iron tailings to cement concrete could provide enough raw materials for infrastructure construction, but the performance of iron tailings concrete under freeze-thaw cycles and sulfate erosion was not very superior. In order to improve the adaptability of iron tailings concrete in low temperature and saline soil areas, iron tailings sand and polypropylene fibers are mixed into cement concrete. Three groups of mix ratios were calculated, and then the compressive strength, flexural strength, mass loss rate, expansion rate, sulfate ion distribution and diffusion coefficient were analyzed after 140 days of freeze-thaw cycles and 5% sodium sulfate erosion. The results indicated that polypropylene fiber could make the compressive strength and flexural tensile strength of iron tailings sand concrete decline slowly; when the content of iron tailings is 30%, the concrete expansion rate of 0.3% polypropylene fiber was 0.0352%, while that of 0% polypropylene fiber was 0.0612%. 0.3% Polypropylene fibers can inhibit the diffusion rate of acid ions in concrete. With freeze-thaw cycles and sodium sulfate erosion, the diffusion coefficient of sulfate ions decreased, and eventually tended to be uniform. The diffusion coefficient of sulfate ions was inversely proportional to the distance from the erosion surface at the same time.

keywords:freeze-thaw cycle; sulfate erosion; polypropylene fiber; iron tailings sand; section test; diffusion coefficient

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铁尾矿砂作为混凝土细集料可行性研究

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摘 要：本研究制备了不同铁尾矿砂掺量水平下的再生混凝土，通过宏观及微观试验研究了铁尾矿砂混凝土的力学性能和孔结构特征，结果表明铁尾矿砂作为混凝土细集料是可行的。铁尾矿砂与天然砂的的矿物组成比较接近，均主要由石英和钙长石组成。各种掺量水平铁尾矿砂混凝土 28d 抗压强度均比天然砂混凝土高。其中铁尾矿砂取代率 100%的再生混凝土 28 d 抗压强度达 50.8MPa，强度比天然细砂混凝土提高了 19.8%。这与铁尾矿砂浆低孔隙量、孔隙率及较少的有害孔与多害孔的孔结构特征密切相关。

关键词：铁尾矿砂；混凝土；砂浆；力学性能；孔结构特征

Feasibility Study of Iron Tailings as Concrete Fine Aggregate

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Abstract:

In this study, recycled concrete with different levels of iron tailings was prepared. The mechanical properties and pore structure characteristics of iron tailings concrete were studied through macro and micro experiments. The results show that it is feasible to use iron tailings as fine aggregate of concrete. The mineral composition of iron tailings is similar to that of natural sand, and they are mainly composed of quartz and calcareous feldspar. The 28-day compressive strength of concrete with various levels of iron tailings is higher than that of natural sand concrete. The 28-day compressive strength of recycled concrete with 100% replacement ratio of iron tailings is 50.8 MPa, which is 19.8% higher than that of natural fine sand concrete. This is closely related to the low pore volume, porosity of iron tailings mortar, and the structural characteristics of less harmful and harmful pore.

keywords: Iron tailings; concrete; mortar; mechanical properties; pore structure characteristics

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钢渣在道路工程中的应用与研究进展

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摘 要：钢渣作为炼钢过程中的副产物，具有许多优良的特性，其资源化利用受到广泛关注。钢渣以优异的抗滑性和良好的耐磨性，作为集料在道路工程中的应用具有较好的前景；钢渣作为良好的吸波材料在自愈合和融冰雪等新型功能路面中也具有较好的应用价值。但钢渣的膨胀性、高密度和高孔隙率限制了钢渣的广泛应用。本文对钢渣的性质和应用进行了总结，对其作为集料在路面基层、沥青面层和水泥混凝土路面应用和研究进行了综述，介绍了钢渣应用于自愈合和融冰雪等新型功能路面的研究进展，指出了钢渣作为集料在道路工程应用中面临的问题。

关键词：沥青路面；基层；水泥混凝土；钢渣；集料

An Overview of Utilization and Research Progress of Steel Slag in Road Engineering

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（Chang'an University）

Abstract:

As by-products during the oxidation of steel pellets in an electric arc furnace, steel slag has many excellent characteristics and its recycling has attracted wide-spread attention. Steel slag has good prospects in road application with excellent skid resistance and good wear resistance. As a good microwave absorbing material, steel slag also has good application value in self-healing and snow-melting new functional pavement. However, the expansive nature, high density and high porosity limit the wide application of steel slag. This paper summarizes the properties and applications of steel slag, overviews the utilization and research on base, asphalt, concrete pavement, introduces the research progress of steel slags applied in new functional pavement such as self-healing and snow-melting, and finally points out the problems faced by steel slag as aggregate in road engineering application.

keywords:asphalt pavement; base; cement concrete; steel slag; aggregate

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HM-Ⅱ高模量改性剂的制备与性能研究

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摘 要：以 HDPE、SBS 为原料，采用双螺杆反应挤出制备 HM 高模量改性剂，研究 SBS 含量对 HM 高模量改性剂的拉伸强度和-40℃断裂伸长率的影响。结果表明：随着 SBS 含量的增加，拉伸强度逐渐降低，-40℃断裂伸长率先增加后降低。通过 HM 高模量改性剂改性沥青性能的测试，发现：HM-II改性剂具有软化点高、10℃延度大，性价比高的优点。通过对比市售高模量剂 SH、PR-S 和 HM-II高模量改性剂制备改性沥青混合料性能。结果发现：HM-II与沥青的溶解性能好，所需的拌和时间最短，仅需 8s 可完全溶解。PR-S 的动态模量最大，HM-II动态模量优于 SH 改性剂。在高温抗车辙性能、低温抗裂性能、抗疲劳性能以及抗水损性能上：HM-II＞PR-S＞SH。HM-II的动稳定度为 18925，比 PR-S 高 32%，比 SH 高 111%。HM-II低温弯曲破坏应变为 2723με，是 SH 改性剂的 1.5 倍，具有较优的低温抗裂性。HM-II的抗水损性能优异，浸水残留稳定度和冻融劈裂强度比分别为 86.6%和 91.1%。

关键词：高模量改性剂;断裂伸长率;高低温性能;疲劳寿命;抗水损性能

Study on Preparation and Properties of HM-II High Modulus Modifier

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Abstract:

Using HDPE and SBS as raw materials, HM high modulus modifier was prepared by twin screw reactive extrusion. The effect of SBS content on the tensile strength and elongation at break of HM high modulus modifier was studied. The results show that with the increase of SBS content, the tensile strength decreases gradually, the elongation at break at - 40 C increases first and then decreases. By testing the performance of HM high modulus modifier modified asphalt, it is found that HM-II modifier has the advantages of high softening point, high ductility at 10 ~C and high cost-performance ratio. The properties of modified asphalt mixture were prepared by comparing SH, PR-S and HM-II high modulus modifiers. The results show that the solubility of HM-II and asphalt is good, and the mixing time is the shortest. It only takes 8 seconds to dissolve completely. PR-S has the largest dynamic modulus, and HM-II has better dynamic modulus than SH modifier. In terms of rutting resistance at high temperature, crack resistance at low temperature, fatigue resistance and water loss resistance, HM-II > PR-S > SH. The dynamic stability of HM-II is 18925, 32% higher than PR-S and 111% higher than SH. The bending failure strain of HM-II at low temperature is 2723 με, which is 1.5 times that of SH modifier, and it has better crack resistance at low temperature. The water loss resistance of HM-II is excellent. The ratio of residual stability of immersion and freeze-thaw splitting strength is 86.6% and 91.1% respectively.

keywords:high modulus modifier, fracture elongation, high and low temperature performance, fatigue life, water loss resistance

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Progress in Permeable Pavement Materials for Sponge City

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Abstract: Permeable pavement, as a new stormwater management method, has been widely concerned and studied, due to its excellent ecological functions such as water permeability, noise reduction, cooling and water purification, etc. Permeable pavement has been applicated in pedestrian zone, parking lots, parks and other areas with low-frequency light load. However, in the process of application, problems such as clogging and insufficient strength gradually become prominent, resulting in the bottleneck for its further promotion, especially for pavements carrying heavy load. In order to clarify the current research progress and future demands, this paper systematically summaries the materials applied in permeable pavement and related design parameters, as well as the existing problems and updated research progress of permeable pavement, so as to provide reference for the follow-up research.

Key words: Sponge City; Permeable Pavement; Permeable Materials

Effects of PEG/SiO_2 Form-Stable Phase Change Materials on Properties of Modified Asphalt

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Abstract: Considering the impacts of high temperature on asphalt pavement, the PEG/SiO_2 form-stable phase change materials (FS-PCMs) were prepared using sol-gel method by impregnating polyethylene glycol into the pore structure of silicon dioxide gel, and the PEG/SiO_2 modified asphalt were prepared by a simple melt-blending method. The heat storage property and thermal stability of FS-PCMs were characterized by differential scanning calorimetric (DSC) test and thermogravimetric analyses (TGA). The effects of PEG/SiO_2 FS-PCMs on physical properties of base asphalt were characterized through softening point test, penetration test, ductility test, dynamic shear rheological test (DSR). Moreover, the photo-thermal conversion experiments were carried out to invsestigate the effects of PEG/SiO_2 FS-PCMs particles on the thermoregulation properties of asphalt, and the chemical compatibility of base asphalt and the prepared PEG/SiO2 FS-PCMs was determined by the Fourier transform infrared spectroscopy (FTIR). Results show that the addition of PEG/SiO_2 FS-PCMs in asphalt binder can increase its softening point, penetration and anti-rutting factor, indicating that the high temperature properties of modified asphalt are sigificantly improved, however, the low temperature property is weakened. In addition, according to the the photo-thermal conversion test, PEG/SiO_2 FS-PCMs can absorb some thermal energy and effectively regulate the temperature of the hot mix asphalt during the heating process. FTIR test indicates that no chemical reactions took place, and there is just a physical interaction between PEG/SiO_2 FS-PCMs and base asphalt.

Key words: Form-stablephase change materials; Modified asphalt; Physical property; Thermoregulation

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Development and Performance Research of FA-based Geopolymer Grouting Materials

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Abstract: Due to simple process, low cost, fast open traffic and other advantages, non-excavation grouting reinforcement technique has become a preferred path for subgrade reinforcement. In order to further increase the greenness of grouting materials, in this paper, industrial solid wastes such as fly ash and slag were chosen as main raw materials. Under the activation of modified water glass, those industrial solid wastes finally turned into geopolymer grouting materials with low carbon, high strength, low shrinkage and other advantages via dissolution, condensation, rearrangement and other processes. Results show that the geopolymerization process of the fly-ash-based geopolymer(FA-based geopolymer) was greatly influenced by Na_2O content and modulus of water glass. In combination with setting time, compressive strength and drying shrinkage, the optium Na_2O content was 9.0wt%, and the optium modulus of water glass was 1.2. The addition of a small amount of slag could increase the rate of geopolymerization and shorten the setting time. On the other hand, the addition of slag significantly increased the compressive strength of the FA-based geopolymer and significantly reduced the drying shrinkage at the 180d age. Field application shows that the preparaed geopolymer could be used as grouting material and repair the uneven settlement of road effectively.

Key words: Geopolymer; Grouting Materials; Subgrade Reinforcement; Mechanical Properties; Drying Shrinkage; Microstructure

弹性体乳液改性不粘轮乳化沥青的性能研究及工程应用

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摘 要：目前市售不粘轮乳化沥青用作粘层材料普遍存在低温延度低、抗施工损伤性能差的问题。本文通过添加不同玻璃化转变温度的弹性体乳液改性不粘轮乳化沥青，有效提升了不粘轮乳化沥青的低温延度和抗施工损伤性能。制备的不粘轮乳化沥青可在 60℃不粘轮；制备乳化沥青的蒸发残留物的软化点达到 81.3℃，15℃延度达 45.7cm；附着力拉拔强度达到 2.42MPa，复合件拉拔强度达到 0.81MPa。通过实际工程应用表明：该方法制备的不粘轮乳化沥青具有存储稳定性优异，较高拉拔强度及高温下不粘轮等优点。

关键词：粘层；不粘轮乳化沥青；弹性体；拉拔强度

Performance Research and Engineering Application of Non-Stick Emulsified Asphalt Modified by Elastomer

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Abstract:

At present, the commercially available non-stick emulsified asphalt had poor ductility at low temperature and poor resistance to construction damage when widely used as an adhesive layer material. In this paper, we can effectively improve the low temperature ductility and construction damage resistance of the non-stick emulsified asphalt by the addition of elastomer in different TG. The prepared non-stick emulsified asphalt can be non-stick wheel at 60℃; the softening point of the evaporation residue of the prepared emulsified asphalt reached 81.3℃, the elongation of 15℃ reached 45.7 cm; the pull strength of binder reached 2.42 MPa, and the pull strength of composite parts reached 0.81 MPa. The practical engineering application shows that the non-stick emulsified asphalt prepared by the method has the advantages of excellent storage stability, high drawing strength and non-stick wheel at high temperature.

keywords:adhesive layer; non-stick emulsified asphalt; elastomer; pull strength

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Mechanical Properties of Light Colored Asphalt After Aging Based on DMA Test Method

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Abstract: Structure and performance characteristics study of light colored asphalt, especially aging with RTFOT & PAV, was urgent needed, although light color asphalt had been widely in China. A representative light colored asphalt and road asphalt aged with RTFOT & PAV was compared used dynamic mechanical test in this paper. Structural characteristics was analyzed based on the Han curve and mechanical property was further analyzed based on frequency scanning. Compared results showed viscoelastic parameters showed an approximate change law after aging for light colored asphalt and petroleum asphalt, and the viscoelastic attenuation degree of light asphalt was lower than that of petroleum asphalt after aging. The reason maybe was that chemical composition of light asphalt was different from road asphalt. Its oil content was higher as a chemical composition, and contained polyolefin modifier although the index was required as common road saphalt. Therefore, the results of this study provided a new research ideas for the study on the existing light colored relevant standards.

Key words: Light color asphalt; Petroleum asphalt; Dynamic mechanical analysis; Aging; RTFOT; PAV

Performance Properties of SMA, Polyurethane, Epoxy Mixtures in Airfield Pavement

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Abstract: Increasing aircraft loads and landing frequency results in challenges to airfield pavement material design. At present, polyurethane has been widely used in various construction industries, including road engineering, but it is a new type of material used in airfield pavement. The objective of this study was to investigate the basic performances of polyurethane concrete and compare these performances with the current stone matric asphalt (SMA) mixture, epoxy asphalt mixture and cement concrete in airfield pavement. A series of tests were performed to determine the characteristics of four types of concretes, such as high temperature stability, low temperature crack resistance, bond strength, shear strength, moisture susceptibility, fatigue property, durability and impermeability. The test results showed that compared with the asphalt concrete, the polyurethane concrete had better high and low temperature performances, stronger interlayer bonding and moisture resistance. The performance of epoxy concrete was slightly lower than that of polyurethane concrete, and it showed great improvement with SMA. In addition, compared with the cement concrete, the polyurethane concrete had higher comprehensive strength, better durability, better impermeability and chloride ion penetration resistance. At the same time, polyurethane concrete had great fatigue resistance. Therefore, the polyurethane concrete could be considered as an excellent bonding material in resisting external environment and load stress..

Key words: Polyurethane Concrete, Asphalt Concrete, Cement Concrete, Durability, Pavement performance

Rheological Performance Investigation and Sustainability Evaluation of Asphalt Binder with Thermochromic Powders Under Solar Radiation

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Abstract: Thermochromic asphalt binder is an innovative and promising road material in adjusting surface temperature of pavement. Instead, durability of this material under natural environment remains to be unknown. In this paper, weathering aging effects on rheological and chemical evolutions of thermochromic asphalt binder were evaluated by complex modulus (G*) master curve, crossover frequency (ω c), non-recoverable creep compliance (Jnr), zero shear viscosity (ZSV), DSR Function value (DSRFn) and carbonyl and sulfoxide indexes. The results indicated that unlike blank sample, rheological indexes of thermochromic asphalt binder were not always increasing or decreasing with growth of weathering aging time, but there was a turning point during the weathering aging. Furthermore, the effects of weathering aging on rheological properties of thermochromic asphalt binder were much less than blank sample. Growth rates and amplitudes of carbonyl and sulfoxide indexes of thermochromic asphalt binder were also much lower than blank sample, illustrating superior weathering aging resistance of thermochromic asphalt binder. In addition, weathering aging behaviors of thermochromic asphalt binder were dependent on combined effects of asphalt matrix and thermochromic powder.

keywords:asphalt; thermochromic materials; weathering aging behavior; rheological properties; Fourier transform infrared spectroscopy

低冰点含砂雾封层的制备与性能研究

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摘 要：本文从‘与底基的粘结性能’ ‘耐磨耗性能’以及‘降低冰-路界面粘结力’出发，选用适宜的评价方法与指标对适用于在役路面的低冰点含砂雾封层进行性能表征，并主要从原材料的选择及用量确定两方面对其进行设计，最终确定低冰点含砂雾封层各组成材料的最佳配比。

关键词：低冰点填料

The Preparation and Performance Research of Low freezing Sand Fog Seal

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Abstract:

In this paper, we use the appropriate evaluation methods and indexes to characterize ‘the bonding properties of the substrate’、‘the wear resistance’ and ‘the reduction of adhesion between road and ice’ of anti-icing sand fog seal, and the design of this functional maintenance material was mainly based on the selection and consumption of raw materials. At the end, the appropriate ratio of each constituent material of anti-icing sand fog seal was determined synthetically.

keywords: anti-icing filler

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用于彩色抗滑路面的粘结材料制备及性能研究

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摘 要：为获得兼具黏结力强、固化时间较短、柔韧耐久的彩色抗滑路面粘结材料，提出了基于力学性能的 TDI-PUP 增韧改性环氧树脂的方法。通过拉拔试验、拉伸试验、弯曲试验及冲击试验研究了 TDI-PUP-M-ER 力学强度和柔韧性能，确定了 TDI-PUP 最佳掺量，优选了固化剂。进一步通过冻融循环试验、低温轮碾试验、高温化学腐蚀试验、高温老化试验系统评价了 TDI-PUP-M-ER 粘结材料的耐久性能。结果表明：TDI-PUP 能够显著改善环氧树脂的柔韧性。TDI-PUP 的最佳掺量为 10 %，TDI-PUP-M-ER 的拉伸强度较纯环氧树脂提高了 52.8 %，断裂伸长率提高了 112 %，弯曲强度较纯环氧树脂提高了 21.6 %，弯曲变形提高了 61.1 %，优选出脂环胺和脂肪胺固化剂。TDI-PUP-M-ER 粘结材料经冻融循环后黏结强度仅衰减 2.8 %，酸溶液腐蚀后，质量损失率仅为 0.69 mg/g，这表明本研究制备的 TDI-PUP-M-ER 粘结材料耐久性能良好。

关键词：TDI-PUP-M-ER；粘结材料；制备；耐久性；彩色抗滑路面

Preparation and Properties of Bonding Material for Colorful Anti-Slip Pavements

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Abstract:

The performance of the bonding materials of colorful anti-slip pavements is a critical factor influencing their service life. Epoxy resins perform well as bonding materials for colorful anti-slip pavements, although they have the drawbacks of long curing time, poor flexibility, and low durability. To obtain a bonding material with a strong bonding force, fast curing rate, good flexibility, and durability based on several mechanical properties, TDI-polyether polyurethane prepolymer modified epoxy resin (TDI-PUP-M-ER) was prepared. The basic performances of TDI-PUP-M-ER were studied by pullout, tensile, bending, and impact tests. Based on the acquired results, the optimal amount of TDI-polyether polyurethane prepolymer (TDI-PUP) and preferred curing agents for the TDI-PUP-M-ER were determined. Furthermore, the durability of the TDI-PUP-M-ER bonding material was systematically evaluated by freeze－thaw cycle tests, rutting tests at low and high temperatures, chemical corrosion tests, and aging tests at a high temperature. The results showed that the flexibility and mechanical strength of the epoxy resin are considerably improved by adding TDI-PUP. When the content of TDI-PUP in epoxy resin was 10 %, the comprehensive performance of TDI-PUP-M-ER was optimal. Compared with the pure epoxy resin, the tensile strength of TDI-PUP-M-ER was improved by 52.8 %, its elongation at break by 112 %, its bending strength by 21.6 %, and its bending deformation by 61.1 %. After the TDI-PUP-M-ER bonding material was frozen and thawed, its bonding strength was reduced slightly by 2.8 %. After corrosion by acidic solutions, the final mass loss rate of the resin was only 0.69 mg/g, showing that the TDI-PUP-M-

ER bonding material exhibits good durability.

keywords:TDI-PUP-M-ER; Bonding material; Preparation; Durability; Colorful anti-slip pavement

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生物油再生沥青胶结料性能研究

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摘 要：传统矿物油再生剂存在价格高、环保性差、不可再生等问题，本文选择三种环保型生物油基再生剂（X-Re、J-Re、S-Re）与一种矿物油基再生剂（K-Re）再生老化 SBS 改性沥青，以老化沥青的针入度、软化点和延度恢复至原样沥青水平为基准，确定了四种再生剂的最佳掺量；通过对比再生沥青的粘温曲线和流变性能发现，再生剂有效改善了老化沥青的施工和易性，可恢复老化沥青流变性能至原样水平；采用红外光谱分析不同再生剂对老化沥青化学特性的影响，并利用亚砜基强度指数变化指标评价其再生效果，发现再生沥青中亚砜基强度指数均降低，表明再生剂对老化沥青有较好的再生效果。

关键词：生物油；沥青再生剂；常规性能；流变性质；红外光谱

Study on Properties of Bio-Oil Recycled SBS Modified Asphalt Binder

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Abstract:

The traditional mineral oil regeneration agent has some problems, such as high price, poor environmental protection, non-renewable and so on，In this paper, three environment-friendly bio-oil-based regenerators (X-Re、J-Re、S-Re) and a mineral oil-based regeneration agent (K-Re) were selected to regenerate aging SBS modified asphalt，based on the penetration, softening point and ductility of aging asphalt to the original asphalt level，the optimum dosage of four regenerating agents was determined；comparison of viscosity and temperature curves and rheological properties of recycled asphalt，the regenerating agent can effectively improve the construction and easiness of aging asphalt, and can restore the rheological property of aging asphalt to the original level，analysis of the effects of different regenerating agents on the Chemical Properties of Aging Asphalt by Infrared Spectroscopy，it was found that the sulfoxide strength index of the recycled asphalt was decreased, which indicated that the regenerating agent had better regeneration effect on the aging asphalt.

keywords: Biooil; asphalt regenerative; conventional performance; rheological property; FTIR

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Laboratory Study and Field Trial of Long-Lasting Epoxy Modified Open-Graded Friction Surface (EGFS)

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Abstract: This China laboratory study and field trial of long-lasting epoxy modified open-graded friction surface (EGFS) were supported by the Ministry of construction science and technology project, focused on the long-lasting pavements. The aim of the research was to investigate the potential of epoxy-modified bitumen as a low-maintenance long-lasting (>10 years) with excellent rutting and skid resistance surfacing material. Investigations into the direct tension and fracture elongation of domestic epoxy modified bitumen with lower amount epoxy (30% in the weight), Marshall stability, cohesive properties, rutting resistance at high temperature, flexural property at low temperature, moisture stability and skid resistance of EGFS were undertaken, and an associated field trial constructed on Lima expressway in Jiangsu in October 2016. Results from the above test indicated that the good properties of the epoxy modified EGFS were markedly superior to those of conventional friction course. Experiments were also conducted with epoxy modified bitumen diluted with up to 70% standard 60－80 penetration grade bitumen, as a possible means of reducing costs. A road trial to evaluate (undiluted) epoxy EGFS sections with 20% air voids was constructed. The trial has been in place for half a year and is performing well. The trial needs ongoing monitoring to assess durability behavior, but it has successfully demonstrated that the full-scale manufacture and construction of an EGFS10 surfacing can be accomplished with standard plant and equipment, and with only very minor changes to practice.

Key words: Epoxy modified bitumen, Open-graded friction course, Mixture design, Pavement performance

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水泥混凝土路面就地再生水泥稳定碎石基层技术应用研究

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摘 要：与沥青路面相比，水泥混凝土路面修复相对困难，水泥混凝土路面的破损给公路管理与养护部门带来了巨大的压力。就地粒化技术是采用回转劈裂破碎法将初步预破碎的水泥混凝土板路面在原路面上破碎出符合设计级配的集料，然后在现场添加一定量的稳定剂形成混合料，经整形、碾压和养生，并成为路面结构层的工艺。本文采用回转就地粒石化技术依托实体工程完成了试验路的就地粒石化再生，确定了最佳破碎方法、最佳水泥剂量等指标，经工后检测，就地粒石化再生水稳基层各项指标均满足设计规范要求，说明就地粒石化技术可应用于农村公路改造工程。

关键词：回转就地粒石化；农村公路；就地再生；水稳基层

Application of In-Situ Recycled Cement Stabilized Macadam Base Technology on Cement Concrete Pavement

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Abstract:

Compared with asphalt pavement, cement concrete pavement repair is relatively difficult, and the damage of cement concrete pavement has brought tremendous pressure to highway management and maintenance departments. In-situ granulation technology is a process of using rotary splitting method to break the preliminary pre-broken cement concrete slab pavement into aggregates conforming to the design gradation on the original pavement, and then adding a certain amount of stabilizer to the site to form a mixture, which is shaping, rolling and curing, and becomes the pavement structure layer. In this paper, the in-situ granular Petrochemical regeneration of the test road is completed by using the rotary in-situ granular petrochemical technology relying on the physical engineering. The optimum crushing method and the optimum cement dosage are determined. After the post-construction testing, the indexes of the water-stabilized base of in-situ granular Petrochemical regeneration meet the requirements of the design specifications, which indicates that in-situ granular petrochemical technology can be applied to the rural highway reconstruction.

keywords: Rotary in-situ granulation; rural highway; in-situ regeneration; water-stable base

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橡胶颗粒沥青混合料耐久性评价试验方法研究

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摘 要：本文以橡胶颗粒沥青混合料自身力学特点、变形性能为基础，结合其所处的环境条件和荷载作用，分析了橡胶颗粒沥青路面在低温、水、行车荷载耦合作用下的破坏机理。为客观评价橡胶颗粒沥青混合料路用性能的耐久性，基于其工作时所经受的低温及动水冲刷作用，提出了专门用于评价橡胶颗粒集料与沥青之间界面黏附性的方法。同时，基于混合料在低温、水、荷载耦合作用下的破坏机理，提出了以老化后冻融煮沸劈裂试验为主、肯塔堡浸水飞散试验为辅的耐久性综合评价方法。本文提出的橡胶沥青混合料耐久性评价试验方法操作简便、可真实模拟混合料实际工作状态、试验结果真实可靠，是一种可专门适用于沥青胶结类路用混合料的耐久性评价方法。

关键词：沥青混合料；橡胶颗粒；耐久性；评价方法；黏附性

The Research of Asphalt Mixture with Rubber Particles Durability Evaluation Method

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Abstract:

In view of the rubber particles evaluation method of the durability of asphalt pavement in addition to the snow and ice ,especially the rubber particles mixture water stability evaluation method. In this paper, the fracture mechanism of the rubber particles in asphalt mixture, put forward the asphalt with coarse and fine aggregate adhesion evaluation method, and the rubber particles water stability evaluation method, and identified as rubber particles durability evaluation method. For the improvement of the rubber particles mixture durability method and application laid a foundation.

keywords: Asphalt mixture; Evaluation method

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黏土改良磷尾矿砂用作路基填料的研究与应用

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摘 要：磷尾矿中主要成分是氧化硅，其几何形状、力学性能以及颗粒组成与天然砂类似，属于细砂或超细砂，黏土改良磷尾矿砂具有类似砂土的内嵌黏聚结构，充分压实后形成密实固结体，是一种优良并有推广价值的路基填料。文中从材料特性、结构强度角度分析磷尾矿砂掺土后性能变化规律，提出了黏土改良磷尾矿砂填筑路基的应用层位、掺配比例和施工方法，工程成本与掺灰土比节约 30%以上，经济社会效益显著。

关键词：磷尾矿砂；黏土改良；黏聚力；内摩擦力；抗剪强度

Study and Application of Clay Modified Phosphorus Tailings Used as Embankment Filler

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Abstract:

The main component of phosphorus tailings is silicon oxide. Its Geometric shapes, mechanical properties and particle composition are similar to natural sand, Belong to fine sand or ultra-fine sand. Clay modified phosphate tailings formed have an embedded cohesive structure similar to sand. Full compaction to form a Dense consolidation body. It is a kind of excellent and popularizing Subgrade filling. In this paper, From the point of Material performance and structural strength, Analyze the Performance change regulation of Phosphorus tailings mixed with soil. Put forward the Application horizon, Mixing ratio and Construction method of Clay modified phosphorous tailings filling roadbed. Compared with lime doped soil, the project cost is saved by 30%. Economic and social benefits are remarkable.

keywords: Phosphate tailings, Clay modification, Cohesive force, Internal friction force， Shear strength

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高粘沥青改性剂的性能评价与工程应用

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摘 要：作为排水沥青路面的核心关键材料，高粘沥青改性剂目前一直由进口产品所垄断，国内高粘改性剂的质量良莠不齐，限制了排水沥青路面的推广应用。针对此，本文以新型道路材料国家工程实验室自主研发的高粘沥青改性剂 PEA 为研究对象，以日本进口改性剂 T 和某国产品牌改性剂 H 作为平行对比例，分别就高粘沥青和高粘沥青混合料各项性能指标进行分析，并铺筑排水沥青路面试验路，研究结果表明，高粘沥青改性剂 PEA 制备的混合料路用性能和施工性能优越，具有较好的抗老化性，各项路面检测指标符合技术要求。

关键词：道路工程；高粘沥青改性剂；性能评价；工程应用

Performance Evaluation and Engineering Application of High Viscosity Asphalt Modifier

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Abstract:

As the key material of porous asphalt pavement, high-viscosity asphalt modifier has been monopolized by imported products at present. The quality of domestic high-viscosity modifiers is unstable, which limits the popularization and application of drainage asphalt pavement. In this paper, PEA, a high viscosity asphalt modifier independently developed by NLARM, is taken as the research object, and the imported modifier T from Japan and a domestic brand modifier H are taken as parallel comparison. The performance indexes of high-viscous asphalt and high-viscous asphalt mixture are analyzed respectively, and the porous asphalt pavement test road is paved. The results show that the mixture prepared by PEA has excellent pavement performance and construction performance. Each pavement detection index meets the technical requirements.

keywords: road engineering; high viscosity asphalt modifier; performance evaluation; engineering application

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植物废油对老化沥青流变性能影响规律研究

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摘 要：收沥青混合料在进行热再生过程中需加入沥青再生剂保证其使用性能，近五年植物油基再生剂因其绿色可再生的优势越来越受到关注。本文选择了一种我国常见的植物废油，并命名为 W-oil。通过对不同 W-oil 掺量下再生沥青的流变性能分析，考察 W-oil 作为沥青再生剂的潜力。研究结果表明：随着 W-oil 掺量的增加，再生沥青的施工和易性、疲劳性能和低温抗裂性能均得到改善，但高温性能逐渐降低。当 W-oil 掺量为 13.4%时，再生沥青高温性能与基质沥青相当，施工和易性略低，疲劳性能和低温性能更优。因此，W-oil 作为沥青再生剂是非常有潜力的。

关键词：RAP；再生剂；植物油；流变性质

The Effect of Waste Vegetable Oil on Rheological Properties of Aged Asphalt

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Abstract:

Asphalt rejuvenator should be added in reclaimed asphalt pavement (RAP) hot recycling to ensure its performance. In the past five years, the vegetablet oil base rejuvenator attracted more and more attention due to its green and renewable advantages. This paper chose a common plant waste oil in China and named it w-oil. Through the analysis of rheological properties of recycled asphalt withr different w-oil content, the possibility of w-oil as asphalt rejuvenator was investigated. The results show that: with the increase of w-oil content, the workability, fatigue performance and low-temperature cracking of rejuvenated asphalt are improved, but the high temperature stability is reduced. When W-oil content is 13.4%, the high temperature stability of rejuvenated asphalt is similar to that of virgin asphalt, while workability is slightly lower, rejuvenated asphalt has better fatigue performance and low-temperature performance. Therefore, w-oil is a potential asphalt rejuvenator.

keywords:RAP; rejuvenator; vegetable oil; rheological proper

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片麻岩的材料特性及工程应用研究进展

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摘 要：片麻岩因其特殊的材料性质在工程中未得到广泛应用，而在缺乏优质石料或片麻岩废渣较多的地区，就地取材成为经济环保的关键。总结了片麻岩匀质性不好、压碎值较大、与沥青粘附性差的材料特性，对国内外学者的研究做了综述，最后提出结合数值模拟手段探究片麻岩材料性质并对其改性利用的工程设计方法。

关键词：公路工程；片麻岩；材料特性；工程应用

Progress in Material Properties and Engineering Applications of Gneiss

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Abstract:

Gneiss has not been widely used in engineering due to its special material properties, but in areas lacking high-quality stone or gneiss waste, local materials have become the key to economic and environmental protection. The properties of gneiss with poor homogeneity, large crushing value and poor adhesion to asphalt are summarized. The researches of scholars at home and abroad are reviewed. Finally, the numerical simulation method to explore gneiss properties and its modification engineering method have been proposed.

keywords: highway engineering; gneiss; material properties; engineering applications

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Influence of Moisture Condition on Adhesive Characteristics of SBS Modified Asphalt-Aggregate Systems with Warm Mix Additives

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Abstract:

Moisture damage has been widely known as one of the main diseases of asphalt pavements, especially for those with warm mix additives. Cohesive strength of asphalt and adhesive strength between asphalt and aggregate are the two fundamental properties that affect moisture stability of asphalt mixture. In the present work, thermodynamic theory based on contact angle tests were applied to investigate the impact of water intrusion on cohesion and adhesion of styrene-butadiene-styrene (SBS) modified asphalt-aggregate systems with different warm mix additives (Sasobit and Evotherm). In addition, the influence of water immersion were evaluated in terms of nano mechanical properties and surface microstructural features. Dry and wet conditioned sample were prepared in the laboratory, adhesive force and surface topography images of these asphalts were obtained using atomic force microscopy (AFM). The results indicate that, under condition of water intrusion, the incorporating of Sasobit can lead to better cohesion but worse anti-stripping performances of SBS modified asphalt. Evotherm shows no obvious effect on cohesion but can be available to improve the adhesion of SBS modified asphalt-aggregate system under wet condition. Water immersion of asphalt can lead to adhesion degradation of warm mix SBS modified asphalt-aggregate systems, but the water-induced adhesion degradation of SBS modified asphalt can be delayed with the inclusion of Sasobit. Furthermore, the results of AFM topographic images reveal that water immersion can lead to more uniform distribution of peri phases in the para phases for the SBS modified asphalt binders with warm mix additives, which seems to be softened after water immersion.

keywords: Asphalt; warm mix additive; water condition; adhesion; morphology

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建筑垃圾在沥青路面各结构层中的应用与研究进展

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摘 要: 建筑垃圾作为房屋拆迁后的废弃物，经分选、破碎、筛分后形成水稳性和抗冻性能良好的骨料，可用于路面各结构层的铺筑中。相关研究表明，建筑垃圾骨料经无机结合料稳定后，其抗压强度、模量、路用性能均可达到规范要求，因此，建筑垃圾在路面各结构层铺筑方面具有良好的发展前景。本文梳理了建筑垃圾在沥青面层、基层和底基层以及路基中的应用与研究，总结了建筑垃圾骨料作为道路建筑材料的特点和应用时的注意事项，指出了建筑垃圾骨料在道路工程应用中所面临的问题，为进一步提高建筑垃圾的利用效率提供参考。

关键词：沥青路面；路基；建筑垃圾；集料

An Overview of Utilization and Research Progress of Construction & Demolition Waste in Asphalt Pavement Structural Layers

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Abstract:

As the demolition of house, construction & demolition waste can be sorted, crushed and screened to be aggregates with good water stability and frost resistance. It can be used in asphalt pavements of various structural layers. Relevant research shows that the compressive strength, modulus and pavement performance of construction & demolition waste could meet the requirements of the specification. Therefore, construction & demolition waste has good prospects in pavement structural layers. This paper combs the utilization and research of construction waste in asphalt surface, base and subbase, and subgrade, summarizes the characteristics of construction waste aggregate as road construction material and points out the problems faced by construction & demolition waste aggregate in road engineering application, and provides reference for further improving the utilization efficiency of construction waste.

key words:asphalt pavement; subgrade; construction & demolition waste; aggregate

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近红外反射型彩色降温路用涂层性能评价与优化分析

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摘 要：高反射路用涂层是缓解热岛效应、延缓道路高温病害的有效方式。基于全频谱反射光学原理，本研究选择近红外反射型填料作为部分功能填料，以水性乳液为基料，制备了近红外反射型彩色降温路用涂层，从光学特性、热学特性、路用性能多方面对涂层性能进行了评价，采用正交试验及多因素综合分析的方法对近红外反射型彩色降温路用涂层进行了优化分析。结果表明：该近红外反射型彩色降温涂层总反射率从 5%提高到 30%-40%，近红外反射率从 3%提高到了 50%-60%；路用降温涂层对路用性能有一定影响但总体良好，能够满足道路应用需求；优化了涂层配方组合涂层材料配方体系，研究结果可为降温路用涂层的开发提供参考，同时，为其工程应用奠定了理论基础。

关键词：热岛效应；高反射涂层；路用性能；全频谱反射性能

Performance Evaluation and Optimization Analysis of Near-Infrared Reflective Colored Coating for Cool Pavement

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Abstract:

High-reflection coating for cool pavement is an effective way to alleviate the heat island effect and delay high temperature disease of pavement. Based on the principle of full-spectrum optical investigation, this study selected near-infrared reflective filler as a partial functional filler, and prepared a near-infrared reflective color cooling coating based on aqueous emulsion. The optical properties, thermal properties and pavement performance were investigated and evaluated. The orthogonal test and multi-factor comprehensive analysis method were used to optimize the near-infrared reflective colored coatings for cool pavement. The results show that the total reflectance of the near-infrared reflective colored coating for cool pavement is increased from 5% to 30%-40%, and the near-infrared reflectance is increased from 3% to 50%-60%. The coating has a certain influence but is generally good enough to meet the needs of road applications; the formulation system of the coating formulation has been optimized. The research results could provide reference for the development of cool pavement coatings, and lay a theoretical foundation for its engineering application.

keywords: Urban Heat Island; high-reflection coating; pavement performance; full-spectrum optical performance

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3D 打印技术在路面工程中的应用

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摘 要：3D 打印技术是一种具有巨大的发展空间的新型制造工艺。本文首先简要介绍了目前主流的 3D 打印技术以及对应的优缺点，其次根据其技术特点简要分析了 3D 打印技术在路面工程中可能具备的优势，以及目前 3D 打印技术在路面工程的应用。根据相关分析，本文提出了 3D 打印技术未来在实现特殊路面结构形式、功能性路面、制作功能梯度路面材料等有一定的发展潜力。

关键词：3D 打印；特殊路面结构；功能性路面；功能梯度材料

Application of 3D Printing Technology on Pavement Engineering

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Abstract:

3D is a new manufacture technology. This paper first classifies the 3D printing technology and its pros and cons. Then the current application of 3D printing on pavement engineering is introduced. Finally, the future possible application of 3D printing on pavements are purposed, which includes special road structures, functional pavements, functionally graded materials etc.

keywords:3D printing; special road structures; functional pavements; functional graded material

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Influence of Temperature and Loading Frequency on Mechanical Properties of Asphalt Mixtures Under Repeat Triaxial Loading Using Microstructural Analysis

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Abstract: Asphalt mixes are used in the construction of high-quality highways and airport pavements, and it is particularly important to achieve high quality for these load scenarios. Since the service life of asphalt pavements depends heavily on temperature as well as loading frequency, which have to be taken into account when planning and analysing pavements, expensive laboratory tests are carried out in order to better predict their service life. With steadily increasing computing power, it is now possible to create precise heterogeneous numerical models that allow observations in the microstructure area of asphalt mixes. In addition, such simulations enable considerably more constant conditions, as a test specimen can be tested again and again under different influences. In this study, a modified triaxial pressure swell test with different load frequencies was performed to investigate the influence of temperatures from -5°C to 15°C on the mechanical properties of the microstructure of the asphalt mixtures. To reconstruct the microstructure of asphalt mixes for numerical simulations, the methods of X-ray computed tomography and Digital Image Processing were used to model the original morphology of the asphalt mixture in finite element models. Numerical simulations were used to study the development of vertical deformation, stress states in

the asphalt mortar and the distribution of maximum principal stresses at different temperatures. The results show that the numerical simulation of asphalt mixture at microstructure can be used to simulate the mechanical responses of asphalt mixtures under different conditions. The performance behaves differently in consideration of different temperatures and loading frequencies. The further research is worthy being carried out to improve the understanding of the mechanical behaviour of the asphalt mixtures.

Key words: Asphalt mixture; Temperature; Loading frequency; Microstructure; Digital Image Processing; Finite element simulation

颗粒流离散元思想在道路的应用研究综述

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摘 要：对于交通土建领域，试验分析是必要且关键的环节，而用颗粒流离散元思想，用数值模拟试验的新方法可以去解决传统试验造价高，试验操作繁琐复杂，材料本构模型复杂等难题，并且可以精确参数值。本文首先对颗粒流离散元思想进行简单的介绍，并且针对于该思想在级配碎石道路和沥青路面中的国内外试验方向和应用进行了总结，并综述了颗粒流离散元数值模拟的代表软件 PFC5.0 的机理及优势特点，最后对未来的交通土木领域应用前景进行了展望。

关键词：离散元

A Summary of the Application Research of Particle Flow Discrete Element Thought in Roads

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Abstract:

For the field of traffic and civil engineering, experimental analysis is a necessary and critical link. With the idea of particle flow discrete element, the new method of numerical simulation test can solve the high cost of traditional experiment, the complicated and complicated test operation, and the complicated material constitutive model. Puzzles and precise parameter values. This paper firstly introduces the idea of particle flow discrete element, and summarizes the domestic and foreign experimental directions and applications of the idea in graded gravel road and asphalt pavement, and summarizes the representative of particle flow discrete element numerical simulation. The mechanism and advantages of software PFC5.0, and finally prospects for the future application of traffic and civil engineering.

keywords: discrete element

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基于空隙填充计算的颗粒混合料分段级配设计模型

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摘 要：随着对道路材料要求的日益增高，传统级配设计理论正逐渐向可计算、可分析的数字化、定量化设计模型发展，其中混合料的空隙率则是道路性能的关键指标之一。本文基于多级粒径组合的空隙填充计算方式，建立了用于颗粒混合料级配设计的离散单元模型，通过单档与组合模型分析，以空隙率为控制指标，对颗粒混合料进行分段合成，从而为级配设计、评价与混合料空隙率预测提供量化手段。

关键词：离散单元法；级配设计；公路工程；空隙填充；颗粒混合料

Segment Gradation Design Model of Granular Mixture Based on Void Filling Calculation

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Abstract:

With the increasing demand for road materials, the traditional gradation design theory is gradually developing into a calculable, analyzable, digital and quantitative design model, in which the voids of mixture is one of the key indicators of road performance. In this paper, a discrete element model for gradation design of granular mixtures is established based on the calculation method of multi-stage particle size combination. Through single-stage and combination model analysis, the granular mixture is segmentally combined with voids as control index, thus providing quantitative methods for gradation design, evaluation and voids prediction of mixture.

keywords: discrete element modelling; gradation design; highway engineering; void filling; granular mixture

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如何在离散元中高效精确地模拟沥青砂浆

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摘 要：沥青混合料是由多档粒径的颗粒作骨架，沥青作粘结料粘结而成的复合材料。本文的主要目的是提供一种可能的方案来解决利用离散元仿真模拟沥青混合料时小颗粒的问题：一方面为了使得仿真结果更加精确对小颗粒的精确模拟是必不可少的，另一方面如果完全按照真实粒径和比例对小颗粒进行模拟将会极大的降低运算效率。本文将由粗集料、细集料及填料组成的矿质混合料根据粒径分为大颗粒(粒径大于 2.36mm)和小颗粒(细集料及填料)。其中，大颗粒是完全按照真是级配的形状、粒径、体积占比来进行模拟，而小颗粒则通过等效粒径和等效体积进行模拟。本文通过研究六种典型级配（AC13 三种，SMA13 三种）确定了离散元仿真过程中的两个关键参数：等效颗粒粒径和等效体积占比。研究发现：(1)如果直接采用大颗粒替代原有级配细料部分，对于各类级配均会产生巨大的干涉，试件内部有巨大的颗粒重叠和内应力；(2)提出了一种生成沥青混合料的方式，且通过对 6 种常见级配的仿真试验，发现对于常见的级配，折减系数可以在 0.82-0.86 之间选取，且细料越多，系数应当越小。

关键词：公路工程；离散元方法；沥青混合料；等效颗粒粒径；小粒径颗粒

Discrete Element Simulation of Smaller Particles in Asphalt Mixture

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Abstract:

Asphalt mixture is a particulate composite of multi-size particles glued by asphalt binder. The major objective of this research is to provide a potential solution to the dilemma situation in discrete element modeling of the smaller particles (less than 2.36mm for instance) in asphalt mixture: on the one hand, accurate simulation of the smaller particles is essential from scientific or practical research purposes, one the other hand, it results in the lower computational efficiency. In this research, mineral aggregates which include coarse aggregates, fine aggregates, and fillers, are categorized into the larger particles (larger than 2.36mm) and the smaller particles (fine aggregates and fillers). The larger particles are accurately simulated with their realistic sizes and the corresponding volumetric fractions according to the gradation curve, while the smaller particles are simulated with the equivalent particle sizes and the equivalent volumetric fractions. Research effects were made in this research on discrete element modeling to determine the key parameters: the equivalent particle sizes and the equivalent fractions. Through this research it was observed that: (1) Directly replacing the fine particles with lager size will cause non-negligible overlap and stress; (2) Based on the virtual test, this article provides a method to simulate asphalt mixture in DEM, and the reduction factor for ordinary gradation is in the range of 0.82-0.86, larger fraction of small particles leads to smaller reduction factor.

keywords: Highway engineering; Discrete Element Method; Asphalt Mixture; Equivalent Particle

Size; Smaller Particles

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不同加载速率下混凝土梁试件动强度提高机理研究

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摘 要：本文研究混凝土类不均匀脆性材料动态强度提高的机理。对不同加载速率下特殊设计的三点弯曲梁的破坏形态进行了理论分析，提出其动强度提高的根源主要是材料的不均匀性和惯性效应联合作用的结果，并认为此类材料的静、动强度与其破坏后裂纹的发展路径有关。静态加载时，裂纹沿着混凝土的最薄弱面发展，材料破坏所需的能量较小；动态加载时，裂纹能够穿过部分高强度区域沿着能量释放更快的路径发展，所需的能量也相应增大，材料不均匀性对动强度提高的贡献显现出来，惯性效应也随着加载速率提高而逐渐显著；当加载速率超过某一临界值时，由材料不均匀性贡献的动强度将不再增长，只有惯性效应的贡献发挥作用。论文通过特殊设计的不均匀脆性材料三点弯曲梁准静态加载试验和不同速率的冲击试验对提出的理论进行了验证，试验结果与理论设想基本相符。

关键词：不均匀脆性材料

Mechanism on the Enhancement of Dynamic Strength for Concrete Beam Specimens Under Different Loading Rates

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Abstract:

The mechanism for dynamic strength increasing of concrete-like nonuniform brittle materials was studied in this paper. The theoretical analysis of failure mode of three-point bending beam was made under different loading rates, the root of dynamic strength increasing attributed to inhomogeneity of materials and inertial effect, the static and dynamic strength was related with the failure route of cracks. The main crack propagated in the weak interface of material and the failure energy was smaller at static failure; the main crack went through partial high strength regions along the path of the faster energy release and the failure energy was increase at dynamic failure. At this time, the contribution of materials inhomogeneity to the enhancement of dynamic strength had emerged, the inertial effect would also be remarkable with the increase of the load rate. The dynamic strength causing by materials inhomogeneity was not increase, therefore, there was only inertial effect. The theory proposed in this paper was verified by specially designing three-point bending beam at quasi-static loading and impact test at different loading rates, the result was basically in accordance with the theoretical assumption.

keywords:nonuniform brittle materials

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一种基于数值流形法的多质混合材料计算模型

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摘 要：针对多质混合材料的特点，以沥青混合料为例，讨论了目前常用的数值算法在计算其力学响应时的缺陷，结合非连续变形分析方法、数值流形法和无网格法提出了一种新的适用于多质混合材料大变形及开裂计算的数值方法。其核心思想是以颗粒材料的形心为中心定义一个广义的物理覆盖，并通过分片函数强制各种材料位移协调。该算法使用非连续变形分析方法考虑粗骨料的位移、变形及骨料间的接触作用，使用数值流形法中物理覆盖策略保证胶结料的粘结作用，实现了连续与非连续问题总体位移近似函数的统一。该方法还可以应用于包括水泥混凝土在内的各类颗粒增强复合材料的力学计算。论文还通过算例对模型的有效地进行了验证。

关键词：多质混合材料；数值计算；流形法；无网格法

A Novel Calculation Model for Multi-Material Mixture Based on Numerical Manifold Method

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Abstract:

According to the characteristics of multi-material mixture, taking the asphalt mixture as an example, the defects of the commonly used numerical algorithms in calculating the mechanical response of asphalt mixtures are discussed. A new numerical method for large deformation and cracking calculation of multi-material mixture is proposed, which combines the characteristics of the discontinuous deformation analysis method (DDA), the numerical manifold method (NMM) and the meshless method. The core idea of this new numerical method is to define a general mathematical coverage over all the particles and using a piecewise coverage function to enforce the displacements of various materials coordinating. The algorithm uses DDA method to consider the displacement, deformation of aggregates and the contact behavior between aggregates, while use the mathematical coverage of NMM to ensure the bonding effect. It realizes the unification of the approximate displacement functions of continuous and discontinuous problems. The model also be validated through an example.

keywords:multi-material mixture; numerical calculation; numerical manifold method; meshless method

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沥青混凝土桥面铺装结构温度行为规律与温度场预估模型

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摘 要：为研究不同环境温度作用下桥面铺装结构层的温度行为特性，通过 ABAQUS 有限元数值分析获取了桥面铺装结构层的温度行为数据,分析了不同结构层厚度对桥面铺装结构层温度场及温度应力的影响作用，构建了铺装结构层温度场的预估模型。研究结果表明：环境温度因素对铺装结构温度场及温度应力具有显著影响，随着铺装结构厚度增加，铺装结构内部温度变化幅度呈现减小趋势;铺装结构顶面温度及温度应力的变化主要受外部环境因素作用，与结构层厚度相关性较低；铺装结构层厚度对结构层内部温度行为有显著影响；考虑铺装结构内部温度的滞后性和累计性,构建了能够满足桥面铺装结构设计的结构层温度场预估模型。

关键词：桥面铺装；温度场；温度应力；数值模拟；预估模型

Asphalt Concrete Bridge Deck Pavement Temperature Behavior and Temperature Prediction Model

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Abstract:

In order to study the temperature behavior characteristics of bridge deck pavement layer under different environmental temperatures, the temperature behavior data of bridge deck pavement layer was obtained by ABAQUS finite element numerical analysis, and the thickness of bridge deck pavement layer was analyzed. Based on the influence of temperature field and temperature stress, an estimated model of the temperature field of the pavement layer was constructed. The results show that the ambient temperature factor has a significant effect on the temperature field and temperature stress of the pavement structure. With the increase of the thickness of the pavement structure, the internal temperature variation of the pavement structure shows a decreasing trend; the top surface temperature and temperature stress of the pavement structure The change is mainly affected by external environmental factors and has a low correlation with the thickness of the structural layer; the thickness of the pavement structure has a significant influence on the internal temperature behavior of the structural layer; considering the hysteresis and cumulativeity of the internal temperature of the pavement structure, the bridge can be constructed to meet the bridge. Temperature field prediction model for structural layer design of surface pavement structure.

keywords: Bridge deck pavement; Temperature field; Temperature stress; Numerical simulation; Prediction model

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Investigation on Permeability of Porous Asphalt Concrete Based on Microstructure Analysis

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Abstract: Drainage is an important function for porous asphalt concrete (PAC), however, permeability is decreased gradually due to pores clogging. The aim of this paper is evaluating the influence of pores on permeability and anti-clogging performance of PAC. To create different types of pore structures, aggregates with different sizes and shapes were used to form specimens, and a self-designed equipment was employed to measure the permeability and anti-clogging performance of PAC. X-ray CT device scanned specimens before and after clogging test, so the influence of aggregates on pores can be determined, and relationship between pore characteristics and anti-clogging performance was investigated. The results show that aggregates with different shapes affect pores states obviously, including volume, number and effective porosity, and permeability of PAC decreases if effective pores are clogged; Clogging happens shortly, and PAC constructed by aggregates with regular shape presents excellent anti-clogging performance; Aggregates with irregular shape cause more tortuous drainage channel compared with regular aggregates, and tortuosity coefficient is an effective indicator that quantifies the complexity of pores and evaluates the anti-clogging performance of PAC.

Key words: Porous asphalt concrete

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乳化剂在石英表面吸附行为的分子动力学模拟

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摘 要:采用分子动力学方法研究了十二烷基苯磺酸钠(SDBS)和十八烷基三甲基氯化铵(STAC)在 SiO_2 表面的吸附行为，并通过电导率试验对模拟结果进行了验证。通过设置两组不同乳化剂溶液模型，从结构特征和动力学特征分析两组模型之间的差异。动力学计算结果表明两种乳化剂分子均能在短时间内吸附到 SiO_2 表面，受疏水碳链和 SiO_2 表面的吸附作用，以及亲水基与水分子的共同作用，形成不同的聚集结构；浓度分布表明乳化剂电离出的离子受到带电亲水基团和水分子的共同作用，同时乳化剂分子吸附于固体表面约 1 Å 处；径向分布函数分析得到两种乳化剂亲水性的强度，表明乳化剂的亲水性对于乳化剂与水在 SiO_2 表面的竞争吸附存在影响；扩散系数准确描述两种乳化剂受 SiO_2 吸附作用的程度，STAC 受到的吸附作用大于 SDBS。通过模拟表明两种乳化剂在 SiO_2 表面吸附的具体差异性，作为对试验的补充，可以提供微观结构信息，同时为进一步研究乳化沥青与集料的吸附行为提供理论支撑。

关键词: 乳化剂；固-液界面吸附；分子动力学

Moleculer Dynamics Simulation of the Adsorption of Surfactants at Quartz Surface

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Abstract:

The adsorption of SDBS and STAC on the solid surface of SiO_2 was studied by molecular dynamics. And the simulation results were verified by conductivity test. The differences between the two models were analyzed from the structural and dynamic characteristics by setting two different emulsifier solution models. The calculation results show that both emulsifier molecules can adsorb to the surface of SiO_2 in a short time, adsorbed by the hydrophobic carbon chain and SiO_2 surface, and the interaction of hydrophilic and water molecules to form different aggregate structures. The distribution indicates that the ions ionized by the emulsifier are affected by the charged hydrophilic group and the water molecule, and the emulsifier molecules are adsorbed on the solid surface by about 1 Å. The radial distribution function analysis gives the hydrophilicity of the two emulsifiers. It is indicated that the hydrophilicity of the emulsifier has an effect on the competitive adsorption of emulsifier and water on the surface of SiO_2. The diffusion coefficient accurately describes the extent to which the two emulsifiers are adsorbed by SiO_2. The simulation shows that the specific difference of adsorption of the two emulsifiers on the surface of SiO_2, as a supplement to the test, can provide microstructural information, and provide theoretical support for further study of the adsorption behavior of emulsified asphalt and aggregate.

keywords: emulsifier; solid-liquid interface adsorption; molecular dynamics

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Microstructural Analysis on Non-Uniform Fatigue Susceptibility for Asphalt Mixtures

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Abstract:

The fatigue resistance of asphalt mixtures has been considered plays an important role on the structural performance. However, in the current structural analysis for the asphalt pavement, the internal properties of the same materials in different layers are usually treated as identical, which ignored the effect of compaction. In order to evaluate the fatigue damage behaviour of asphalt layers under repeated compacted load, field pavement was built, and test cores were drilled to sliced into test specimens with varying compactness that can reflect the real internal state of asphalt pavement. The indirect tensile fatigue test with 70000 loading cycles was designed to capture the fatigue properties of asphalt samples at 10° C, the frequency of sinusoid load was 0.1 Hz, the minimum value was 0.035 MPa and maximum value was 0.5 MPa. The two-dimensional imaging technique and processing procedure were utilized to investigate the morphology change of internal structures using X-ray CT technology. According to the results of this study, microscopic analysis can effectively evaluated reflected the evolutions of the internal structures of asphalt mixture. Compaction efforts significantly causes the difference of affect the structural properties for the air voids, as well as the fatigue performance for the asphalt mixtures. The damage ratio obtained from air void analysis were determined to be the fatigue indicator for dense-graded asphalt mixtures. This study could provide support for the further research and application on the relationship between the mechanical analysis and actual stressing state.

keywords: asphalt mixture; X-ray Computed Tomography; compaction; fatigue damage; microstructural characteristics

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Performance Evaluation and Numerical Investigation of Fully Permeable Pavement Subjected to Dynamic Loading

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Abstract: Pervious pavement is gaining popularity in pavement industry because of its extraordinary water permeability, traffic noise reduction, and wet driving safety. However, the larger air voids of permeable pavement bring high susceptibility to damage resulting from water and traffic stresses. Therefore, focusing on the service performance and stress state of permeable pavement under various moisture and loading conditions is of critical importance. This paper presents a study which aims to investigate the hydro-mechanical interaction of fully permeable pavement (FPP) topped with polyurethane-bounded pervious mixtures (PUPM) under various loading and environmental conditions. To achieve this objective, a full-scale test track was constructed. The pore pressures and total vertical stress within the pavement was measured and characterized under the accelerated pavement test (APT) in three different saturated conditions. Based on the modified theoretical framework, the coupled hydro-mechanical model for porous permeable pavement was established and implemented into the finite element method (FEM) to simulate the practical behavior in pore structures. The results were validated by comparing the in-situ measured data. Based on the development of the fully coupled hydro-mechanical model, the damage mechanism of the porous pavement structure was revealed.

Key words: Hydro-mechanical Interaction; Fully permeable pavement (FPP); Polyurethane; Pore pressures

城乡结合部公路平纵面设计研究

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摘 要：随着城市化的不断发展，城乡结合部公路必将改造成城市道路，如何预先考虑其城市化改造，科学、合理的确定其平纵面，使其能够有利于城市的发展，同时在未来城市化改造中能够最大限度利用现有公路，是城乡结合部公路平纵面设计需要研究的重要内容。本文通过分析目前城乡结合部公路平纵面设计存在的主要问题，提出了城乡结合部公路平纵面设计的总体思路，并结合工程实例从平面、纵面两个维度提出具体设计对策，对类似项目的规划、设计具有很强的参考价值。

关键词：道路工程；城乡结合部公路；设计思路；平面设计对策；纵面设计对策

Research on Plane and Vertical Design of Rural-Urban Continuum Highway

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Abstract:

With the continuous development of urbanization, the highway in the urban-rural continuum will be transformed into the urban road. It is the focus of the highway plane and vertical design in the urban-rural continuum that how to consider its urbanization in advance and determine its plane and vertical design scientifically and rationally, so that it can be conducive to the development of the city, and that make full use of the existing highway in the future urbanization transformation at the same time. This paper analyzes the main problems existing in the plane and vertical design of the highways in the urban-rural continuum . And then puts forward the general idea of the plane and vertical design of the urban-rural junction highway, and puts forward specific design countermeasures from the plane and vertical dimensions combined with engineering examples, which has a strong reference value for the planning and design of similar projects.

keywords: road engineering；highways in rural-urban continuum；design ideas；plane design countermeasure；vertical design countermeasure

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暴雨条件下高速公路超高缓和段积水深度分布模型构建

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摘 要：暴雨条件下高速公路超高缓和段积水易造成行车安全风险问题。为研究超高缓和段的积水深度分布情况，提供道路设计的理论指导，通过引入流体力学中的圣维南方程和曼宁公式，提取道路几何模型并划分道路网格，利用有限元的方法对道路网格单元间的径流传递特征和径流深度进行分析，构建了暴雨条件下的超高缓和段积水深度分布模型。以双向四车道高速公路的超高缓和段进行试验分析，试验结果表明，积水深度分布模型能够客观反应不同道路纵坡、超高横坡和降雨强度下的超高缓和段积水深度分布状况。结合公路超高缓和段积水深度分布模型，对不同坡度、线形组合进行积水深度分布试验，可得到不同道路线形组合条件下排水的最佳坡度组合，为道路超高缓和段的设计提供借鉴与指导。

关键词：公路工程；超高缓和段；积水深度分布模型；圣维南方程；曼宁公式

The Accumulated Water Depth Distribution Model of Ultra-High Transition Section of Highway Under Rainstorm Conditions

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Abstract:

Under the rainstorm conditions, the ultra-high transition section of the highway is likely to cause traffic safety risks. In order to study the distribution of accumulated water depth in the ultra-high transition section, and to provide the theoretical guidance for road design, and by introducing the Saint-Venan equation and the Manning formula in fluid mechanics, and extracting and dividing the road geometry model, and making use of the finite element method to analyze the runoff transfer characteristics and runoff depth between the road grid units are analyzed, then the ultra-high transition water depth distribution model under rainstorm conditions is constructed. Based on the test of the ultra-high transition section of the two-way four-lane expressway, the results show that the accumulate water depth distribution model can objectively reflect the distribution of accumulate water depth under the ultra-high transition section of different road longitudinal slopes, ultra-high cross slopes and rainfall intensity conditions. Combined with the model, testing for different slope and line combination can be used to obtain the optimal slope combination of drainage under different road line combination conditions, which provides reference and guidance for the design of road super-high transition section.

keywords: Highwayengineering;ultra-high transition; waterdepth distribution model; Saint-Venant equation; Manning formula

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基于行车动力学的高速公路积水路段行车风险分析

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摘 要：为了研究高速公路积水路段小客车行车风险，综合考虑车速、驾驶行为和积水路段线形等因素，利用行车动力学仿真软件 Carsim，建立了车辆动力学模型、道路模型以及小客车换道轨迹模型。在车辆侧向偏移值和质心侧偏角基础上引入临界积水路段长度作为评价指标，通过改变道路圆的曲线半径、超高、纵坡、车速和驾驶行为，分析了小客车在积水路段的行车风险影响因素，运用 MATLAB 回归分析建立了积水路段小客车行车风险预测模型，对多雨地区高速公路某积水路段进行了行车风险分析。研究结果表明：圆曲线半径、超高、车速对积水路段行车风险有显著性影响，纵坡在 2%以内对行车影响较小；制动和向内侧换道行为会增加车辆甩尾事故风险，向外侧换道会增加车辆侧滑事故风险。建议车辆在通过积水路段时，采取提前减速措施，低速通过，并避免采取换道行为。

关键词：公路工程；积水路段；行车风险分析；Carsim 仿真；风险预测模型

Traffic Risk Analysis of Freeway Water Conservancy Section Based on Driving Dynamics

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Abstract:

In order to study the traffic risk of small passenger cars on the water accumulation section of the expressway, considering the factors such as vehicle speed, driving behavior and the line shape of the accumulated water section, the vehicle dynamics simulation model Carsim was used to establish the vehicle dynamics model, the road model and the lane change track model of the passenger car. Based on the vehicle lateral offset value and the centroid side declination, the length of the critical water section is introduced as the evaluation index. By changing the curve radius, super elevation, longitudinal slope, vehicle speed and driving behavior of the road circle,the influencing factors of the traffic risk of the passenger car in the water section are analyzed.The driving risk factors of the road sections were analyzed by MATLAB regression analysis. The risk prediction model of small passenger cars in the water section was established, and the traffic risk analysis of a waterway section of the highway in the rainy area was carried out. The results show that the radius of the curve, the super-high speed and the vehicle speed have a significant impact on the traffic risk of the water-storage section. The longitudinal slope has less impact on the traffic within 2%; the braking and the inward-changing behavior will increase the risk of vehicle tail-fighting accident. Changing lanes to the outside will increase the risk of general skid accidents. It is recommended that the vehicle adopt early deceleration measures when passing through the water accumulation section, pass at low speed, and avoid changing lanes.

Key words: Highway engineering; Waterlogged section; Driving risk analysis; Carsim simulation; Risk prediction model

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基于 SWMM 的透水铺装内涝控制效果分析

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摘 要：基于 SWMM（Storm Water Management Model）建立透水路面和区域模型，首先分析三种透水路面结构的水文特点，其次分析研究区域采用透水路面前后水文、水力性能的差异。结果表明，在短历时暴雨下，水文性能由低到高分别为排水路面、半透水路面、全透水路面。研究区域在采用透水路面后，可有效减少径流系数，削减节点溢流时间、溢流体积，有利于缓解城市内涝问题，以此为透水路面应用于海绵城市的建设提供参考。

关键词：SWMM； 透水路面； 城市内涝

The Reduction Effects of Permeable Pavement on Urban Flooding Based on SWMM

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Abstract:

Abstract:Based on SWMM (Storm Water Management Model), the permeable pavement and an urban catchment model were established. Firstly, the hydrological characteristics of three permeable pavements were analyzed. Secondly, the hydrological and hydraulic performance of different permeable pavement layout schemes were compared. The results showed that under short-duration rainstorms, the hydrological performance from low to high is drainage pavement, semi-permeable pavement, and fully permeable pavement. After adopting the permeable pavement, the urban catchment can effectively reduce the runoff coefficient, flooding time and flooding volume, which helps to alleviate the urban flooding problem.

keywords: SWMM; permeable pavement; urban flooding

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高速公路大型满载货车上坡路段运行速度预测模型研究

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摘 要：为研究高速公路长上坡路段大型货车行速度特征，确保大型货车行速度协调，保证行车安全。以公路项目安全评价规范中的预测模型为研究对象，采用雷达测速仪和AxleLight路侧激光仪于绵广高速五处连续上坡采集了路段交通流数据。通过对实际运行速度与预测模型的对比验证，发现现有高速公路纵坡路段运行速度模型与小客车以及两轴大货车的实际运行速度适应性较好，但对于满载半挂铰接列车，模型误差较为显著，其平均误差率达到了 25.37%，因此以半挂铰接列车作为研究车型。进一步研究发现规范模型提出的时间较早，没有考虑到大货车比例、车辆质量功率比的变化对运行速度的影响，且模型未对3%以上的纵坡进行分类考虑，且未考虑 3%以下纵坡对大货车速度的影响。据此，采用回归分析法构建了适用于特大型货车的运行速度预测模型。研究结果表明：长上坡路段特大型车满载时的运行速度与坡度、坡长呈负相关，与车辆质量功率比呈正相关；建立模型通过了回归参数显著性以及平均相对误差检验，且该模型预测值与实测值的误差平均值均小于10%，满足精度要求。

关键词：高速公路；运行速度预测；回归分析；大型满载货车；纵坡路段

Prediction Model of Large Full-Loaded Truck Operating Speed in Continuous Slope Uphill Section of Expressway

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Abstract:

For learning the speed characteristics of large trucks on the section of the highway, to ensure safe driving. Researching the prediction model of the specification, the radar speedometer and the AxleLight instrument were used to collect the traffic data of on the continuous uphill slope. By comparing the actual running speed with the prediction model, it is found that the running speed model has better adaptability to the actual running speed of the small passenger car and the two-axle truck, but for the full load semi-hook articulated train, the error is more significant, the average error rate reached 25.37%, so the semi-trailed articulated truck was used as the research model. Further research found that the normative model proposed earlier, did not consider the impact of changes in the proportion of large trucks, vehicle mass to power ratio on the operating speed, and the model did not classify the longitudinal slope of more than 3%, and did not consider 3% or less.. Based on this, the regression analysis method is used to construct the running speed prediction model for large-sized trucks. The results show that the running speed of the oversized road with large load is negatively correlated with the slope and slope length, and positively correlated with the vehicle mass-to-power ratio. The model is established by regression parameter saliency and average relative error test. The average value of the error between the measured value and the measured value is less than 10%, which satisfies the accuracy requirement.

keywords: Highway;running speed prediction model;regression analysis;large full-load truck; longitudinal slope section

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Exploration of Highway Fair and Vertical Curve Index Considering Night Parking Visual Distance

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Abstract： The safety of night driving is far lower than that of daytime driving. Considering the route index only, one important reason is that the control of route index does not consider the requirement of night parking sight distance. According to the scattering angle, headlight height and elevation angle of vehicle headlights, this paper calculates the relevant parameters of night parking sight distance for highway designers. The research results show that the minimum horizontal and vertical curve radius satisfying the night parking sight distance of automobiles is larger than the minimum radius required by Highway Route Design Code, and in some cases even larger than the general minimum radius required by Highway Route Design Code. The reference range of parameters is given.

Key words: highway engineering; night stopping sight distance; radius of plane curve; radius of vertical curve

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箱涵预制方案比选及箱涵吊装工艺控制

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摘 要：依托西部戈壁地区预制箱涵工程施工组织实践，主要对预制箱涵的应用和施工技术做了详细介绍，并给出在该地区缺水和大温差的环境特点下的施工控制重点和技术，为今后其他预制装配式箱涵工程的应用和实施提供参考和借鉴。

关键词：预制箱涵；方案比选；吊装工艺

The Schemes Comparison and Selection of Precast Box Culverts and Hoisting Technology Control of Box Culverts

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Abstract:

Based on the practice of precast box culverts construction in the Gobi region of Western China, This thesis introduced the application and construction technology of precast box culverts in detail, the key points and techniques of construction quality control under the environmental characteristics of water shortage and large temperature difference in this area are listed, which provides references for the applications and implementations of other precast box culverts in the future.

keywords: Precast box culvert; schemes comparison selection; hoisting technology

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是机遇，更是挑战——VR、BIM 在道路立交几何设计应用中的关键技术研究

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摘 要：BIM 技术通过近几年自上而下的大力推广，已经成功吸引了广大交通建设从业人员的注意。各省市大的交通设计单位纷纷成立 BIM 研究中心，2017 交通部年认定五家挂牌 BIM 技术研发中心。由于国内交通建设产能严重过剩、行业竞争日益激烈，VR、BIM 技术理念一经提出，迅速成为各交通设计单位提高竞争力的新机遇。尽管设计单位纷纷在 BIM 技术投入巨额资金，成果却不尽人意，使得 BIM 技术的应用推广面临巨大挑战。对设计单位来说，迫切需要一款功能强大、高质高效的道路立交专业 BIM 设计软件，而这样的一款 BIM 软件需要解决以下关键技术：卫星图片校正、交通设施专业快速建模、交通仿真等等技术。

关键词：道路桥梁；互通立交；三维建模；交通仿真；VR；BIM

It's a Chance and Even a Challenge-Research on Key Technologies of VR and BIM in Geometric Design of Road Interchange

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Abstract:

BIM technology has successfully attracted the attention of traffic construction practitioners through vigorous promotion from top to bottom in recent years. The BIM research centers have been set up by major transportation design units in each province and city. In 2017, the Ministry of Communications identified five listed BIM technology research and development centers. Because of the serious overcapacity of domestic transportation construction and the increasingly fierce competition in the industry, the technical concept of VR and BIM has been put forward, which has rapidly become a new opportunity for all traffic design units to improve their competitiveness. Despite the huge investment in BIM technology, the results are unsatisfactory, which makes the application and promotion of BIM technology face enormous challenges. For design units, there is an urgent need for a powerful, high-quality and efficient BIM design software for Road Interchange specialty, and such a BIM software needs to solve the following key technologies: Satellite image correction, traffic facilities professional rapid modeling, traffic simulation and so on.

keywords: Road and Bridge；Interchange； 3D modeling；Traffic Simulation；Virtual Reality；Building Information Modeling

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互通式立交分流鼻识别视距控制路段纵断面设计研究

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摘 要：通过对现行规范中分流鼻前识别视距控制路段识别视距和纵断面设计参数研究，分析规范中对分流鼻前识别视距问题规定的不完善之处，得到了在不同纵断面线形组合条件下分流鼻地面标线识别距离的计算方法，并提出了在设计过程中立交分流鼻前识别视距规范符合性验证方法，结合设计实例对此问题进行了进一步说明，研究表明：规范中对于设计速度120km/h 条件下的识别视距控制路段凸形竖曲线半径的规定有待进一步论证，进而提出了不同线形组合条件下识别距离计算和验证方法。

关键词：分流区识别控制路段

Research on Longitudinal Section Design of Intersection Crossing and Identifying Line of Sight Control

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Abstract:

Abstract: Through the study of the identification of line-of-sight and longitudinal section design parameters of the pre-nose identification line-of-sight control section in the current specification, the imperfections in the specification of the pre-nose identification line-of-sight problem in the specification are analyzed, and the linear combination conditions in different longitudinal sections are obtained. The calculation method of the recognition distance of the subdivision nasal ground line is proposed, and the verification method of the conformity identification of the line-of-sight identification in the design process is proposed. The problem is further explained by the design example. The research shows that the specification is for the design. The regulation of the convex vertical curve radius of the identified line-of-sight control section under the condition of speed of 120km/h needs to be further demonstrated, and the calculation method of the recognition distance under different linear combination conditions is proposed.

keywords:diversion area identification control section

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高速公路连续长下坡路段货车专用缓速车道研究

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摘 要：为降低大型载重货车的下坡风险，提升我国高速公路连续长下坡的行车安全性，研究了连续下坡货车专用缓速车道。分析了大型货车在发动机辅助制动下坡时的行驶特性，基于货车制动毂温度和速度特性，提出下坡路段应在必要时增设货车专用缓速车道。以六轴铰接列车为设计主导车型，针对铰接列车下坡安全性对缓速车道架构体系进行了研究，明确了设置方法，提出了包括渐变段、缓冲区和稳速区等组成架构及其线形指标，分析了缓速车道合理限速值以及推荐档位。最后以 G5 京昆高速某长大下坡为例，通过模拟预测多种通行方式下货车制动毂的温升数值，对比验证了缓速车道安全通行性。结果表明：相较于自由流速度下坡和分车道限速下坡，设置缓速车道后的坡底制动毂温度分别降低了 114℃、79℃，降温幅度分别达到 32.9、25.3%，且缓速车道路段内最高温度低于安全临界温度。因而在连续长下坡内增设缓速车道可极大缓解制动毂温升态势，降低货车制动失效概率。

关键词：道路工程；货车专用缓速车道；下坡特性；连续长下坡；制动毂温升

Research on Exclusive Low Speed Truck Lane of Highway Continuous Long Slope Downhill Section

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Abstract:

In order to reduce the downhill risk of trucks under the condition of existing vehicles and improve the driving safety of continuous downhill slopes in China's expressways, the continuous downhill Exclusive Low Speed Lane for trucks are studied. Analyzed the driving characteristics of the truck under the condition of the engine auxiliary braking during downgrade. Based on the temperature and speed characteristics of the brake drum, it is proposed that the downhill section should be equipped with a exclusive low speed lane for the truck when necessary. Taking the six-axis articulated train as the guiding type, the low speed lane structure system is studied for the safety of the articulated train when downgrade. The setting method is clarified, and the structure including the transition section, the buffer zone and the steady speed zone and its linear shape are proposed. And then analyzed the reasonable limit speed value and recommended gear of the low speed lane. Finally, taking a long downhill slope of G5 Jing-kun Expressway as an example, the temperature rise value of the truck brake drum under various traffic modes is predicted by simulation, and the passing safety of the low speed lane is verified. The results show: compared with downgrade with the free-flow speed downhill and the limit speed limit, the temperature of brake drum on slope bottom is reduced by 114℃ and 79℃ after the slow lane is set, respectively. And the cooling amplitude reaches 32.9% and 25.3%, respectively. The maximum temperature in the section of the low speed lane is lower than the critical safety temperature. It shows that adding a Low Speed Lane in the continuous long downhill section can greatly alleviate the temperature rise situation of the

brake drum and reduce the brake failure probability of the truck.

keywords: Road engineering; Low speed lane; Downhill characteristics; Continuous and long downhill; Brake heating

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BIM+GIS 技术在山区公路地形环保选线中的应用研究

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摘 要：复杂山区公路路线设计方案受地形、地物、地质条件影响较大。如何有效利用多源地理信息数据对关键节点进行合理布设，是确保设计质量、控制工程造价的关键。本文以实际山区公路工程为例，论述了 BIM 与 GIS 数据的结合要点，提出了多专业协同设计方法，并进行了 BIM+GIS 技术在山区公路地形、地质、环保选线中的应用研究。研究结果表明：1）基于 BIM+GIS 三维地理信息模型可以更直观审视路线方案，更准确进行工程量统计校核。2）BIM+GIS 模型融入地形、地质、环保等控制因素，便于更快速选择最优方案，减少设计变更、提高设计质量。

关键词：BIM+GIS 技术；山区高速公路；方案比选；地质选线；环保选线

Research on BIM+GIS Technology Application in Topographic Geological Route Selection of Mountainous Highway

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Abstract:

The design of highway route in complex mountainous areas is greatly affected by topography, landform and geological conditions. How to effectively use multi-source geographic information data to rationally lay out key nodes is the key to ensuring design quality and controlling project cost. This paper takes the actual mountain highway project as an example, discussed the key points of combining BIM and GIS data, proposed a multi-disciplinary collaborative design method, and applied the BIM+GIS technology in the mountain road topography, geology and environmental protection line selection. The research results show that: 1) Based on the BIM+GIS three-dimensional geographic information model, the road design scheme can be more intuitively compared, and the engineering quantity statistical check can be performed more accurately. 2) BIM+GIS model integrates terrain, geology and environmental factors, which can select the optimal solution faster, reduce design changes and improve design quality.

keywords:BIM+GIS Technology; Mountain Highway; Scheme Comparison; Geological Route Selection; Environmental Route Selection

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上海至武汉高速无为至岳西段绿色公路总体设计

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摘 要：上海至武汉高速公路无为至岳西段作为交通部绿色公路示范工程，也是安徽省首条绿色公路示范工程，以“质量优良、安全耐久、资源节约、生态环保、节能高效”为建设目标，在绿色公路理念引领总体设计方面，桥梁工业化建造、装配式涵洞通道的大力推广方面，针对不同地形条件下的土石方综合利用手段方面，以及合安改扩建段实施绿色升级等方面均进行了成功实践，对后续类似工程项目有一定的借鉴意义。

关键词：绿色公路

General Design of Green Road from Wuwei to Yuexi Section of Shanghai-Wuhan Expressway

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Abstract:

As the green road demonstration project of the Ministry of Communications, the Wuwei-Yuexi section of Shanghai-Wuhan Expressway is also the first green highway demonstration project in Anhui Province. With the construction goal of "good quality, safety and durability, resource saving, ecological environmental protection, energy saving and efficiency", the concept of green highway leads the overall design, and the industrialized construction of bridges and the vigorous promotion of assembled culvert passages are also included. Successful practices have been carried out in terms of comprehensive utilization of earthwork and rockwork under different terrain conditions, as well as the implementation of Green Upgrade in Hean reconstruction and expansion section, which has certain reference significance for similar projects in the follow-up.

keywords: Green Road

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基于惯导及激光点云数据的互通式立交三维高精地图关键技术研究

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摘 要：高精地图是自动驾驶不可或缺的一部分，是实现智慧交通的前提基础。传统 GIS 地图受精度及维度的限制无法应用于自动驾驶。目前基于数据采集车的高精地图绘制技术，在区域覆盖、地图精度上都较传统 GIS 地图有较大提升，然而受采集车行驶中颠簸、偏移的影响，其获取的道路线形信息准确度上仍有待提高。本文利用车载三维线扫激光系统和惯导系统高效采集道路线形轨迹及路面激光点云数据，并提出一套能消除车载设备必然缺陷的道路三维线形要素自动计算、校正方法。首先，利用膨胀腐蚀几何形态学操作算法及改进 Canny 边缘检测算法，对路面二维激光图像的车道边缘线进行识别与定位，结合采集车行驶轨迹提取车道中心线轨迹。然后，通过层次聚类模型、线性拟合算法、弦线支距法进行圆直/直圆点定位、圆曲线半径计算。最后，利用线扫激光采集的路面横剖线数据及双边滤波算法对道路坡度信息进行计算校正。本文以福州市橘园洲及浦上大桥互通式立交为例，绘制三维高精地图，并通过人工实地测量验证地图的精准性。结果表明，本研究所绘制的三维高精地图具有较高的精度，其在圆直/直圆点定位及圆曲线半径测量的误差分别为 2.89%、2.69%、1.32%；横纵坡度与真实值对比的 Dunnett 试验 P 值分别为 0.631、0.945。本研究为自动驾驶奠定了数据基础，为智慧公路提供了技术支持。

关键词：三维高精地图；互通式立交；线扫激光系统；惯导系统；自动驾驶

3D High Definition Map of Grade-Separated Interchanges Using LiDAR and INS Data

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Abstract:

3D High Definition (HD) map is a critical part of driverless systems and a basis of intelligent transportation. The traditional GIS map is not suitable for driverless due to some limitations. Currently, the data for High Definition (HD) maps is acquired by survey vehicle. Comparing with GIS maps, the HD maps play to the superiority of resolutions and coverage. However, due to the vibration and wandering of survey vehicle the accuracy of road alignment on HD maps cannot meet the requirements. This study collects road alignment data by LiDAR system and Inertial Navigation System (INS), and provides a series of algorithms for roadway alignments extraction and calibration, which can eliminate the impacts of vehicle vibration and wandering. Firstly, the lane markings are identified and positioned from 2D laser imaging based on dilation and erosion operation and Canny edge detection. Based on the lateral position of lane marking on 2Dlaser images the center line of the lane is obtained. Subsequently, the Point of Tangent (PT) and Point of Curvature (PC) are detected by Hierarchical clustering model and linear fitting analysis, and curve radii is calculated using Chord offset method. Finally, the cross slope is calibrated by transverse profile data, and the longitudinal grade is calibrated by bilateral filtering algorithm. This study provides a case study of

3D HD maps creation for Juyuanzhou grade-separated interchanges and Pushang grade-separated interchanges on Fuzhou. The field test by manual method is conducted to validate the accuracy of roadway alignments of 3D HD maps. The test results show that the errors of PT/PC detection are 2.89% and 2.69%, and the errors of curve radii measurement is 1.32%; the P-values for validation tests of cross slope and longitudinal grade measurement are 0.631 and 0.945 respectively based on Dunnett’s test. It implies that the 3D HD maps provide in this study have high accuracy on roadway alignment measurement. This study provides data basis for driverless system and technologies for intelligent transportation.

keywords:3D High Definition Map; Grade-Separated Interchanges; LiDAR System; Inertial Navigation System; Driverless System

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Study on Minimum Clear Distance between Tunnel Exit and Expressway Mainline Toll Station

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Abstract: The mainline toll station and tunnel are the important parts of the expressway system. The rationality of the clear distance affects the traffic capacity and safety. Based on the characteristics and the implementation status of expressway construction, combined with the relevant standards and research results at home and abroad, the clear distance between tunnel exit and mainline toll station has been defined and divided into the light adaptation distance, the traffic signs recognition distance, the operation distance and the lane confirmation distance. On the basis of analysing various constraints, the research has been carried out to establish a calculation model for the clear distance between the tunnel exit and the mainline toll station. It is proposed that under the secondary service level of the 4-lane expressway, under the design speed of 120km/h, the general value of the clear distance between the tunnel exit and the mainline toll station should be greater than 750m; when it is limited by terrain and route corridors, the minimum clear distance should be no less than 600m. It provides a valuable reference for the design and management of tunnels and mainline toll stations.

Key words: traffic engineering; traffic safety; tunnel; expressway mainline toll station; clear distance; recommended value

谈右行左置的高速公路断面

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摘 要：我国高速公路分幅定向通行，通常由左、右幅构成整体式断面，或相互独立形成分离式断面，左、右幅断面在道路正常行驶功能上基本独立。本文从安全、适用、经济、灵活性等方面对右行左置的断面构成进行初步论证，认为其具有宽大中央分隔带、共用服务区等优势，在合适条件下具备实际操作性。

关键词：右行左置

Highway Section of Right Lane Set in the Left Side

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Abstract:

Highways section is composed of integral and separated,with the aim of framing the directional and independent driving function. This paper makes a preliminary demonstration on the left section composition of the right row from the aspects of safety, applicability, economy and flexibility.The result shows that it has practical operation under appropriate conditions due to the advantage of wide central divider and Shared service area.

keywords:right lane set left

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中央分隔带凹形竖曲线防眩设施高度计算模型研究

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摘 要：为解决不同平纵线形组合条件下下中央分隔带防眩设施高度设置相同、固定而导致某些特定路段防眩效果较差的问题，本文通过分析凹形竖曲线与直线路段、平曲线路段的两种不同组合对防眩设施高度的影响，提出了凹形竖曲线路段在不同平、纵面线形组合下的中央分隔带防眩设施高度的计算模型和程序实现的计算流程。研究结果表明：不同平纵组合的凹形竖曲线路段防眩设施高度的计算方法不同，凹形竖曲线路段防眩设施高度比平直路段高。

关键词：中央分隔带；防眩设施；凹形竖曲线；高度计算

Research on the Anti-Dazzle Facility Height of the Concave Vertical Curve in Medial Strip

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Abstract:

Because of the same height of anti-glare facilities in medial strip, the anti-glare effect of some specific sections of roads is poor. In order to solve this problem, this paper analyses the influence of two different combinations of concave vertical curve and straight line or horizontal curve on the height of anti-glare facilities. Expounded detail design of the anti-dazzle facility height of concave vertical in median strip. The results show that: when the combination of horizontal and vertical is different, the calculation method of anti-glare facility height are different. And the anti-glare facility height of concave vertical curve section is higher than that of straight section.

keywords:medial strip; anti-dazzle facility; concave vertical curve; height calculation

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基于运行速度的高速公路线形协调性评价——以绥延高速为例

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摘 要：为了使高速公路的线形设计指标与车辆行驶特征相协调，对容易形成隐患的车速变化敏感路段进行识别并采取有效调整措施，本文提出了基于运行速度的高速公路线形协调性评价理念。在借鉴国内外研究的基础上，根据交通部现行的公路项目安全性评价规范和其他相关规范，通过线形设计指标对高速公路进行了典型路段划分，提出了各典型路段的运行速度预测模型并进行修正；通过对运行速度协调性和设计速度协调性进行评价，来衡量高速公路线形协调性水平。最后，根据绥延高速公路的工程设计资料，对 K0 至 K21 段进行了运行速度预测，并对该路段的线形协调性进行了评价，找出了线形协调性不良路段并提出了安全性调整方案。

关键词：路线设计；线形协调性；运行速度；行车安全；高速公路

Evaluation of Expressway Alignment Coordination Based on Operating Speed-A Case Study of Suiyan Expressway

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Abstract:

In order to make the alignment index of the expressway coordinate with the vehicle driving characteristics, this paper puts forward the concept of expressway alignment coordination evaluation based on the operation speed, which can be used to recognize dangerous sections which are sensitive to speed changes. Based on the domestic and foreign research, and according to the current highway project safety evaluation standard and other relevant regulations, the typical road sections of the expressway are divided by their alignment design index, meanwhile the operating speed prediction model of each typical section is put forward. On basis of this, a method of evaluating the alignment coordination is proposed by means of operating speed coordination and design speed coordination. Finally, according to the design data of Suiyan expressway, the operating speeds of K0 to K21 are predicted, and the alignment coordination of the expressway is evaluated to find out dangerous sections and put forward safety adjustment schemes.

keywords: Route Design; Alignment Coordination; Operating Speed; Safety; Expressway

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高速公路互通立交出口匝道安全评价研究

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摘 要：通过对山区高速公路的出口匝道进行多次调研，发现科学的评价互通立交出口匝道的安全性，对提高高速公路行车安全性、减少交通事故发生具有重要的意义。为评价互通立交出口匝道安全性，选取了出口匝道道路摩擦系数、转弯半径、变速车道长度、行车视距和出口标志信息四个方面的因素，对各因素指标进行了具体化，构建了评价指标体系。引入熵权物元评价方法，建立了互通立交出口匝道安全评价模型，并选取了重庆高速某互通立交出口匝道为案例进行了评价分析。评价结果表明，基于熵权物元模型的互通立交出口匝道安全评价定量计算结果相比其他评价方法更为准确和客观，并对影响评价等级较低的因素进行分析研究，并提出相应的建议对策。

关键词：出口匝道；熵权物元；评价模型；安全性

Study on Safety Evaluation of Exit Ramp of Expressway Interchange

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Abstract:

Through a number of investigations on the export ramps of mountainous highways, it is found that the scientific evaluation of the safety of interchange railroads is of great significance for improving the safety of highway traffic and reducing traffic accidents. In order to evaluate the safety of the export interchange, the factors such as the friction coefficient of the exit ramp, the turning radius, the length of the lane, the line of sight and the exit sign information were selected. The indicators of each factor were embodied and the evaluation indicators were constructed. system. The entropy weight element evaluation method was introduced, and the safety evaluation model of the interchange interchange was established. The evaluation and analysis of the Chongqing Expressway's interchange interchange ramp were selected. The evaluation results show that the quantitative calculation results of the safety evaluation of the interchange interchange based on the entropy weight matter element model are more accurate and objective than other evaluation methods, and analyze and study the factors with low impact evaluation level, and propose corresponding countermeasures.

keywords:off-ramp; entropy weight element; evaluation model; linear safety

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田桓铁路大前石岭隧道进口块碎石冻土成因机理研究

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摘 要：田桓铁路大前石岭隧道进口发现岛状多年冻土，该区域现在不具有发育多年冻土的气候、地理条件。根据对研究区的冰缘地貌现象分析和对冻土采用不平衡 U 系法测年得知该冻土非现在气候条件下形成，其形成于晚更新世末次冰期冰盛期，年龄为 12279±79a。现场对冻层测温表明该冻土是由于表面块石层气冷作用得以保持其热稳定性并保存至今，冻土表面 7m 厚的块石层气冷作用使冻土温度平均降低约 1.5℃。开挖可能破坏了现有的热平衡体系，建议类似工程尽量减少表层块石、碎石层的开挖。

关键词：多年冻土；成因机理；末次冰盛期；气冷作用

Study on the Genetic Mechanism of Block and Detritus Permafrost in Daqianshiling Tunnel Entrance Section of Tianshifu-Huanren Railway

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Abstract:

Island-shape permafrost is discovered in Daqianshiling tunnel entrance section of Tianshifu-Huanren railway, but there is no climatic and geographical conditions for the formation of permafrost in this area. By analysis of periglacial geomorphology in research area and Uranium series dating on the permafrost, the permafrost with the age of 12279±79a is proved to be non-modern climate products and formed in the late Pleistocene LMG. The air conversion effect of the 7m thick surface ballast layer which decreased the temperature by 1.5℃ averagely is proved to be the preservation cause for the permafrost through temperature measuring in the field. The existing heat balance system might be destroyed by excavation. It is recommended to reduce the excavation to the stone and gravel layer.

keywords:permafrost; genetic mechanism; the last glacial maximum; the air conversion effect

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Permeability Experimental Study of Bedding Shale Under Triaxial Compression

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Abstract: The seepage test of shale with 90 degree bedding is carried out by using the RLW-2000M coal rock three axis rheological testing machine, to reveal its variation rule in the process of deformation and failure, and analyze the relationship between permeability coefficient with confining pressure, circumferential strain and volumetric strain. The results shows that: (1) The confining pressure has an effect on the initial permeability coefficient and permeability coefficient of the bedding shale. The influence of confining pressure on its permeability is characterized by stages in the process of gradual compaction and wreck of shale, In compaction stage, the greater the confining pressure, the greater the decrease of permeability coefficient of shale. From elastic stage to elastic-plastic stage, the smaller the confining pressure, the greater the slope of permeability coefficient. In general, with the increase of confining pressure, the initial value, peak value and minimum value of shale permeability decrease with negative exponential function. (2) The variation of permeability coefficient with circumferential strain is basically the same under different confining pressures, that is, when the circumferential strain increases, it first decreases, then increases and decreases, showing an inverse "S" shape. Compared with the axial strain, the permeability coefficient of the shale is more sensitive to the cyclic strain. (3) The volume strain of shale can be divided into two stages of compaction and expansion. The minimum permeability of the specimen appears at the front of the volume strain inflection point. According to the test results, the permeability and volumetric strain change laws of shale in compaction and expansion stage are fitted. Exponential function and logarithmic function can better reflect the change rule of permeability coefficient with volume strain in two stages of compaction and expansion.

Key words: Shale; bedding; permeability test; confining pressure; circumferential strain; volume strain

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孔压静力触探试验（CPTU）负孔隙水压形成机理及对土体分类的意义初探

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摘　要：孔压静力触探（CPTU）作为 20 世纪 80 年代在国际上兴起的新型原位测试技术，因其诸多优点，目前在欧美诸国已得到广泛应用。探头贯入土体过程中，尤其遇到粘土-砂土交互地层，会出现负的孔隙水压力，目前的对 CPTU 贯入过程中负孔压形成机理的研究较少，因此，本文主要探讨孔压静力触探试验过程中负孔隙水压力的形成机理，同时探讨负孔隙水压力对后期数据解译，特别是土体分类的指导意义。

关键词：孔压静力触探试验；负孔隙水压力；机理；土体分类

Forming Mechanism and Significance to Soil Classification of Negative Pore Water Pressure in Cone Penetration Test

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Abstract:

As a new in-situ testing technology, CPTU has been widely used in Europe and America. Probe penetration in the process of soil, especially in clay - soil interaction stratum, there will be a negative pore water pressure, the current in the process of CPTU penetration study is less, the formation mechanism of negative pore pressure as a result, this paper mainly discusses the static sounding test pore pressure forming mechanism of negative pore water pressure in the process, and discusses the negative pore water pressure of the late data interpretation, especially the guiding significance of soil classification.

keywords: cone penetration test; negative pore water pressure; mechanism; soil classification

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基于电学与电磁学理论的工程物探方法综述

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摘　要：工程物探可有效解决工程上很多方法难以解决的难题，具有快速、便捷、经济的优点。随着我国城市化进程的加速，其理论方法、技术设备、应用领域得到了不断发展。该文对电学与电磁学基本理论进行了介绍，并重点介绍了基于电学与电磁学理论的高密度电法测试技术和地质雷达技术，综述了近年来此两种方法的研究进展及应用实践。展望了未来工程物探技术的发展方向。

关键词：工程物探；高密度电法测试技术；地质雷达测试技术

Survey of Engineering Geophysical Methods Based on Electrical and Electromagnetic Theory

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Abstract:

Geophysical exploration methods can effectively solve many difficult problems in engineering, and has the advantages of fast, convenient and economic. With the acceleration of China's urbanization process, its method, technology equipment and application field will continue to expand. In this paper, the basic theories of electricity and electromagnetism are introduced. The electrical resistivity tomography technology (ERT) and ground penetrating radar (GPR) technology based on the theory of electricity and electromagnetism are introduced in detail. The two methods are reviewed in recent years including research progress and application practice. Prospected the future development of engineering geophysics technology.

keywords: Engineering Geophysics; Electrical Resistivity Tomography; Ground penetrating radar

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基于 CPTU 测试的土-膨润土隔离墙非标准消散类型固结系数评价

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摘 要：本文基于孔压静力触探（CPTU），针对非标准孔压消散类型，采用不同的评价方法估算土-膨润土隔离墙的固结系数。分析结果表明：通过时间平方根法与时间对数法评价的固结系数结果比较接近，而修正 t50m 法评价的结果相对较大；针对非标准消散类型的消散时间 t 小于 t50 的情况，可应用 Sully 提出的时间平方根法来预测超孔压消散一半的时间 t50 值，可缩短了 CPTU 测试工期，节约 CPTU 测试成本；在孔压非标准消散类型的固结系数评价中，时间对数法实际上是对孔压消散曲线的一种简化，即去除了孔压上升期间的数据，以孔压最大值为初始值，采用时间对数坐标来评价固结系数的方法。

关键词：CPTU；土-膨润土；非标准消散；固结系数

Evaluation of Consolidation Coefficient of Non-Standard Dissipation Types of Soil-Bentonite Wall Based on CPTU

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Abstract:

Based on pore pressure cone penetration test (CPTU), different evaluation methods are used to estimate the consolidation coefficient of soil-bentonite wall for non-standard pore pressure dissipation types. The results show that the consolidation coefficient evaluated by the time square root method is close to that by the time logarithm method, but the result of the modified t50m method is relatively large. For the case that the dissipation time of non-standard dissipation type is less than t50m, the time square root method proposed by Sully can be used to predict the time t50m value of half of the excess pore pressure dissipation, which can shorten the CPTU test duration and save CPTU measurement. In the evaluation of consolidation coefficient of non-standard dissipation type of pore pressure, the time logarithm method is a simplification of pore pressure dissipation curve, that is, removing the data during the rise of pore pressure, using the maximum pore pressure as the initial value, and using the time logarithm coordinate to evaluate the consolidation coefficient.

keywords: CPTU; soil-bentonite; non-standard dissipation; consolidation coefficientcone

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珠江三角洲场区围堰土层工程特性评价

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摘　要：为研究珠江三角洲场区围堰土层的工程特性，以深圳机场三跑道扩建工程为依托，从土的成因、物理化学特性等方面出发，通过开展室内物理化学试验、现场钻探、标准贯入等试验，研究了该场地的岩土层分布规律及其物理力学性质，得到了该区域土层的渗透性、压缩性、水土腐蚀性及强度等参数。研究结果表明：场区主要为软土层，压缩性高，地基土沉降量较大，整个场区承载力较低，需对土层加固处理；场区水、土的腐蚀性指标基本处于微弱腐蚀范围内，对钢筋混凝土结构物的腐蚀性较低。研究结论对指导珠江三角洲地区的工程勘察和实践具有重要参考价值。

关键词：珠江三角洲；围堰区土层；土层分布规律；物理力学性质；腐蚀性

Evaluation of the Engineering Characteristics of the Cofferdam Soil in the Pearl River Delta

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Abstract:

To study the engineering properties of cofferdam soil layer in the Pearl River Delta Area, based on the extension project of the three runway of Shenzhen airport, from the cause of formation, physical and chemical properties etc., the distribution law, physical and mechanical properties of soil layers are investigated through the experiments of physical and chemical tests, field drilling and standard penetration, and the parameters such as permeability, compressibility, corrosion and strength of soil and soil are obtained. The results show that the site area is mainly soft soil with high compressibility, large settlement and low bearing capacity. Therefore, the reinforcement of soil layers is required. The corrosion index of the water and soil in this field is basically in the weak corrosion range, and the corrosiveness of the reinforced concrete structure is low. The conclusions are meaningful to guide engineering investigation and practice in the Pearl River Delta area.

keywords: Pearl river delta; cofferdam soil layer; distribution of soil layers; physical and mechanical properties; corrosive; Pearl river delta; cofferdam soil layer; distribution of soil layers; physical and mechanical properties; corrosive

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高速公路连续下坡缓坡设计指标研究

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摘　要：为了明确中国山区高速公路长下坡缓坡设计指标，在汽车动力学理论的基础上，以六轴铰接列车为研究对象，分析其在发动机辅助制动方式下坡时的货车速度特性和制动毂降温特性，建立力学平衡方程，构建了档位-速度-临界坡度模型，求解了不同速度和档位条件下的缓坡临界坡度值，进一步考虑我国高速公路设计控制条件与货车行驶特性，以 12 档和 11 档时对应的临界坡度作为高速公路缓坡设计控制指标；以货车降速和降温为安全边界条件分别提出了缓坡坡长控制及评价指标，并分析了进行缓坡设计及评价时的方法与流程。研究结果表明：当六轴铰接列车以不同速度入坡时，速度降低 10km/h 所需缓坡坡长大多不超过 1000 米；当六轴铰接列车以不同速度行驶时，降低一定温度所需的缓坡坡长大多长达数千米。因而基于货车下坡速度特性的缓坡坡长对纵坡设计具有指导意义；基于制动毂降温特性的缓坡坡长值相对较大，可用于评价缓坡对货车制动毂的温控效果。通过上述方法可对高速公路连续下坡缓坡路段的设计进行合理取值，提升连续长下坡路段车辆的行驶安全性。

关键词：道路工程；缓坡设计；货车下坡特性；连续长下坡路段

Transition Slope Design Indexes of Continuous Long Downhill Slope of Expressway

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Abstract:

To determine the design index of long downhill transition slope of the expressway in China's mountainous area, the six-axis articulated truck was taken as research object. The speed characteristics of truck based on the theory of vehicle dynamics and the cooling characteristics of brake hub was analyzed when it’s under engine auxiliary braking. The gear-speed-critical slope model was built after mechanical equilibrium equation was established, and then the critical slope values under different speed and gear conditions were solved. Further considering the control conditions of highway design as well as the driving characteristics of truck, and the critical slope corresponding to 11~12 gears was used as the index of the transition slope design of expressway. The control and evaluation index of the transition slope length were proposed respectively according to the safety boundary conditions of truck speed reduction and cooling characteristics. The method and process for the design and evaluation of transition slope were analyzed. The result show that when the six-axis articulated truck enters transition slope at different speeds, the slope length required for the speed reduction of 10km/h is mostly less than 1000m; when the six-axis articulated truck was driven at different speeds, Most of the transition slope length which required to reduce a certain temperature is several kilometers. Therefore, the transition slope length based on the downhill speed characteristics of truck is instructive for the longitudinal slope design; the transition slope length based on the cooling characteristic of brake hub is relatively large, which can be used

to evaluate the temperature control effect of transition slope on the brake hub of truck. Through the above method, the design of continuous downhill slope section of expressway can be reasonably valued, and the driving safety of vehicle in continuous long downhill section can be improved.
keywords: road engineering; design of transition slope; downhill characteristics of truck; continuous long downhill slope

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浅析强岩溶富水地下工程止水关键控制技术

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摘　要：随着地下空间的不断扩展，在岩溶区地下工程施工过程中遇岩溶与富水的情况越来越多，为保证施工及环境安全，对岩溶水的处理问题最为突出。地下工程的施工，遇岩溶和岩溶水开挖时破坏了原生岩土状态，改变了地下水的平衡，严重威胁着施工安全及周边环境的安全。为了有效控制地下岩溶水的危害，采用先进的瑞雷波检测技术和行之有效的注浆止水措施对工程风险的控制，尤为关键。

关键词：地下工程；岩溶富水；止水施工；关键技术

Analysis on the Key Control Technology of Sealing Water in the Strong Karst Water-Rich Underground Project

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Abstract:

With the continuous expansion of underground space, there are more and more cases of karst and rich water in the construction process of underground engineering in karst area. In order to ensure the construction and environmental safety, the treatment of karst water is the most prominent. In the construction of underground engineering, the state of primary rock and soil is destroyed when karst and karst water is excavated, the balance of groundwater is changed, and the safety of construction and surrounding environment is seriously threatened. In order to effectively control the hazards of underground karst water, it is particularly critical to adopt advanced Rayleigh wave detection technology and effective grouting measures to control the engineering risk.

keywords: underground engineering; karst water enrichment; watertight construction; key technology

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浅析岩溶地区地铁车站深基坑溶槽的处治技术

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摘　要：随着地铁建设的不断发展，在我国西南典型喀斯特地貌地区的地铁修建过程中，由于岩溶的强发育，导致在基坑开挖过程中基底由于岩溶管道甚至是大型连通溶槽引起基坑涌水等风险的存在。为解决在地铁深基坑出现大型溶槽后的处治，达到快速有效封堵基坑涌水，确保深基坑施工及周边建筑物的安全。本文提出了一种深基坑溶槽的处理方法，其通过采用先收集散水，再帷幕，最后单点处治的施工方法，不但具有操作简单，而且效果明显，对水的处治很有针对性，确保了基坑及周边环境的安全。本文所提到的深基坑溶槽的处治方法对今后地下类似工程的设计施工提供一定的借鉴。

关键词：岩溶；深基坑；溶槽；地铁车站

Treatment Technology of Deep Foundation Pit of Subway Station in Karst Area

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Abstract:

With the continuous development of subway construction, in the process of subway construction in typical karst landforms in southwest China, because of the strong development of karst, In the process of foundation pit excavation, the risk of foundation pit water gushing is caused by karst pipeline or even large connected channel. In order to solve the problem of treating the underground deep foundation pit after it appears large tank, it can quickly and effectively seal the foundation pit water gushing, and ensure the safety of the deep foundation pit construction and surrounding buildings. In this paper, a treatment method of deep foundation pit solution trough is put forward. By adopting the construction method of collecting scattered water first, then curtain, and finally treating single point, it has not only simple operation, but also obvious effect on water. The treatment is very targeted and ensures the safety of the foundation pit and its surrounding environment. The treatment method of deep foundation pit solution tank mentioned in this paper can be used for reference for the design and construction of similar underground engineering in the future.

keywords: Karst; Deep Foundation Pit; solution trough; Metro Station

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新疆伊犁则克台河黄土滑坡分布规律及控制要素分析

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摘　要：伊犁谷地是新疆地区黄土滑坡灾害最为发育地区之一，大量黄土滑坡对工程建设和人员财产危害较大，但由于其独特黄土特性和湿润气候环境，黄土滑坡形成条件和成灾机制有别于其他黄土地区，当前缺少针对性的研究。本文选取新疆伊犁地区的则克台河作为研究区，统计分析黄土滑坡基本信息发现，90%左右为中小型滑坡，94%为中浅层滑坡，88%为推移式滑坡，滑动面多位于黄土内部与下伏基岩接触面，滑坡数量随着斜坡高程、高度和坡度呈现单峰分布，几乎 80%黄土滑坡多分布在 1400m～2000m 高程区内，相应斜坡坡度为 20°～50°之间，斜坡高度为 100m～400m 范围内，具有显著高位滑坡特征. 同时，滑坡分布具有明显方向性，78%滑坡分布在山体阴坡，而且黄土滑坡也具有显著季节性分布规律，发生高峰期出现在 3 月至 6 月，4 月黄土滑坡发生次数最多。则克台河内黄土滑坡形成和演化是区域内外动力共同作用结果，其中，特殊组构的厚层黄土是滑坡形成的内在物质基础，春夏季融雪和降雨的耦合是诱发黄土滑坡的最主要外在动因。研究成果可为区域公路工程建设和防灾减灾提供基础信息和技术指导。

关键词：黄土滑坡；伊犁谷地；则克台河；控制因素；融雪；降雨

Distribution Characteristics and Controllable Factors of Loess Landslides in Zeketai River, Yili of Xinjiang

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Abstract:

Loess landslides are widely distributed in Yili valley which is one of the most developed areas in Xinjiang, and they threaten engineering construction and personal property seriously. However, due to unique loess characteristics and humid climate environment, the forming condition and inducing mechanism of loess landslides are different from other loess regions, and currently the corresponding research is lack. This paper selects Zeketai River in Yili as a study area, and the basic information about loess landslides is obtained and analyzed. The authors found that loess landslides are vast expanse of distribution with characteristics of small-medium landslides of 90% , shallow landslides of 94% and thrust load caused landslides of 88%, and the sliding planes almost occur inside the loess layer or near contact surface between the loess layer and subterrane. Landslide density display unimodal distribution with change of slope elevation, altitude and gradient, and nearly 80% landslides are distributed among elevation range of 1400-2000m, corresponding to slope gradient of 20-50°.Most landslides show remarkable high slope features with slope altitude of 100-400m, and present obvious directionality with 78% shady slope distribution. In addition, loess landslides also display obvious seasonal distribution rule, and most of which occur from March to June, and the occurrence frequency in April is highest. The formation and development of loess landslides in Zeketai River results from the coupling effect of endogenic and exogenic geological

processes, among which the thick layer loess with unique composition and structure is the internal material base of landslide occurrence, and the coupling of snowmelt and rainfall during spring and summer is the uppermost dynamic factor. The results can provide basic information and technical guidance for the regional road engineering construction and disaster prevention.
keywords: loess landslide; Yili valley; Zeketai River; controllable factor; snowmelt; rainfall

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松散层水下隧道岩土参数的获取

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摘　要：根据现行《城市轨道交通岩土工程勘察规范》，围堰明挖法施工的第四系松散层水下隧道需要提供密度、黏聚力、内摩擦角、静止侧压力系数、无侧限抗压强度、水平基床系数、水平抗力系数的比例系数等岩土参数。针对场地地层以粉质土和砂性土为主的特点，采用标贯、双桥静力触探、旁压试验、扁铲侧胀试验等原位测试结合室内试验的手段，通过直接测取或经验公式计算，获取相关岩土参数，并对这几种方法获取的参数进行对比验证，为设计提供可靠的岩土参数。

关键词：围堰明挖；第四系松散层；水下隧道；岩土参数；原位测试；对比验证

Acquisition of the Geotechnical Parameters of the Underwater Tunnel with Unconsolidated Layer

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Abstract:

According to the current 《Code for geotechnical investigation of urban rail transit》,the Quaternary unconsolidated layer of underwater tunnel constructed by the cut-and-cover with cofferdam method needs to provide density,cohesion,friction,coefficient of lateral pressure at-rest,unconfined compressive strength,horizontal foundation coefficient,proportional coefficient of the horizontal resistance coefficient and other geotechnical parameters.According to the characteristics of the stratum in silty soil and sand soil,using the in-situ test such as standard penetration test,cone penetration test,pressuremeter test,flat dilatometer test, combined with indoor test,obtaining the relevant geotechnical parameters by measuring and calculating through the empirical formulas,comparing the parameters obtained by these methods to verify,providing reliable geotechnical parameters for the design.

keywords: cut-and-cover with cofferdam; the Quaternary unconsolidated layer; underwater tunnel; geotechnical parameters; in-situ tests; comparison and validation

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一种基于模拟退火法的多相沥青混凝土三维数字重构方法

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摘　要：三维细观数字模型的正确建立是使用数值计算方法研究沥青、混凝土等胶结颗粒材料物理力学特性的前提。现行的三维细观模型建立方法在考虑骨料颗粒、胶凝材料与孔洞的分布方面有所缺失。该文从真实三维骨料颗粒重建出发，经过样本空间中对数字骨料颗粒进行随机排布、基于能量最小原理引入孔洞分布等步骤，最后通过模拟退火优化算法得到符合材料在自然界中赋存状态的三维数字模型。

关键词：三维细观数字模型；颗粒排布；模拟退火算法

Three-Dimensional Mesoscopic Digital Model Reconstruction Method for Complex Cemented Particle Materials

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Abstract:

The correct establishment of the three-dimensional mesoscopic digital model is the premise of using numerical calculation methods to study the physical and mechanical properties of cemented particulate materials such as asphalt and concrete. The current three-dimensional meso-modeling method is missing in considering the distribution of aggregate particles, cementitious materials and pores. Starting from the reconstruction of real three-dimensional aggregate particles, a three-dimensional digital model is obtained by random arrangement of digital aggregate particles in sample space, introduction of void distribution based on energy minimization principle, etc. Finally, a simulated annealing optimization algorithm is used to obtain the three-dimensional digital model which conforms to the existing state of materials in nature.

keywords: three-dimensional mesoscopic digital model; particle arrangement; simulated annealing algorithm

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千枚岩节理面强度各向异性特征数值分析

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摘　要：运用 FLAC3D 软件对β角为 30°、45°、60°、75°和 90°情况下的千枚岩真三轴试验进行数值模拟，运用 M-C 准则对模拟结果进行理论分析，研究结果表明：随着角度的增加，千枚岩的抗压强度和抗剪强度都是一个逐渐增大的过程，破坏模式逐步由沿着节理面的剪切破坏逐渐转化为张拉破坏。

关键词：千枚岩；真三轴模拟；强度；破坏模式

Numerical Analysis of Strength Anisotropy of Jointed Surfaces of Phyllite

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Abstract:

The true triaxial tests of phyllite with beta angles of 15, 30, 45, 60, 75 and 90 degrees are simulated by FLAC3D software. The theoretical analysis of the simulation results is carried out by using M-C criterion. The results show that the compressive strength and shear strength of phyllite decrease first and then increase with the increase of angle. The compressive strength obtained at beta angles of 30 degrees is a process of decrease and increase. The strength and shear strength are the smallest, and the failure mode gradually changes from shear failure along the joint plane to tension failure.

keywords: phyllite; true three axis; simulation; strength; failure mode

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Study on the Behavior of Double-Row Anti-Slide Piles in Weathered Slate Formation

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Abstract: In order to study the stress behavior of double-row anti-slide piles during excavation, the model of site excavation was established by numerical simulation. The surface settlement around the foundation pit during excavation, the horizontal displacement of the pile body and the internal force of the pile body were analyzed. The data is compared to verify the reliability of the numerical analysis; and the row spacing and rigidity of the steel frame beam are studied.And the variation of the pile body deformation and internal force by factors such as the stiffness of the pile body provide reasonable suggestions for the optimization of construction and design. The results show that in the process of foundation pit excavation, the ground settlement and the horizontal displacement of the pile top should be monitored in the depth of the excavation depth of the foundation pit; the bending moment of the rear pile should be greater than the bending moment of the front pile. In the design process, different reinforcements should be used for the front and rear rows of piles to achieve better support. The row spacing is in the range of 2-6m, which can make the front and rear row piles better play the overall performance; appropriately increasing the stiffness of the steel frame beam and the stiffness of the pile body can effectively limit the horizontal displacement of the pile body and coordinate the internal force of the pile body.

Key words: stress properties

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Characteristics and Genesis of Loess High Slope on the West Side of Shuiliandong Colliery in Binxian County

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Abstract: The loess high-slope on the west side of water curtain cave colliery is an old landslide debris back-wall. There is an old landslide debris deposit at bottom of the slope. Surface water can infiltrate into the slope through loess uprightness joints and cranny. The groundwater flow gradually causes the formation of water cavities in the upper slope region. The slope further has loess stratification, obliquity(from 5°to 10°) and paleosols place. Surface water infiltrate into paleosol and induce water cavity exit with the top water cavity transfixion. The paleosol ideally prevents water. The loess stratification leans to ravine. The slope is unstable and will fail under the action of precipitations.

Key words: high slope; water cavity; stratification; paleosol; loess

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Regional Evaluation of Liquefaction Induced Lateral Land Deformation and Its Application in an Urban Area

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Abstract: In this paper, a regional scale analysis of land surface deformation caused by soil liquefaction in an earthquake event is performed. We demonstrated an integrated framework for evaluating liquefaction hazard in an area based on geotechnical in-situ testing data. The spatial uncertainty of the geotechnical data is quantified using a random field model. The framework is found capable of detecting critical areas vulnerable to liquefaction. We applied the framework to an urban area in Alameda, California and the impact of liquefaction on city ground transportation system is evaluated.

Key words: Liquefaction, Land damage, Ground Transportation

Model for Predicting Resilient Modulus of Unsaturated Subgrade Soils in South China

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Abstract: Subgrade soils are often unsaturated and the resilient modulus (MR) of subgrade soils is usually subjected to the climate environment and traffic loading in the field. Therefore, the matric suction (MS) and traffic loading are considered to be two important parameters associated to the MR prediction model. To verify the MR prediction model, the MS of the typical subgrade soil were determined through the pressure plate test. In this study, the soil-water characteristic curves were also described using the Fredlund & Xing’s model. Then, the dynamic MR of the typical subgrade soil under various stresses and water contents was measured. After that, a new prediction model was proposed with the model variables including the minimum bulk stress, octahedral sheer stress and matric suction, and the validity of the new model was verified by previous research results. Finally, the correlations between the physical properties of subgrade soils including the percentage passing through the No. 200 sieve(0.075mm), plasticity index, liquid limit, dry density and the regression coefficients of the new model were established. The results show that the new model can be used to predict the MR well, and it effectively solves the problem that the bulk stress is equal with a different combinations of the confining pressure and deviator stress. At the same time, the MR can be predicted much more easily with physical parameters of subgrade soils rather than conducting triaxial tests.

Key words: unsaturated subgrade soil; resilient modulus; cyclic triaxial test; matrix suction; prediction model

砾石含量和形状对土石混合体力学行为的影响研究

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摘　要：土石混合体边坡在世界各地分布广泛。由于不同的地质成因，土石混合体的含石量和砾石形状往往不同。以往的研究发现土石混合体存在两个典型的含石量阈值，但阈值范围存在一定离散性。为了进一步明确土石混合体的含石量阈值，并研究砾石形状对该阈值的影响，本文选取两组不同形状的圆砾和角砾作为粗颗粒，并分别配置不同的含石量试样进行不排水三轴剪切试验，系统研究了砾石含量和形状对土石混合体力学行为的影响规律。研究结果表明土石混合体的含石量阈值分别为 40%和 80%-100%，即当含石量小于 40%时，土石混合体的力学行为主要受细粒土控制；当含石量大于 40%而小于 80%时，土石混合体的力学行为受细粒土和砾石共同作用，试样的峰值内摩擦角随含石量增加而增加；当含石量大于 80%-100%时，试样的峰值内摩擦角随含石量增加而缓慢增加，表明此时土石混合体的力学行为主要受砾石控制。当含石量小于 40%时，砾石悬浮于细粒土中，砾石形状对土石混合体抗剪强度影响较小，当含石量大于 40%时，特定含石量下的角砾试样对应的抗剪强度大于圆砾试样对应的抗剪强度，但砾石形状对土石混合体对应的强度阈值影响较小。此外，土石混合体试样的峰值抗剪强度主要由摩擦效应提供。

关键词：土石混合体；三轴试验；砾石含量；砾石形状；阈值

Study on Effect of Gravel Content and Shape of Gravel on the Mechanical Behavior of Soil-Gravel-Mixture

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Abstract:

The soil-gravel-mixture (SGM) slope is widely distributed around the world. The gravel content and the particle shape of gravel are generally different due to the different geological causes. Previous studies indicate that there are two typical thresholds exist, but the thresholds are discrete to some extent. To determine the thresholds of SGM and explore the particle shape of gravel on the thresholds, two particle shape of gravels (i.e., round-stone and sharp grit) are selected to prepare the samples with different gravel content. After that, series of triaxial tests are conducted. The effects of gravel content and gravel shape on the mechanical behavior of SGM are explored based on triaxial tests. The results indicated that the gravel particle contents of 40% and 80%-100% are two limits on the shear strength of SGM. Specifically, the peak strength of the mixture is mainly controlled by the soil composition when the gravel content is less than 40%. The peak strength of the mixture is the combined effects of the soil and gravel compositions when the gravel content is between 40% and 80%. The peak strength of the mixture is controlled by the gravel composition when the gravel content is larger than 80%-100%. When gravel content is less than 40%, gravels are almost floated in the matrix of soils, the particle shape of gravel has only a small effect on the shear strength of SGM. When gravel content is greater than 40%, for a given gravel content, the

shear strength of SGM with sharp grit is greater than that of SGM with round-stone. Alternatively, it is found that the peak shear strength of SGM is mainly provided by the friction effect among the particles.

keywords: soil-gravel-mixture; triaxial tests; gravel content; shape of gravel; thresholds

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公路挡墙后有限宽度土体土压力计算方法的试验与理论研究

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摘　要：本文首先开展了刚性挡墙平动变位模式情况下墙后有限宽度土体破坏试验，试验结果表明，在墙后土体宽度较小情况下，土体破坏面为通过墙踵的对数螺旋曲线。然后重点分析了在墙后土体有限宽度情况下土体土拱效应的形成机理，并假定小主应力拱为圆弧线，考虑挡墙与土体摩擦点的极限平衡条件，导得了大小主应力的偏转角表达式。在此基础上，考虑刚性挡墙平动变位模式情况，结合水平微分单元法，建立了墙后有限宽度土体的主动土压力合力及强度的理论表达式。与室内试验数据及前人方法的对比表明，该方法得到的土压力值具有较好合理性。最后，分析了不同填土宽高比 n 下的主动土压力分布规律，结果表明，主动土压力随 n 增加而逐渐增加，但 n 达到 0.5 时趋于稳定，该值可作为墙后土体有限宽度的界限值。

关键词：公路工程；挡土墙；主动土压力；有限填土；试验与理论研究

Experimental and Theoretical Study on the Earth Pressure for Finite Width Soil Behind Retaining Wall of Road

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Abstract:

In this paper, an experiment is conducted to determine the active earth pressure for soil with limited width behind a retaining wall in translational motion. The test results show that a logarithmic helix curve failure surface of limited-width soil behind a retaining wall passes through the wall toe. Then the formation mechanism of soil arching effect under the condition of finite width of soil behind the wall is emphatically analyzed. It is assumed that the small principal stress arch is circular arc. Considering the limit equilibrium condition of the friction point between the retaining wall and the soil, the expression of the deflection angle of the large and small principal stress is derived. On this basis, considering the translational displacement mode of rigid retaining wall and the horizontal differential element method, the theoretical expressions of active earth pressure resultant force and intensity distribution of finite width soil behind the wall are established. Comparison with laboratory test data and previous methods, indicates that the earth pressure value obtained by this method has preferably rationality. Finally, the distribution of the active earth pressure is analyzed under different ratios n of the width to height of the backfill. The results show that the active earth pressure increases with the increasing of n, but approaching to a constant value as n reaches a threshold of limited width of 0.5.

keywords: road engineering; reatinning wall; active earth pressure; limited backfills; experimental and theoritical study

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基于球型全流触探测试的太湖隧道水下超软土强度特性评价研究

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摘　要：沿海和湖泊沉积地区广泛存在大量的超软土，这种超软土含水量高（大于 100%），呈流塑状态，具有高压缩性、极低强度和高灵敏度的特点，并具有结构性，该类超软土几乎无法进行取样和室内试验，现有勘察测试技术难以评价其强度和变形特征，只能通过原位测试方法。近年来国际上发展起来的球型全流触探技术为评价超软土工程性质提供了可靠方法。以无锡太湖隧道场地水下超软土为对象，采用球型全流触探技术对超软土进行现场试验，并结合了现场十字板剪切试验，通过球型全流贯入阻力评价了太湖流域水下超软土的不排水抗剪强度，为现场工程特性研究提供参考。

关键词：球型全流触探；原位测试；不排水抗剪强度；超软土

Study on Evaluation Method of Strength Characteristics of Underwater Ultra-Soft Soil in Taihu Tunnel Based on Ball-Bar Full Flow Penetration

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Abstract:

A large number of ultra-soft soils are widely found in coastal and lacustrine sedimentary areas, which are characterized by high water content, high compressibility, low undrained shear strength, low coefficient of consolidation, and low penetrability. Since the underwater ultra-soft soil can hardly be sampled and tested in laboratory, it is difficult to evaluate its strength and deformation characteristics by existing common testing techniques. In recent years, the ball-bar full flow penetration technology developed in the world provides a reliable method for evaluating the engineering properties of underwater ultra-soft soil. In this paper, in the case study of Taihu Tunnel in Wuxi City, the field test of underwater ultra-soft soil was carried out by applying the ball-bar full flow penetration technology, and the field vane shear test was combined. The undrained shear strength of underwater ultra-soft soil in Taihu Lake basin is interpreted by the ball-bar full-flow penetration resistance, which provides a reference for the study of field engineering characteristics.

keywords: ball full flow penetration; in situ testing; undrained shear strength; underwater ultra-soft soil

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陕西白鹿原与宁夏固原原状黄土显微结构特征分析与比较

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摘　要：利用扫描电子显微镜对陕西白鹿原与宁夏固原原状黄土进行微观结构扫描，得到大量微观结构图片。根据扫描电镜结果探究微观形态与黄土湿陷性的关系。扫描结果表明：西安白鹿原地区黄土，其碎屑结构应属粉土微粒结构类型，骨架颗粒主要为分散分布，其结构类型是以镶嵌结构为主的凝块状。宁夏固原的黄土颗粒粒径较大，细砂粒径级配（粒径>0.05mm）所占比重较大，骨架颗粒的形态排列不规则，以单粒状碎颗粒为主，孔隙的类型为支架孔隙为主。

关键词：原状黄土；显微结构；黄土湿陷性

Comparison and Analysis of Microstructure of Bailu and Guyuan Intact Loess

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Abstract:

The KYKY-EM3900 high performance scanning electron microscope was used to scan the microstructure of Shanxi Bailuyuan and Ningxia Guyuan intact loess, and microscopic structures were obtained. Base on the test results, the relationship between microstructure and loess collapsibility was investigated. The scanning results show that the detritus structure of the loess in Xi'an Bailu area should be of the silt particle structure type, and the skeleton particles are mainly distributed and the structure type is clot-like. The loess particles of Guyuan in Ningxia are coarser, fine sand particle size grading (particle size >0.05mm) accounts for a large proportion, the morphology of the skeleton particles is irregular, mainly composed of single-grained particles. The pore type is dominated by mesopores composed of scaffold pores.

keywords: Undisturbed loess; Microstructure; Collapsibility of loess

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The Undrained Shearing Responses of Saturated Loess Soils in NW China

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Abstract: Comparison study of soil undrained behaviour have not been conducted. A series of undrained shearing triaxial tests on intact and reconstituted samples retrieved from sandy loess zone, silty loess zone and clayey loess zone were carried out. The intact loess soils tested exhibit a very similar strain-softening behaviour. The normalized excess pore water pressure by confining pressure at critical state is up to 0.8-1.0 for intact clayey and silty loess soils, higher than that of sandy loess of 0.76. The brittleness index is around 0.55-0.80 for the intact loess soils. The undrained shearing behaviour of remoulded samples was significantly influenced by soil density prepared. For the loose samples, it shows a transient strain softening followed by a dilatation or even a total strain softening. For the dense samples, they showed a total dilatation. Test results show the differences in undrained shearing responses for intact loess soils, especially for silty and clayey loess might have been overestimated. They are very similar at least in this study. The differences in soil mechanics of undrained shearing seems not a suitable factor to influence the distribution laws of flowslides in NW China though loess mechanics do play an important role in landslide itself development Comparison study of soil undrained behaviour have not been conducted. A series of undrained shearing triaxial tests on intact and reconstituted samples retrieved from sandy loess zone, silty loess zone and clayey loess zone were carried out. The intact loess soils tested exhibit a very similar strain-softening behaviour. The normalized excess pore water pressure by confining pressure at critical state is up to 0.8-1.0 for intact clayey and silty loess soils, higher than that of sandy loess of 0.76. The brittleness index is around 0.55-0.80 for the intact loess soils. The undrained shearing behaviour of remoulded samples was significantly influenced by soil density prepared. For the loose samples, it shows a transient strain softening followed by a dilatation or even a total strain softening. For the dense samples, they showed a total dilatation. Test results show the differences in undrained shearing responses for intact loess soils, especially for silty and clayey loess might have been overestimated. They are very similar at least in this study. The differences in soil mechanics of undrained shearing seems not a suitable factor to influence the distribution laws of flowslides in NW China though loess mechanics do play an important role in landslide itself development.

Key words: undrained shearing responses; three loess zones; strain softening; flowslides

Implicit and Explicit Integration Schemes of a Double Structure Hydro-Mechanical Coupling Model for Unsaturated Expansive Clays

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Abstract: Comparative studies on the accuracy and convergence of implicit and explicit integration schemes are conducted for a double structure hydro-mechanical coupling model of unsaturated expansive clays at an integration point level. The published constitutive model is built on the basis of two pore levels in expansive clay. In this paper, firstly, the implicit and explicit integration schemes based on the Euler backward and forward integration algorithms are proposed. An automatic sub-stepping technique is adopted for the explicit scheme to control calculation errors. These schemes can deal with multi-plastic mechanisms defined in the model, and distinguish various cases in relation to the number of plastic mechanism active. Secondly, the performances of the integration schemes are demonstrated by comparisons of calculation results of a control-strain test with different strain increment sizes.

Key words: unsaturated expansive soils; double structure; hydro-mechanical coupling; integration algorithm

Demonstration of Using a Steel Split Mold to Evaluate Influences of Moisture and Density on Shear Strength and Stiffness Parameters of Compacted Geomaterials

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Abstract: Compaction is the most commonly used soil improvement method to increase the bearing capacity, shear strength, and stability for engineering projects. The Proctor compaction test is the standard test for determining moisture content and density relationships of geomaterials, and test results are used to set field quality assurance and quality control (QA/QC) specifications for compaction work. However, the safety and stability of sustained structures are governed by shear strength and stiffness of foundation materials, so the moisture and density are not performance-based parameters. Therefore, it is desirable to determine the relationships between dry unit weight, moisture content, and other significant engineering properties (i.e., shear strength and stiffness) of compacted geomaterials. Conventional lab tests for shear strength and stiffness parameters are time consuming and expensive, and as a result, those parameters of compacted geomaterials are not usually specified for projects. In this study, a portable split steel mold developed at Iowa State University (Iowa K test) was evaluated for rapid determination of undrained cohesion, friction angle, and other strength and stiffness parameters of compacted geomaterials. To evaluate the performance of the modified Iowa K test, give types of geomaterials were tested. The present paper introduces the modification and calibration procedures of the test device, explains the data analysis method, and shows sample test results of two types of materials. The test results showed that the friction angle values determined by the Iowa K test agreed well with those determined using the direct shear test. In addition the testing device can quickly determine influences of moisture and density of materials on their shear strength and stiffness parameters, which can be used to set performance-based QA/QC specifications for field compactions.

Key words: compaction; moisture; density; strength; stiffness; specification; compaction energy; test

基于 Biot 动力固结方程的饱和土介质黏弹性动力人工边界研究

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摘　要：通过对 Biot 动力固结方程进行变型，采用算子分解及分离变量法分别得到饱和土平面内法向、出平面切向和平面内切向三种情况下的方程组，并得到相对应条件下的位移解析解。运用几何方程将 Biot 饱和多孔介质的物理方程表达成两部分，从而建立饱和土平面内法向、出平面切向和平面内切向情况下考虑能量耗散和转化的三维人工边界形式。最后通过典型的波动问题算例证明了给出的三维人工边界具有较高精度，可以方便地应用于三维波动问题的模拟分析。

关键词：饱和土；粘弹性人工边界；超孔隙水压力

Study on Viscous-Spring Dynamic Artificial Boundary of Saturated Soil Medium Based on Biot's Dynamic Consolidation Equation

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Abstract:

Transforming Biot’s dynamic consolidation equation, by virtue of differential operator splitting and variable separation method, the equations of saturated soils are obtained in three cases: in-plane normal direction, out-plane tangential direction and in-plane tangential direction, respectively. And the displacement analytical solutions under corresponding conditions are obtained. The physical equation of Biot saturated porous medium is expressed in two parts by using geometric equation, and the three-dimensional artificial boundary form considering energy dissipation and transformation in the normal, out-of-plane and in-plane directions of saturated soil is established. Finally, the typical wave problem is used to illustrate that the given three-dimensional artificial boundary has high precision and can be easily applied to the simulation analysis of three-dimensional wave problems.

keywords: saturated soil; viscous-spring artificial boundary; excess pore water pressure

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纤维/水泥改性泥浆短期无侧限抗压性能

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摘　要：建筑废弃泥浆的资源化利用是城市建设中亟待解决的问题，基于水泥土研究成果，提出采用纤维/水泥改性泥浆的措施使其满足路基填料要求。通过无侧限抗压强度试验获得了水泥掺量分别为 5%、10%、15%、20%、25%和 30%，以及水泥掺量为 20%时纤维掺量分别为 0%、0.25%、0.5%、0.75%和 1%的纤维/水泥改性泥浆 7d 无侧限抗压应力应变曲线；采用 BP 神经网络算法对其应力应变曲线进行拟合得到满足精度要求的拟合方程，并以峰值强度、屈服应变、初始模量、残余强度和能量耗散等五个变量表征纤维/水泥改性泥浆的无侧限抗压性能，结果表明水泥掺量对纤维/水泥改性泥浆的短期无侧限抗压性能影响明显，而纤维掺量对其影响不明显。

关键词：泥浆；水泥改性；无侧限抗压性能；应力应变曲线；BP 神经网络

Short-Term Unconfined Compressive Properties of Fiber and Cement-Modified Slurry

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Abstract:

The resource utilization of construction waste slurry is an urgent issue needed to be solved in urban construction. Based on the research results of cement soil, modification of slurry using fiber/cement was proposed to ensure that the mechanical properties of modified slurry satisfied the requirements of subgrade filling. Unconfined compressive stress－strain curves of 7d slurry modified by cements with mixing amounts of 5%, 10%, 15%, 20%, 25%, and 30%, slurry modified by cement with a mixing amount of 20%, and fibers with a mixing amount of 0%, 0.25%, 0.5%, 0.75%, and 1% were obtained by unconfined compressive strength testing. A fitting equation satisfying the accuracy requirement was obtained by fitting the aforementioned stress－strain curves using the Back Propagation (BP) neural network algorithm. Five parameters, including peak strength, yield strain, initial elastic modulus, residual strength, and energy dissipation, were used to characterize the unconfined compressive property of fiber/cement-modified slurry. The results showed that the mixing amount of cement affected significantly the short-term unconfined compressive property of fiber/cement-modified slurry, in which the property influence of mixing amount of fiber was unobvious.

keywords: slurry; cement modification; unconfined compressive property; stress－strain curve; BP neural network

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纳米 MgO-纤维与水泥固化路基土的无侧限抗压试验研究

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（绍兴文理学院）

摘　要：为了改善水泥土存在的不足，采用纳米 MgO、聚丙烯纤维和水泥对滨海软土路基进行固化，分析探讨了纳米 MgO-纤维水泥土的受压破坏方式以及不同掺和料的种类和配合比对水泥土无侧限抗压强度影响。试验设计了四种复合材料，它们分别是水泥土 CFN30-0-0、水泥土+1%纤维 CFN30-1-0、水泥土+1%纳米氧化镁 CFN30-0-1 和水泥土+1%纤维+1%纳米氧化镁 CFN30-1-1。试验结果表明，养护 14 天后：（1）CFN30-1-0 的强度较 CFN30-0-0 最大增加了 6%，CFN30-0-1 的强度较 CFN30-0-0 却最大减少了 14%；（2）CFN30-1-1 的强度较 CFN30-0-0 最大增加了 13%；（3）掺纤维能明显改变水泥土的脆性破坏形式。

关键词：软土；纳米 MgO；纤维；水泥土；无侧限抗压特性

Unconfined Compressive Behavior of Cement Stabilized Road Foundation Mixed with Nano-MgO and Fiber

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Abstract:

In order to improve the current shortage of cement clay, the nano-MgO, polypropylene fiber and cement be used to reinforced the soft clay road foundation. The pressure destructive mode of nano-MgO-fiber cement clay is analyzed. Discuss the influence of unconfined compressive strength of cement clay by different kinds of mixtures and mixture ratio. Four composite materials were designed for the unconfined compressive strength of cement clay. They were CFN30-0-0 (30% cement), CFN30-1-0 (30% cement clay and 1% fiber), CFN30-0-1 (30% cement and 1% nano-MgO) and CFN30-1-1 (30% cement, 1% fiber and 1% nano-MgO). The test results show that ：After curing for 14 days，(1) The strength of CFN30-1-0 is increased by 6% compared with CFN30-0-0. The strength of CFN30-0-1 is lower by 14% compared with CFN30-0-0; (2) The strength of CFN30-1-1 is 13% higher than CFN30-0-0; (3) Fiber blending can significantly change the destructive form of cement soil.

keywords: soft clay; nano-MgO; fiber; cement clay; unconfined compressive behavior

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粉煤灰改性滨海水泥土压缩特性及微观机理

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摘　要：探讨改性后的滨海水泥土固结特性具有重要的研究意义。以粉煤灰改性滨海水泥土为对象，其水泥掺量为 20%，粉煤灰掺量分别为 0%、5%、10%和 20%，含水率为 80%，进行养护 7d 和 28d 的单向固结压缩试验以及扫描电镜和 EDX 测试等微观测试。固结试验结果表明：（1）在最终的 800kPa 荷载下，28d 龄期下的滨海水泥土的变形压缩量较 7d 龄期下的滨海水泥土下降了 1.71mm，孔隙比变化下降了约 0.24；（2）掺入 20%的粉煤灰较未掺入粉煤灰的滨海水泥土的变形量下降了约 3.64mm，孔隙比变化较滨海水泥土有明显减小趋势，约减小 0.5。微观试验结果表明：掺入粉煤灰后，试样微观颗粒间形成了骨架，提高了其抗压缩变形能力。以上研究表明，采用粉煤灰改性滨海水泥土提高其压缩特性具有一定的可行性。

关键词：软土；粉煤灰；水泥土；压缩特性；微观机理

Compression Characteristics and Microcosmic Mechanism of Coastal Cement Clay Modified with Fly Ash

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Abstract:

Study the consolidation characteristics of the modified coastal cement clay is great significance. Take coastal soft soil with cement and fly ash as the research object, the cement content is 20%, fly ash content is 0%, 5%, 10% and 20%, the moisture content is 80%. The specimens were subjected to unidirectional consolidation compression tests with curing ages of 7d and 28d, as well as microscopic tests such as SEM and EDX tests. Consolidation test results are shown as follows：(1) Under the final load of 800 kPa, the deformation and compression of the seashore soil-cement with a curing age of 28 days are 1.71mm lower than that of the seashore soil-cement with a curing age of 7 days, and the variation of the void ratio is reduced by about 0.24.(2) Compared with the coastal soil-cement without fly ash, the deformation of the fly ash mixed with 20% decreased by about 3.64mm, and the change of pore ratio was significantly decreased by about 0.5 compared with the coastal soil-cement. The microcosmic test results show that the skeleton is formed between the microcosmic particles of the sample after fly ash is added, which improves its compressive deformation resistance. The above research shows that it is feasible to improve the compression characteristics of coastal soil-cement by using fly ash.

keywords: soft clay; fly ash; cement clay; compression characteristics; microcosmic mechanism

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高速公路路基堆载作用下桥梁桩基力学特征及加固方案

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摘　要：通过对珠三角软土地区某城际铁路桥梁桩基在路堤偏载作用下的力学响应进行三维仿真模拟，研究了桥梁桩基的变形受力特征，验算了桥梁下部结构的安全性，对比分析了增设斜桩、增加横向桩排数、设置群桩基础保护帷幕桩墙及高压旋喷桩维护墙 3 种桥梁桩基加固方案对桥梁桩基的加固效果，推荐采用靠近路基侧桩基设置保护帷幕桩墙、高压旋喷桩维护墙等结构加固，以最大限度地减小路基偏载对桥梁结构安全的影响。

关键词：高速公路；路堤偏载；桥梁桩基；受力变形；加固措施

Mechanical Characteristics and Reinforcement Scheme of Bridge Pile Foundation Under Highway Subgrade Loading

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Abstract:

Through the three-dimensional simulation of the mechanical response of an inter-city railway bridge pile foundation under the eccentric load of the embankment in the soft soil area of the Pearl River Delta, the deformation characteristics of the bridge pile foundation was studied, and the safety of the bridge substructure was checked. Contrasting and analyzing the reinforcement effect of three types of bridge pile foundation reinforcement schemes, such as adding inclined piles, increasing the number of transverse piles, setting up group pile foundation protection curtain pile wall and high pressure jet grouting pile maintenance wall, it is recommended to use pile foundation near the subgrade side. Structural reinforcement such as curtain wall and high-pressure jet grouting pile maintenance wall shall be provided to minimize the impact of subgrade eccentric load on bridge structure safety.

keywords: highway; bridge pile foundation; embankment partial load; force-deformation; reinforcement measures

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高液限黏土固化理论及路用性能试验研究

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摘　要：针对不能直接用作路基填料的高液限黏土，在揭示 GURS 系列固化剂作用机理的基础上，以采用 GURS-501 固化剂固化处理的天津东丽区高液限黏土为试验对象，开展室内试验研究其路用性能。研究表明，GURS 系列固化剂对高液限黏土的固化作用机理可分为搅拌共溶、反应、凝结硬化排斥三个阶段；固化高液限黏土存在最佳搅拌含水量，并随着固化剂掺量的增加而增大；固化高液限黏土的水稳系数在 0.9~1.0 之间，具有较好的水稳性；当 GURS-501 固化剂掺量大于 5%时，固化高液限黏土在冻融循环后强度损失率小于 25%。研究成果可为高液限黏土的固化改良用作路基填料或道路底基层提供指导。

关键词：路基工程；高液限黏土；GURS 固化剂；固化机理；最佳搅拌含水量

Curing Theory and Road Performance Experimental Study of High Liquid Clay

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Abstract:

On the basis of revealing the mechanism of GURS series curing agent, we carried out research on high liquid limit clay (CH) that can not be directly used as subgrade filler. Taking GURS-501 curing agent solidified CH in Dongli District of Tianjin as the test object, we carried out indoor test to study its road performance. The research results shows that the curing mechanism of GURS on CH can be divided into three stages: stirring and dissolving, reacting and condensation hardening. The Optimum moisture content (OMC) exists when curing CH and the content increases with the increase of curing agent content. The solidified CH had good water stability, the water stability coefficient between 0.9 and 1.0. When the content of GURS-501 curing agent is more than 5%, the strength loss of solidified CH after freeze-thaw cycles is less than 25%. The results of this study can provide guidance for curing improvement the CH as subgrade or subbase filler.

keywords: subgrade engineering; high liquid limit clay (CH); GURS series curing agent; curing mechanism; optimum moisture content (OMC)

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公路路基施工质量管控系统的开发与应用研究

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摘　要：路基的压实质量直接关系到道路的使用寿命，有效地对路基施工过程管控是保证路基压实质量的关键。因此，通过信息化的检测方法对施工压实质量进行实时、全面、快速、精确的预测，是加快施工进度、确保路基压实质量的重要保障。本文从系统的功能出发，提出了系统开发的原则及系统开发所使用的开发模式，并且对开发系统进行了实时展示，做到路基施工质量的全过程控制。

关键词：路基施工；压实质量；管控系统；全过程控制

Development and Application of Highway Subgrade Construction Quality Management and Control System

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Abstract:

The compaction quality of roadbed is directly related to the service life of road. Effective control of roadbed construction process is the key to ensure the compaction quality of roadbed. Therefore, real-time, comprehensive, fast and accurate prediction of construction compaction quality by means of information-based detection method is an important guarantee for speeding up construction progress and ensuring subgrade compaction quality. Starting from the function of the system, this paper puts forward the principle of the system development and the development mode used in the system development, and displays the development system in real time, so as to control the whole process of subgrade construction quality.

keywords: Subgrade construction; compaction quality; management and control system; whole process control

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不同土石比土石混合料大三轴试验

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摘　要：采用大三轴剪切试验机，对直径 30cm、高 60cm 的土石混合料试件进行三轴试验。试验获得了不同土石比例的土石混合填料的应力应变关系及其强度特性。通过分析不同土石比例土石混填料的抗剪强度与变形特性，表明采用土石混合填料对减小高填方路堤的沉降与增强高填方边坡的稳定性有利。对于不同土石比的混填料抗剪强度来说，土石比为 30%：70%的混填料抗剪强度最好。通过对四组不同土石比例的混合填料的试验表明，含石量 70%以上的土石混填料随着围压的增大，其抗剪强度增长的幅度较大。

关键词：大三轴试验；抗剪强度；应力；应变关系；变形特性

Large Tiaxial Test of Different Earth-Rock Ratio Earth-Rock Mixture

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Abstract:

Large scale triaxial test was carried out on a soil-rock mixture test piece having a diameter of 30 cm and a height of 60 cm using a large triaxial shear tester. The stress-strain relationship and strength characteristics of soil-rock mixed fillers with different soil-rock ratios were obtained, and the shear strength and deformation characteristics of soil-rock mixed fillers with different soil-rock ratios were analyzed. The test results show that the use of earth-rock mixed filler is beneficial to reduce the settlement of high-fill embankment and enhance the stability of high-fill slope. For the shear strength of mixed fillers with different earth-rock ratios, the 30%:70% mixed filler has the best shear strength. Through the test of four groups of mixed fillers with different soil-rock ratios, it is shown that the soil-rock filler with more than 70% stone content increases with the increase of confining strength.

keywords: Large scale triaxial test; the shear strength; the shear strength; the stress-strain relationship characteristics; deformation behaviors

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Integrated Approaches for Predicting Resilient Modulus of Subgrade Soils

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Abstract: The resilient modulus has been used to characterize the stress-strain non-linear behaviour of subgrade soils and is an important parameter for pavement design and analysis. This study aims at developing an accurate and efficient methodology to estimate the resilient modulus of subgrade soils. Therefore, repeated load triaxial tests were carried out in this study. The soil matric suction was measured by the pressure plate test and the soil-water characteristic curve (SWCC) was described using the Fredlund & Xing model. Then, the influence of stress state, matric suction and relative compaction on the resilient modulus were analyzed. Subsequently, a new resilient modulus model was proposed to incorporate the relative compaction and matric suction in addition to the stress state. The new model matched 7 sets of experimental data well and the coefficients of determination were high, which indicates that this new model is reasonable and widely applicable. Finally, the correlations between the basic properties variables of soil samples and the regression coefficients of the new model were established.

Key words: resilient modulus; prediction model; relative compaction; matric suction; subgrade soils

Deterioration Mechanism and Rapid Evaluation of the Performance of an Existing Subgrade in Southern China

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Abstract: When subgrades need to be widened to relieve the increasing traffic load, a rapid detection of the properties for characterizing their performances, such as rigid, moisture content and compaction degree, is very important for their reasonable evaluation and maximized utilization. For this reason, three commonly used detecting methods were selected to determine the moisture content, compaction degree and resilient modulus of five types of soil from an existing highway subgrade in southern China. And then, the detected moisture content and compaction degree were compared with the design values of the subgrade. The results show that the moisture content of the existing subgrade increases obviously, and the compaction degree decreases sharply. This attributes to the drastic moisture and heat exchange between the subgrade and its surroundings due to the hot and humid climate in the summer of southern China. The moisture and heat exchange also produces a decrease in the resilient modulus detected via the plate load test from the standard modulus of 60 MPa down to 40 MPa. Afterwards, two rapid detecting methods, i.e., the portable falling weight deflectometer (PFWD) and dynamic cone penetrometer (DCP), were selected to evaluate the subgrade performances. Subsequently, the PFWD dynamic modulus and the DCP penetration rate were correlated with the resilient modulus detected by the plate load test, deflection detected by the Beckman beam test, compaction degree and moisture content based on the data of 60 test points of three types of soil. The analysis of correlation coefficients indicates that both the PFWD and DCP methods are suitable to evaluate the subgrade performances. Furthermore, the accuracy and efficiency of PFWD and DCP were compared. The results show that the former has a higher accuracy and is more timesaving. Therefore, the PFWD method was recommended to be used to evaluate the subgrade performances.

Key words: Deterioration Mechanism

Influence of Unilateral Widening by Gravel Soil on Expressway Road

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Abstract: Gravel soil is a kind of filling material with excellent mechanical properties, which can be widely used in roadbed filling. In this paper, the calculation by finite element analysis shows that the maximum tensile stress of the surface layer is reduced from 1.34MPa to 1.05MPa and that of the base layer is reduced from 0.54MPa to 0.42MPa after the new subgrade is completely filled with crushed stone soil. The maximum settlement value of unilateral widening is reduced from 11.43 cm to 8.7 cm. The use of gravel soil to fill new roadbed cannot only reduce subgrade settlement, but also reduce pavement deflection.

Key words: gravel soil; subgrade settlement; pavement deflection

Field Studies on the Dynamic Compaction of Fly Ash Over Soft Soil

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Abstract: Taking a large oil tank foundation project for example, the experiment scheme of dynamic consolidation method on the filled fly ash above soft soil is introduced in detail. The increasing and duration laws are analyzed. Before and after the experiment all kinds of in-situ tests and soil mechanics laboratory tests are carried out in order to make a conclusion of the efficiency of foundation improvement by dynamic consolidation method, research results show that it is beneficial to dissipate for the water pore pressure in the fly ash filling layer and silty sand layer and it is helpful to the drainage consolidation of the soft soil in the deep layer and increases the effective depth of dynamic compaction and improve the physical and mechanical properties of the soft soil in the deep layer and enhances bearing capacity of foundation when plastic drainage plates are added to the foundation treated by dynamic compaction, so it is feasible to treat the saturated soft soil covered with fly ash filling layer by dynamic consolidation method, of which effective improvement depth is four to six meters, and the research conclusions can provide an example for such engineering design and construction.

Key words: fly ash filling layer; saturated soft c1ay; dynamic compaction; experiment

台背回填高速液压夯实机补强路基质量控制标准

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摘 要：本文基于波体特性的夯击能传递原理，提出了影响高速液压夯实机补强路基效果的主要因素为夯击档位、夯击次数和夯点间距。进而根据现场试验，研究了不同因素对夯击效果的影响，提出了台背回填高速液压夯实机补强路基质量控制标准，对指导台背路基工程施工具有重要意义。

关键词：台背；高速液压夯实机；路基工程

Quality Control Standard for Reinforcing Subgrade of High-Pressure Hydraulic Compaction Machine with Back-Filling

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Abstract:

Based on the principle of slamming energy transmission, the main factors affecting the effect of high-speed hydraulic compaction machine on roadbed are sniper gear position, slamming frequency and spurting point spacing. According to the field test, the influence of different factors on the slamming effect is studied. The quality control standard for the subgrade backfill high-speed hydraulic tamping machine is proposed, which is of great significance to the construction of the subgrade foundation.

keywords: platform back; high speed hydraulic compactor; roadbed engineering

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黄土地区公路复合边坡变形破坏机理及防治对策

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摘　要：黄土地区公路复合边坡是指坡体上部为黄土，下部为基岩的结构型式边坡，这类边坡在陕北黄土区国道 210（G210）沿线较为常见，且边坡灾害频发。通过对 G210 延安至黄陵段（K611+000～K738+800）的调查，总结分析了沿线自然环境条件、边坡结构及崩塌、落石、滑塌等灾害特征；利用 PLAXIS 有限元计算软件，进行典型坡体结构（黄土+砂页岩互层）力学分析，得出了水平应变、剪应变和剪应力的集中分布区。结合致灾因素，分析了边坡变形破坏机理。根据灾害特征及防治资金等情况，提出了完善排水设施、加强养护与监测、工程措施等 3 方面防治对策，以指导公路边坡的灾害防治。

关键词：黄土地区；国道 210；复合边坡；变形机理；防治对策

Mechanism and Prevention Measures for Deformation of Highway Compound Slope Structure in Loess Area

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Abstract:

Compound slope structure is formed by two parts, the upper is formed by loess and lower by rock. This highway slope is a common slope structure in loess area and its failure occurs frequently in loess area of Northern Shaanxi Province. Based on the investigation of Yan'an-Huangling Segment (K611+000～K738+800) of G210, this paper analyses the environmental conditions along G210, slope structure and the features of rockfall and landslide. The concentrated distribution area of horizontal strain and shear strain are concluded by PLAXIS finite element software. In combination with hazard-caused factors, the mechanism of slope deformation and failure is summarized. According to the condition of hazard features and preventive funds, this paper provides three aspects of control measures: improvement of drainage facilities, further maintenance and monitoring, engineering measures etal, so as to guide the prevention of highway slope failure.

keywords: loess area; G210; compound structure slope; deformation mechanism; prevention measure

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Research on Uneven Settlement of Subgrade with Micro-Piles

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Abstract: The micro-pile of Qingdao-Yinchuan Expressway K555+070-K557+710 was used to control the uneven settlement of the embankment. The earth pressure was monitored by site-placed pressure box, subgrade deformation was calculated, and Midas/GTS was used to establish the subgrade filling and operation model. The model is divided into three phases: completion, operation period and post-treatment analysis. By comparing and analyzing the numerical simulation results and the actual monitoring data, it is found that the differential pile settlement of the subgrade by the micro piles can effectively control the vertical settlement and horizontal displacement, and greatly improve the stability of the subgrade. The effect of micro piles on uneven settlement is obvious, and the optimal vertical pile spacing is 3m. Provide reference for similar projects.

Key words: micro pile; numerical simulation; fill subgrade; uneven settlement

古尔沟隧道出口崩塌危岩体灾害分析与治理

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摘　要：崩塌落石是山区常见的地质灾害之一。汶马高速公路沿线两侧山体发育大量的危岩体，崩落后对路线施工运营安全造成影响。本文通过对古尔沟隧道出口崩塌危岩的特征、形成机制、影响因素和稳定性分析，针对崩塌危岩采用相应的综合治理措施，治理效果明显。因此，对汶马高路公路及其他类似工程治理起到一定的指导和借鉴意义。

关键词：汶马高速公路；古尔沟隧道；崩塌危岩体；灾害分析；治理

Analysis and Treatment of Collapse and Dangerous Rock Mass Disaster at Exit of Guergou Tunnel

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Abstract:

The Collapse dangerous rock is one of the most common geological disasters. There are a lot of geological hazards of collapse and dangerous rock on both sides of the mountain along the Wenma highway, Impact of collapse on the safety of route construction and operation. Through the analysis of the characteristics, forming mechanism, influencing factors and stability of the collapse rock at the exit of Guergou tunnel, the corresponding measures are adopted for comprehensive treatment of collapsed rocks, and the control effect is obvious. Therefore, it has a certain guidance and reference significance for the management of Wenma Highway and other similar projects.

keywords: The Wenma highway; The Guergou tunnel; Collapse rock mass; Disaster analysis; Administe

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支挡结构的技术创新与风险预防

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摘　要：传统的支挡结构存在造价高安全性差等问题，新时代呼唤创新型技术。本文从当前的创新形势出发，阐明了技术创新对勘察设计企业的作用，列举了实际施工过程中，原有技术无法解决但创新技术完美攻克的实际例子，并对支挡结构技术创新的作用与效果进行了剖析，同时，对当年运用“新技术”失败的案例进行了分析与总结，提出了预防技术创新风险的建议。该研究能为创新技术研发者和使用者提供一定的理论指导。

关键词：支挡结构；技术创新；风险预防

Technological Innovation and Risk Prevention of Retaining Structure

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Abstract:

The traditional retaining structure has some problems such as high cost and poor safety. Starting from the current situation of innovation, the impact of technological innovation, in survey and design enterprises, is illustrated. Then, the paper lists practical examples in which the traditional technology can not be solved but the innovative technology can be perfectly conquered in the actual construction process. Basis on these, the function and effect of technological innovation of retaining structure are analyzed. At the same time, it analyses and summarizes the failure cases of using "new technology" in past, and puts forward some suggestions. This study can provide some theoretical guidance for innovative technology developers and users.

keywords: Support structure; technology innovation; risk prevention

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基于非等比例双强度参数折减法的边坡稳定性分析

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摘　要：本文基于 Drucker-Prager 准则和强度参数非等比例相关联折减理论推导出一种基于 D-P 系列准则的非等比例折减方法，通过算例计算，探讨了基于不同强度折减方式作用下的边坡稳定性影响，结果表明采用不同的强度参数折减方法并不会影响到各强度准则下的边坡稳定性结果排序，并且基于非等比例折减方式获取的边坡安全系数安全储备更高。

关键词：Drucker-Prager 准则；非等比例；强度折减法；安全系数

Slope Stability Analysis Based on Non-Equal Proportional Double Strength Parameter Reduction Method

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Abstract:

Based on the Drucker-Prager criterion and the non-equidistant correlation reduction theory of strength parameters, a non-equal scale reduction method based on D-P series criterion is derived. By calculation, the edges based on different strength reduction methods are discussed. The slope stability effect, the results show that the different strength parameter reduction methods will not affect the slope stability results under the various strength criteria, and the safety margin of the slope safety factor obtained based on the non-equal reduction method is higher..

keywords: drucker-Prager criterion; non-equal ratio; strength reduction method; safety factor

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山区斜坡病害对高速公路危害评价系统分析

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摘　要：对于修建在山区斜坡坡表的高速公路，虽在建设期间对存在的斜坡病害对高速公路的影响进行过不同程度的处置，　但随着地形地貌的变化，地表水径流通道的改变，以及卸荷风化作用的集聚，通常在通车数年后，坡体的病害会逐渐出现，影响高速公路的营运。高速公路中出现的山区斜坡病害如何评价，文章通过从病害产生的影响因素入手，结合病害对高速公路产生的影响，提出了对高速公路营运后，斜坡病害的多因素综合影响叠加法，并采用层次分析法对其中各因素的影响权重进行了分析，对如何指导管理养护对于高速公路建设以及后期管理养护具有现实的指导意义。

关键词：山区高速公路　斜坡病害　养护评价

System Analysis of Highway Slope Damage Assessment Based on Slope Disease in Mountain Area

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Abstract:

For a highway built on slope surface in Mountainous Areas, During the construction period, although the influence of the existing slope diseases on the highway has been dealt with in different degrees, With the change of topography and surface water runoff channel and the aggregation of unloading weathering. Usually, after several years of opening to traffic, the disease of the slope will gradually appear, which will affect the operation of the highway. How to evaluate slope diseases of highway in mountain area, In this paper, Starting from the influence factors of disease, Multi factor comprehensive influence superposition method of slope disease was put forward with combining the influence of disease on highway after highway operation, This method has practical guiding significance for the management and maintenance of highway construction and later operation.

keywords: mountain highway; slope disease; maintenance evaluation

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Development of a New FBG-Based and Terfenol-D Inclinometer for Measuring Displacements in Slopes

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Abstract: Slope displacement monitoring is an important means for early warning of landslide hazards, which is of great significance for predicting landslides and preventing building damage, casualties, and economic losses. Considering the potential advantages of fiber Bragg grating (FBG), such as small size, lightweight, anti-electromagnetic interference, good durability, easy online monitoring and intelligence, this study describes a new in-situ inclinometer based on FBG sensing technology and magnetostrictive effects. This kind of inclinometer, designed to be inserted into the conventional inclinometer casing, can be used to measures the relative deflection between the segments. The FBG-based inclinometer mainly comprises four parts: a rigid unit, a magnetostrictive unit, a permanent magnet, and a connecting pin. The magnetostrictive unit containing Terfenol-D bar is embedded as a sensing medium in the joint of the inclinometer. A series of FBG sensors were attached to the surface of the Terfenol-D to measure the magnetostrictive strain under different magnetic fields. When the soil mass inside the slope is deformed, the rigid unit will be deflected at the joint and drive the magnetostrictive unit to rotate. The authors performed multiple sets of calibration experiments in the laboratory to obtain significant results. Furthermore, this study used the linear relationship between the center wavelength of FBG and the rotating angle of Terfenol-D to obtain the relative deflection angle between the rigid elements. The experiments show that the calibration results are in good agreement with the theoretical results. The developed inclinometer has good linearity, high tilt measurement sensitivity and high resolution, which can be used for in-situ monitoring of large deformation of the slope.

Key words: slope monitoring; FBG-based inclinometer; Terfenol-D; fiber Bragg grating (FBG); displacement measurements

基于遥感技术的弃渣场稳定性初步判识

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摘　要：随着公路各方面技术的发展和完善，作为附属设施的弃土处置已经成为现阶段我国山区公路建设的突出问题和薄弱环节。弃渣场作为一种巨型人工松散堆积物，破坏类型可分为：1. 高速远程滑坡—碎屑流；2. 低速远程运动；3. 局部化破坏滑坡；4. 泥石流。利用遥感技术识别弃渣场稳定性的过程大致分为两步：1. 信息采集，采用图像处理及 GIS 技术，将弃渣堆积前后遥感图、高程图及环境信息源整合配准以构成解译基础；2. 基于弃渣场失稳破坏的理论，以人机交互目视解译，初步识别弃渣场稳定性。识别的主要内容为：弃渣场类型、弃渣场构造完整程度及其效果、弃渣对周边环境影响四个方面。相较于传统方法，遥感识别具有快速、直观、全局观以及可批量处理等优势。

关键词：遥感；模式识别；弃渣场；稳定性

The Preliminary Identify of Stability of Slag Dump Based on Remote Sensing Technology

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Abstract:

The slag dump as an auxiliary facility of highway has become a prominent problem and weak link in the construction of mountain roads in China at this stage. As a kind of giant artificial loose deposit, the waste style of slag field can be divided into four: 1. high-speed remote landslide-debris flow; 2. low-speed long-distance movement; 3. debris flow; 4 localized failure landslides. The process of using remote sensing technology to identify the stability of the waste dump is roughly divided into two steps. First, information collection, the remote sensing map before and after the accumulation of waste slag, and the DEM and environmental information source are integrated and registered to form the basis of interpretation using image processing and GIS technology. Second, though the remote sensing interpretation and time-space analysis, the stability of the dump are obtained by means of men-PC interactive mode, with the guide of theory of land-slide.The main content of the initial identification of the stability of the waste dump are four. The type of the dump, the integrity and effectiveness of the dump accessory structural, and the impact of the waste dump on the surrounding environment. Compared with the traditional methods, remote sensing identification can do a batch processing for the dumps in an area rapidly and comprehensively.

keywords: remote sensing; pattern recognition; waste dump; stability

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岩溶地段桩基施工溶洞决策表法处理研究

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摘　要：结合广州某高速岩溶地段桥梁桩基施工遇到的溶洞处理问题，对整个场地的桩基溶洞勘察数据信息进行了分类统计分析，在经济适用的原则下，提出了不同溶洞、不同处理方式的决策表机制，达到了全面考虑、简化决策、及时处理的目的，同时可以对溶洞处理措施费用进行事前预算，加强了工程管理措施手段，取得了较好的实践效果。

关键词：岩溶处理；桩基；决策表

Research on Treatment of Karst Cave Decision Table Method in Pile Foundation of Karst Area

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Abstract:

Combined with the problem of karst cave treatment encountered in the construction of bridge pile foundation in a high-speed karst section of Guangzhou, the classification and statistical analysis of pile-based cavern survey data of the whole site was carried out, under the principle of economic application, the decision-making mechanism of different caves and different treatment methods is proposed, achieved the purpose of comprehensive consideration, simplified decision-making, and timely processing, at the same time, the cost of the cave treatment measures can be budgeted in advance, achieved good practical results.

keywords: karst treatment; pile foundation; decision table

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Composite Sliding Surface-Based Limit Equilibrium Analysis for Surficial Stability of Soil Slope

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Abstract: The classical infinite slope method for surficial stability of soil slope doesn't take the edge effects of landslides into consideration. Under saturated downslope seepage flow, stress conditions and limit stress state discrimination based on Mohr-Coulomb strength criterion in infinite slope were analyzed. A composite sliding mode including three sliding zones, namely, the upper tension zone, the middle shear sliding zone, and the lower compression zone were presented. With the application of finite differential method, failure surfaces of the upper and lower edge have been found and verified to be a log spiral trace. For surficial stability of soil slope with the consideration of edge effects, a semi-analytical framework has been proposed using composite sliding surface-based limit equilibrium analysis. For assessing the validity of infinite slope method, a slope with silty sand soil was tested. The results show that: The infinite slope method is always conservative due to the neglect of the upper and lower edge resistance, particularly when the ratio of length to depth (L/zw) is less than 10; The relative difference between predictions usually falls within 5% with L/zw increasing to 20, at which the edge effects can be neglected reasonably and the infinite length assumption will be valid.

Key words: soil slope; surficial stability; composite sliding surface; infinite slope; edge effects

多年冻土区高等级公路地温调控措施设计探讨

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摘　要：根据国家高等级公路建设发展的需要，本文就多年冻土区公路传热过程、建设中可能遇到问题进行分析，分析表明：冻土铁路与公路和高等级公路的热量来源、传热过程、传热强度等均存在本质区别。由此揭示，青藏铁路所得到的有益成果将难以直接应用于高等级公路建设中。针对高等级公路传热特点、青藏铁路的建设经验以及现有调控措施的优缺点，从对流、传导、辐射方面研发适合高等级公路建设的地温调控措施，并就工程措施的特点、合理性进行分析介绍。

关键词：多年冻土；高等级公路；传热特点；工程措施

Discussion on Design of Geothermal Control Measures for High-Grade Highways in Permafrost Regions

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Abstract:

According to the needs of national high-grade highway construction and development, this paper analyzes the heat transfer process of highways in permafrost regions and the problems that may be encountered during construction. It is showed that the heat source, heat transfer process and strength of railway, highway and high-grade highway in permafrost regions are essential differences. This reveals that the beneficial results obtained by the Qinghai-Tibet Railway will be difficult to directly be apply to the construction of high-grade highway. In view of the heat transfer characteristics of high-grade highway, the construction experience of Qinghai-Tibet Railway, and the advantages and disadvantages of the existing geothermal control measures, it was been developed that geothermal control measures suitable for high-grade highway construction from convection, conduction and radiation, and the characteristics and applicability of engineer measures were discussed.

keywords: Permafrost; High-grade highway; Heat transfer characteristics; Engineering measures

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Experimental Study on the Shear Strength and Dynamic Shear Modulus of Lignin Modified Laterite Soil

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Abstract: To evaluate the effect of lignin on improving laterite soil, the calcium lignosulfonate is utilized to mix into laterite soil, laboratory static and dynamic triaxial compression tests were carried out to study the change rule of shear strength indexes (cohesive force and internal friction angle) and dynamic shear modulus of imporved soil.The results indicate that shear strength indexes and dynamic shear modulus first increase and then decrease with an increase in lignin amount.The optimum amount for laterite soil used in these tests is 9%.The increase in curing time make increase in shear strength and dynamic shear modulus, but increase slow down after 1 day of curing. The dynamic shear modulus increases with confining pressure increases, but the increase rate is getting smaller. H-D model can illustrate relationship between dynamic shear modulus and dynamic strain. Linear function can describe numerical relationship between shear strength and maximum dynamic shear modulus. The results confirm lignin can effectively improve shear strength and dynamic shear modulus of laterite soil as a modifier.

Key words: laterite soil; lignin; dynamic shear modulus; shear strength

天津滨海软弱地层地铁车站——隧道系统大面积降水诱发工后沉降的模拟研究

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摘　要：无论是大面积区域还是局部地层，软土地层沉降的主要肇因仍然是传统理论中土层有效应力的增加从而引起软土固结引起。然而，导致土层有效应力增加的途径一是荷载增加，二是地下水水位降低，或者两者都有，准确预测沉降则难度较大。地铁车站-隧道系统建成后的沉降既有地下水位的降低引起，兼有有效应力增加，导致系统周围软土的固结沉降。以天津地区软土环境中的地铁车站-隧道系统为例，本文采用对承压水压力降低的模拟能有效地模拟地层沉降，介绍了如何确定地下水头降低的方法，并获得了地铁车站-隧道系统不同部位的沉降值以及沉降导致的应力集中。分析表明这些部分是整个地铁车站-隧道系统在软土环境中的薄弱环节，在工程设计和运营维修阶段应加强重视，并采取相应的措施保证整个系统的安全。

关键词：地表沉降；隧道连接；有效应力；地下水水头

FEA Simulations for Post-Construction Settlement of Subway Station-Tunnel System in Tianjin Binhai Soft Soils

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Abstract:

No matter it is an open large-area zone or a small human being built environment, the main reason of the settlement of soft soil is the increase of the effective stress that cause consolidation of soft soils. This follows the traditional consolidation theory. However, increase the effective stress may be induced by the increase of the load, or groundwater level lowering, or both, and prediction of settlement is not easy. After the completion of the metro station-tunnel system, the settlement is caused by groundwater level lowering, which may be caused by many reasons. This paper presents a Finite Element Analysis study on the settlement of subway station-tunnel system built in Tianjin soft soils by simulating the groundwater dropping. The method to determine the drop of groundwater head is introduced, and the subsidence in different parts of the system and stress concentrations caused by the subsidence are introduced and discussed. The analyses show that these parts are vulnerable of the system built in soft soils, mitigation measures shall be considered in design phase to reduce the efforts and costs in operation and maintenance stages, as well as for the safety of the entire system.

keywords: surface settlement; station-tunnel connection; effective stress; groundwater head

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Study on Water and Salt Migration of Saline Soil Under the Condition of Freeze-Thaw Cycles

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Abstract: In order to study the effect of freeze-thaw cycles on the water-salt migration of saline soil subgrade, the saline soil was subjected to zero, three, five, seven and nine times respectively under the conditions of optimum water content and salt content of 2%. The sub-freeze-thaw cycle test was carried out to monitor the change of water and salt, and the test results were compared and analyzed. The results show that with the increase of freeze-thaw cycle times, the water content at each layer height increases and the water channel gradually penetrates. The water content shows a tendency of upper part and small part. The initial state salt is evenly distributed. With the increase of freeze-thaw cycle times and with the boundary of 40cm, the salt content of the upper part of the soil column shows an increasing trend, and the salt content of the lower part shows a decreasing trend. The salt migration channel begins to form after the three cycles. After the channel is completely formed, the salt in the subgrade gradually migrates from the bottom to the cold end; the freeze-thaw cycle contributes to the formation of water and salt migration channels, and promotes the migration of water and salt.

Key words: freeze-thaw cycles; saline soil; water; salt; migration

多年冻土地区路堤高度对温度场影响的数值分析

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摘　要：当土基中含有多年冻土时，其强度较一般土基强度高。但随着外部环境的变化，冻土会逐渐衰退，随之而来就会出现融沉等病害。影响冻土衰退的因素有很多，如路堤高度、大气温度、太阳辐射等。以青藏高原多年冻土地区为背景，主要运用 GeoStudio 有限元分析方法，对不同路堤高度的路基温度场进行数值模拟，研究路堤高度对冻土上限的影响，从而揭示路堤高度对冻土上限影响的一般规律，为冻土地区的施工及病害防治提供理论依据。

关键词：多年冻土

Numerical Analysis of Influence of Embankment Height on Temperature Field in Permafrost Region

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Abstract:

Abstract:When permafrost is contained in subgrade, its strength is higher than that of general subgrade.However, with the change of external environment, the permafrost will gradually decline, followed by thawing and sinking diseases.There are many factors affecting permafrost deterioration, such as embankment height, atmospheric temperature, solar radiation and so on.Based on the qinghai-tibet plateau permafrost region as the background, mainly through the finite element analysis method, GeoStudio on different embankment height of temperature field numerical simulation, the influence of the research on the upper limit of permafrost embankment height, which reveal that the general law of the upper limit of permafrost embankment height, for the construction of the permafrost regions and provide theoretical basis for disease prevention.

keywords: permafrost

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Field Measurement and Numerical Prediction of Moisture Content in Unsaturated Clay Embankments in South China Due to Soil-Atmosphere Interaction

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Abstract: To determine the moisture content of unsaturated clay embankments in South China, 753 measured moisture data of two existing clay embankments built for about 20 years in South China were gained. Subsequently, a finite element model considering the stress-dependent soil-water characteristics curve (SDSWCC) of unsaturated clays for a typical embankment was built. Then, the variation of the moisture content in clay embankments in South China due to soil-atmosphere interaction was predicted. The calculated and measured moisture contents showed a high consistence, which indicates the rationality of the numerical model. For the existing clay embankments in South China, their moisture contents increase gradually from the optimum moisture content and eventually reach an equilibrium state, in which they are close to the plastic limit and increase by 99% of the optimum moisture content. In addition, the resilient modulus values of different locations in embankments and of the whole embankment are reduced by 50% to 60%. Similarly, the safety factor of slope decreases obviously and its reduction is greater than 60%.

Key words: field measurement; numerical prediction; moisture content; unsaturated clay embankments

基于残差修正灰色理论的下伏溶洞影响下桩基承载力预测

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摘　要：为了探明岩溶区下伏溶洞洞高、洞跨对桩基承载力的影响，预测溶洞尺寸不同时的桩基承载力，本文根据岩溶区桩基的工程特点，基于灰色理论及有限元数值模拟，建立了不同溶洞尺寸的数值仿真模型，分析了桩基承载力受下伏溶洞尺寸的影响规律，导出了考虑下伏溶洞洞跨影响的桩基承载力预测公式，并建立了桩基承载力残差修正灰色理论模型，导出了精确度更高的桩基承载力预测公式。研究结果表明：岩溶发育区桥梁桩基承载力受下伏溶洞洞高影响不大，但其受洞跨影响显著，承载力随洞跨增大而减小，洞跨由 4m 增大到 6m 时桩基承载力降幅达到 33.44%；通过 GM（1，2）模型导出的考虑下伏溶洞洞跨影响的桩基承载力预测公式，其预测结果与数值仿真模拟结果进行对比，所得后验差比值 C 为 0.2893，精度高。残差修正 GM（1，1）模型可对原预测公式进行优化，优化后 C 可达到 0.0497，预测精度显著提高，该研究成果具有一定的理论与工程实用价值。

关键词：岩土工程；溶洞尺寸；桩基承载力；灰色理论；残差修正

Prediction of Bearing Capacity of Pile Foundation Under the Influence of Lower Cavern Size Based on Residual Modification Grey Theory

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Abstract:

In order to figure out the effect of cavern height and span and study the prediction method considering the influence of cavern size of the bearing capacity of the pile foundation in the karst area, this paper established numerical simulation model of different cavern size based on the engineering characteristics of pile foundation in karst area. Based on the gray theory and combined the result of the numerical simulation, the influence of the cavern size on the bearing capacity of the pile foundation is analyzed, and the prediction formula of bearing capacity of the pile considering the influence of the cave is derived. This paper also established the gray theoretical model of corresponding residual. The result shows that, the bearing capacity of bridge piles in karst development area is not affected by the cavern height, but it is affected by the cavern span and decreases with the increase of the span. When the span is increased from 4m to 6m, the bearing capacity of the pile reduced by 33.44%. The prediction formula of bearing capacity considering the influence of span is derived by GM (1, 2) model. The prediction results are compared with the numerical simulation results and the posterior difference ratio C is 0.2893, and the accuracy is very high. The residual correction GM (1, 1) model can optimize the original prediction formula. After optimization, C can reach 0.0497. The prediction accuracy is improved significantly. It has certain theoretical and engineering practical value in karst area.

keywords: geotechnical engineering; Pile in the cavern area; the bearing capacity of pile; grey theory; corresponding residual

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多年岛状冻土路基坡向性热效应数值模拟分析

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摘 要：在多年岛状冻土区由于公路的走向，有时会使路基两侧坡面及其下伏土层的地温环境存在较大差异，从而导致路基结构发生不均匀热变形，继而引发边坡滑塌、纵向开裂等严重的路基病害，直接威胁行车安全。掌握该类路基坡向性差异特征是提高公路设计质量，改善路基热稳定性的基础前提，因此，本文以实际工程为载体，通过在路基两侧坡面施加差异性热流密度，对多年岛状冻土路基的热稳定状态进行了数值模拟，研究结果表明随着路基两侧坡面温差的不断增大，路基土体温度与热变形的不对称性愈加显著，根据不同热差异时的路基地温场及位移场的等值线分布情况，分别揭示了路基在冻结和融化状态下的坡向性地温分布特征、位移变化特点及可能诱发的路基病害。

关键词：多年岛状冻土路基；坡向性；地温场；位移场；数值模拟

Numerical Simulation Study on Slope-Directive Thermal Effect for Patchy Permafrost Subgrade

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Abstract:

There are great differences of ground temperature circumstance on both slope sides of subgrade and the underlying soil layers because of the highway direction in patchy permafrost areas sometimes, which caused the inhomogeneous thermal deformation of subgrade structure and bringed about a series of serious subgrade diseases such as slope sliding, longitudinal cracking and so on, so then it has threatened the driving safety directly. Mastering the characteristics of slope-directive difference is the basic premise of improving design quality and enhancing thermostability for this subgrade, so based on the practical project, this paper simulated and analyzed the thermal steady states by applying different heat flux densities on slope sides for patchy permafrost subgrade, the results show that the asymmetry of soil temperatures and thermal deformation became more obvious as the temperature difference increases of subgrade slopes, and then based on the isoline distributions of ground temperature field and displacement field under different temperature differences, the study presented the slope-directive distribution characteristics of ground temperature, the displacement changing characteristics and the possible subgrade diseases in frozen and thawing states respectively for patchy permafrost subgrade.

keywords: patchy permafrost subgrade; slope direction; ground temperature field; displacement field; numerical simulation.

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多年冻土路基竖向位移地温响应数值模拟分析

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摘　要：多年冻土区公路工程的主要问题是由于地温环境的变化，导致路基土体的热力学性质及路基内的“冰—水”相构发生改变，从而引起较大的竖向变形，直接威胁行车安全，掌握该类路基竖向位移的地温响应规律是提高路基热稳定性的前提条件。因此，本文以实际工程为依托，采用有限元数值模拟的方法，对工后一年内的竖向热位移进行瞬态模拟分析，并与实测数据进行对比验证，提出了高纬度地区多年冻土路基竖向位移的年周期性地温响应过程可分为“冻结—过渡—融化”三个阶段，并根据数值模拟结果，揭示了各阶段路基竖向热位移的变化特征。

关键词：多年冻土路基；竖向位移；地温响应；对比验证

Numerical Simulation Analysis on Vertical Displacements Response of Permafrost Subgrade Along with Ground Temperature

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Abstract:

The main highway engineering problem is the large changes of thermodynamics properties and “ice-water” phases structure for subgrade soil body in permafrost areas, which caused by the change of ground temperature environment, and then it produced large vertical deformation and threatened the driving safety seriously, so mastering the response laws of vertical deformation along with ground temperature is the precondition of enhancing thermal stability for this subgrade. Therefore, based on practical project, this paper simulated and analyzed the transient process of vertical thermal deformation by finite element numerical simulation during one year after the project was done, and through comparing with measured datas, the study results shows that the annual cyclical response process of vertical deformation along with ground temperature can be divided into “freezing-transition-thawing” three stages in high latitudes, and based on the numerical simulation results, it presented the change characteristics of vertical thermal deformation for each period.

keywords: permafrost subgrade; vertical displacement; response with ground temperature; comparison validation

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Influence of Gully Topography on Pressures and Fill Settlement Characteristics of High Fill Slab Culverts

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Abstract: In order to explore the influence of gully topographic on the pressure and the fill settlement characteristics deformation of the high fill slab culverts, based on a self-developed model test platform, which can fully reflect the stress and settlement deformation characteristics of the slab culvert under gully topography. Based on this platform, the culvert-soil interface soil pressure of slab culvert and fill settlement deformation on the culvert top in different gully width and different gully slops under slab culverts are analysed. Based on the test results, some technical recommendations are proposed. The results indicate: the topographic conditions of the gully have great influence on the stress characteristics of the culvert-soil system. The increase of soil pressure in the culvert-soil interface is positively correlated with the gully width, and negatively correlated with the gully slope. The vertical soil pressure concentration coefficient in top culvert Ks is smaller when the gully width is smaller and the gully slope is larger. The top soil settlement deformation curve of the slab culvert is "W-shaped". With the increase of the gully width, the settlement difference －δ between the inside and outside of the culvert soil increases gradually. With the increase of the gully slope, the variation of settlement difference between the inside and outside of the culvert is +δ to 0 to -δ. The vertical soil pressure concentration coefficient at the top of the slab culvert under the influence of the gully slope is not linearly positively correlated with the difference ±δ between the inside and outside settlement of the culvert top. When the gully width is 1.5D~5D, the variation range of the height of the corresponding equal settlement section is 12.2m~13.7m. When the gully slope is 0°~60°, the variation range of the height of the corresponding equal settlement section is 12.5m~13.7m. In this paper, it is proposed that high fill

slab culvert can be defined by the height of equal subsidence surface, taking 14m as the height of the culvert. It is suggested that the original landforms should be fully utilized in practice projects. Under the conditions of economic rationality and technical feasibility, the slopes should be retained as far as possible, or artificial back-excavation construction should be carried out to increase the slope and reduce the width of the gully. The condition that gully width B is less than 3D, and the gully slope equal to 45 degrees is appropriate.

Key words: geotechnical engineering; gully terrain; centrifugal model test; slab culvert; soil pressure; settlement

基于数值计算的填挖交界路基施工优化

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摘　要：受山区地形条件限制，山区公路的路基部分通常具有高填深挖或半填半挖的特点。为规避填挖交界处路基的施工安全隐患，减少因路基不均匀沉降导致的路面结构破坏，本文对山区公路半填半挖路基的施工过程优化进行了研究。首先，建立适用于山区公路路基填料的 Merchant 计算模型，并实现其在有限元分析软件上的应用；其次，利用有限单元法，对工程实例进行模拟计算，分析了不同施工过程中填挖方土体的变形规律。计算结果表明，在不同的施工方式下，路基的变形规律趋于一致，其中“边填边挖”的施工方式具有一定优势。相关成果为类似工程的合理优化提供明确的技术依据。

关键词：数值模拟；有限单元法；填挖交界；施工优化；沉降变形

Construction Optimization of Filling-Excavation Subgrade Based on Numerical Calculation

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Abstract:

Due to the limitation of mountain terrain, the subgrade of mountain highway usually has the characteristics of high filling and deep excavation or half filling and half excavation. In order to avoid the hidden danger of subgrade construction safety at the junction of filling and excavation and reduce the damage of pavement structure caused by uneven settlement of subgrade, this paper studies the optimization of construction process of semi-filling and Semi-excavating subgrade of mountain highway. Firstly, a Merchant calculation model for subgrade filling in mountainous areas is established, and its application in finite element analysis software is realized. Secondly, the finite element method is used to simulate the engineering case and analyze the deformation law of filling and excavating soil in different construction processes. The calculation results show that the deformation law of subgrade tends to be consistent under different construction methods, and the construction method of "filling while digging" has certain advantages. Relevant results provide a clear technical basis for the rational optimization of similar projects.

keywords: numerical simulation; finite element method; filling-excavation; construction optimization; settlement deformation

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土体在冻融条件下力学特性的探讨

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摘　要：季节性冻土在我国分布广泛，研究冻融循环作用下土体的物理力学特性，对冻土地区路基病害防治处理、边坡工程设计等具有重要意义。首先，对现有的研究成果进行整理，总结了影响冻土物理力学性质的主要因素，其次，重点了阐述冻融温度、冻融次数、含水率、围压、 塑性指数等对冻土物理力学性质的影响及其主要结论。最后，初步展望了冻土研究的新趋势。

关键词：冻土

The Discussion on Mechanical Properties of Soil Under Freeze-Thaw Conditions

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Abstract:

Seasonal frozen soil is widely distributed in China, the study of the physical and mechanical properties of soil under freezing and thawing cycles is of great significance to the prevention and treatment of subgrade diseases and the design of slope engineering in Permafrost Regions. Firstly, the existing research results are sorted out, and summarized the main factors affecting the mechanical properties of frozen soil. Secondly, the key elaborated freeze-thaw temperature, freeze-thaw cycles, moisture content, confining pressure and plastic index on the mechanical property of frozen soil and its main conclusions. Finally, the new trend of frozen soil research is prospected.

keywords: frozen soil

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严寒地区风积沙改良土冻融特性研究

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摘　要：我国沙漠面积约占全国总面积的 7.4%，对风积沙及其改良土的性质进行研究对该地区工程建设具有重要意义。本文通过对不同配比风积沙改良土进行冻融循环作用，并对冻融作用后的风积沙改良土进行单轴抗压强度试验和劈裂抗拉强度试验，研究冻融循环作用下不同配比风积沙改良土的强度变化规律。试验结果表明：当冻融循环次数较少时，风积沙改良土以水泥水化反应为主，冻融损伤作用为辅，试样的单轴抗压强度和劈裂抗拉强度不断提高，当水泥水化反应到后期趋于稳定时，冻融损伤作用占据主导位置，试样的单轴抗压强度和劈裂抗拉强度呈现减小趋势；添加水泥和粘土比单独添加水泥更能增大风积沙的强度，但随粘土含量的增加，其强度呈现先增后减的趋势。实验结果可为高寒地区风积沙改良土的工程应用提供试验参考。

关键词：风积沙改良土；冻融循环作用；单轴抗压强度；劈裂抗拉强度

Study on Mechanical Properties of Modified Aeolian Sand Under Freezing and Thawing Cycle

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Abstract:

The study on the freeze-thaw characteristics of aeolian sand modified soil has important engineering significance for the construction and operation of high-grade line projects in cold regions. The freeze-thaw cycle test of different ratio of aeolian sand modified soil was carried out, and the uniaxial compressive strength test and splitting tensile strength test of the aeolian sand modified soil after freeze-thaw cycles were carried out to study the strength variation law of different ratio of aeolian sand modified soil. The test results show that when the times of freeze-thaw cycles are fewer, the cement hydration reaction is the main factor, and the freeze-thaw damage is the auxiliary factor. Thus, the uniaxial compressive strength and splitting tensile strength of the sample are continuously improved. When the hydration reaction of cement tends to be stable in the later stage, the freeze-thaw damage plays a dominant role, and the uniaxial compressive strength and splitting tensile strength of the sample show a decreasing trend. The strength of aeolian sands can be more increased by adding cement and cohesive soil than by adding cement alone. But with the increase of the content of cohesive soil, the strength tends to increase first and then decrease later. The test results can provide experimental reference for the application of aeolian sand modified soil in desert engineering in cold regions.

keywords: Modified aeolian sand;　Freezing and thawing cycle;　Uniaxial compressive strength; Split tensile strength

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基于图像二维和三维信息的路面抗滑性能评价方法的对比

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摘　要：路面良好的抗滑性能是行车安全的重要保障，针对现行路面抗滑性能评价方法存在易干扰、普适性差等问题，以沥青路面抗滑性能准确评价为研究对象，以信息化、智能化为牵引，开展计算机视觉技术在路面抗滑性能评价中的应用研究。结合相关性分析和回归关系拟合，分别从二维纹理和三维形貌的角度对比分析表征指标同抗滑性能间的关系。结果表明，二维纹理从一定程度上弱化了路面粗糙信息的表达，难以取得较好的评价效果；而三维形貌却能更全面、更准确地反映路表粗糙特性，适用于抗滑性能的准确评价。

关键词：公路工程；图像处理；二维纹理；三维形貌；抗滑性能

Comparison of Pavement Anti-Sliding Performance Based on 2D Texture and 3D Morphology Information from Images

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Abstract:

The satisfactory sliding resistance of pavement is an important guarantee for traffic safety. However, the current common evaluation methods of sliding resistance have lots of shortcomings, such as: easily disturbed, poor generality, etc. Hence, regarding accurately evaluating sliding resistance of pavement as research object, the application of computer vision technology in the evaluation of pavement skid resistance is studied based on informatization and intelligentialize. Correlation analysis and regression analysis were used to analyze the relationship between the characteristic indexes and sliding resistance from the perspective of two-dimensional texture and three-dimensional morphology. The results show that two-dimensional texture partly weakens the expression of rough information of pavement and it is difficult to obtain a good evaluation effect. While the three-dimensional morphology can reflect roughness of pavement more comprehensively and accurately, that is suitable for the accurate evaluation of sliding resistance.

keywords: highway engineering; image processing; two-dimensional texture; three-dimensional morphology; anti-sliding performance

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Investigation of Deterioration of Typical Pavement Structure for Trunk Road in South China

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Abstract: Pavement performance prediction model is one of the most important parts in a pavement management system and the basis of decision-making, it has great impacts on the allocation of funding and determination of corresponding measures in a certain period. The automatic pavement condition inspection work has been carried out in a typical province in south China for 9 years, based on the large pavement condition data, this paper describes the research work on the development of prediction model that can be used in the Chinese pavement management system. It has proposed different forms of relationships between Pavement Condition Index (PCI) and pavement age for typical asphalt and concrete structures. A practical collaboration method using the concept of "conversion of time and location" for a specific road section has been proposed and used for the formulation of the model; it is found that a tri-linear model for asphalt pavement and quadratic polynomial model for concrete pavement can be used for the interpretation of the variation of pavement condition index at different ages. The evaluation method of maintenance technologies in terms of short term and long term benefits has been also discussed for typical maintenance measures. It is found that the original cement concrete pavement covered with 5cm and below asphalt overlay is effective for the improvement of short term benefit. The original cement concrete pavement with 8-10cm asphalt overlay can effectively improve the pavement technical performance and reduce the occurrence of reflective cracks, it is considered as the most cost-effective maintenance measure in a short period; For road sections with original surface layer milled and reconstructed with new surface, the pavement condition index changes from excellent to fair condition at the fourth year, which is the best time to implement preventive maintenance.

Key words: maintenance measure; regression analysis; common trunk road; road condition; performance prediction

The Weigh-In-Motion Direct Enforcement Methodology

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Abstract: The paper introduces Weigh-In-Motion (WIM) methodology about bar weighing sensors interleave layout and matching algorithm between ANPR and vehicle weight result to guarantee weight measurement result accuracy and accurate enforcement management. Additionally, the paper has WIM data rest result about different vehicle type, loading, speed and driving behaviour.

Key words: WIM Direct Enforcement, bar sensor layout, matching algorithm, truck vibration on WIM result

高速公路可视化养护管理系统的研究与实现

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摘　要：目前我国的高速公路交通体系日益完善，高速公路路网呈现出多样化、复杂化的特点，这就要求高速公路养护管理工作不但要高效率，更要保证相关信息的准确性。为适应新形势下的高速公路养护管理工作，高速公路养护管理系统的开发意义重大。对高速公路地形图数字化模型所涉及的不规则曲线长度的计算模型和不规则曲线均分坐标计算模型的原理、算法进行分析、研究，在此基础上对路损事件的可视化管理及系统的统计分析性能进行了分析说明。同时也分析了系统的数据持久化及网络架构的比选问题。最后对系统的最大有效数据容量测试及应用服务器平台的测试、选用情况进行了介绍。

关键词：高速公路；养护管理系统；可视化；模型

Research and Realization of Expressway Visual Maintenance Management System

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Abstract:

At present, China's highway traffic system is becoming increasingly perfect, and the highway network presents the characteristics of diversification and complexity, which requires the highway maintenance and management work not only to be efficient, but also to ensure the accuracy of relevant information. In order to adapt to the expressway maintenance and management under the new situation, the development of expressway maintenance and management system is of great significance. The principle and algorithm of the calculation model of irregular curve length and the calculation model of even partial coordinate of irregular curve involved in the digitized model of highway topographic map are analyzed and studied. At the same time, the data persistence and network architecture comparison are analyzed. Finally, the paper introduces the maximum effective data capacity test of the system and the test and selection of the application server platform.

keywords: expressway; management system; visualization; model

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多孔隙沥青混凝土铺面绩效之影响因素

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摘　要：多孔性沥青混凝土(Porous Asphalt Concrete，PAC)具有透水性能、表面粗糙，提供足够摩擦阻力，提升安全性等特性，逐渐为公路主管单位使用。本研究探讨 PAC 铺筑于现地道路之绩效，合计共 23 试验路段，评估铺面绩效包含功能性、耐久性及安全性三大类别，并且将开放级配摩擦层(OGFC)纳入比较，探讨不同最大标称粒径(NMAS)、铺筑厚度、沥青种类，以及传统一般刨除和细纹刨除方式分别比较，并评估交通荷重单轴载重当量数(ESAL)值对铺面绩效的影响。研究显示铺筑厚度与最大标称粒径(NMAS)大小皆影响路面减噪效果，铺筑厚度从 3cm 增加至 5cm，减噪效果越佳，且交通压实后的透水量越能维持，也较能抵抗交通载重形成之车辙量。铺筑完成后的养护时间直接影响 PAC 路面的功能性及耐久性，同样铺筑厚度情况下，充足养护时间路段之透水性和车辙量相似，沥青种类亦对绩效有明显影响，使用高黏度沥青的 PAC 路面功能性和耐久性较佳；从短期绩效数据显示刨除方式对 PAC 绩效之影响不大。考虑成本、施工和长期绩效，建议维修路段铺设 4cm 厚、NMAS 19 mm 之 PAC。
关键词：多孔隙沥青混凝土、铺面绩效、功能性、耐久性

Factors Affecting Pavement Performance of Porous Asphalt Concrete

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Abstract:

Porous asphalt concrete (PAC) is primarily used to improve safety by increasing the frictional properties of the pavement surface during wet weather, and reducing the potential for hydroplaning by allowing surface water to drain through the pavement. This study is to analyze the performance of different PAC sections. A total of 23 test sections were evaluated for their functionality, durability and safety. Open-graded friction course (OGFC) was also included in analyzing the comparative effects of nominal maximum aggregate size (NMAS), thickness, and asphalt type on pavement performance. Test results indicated that PAC thickness and aggregate size affect noise levels. As pavement thickness increased from 3cm to 5cm, a better noise reduction was observed. PAC pavements were shown to be resistant to traffic loading and resulted in low rut depth. Curing time after the completion of the road paving directly affected the functionality and durability of PAC pavements. Adequate curing time led to high permeability values and durable pavement surfaces. Asphalt types significantly influenced pavement performance with high-viscosity binders showing better functionality and durability. It is recommend that porous asphalt mixtures having a maximum aggregate size of 19 mm are placed 4 cm thick for maintaining the long-term performance of PAC pavements.
keywords: porous asphalt concrete, pavement performance, functionality, durability
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Three-Dimensional Asphalt Pavement Crack Detection Based on Fruit Fly Optimization Density Peak Clustering

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Abstract： Asphalt pavement crack detection is very important for pavement condition evaluation and maintenance management. The existing 3d pavement crack detection methods can solve the shortcomings of 2d detection that are easily affected by the environment, but they cannot overcome the defects of complex pavement texture and much noise. There are significant differences in the height values of noise, pavement, crack and sundries in the 3d data of asphalt pavement. In this paper, a 3d asphalt pavement crack detection algorithm based on fruit fly optimization density peak clustering (FOA-DPC) is proposed. Firstly, fruit fly optimization algorithm is adopted to improve the density peak clustering algorithm, which requires manual setting of cutoff distance dc and selection of clustering center. Then, clustering analysis is carried out on the height characteristics and distribution characteristics of 3d data of asphalt pavement, which can accurately detect cracks, and obtain the parameters of the length, width and depth of pavement cracks, providing an accurate basis for pavement distress assessment. The results show that the proposed algorithm can achieve an accuracy of 93.66%.

Key words： road engineering; crack detection; clustering; FOA-DPC; 3d image

基于深度卷积网络的路面裂缝分割方法

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摘　要：路面裂缝作为路面常见病害之一，是公路养护管理工作的重点。将裂缝从路面背景中精确的分割是裂缝检测和修补的基础。传统的裂缝分割方法易受到光照强度和路面噪声的影响，分割效果有待提高。本文提出了一种基于深度卷积网络的路面裂缝分割方法。该方法采用深度卷积网络对路面裂缝进行特征学习和提取，同时结合多尺寸特征图进行裂缝的分割。通过采用深度卷积网络，可以克服多种因素对裂缝分割的干扰。通过过联合多尺寸特征图对裂缝进行分割，可以提高神经网络分割的准确性。本文同时将该方法与阈值分割方法、FCN 进行了对比。结果表明，本文提出的裂缝分割方法明显优于其他方法。

关键词：路面裂缝；深度卷积网络；裂缝分割

An Innovation of Pavement Crack Segmentation Based on Deep Convolutional Network

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Abstract:

Pavement crack as one of the common diseases is the key point of highway maintenance and management. Precise segmentation of crack from the background is the fundament of crack detection and mending. Traditional crack segmentation methods are easily affected by light intensity and pavement noise, and the accuracy of segmentation needs to be improved. An innovation of pavement crack segmentation based on deep convolutional network is put forward in this paper. The deep convolution network is used to learn and extract the characteristics of pavement cracks, and multi-dimensional feature maps are combined for the segmentation of cracks. By using deep convolution network, the interference of many factors to crack segmentation can be settled. The accuracy of neural network segmentation can be improved by combining multi-dimensional feature maps. This method is compared with threshold method and FCN, the results show that the proposed method is superior to other methods.

keywords: pavement crack; deep convolutional network; segmentation

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An Enhanced Driving Safety Analysis Using 3D Technology and Grid-Based Water-Filled Rut Depth Distribution

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Abstract : Rutting causes hydroplaning safety concerns, especially when there is an unbalanced water-filled depth and friction. Although there are many water-filled rutting-safety analysis methods, the accuracy of vehicle safety analysis is hindered by the current maximum rut depth method that is commonly used. With the advancement of 3D technologies, high-resolution 3D pavement surface data has become available. This paper proposes an enhanced driving safety analysis method using 3D technology and grid-based water-filled rut depth and friction coefficient distribution. A case study is conducted by comparing the proposed method and the current maximum depth computation method. Results show that the proposed method will significantly increase the accuracy of safety risk and the proposed method provides more reliable and accurate instantaneous vehicle response, which will be beneficial to future autonomous vehicles for manoeuvring through unbalanced water-filled rutting conditions.

Key words: rut depth; 3D technology; grid-based; driving safety analysis

Distributed Pavement Subgrade Shape Monitoring Based on FBG Sensing Technique

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Abstract: It is often difficult to monitor the subgrade performance of an in service highway structure due to its depth and large in size. Traditional sensors for pavement performance monitoring are usually pointwise sensors and therefore cannot fulfil the requirement for large coverage. This paper introduces a shape measurement sensor based on Fiber Bragg Grating (FBG) sensing technique for pavement structure developed by our research group. It can provide large-scale layer shape measurement using only one FBG sensing element and can bear the high compaction force and high temperature during pavement construction. The proposed sensor has been test in lab to show high accuracy in measurement. In the construction of the He-da highway in Jilin province, the proposed sensor has been applied to monitor the subgrade performance for the first time. Ten sets of the sensors with individual length of about 15 m have been embedded and the performance data have been collected twice. The embedding process and monitoring data will be introduced and discussed. The results have shown the potential of the proposed sensor for future large scale application.

Key words: optical fiber; FBG; pavement structure; shape monitoring

冬季结冰路面摩擦系数预测模型研究

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摘　要：冬季路面结冰是影响道路交通安全的重要因素，而路面的摩擦系数是表征路面安全性能主要指标。本文首先分析了影响冬季结冰路面摩擦性能的主要因素，利用恶劣气象模拟试验箱测试了不同路面温湿度条件下不同路面的摩擦系数，分析了结冰路面摩擦系数与主要影响因素之间的相关关系，并建立了基于路面温度的不同路面摩擦系数预测模型。结论表明，路面温度是影响结冰路面摩擦性能的主要因素，湿度对结冰路面的摩擦性能影响并不明显。

关键词：道路工程；结冰路面；摩擦系数；预测模型

Study on Prediction Model of Friction Coefficient of Icy Road in Winter

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Abstract:

Road icing is an important factor affecting road traffic safety in winter. Friction coefficient of icy road is an important index reflecting road safety performance in winter. First, the main influencing factors of friction coefficient of icy road are analyzed. Using the simulate test box of the bad weather traffic condition to simulate the friction performance test of the road surface, analyze the relationship between the main influencing factors and the friction coefficient of the road surface, the prediction model of the road friction coefficient of the road surface is established. The results indicate that the road temperature is the main factor influencing the friction coefficient of the winter ice road surface, the influence of the relative humidity of the environment on the friction coefficient of the ice road surface is not obvious.

keywords: road engineering; icy road surface; friction coefficient; prediction model

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红外光谱对改性沥青中 SBS 含量的评价方法研究

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摘　要：在改性沥青中，SBS 改性剂掺量的控制是质量控制的重点。本文根据 Lambert-Beer 定律，确定基质沥青、SBS 改性沥青典型的吸收特征峰，采用红外光谱对 SBS 掺量进行定量检测，得到以下研究结论：（1）基于 Lambert-Beer 定律，可以通过 SBS 含量与红外光谱图中 966cm-1 和 1377cm-1 吸收峰面积比建立标准曲线，对 SBS 改性沥青样品中的 SBS 含量进行定量检测；（2）建立三种品牌沥青的 SBS 含量标准曲线，相关系数达可到 0.99；（3）本文建立的标准曲线具有较高的精度，可用于实体工程中的 SBS 含量检测。
关键词：红外光谱；SBS 含量；特征峰

Research on the Evaluation Method of SBS Content in Modified Asphalt by Infrared Spectroscopy

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Abstract:

In modified asphalt, the control of SBS content is the key point of quality control. According to Lambert-Beer law, we confirmed the typical characteristic absorption peak of matrix asphalt and SBS modified asphalt. Infrared spectroscopy is used to detect the content of SBS and we have the conclusion below:(1)According to Lambert-Beer law, we can make quantitative detection of SBS content in SBS modified asphalt by establishing a standard curve by the SBS content and the area ratio of 966cm-1 and 1377cm-1 absorption peak in infrared spectrogram.(2)Three brands of asphalt’s SBS content standard curve were established, the correlation coefficient can reach to 0.99.(3)The standard curves established during the research are highly accuracy thus can be used for detection of SBS content in solid engineering.In modified asphalt, the control of SBS content is the key point of quality control. According to Lambert-Beer law, we confirmed the typical characteristic absorption peak of matrix asphalt and SBS modified asphalt. Infrared spectroscopy is used to detect the content of SBS and we have the conclusion below:(1)According to Lambert-Beer law, we can make quantitative detection of SBS content in SBS modified asphalt by establishing a standard curve by the SBS content and the area ratio of 966cm-1 and 1377cm-1 absorption peak in infrared spectrogram.(2)Three brands of asphalt’ s SBS content standard curve were established, the correlation coefficient can reach to 0.99.(3)The standard curves established during the research are highly accuracy thus can be used for detection of SBS content in solid engineering.
keywords: Infrared Spectroscopy; SBS content; Characteristic Absorption Peak

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低空倾斜摄影在公路建模的应用关键技术研究

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摘　要：本文首先对倾斜摄影应用技术方案进行了简要的研究，并分析了该技术在现场应用的实施效果。通过现场倾斜摄影的实施，形成了倾斜摄影设备选择、数据采集、三维建模、软件分析等关键环节的成套应用技术；并通过数据预处理和模型重建，建立了精度达到 3cm 的 6km 路段的真三维模型；同时实现了距离/尺寸量测、广告牌外观检查、控制区管理、路径漫游和道路属性标识等功能。

关键词：倾斜摄影；数据分析；三维建模；现场实施；应用效果

Research on the Key Technology of Low Altitude Tilt Photography in Road Modeling

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Abstract:

Firstly, the application scheme of tilt photography is briefly studied, and the effect of application of tilt photography is analyzed. Through the implementation of tilt photography on the spot, a set of applied technology in the key links has been formed, such as the selection of tilt photography equipment, data acquisition, three-dimensional modeling, software analysis and so on. Through data pre-processing and modeling reconstruction, a true three-dimensional model of 6 km road section with a precision of 3cm has been established. Meanwhile, the distance/dimension measurement the billboards visual inspection, control area management, path roaming and road attribute identification have been realized.

keywords: tilt photography; data analysis; three-dimensional modeling; field implementation; application effect

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Super-Resolution Reconstruction of Road Crack Image Based on Enhanced Generative Adversarial Networks

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Abstract: Due to cost constraints, road image acquisition at this stage often comes from a variety of motion cameras such as sports cameras or mobile phones. If the image collected by this device is directly subjected to crack detection or road performance analysis, there may be a large error. Aiming at such problems, a super-resolution method for road surface crack image based on Generative Adversarial Networks(ESRGAN) is proposed in this paper. Both the generator and the discriminator are designed as end-to-end self-encoder structures with skip connection in this paper. First, the image is subjected to resolution enlargement and color filling by generating network. Then the image is corrected by discriminating network. Finally, the image is reconstructed into a high definition image. The experimental results show that the model can improve the accuracy of crack detection while maintaining the image quality under the fixed area, and the model has strong robustness. At the same time, it can provide advanced technical support for road maintenance and repair.

Key words: pavement crack image; super-resolution; generative adversarial networks; crack detection

基于一次马尔可夫链的路面使用性能预测

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摘　要：为了从宏观角度把握公路路面技术状况的变化规律，以便公路养护部门及时调整管养策略，作者以辽宁省普通国省干线公路 2015 年至 2017 年路面技术状况检测数据为研究对象，以 1km 公路长度为最小评价单元，以 PQI 为评价指标，借助一次马尔可夫链预测方法，根据《公路技术状况评定标准》将路面使用性能划分为优、良、中、次、差五个等级（即马尔可夫链的状态空间），以 2017 年各等级公路里程（或百分比）作为初始概率，以 2015 年处于某一状态的路段数在 2016 年分别处于各状态的路段数所占的比例作为不同状态之间的一步转移概率并建立矩阵，将构成的一步转移概率矩阵作为当前管养水平下的转移概率矩阵，用此概率矩阵对 2018 年处于不同路面使用性能的公路里程（百分比）进行预测。沿用 2015-2016 年的管养手段，2018 年预测结果与 2017 年相比，得出 PQI 为优的公路里程、PQI 为良的公路里程、PQI 为中的公路里程、PQI 为次的公路里程、PQI 为差的公路里程的变化情况，为辽宁省公路养护部门的养护资金投入提出指引，以提升辽宁省普通国省干线公路整体使用性能。

关键词：交通运输；公路养护措施；马尔可夫链；路面使用性能（PQI）

Pavement Condition Prediction Based on a Markov Chain

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Abstract:

In order to grasp the changing laws of the road surface technical conditions from the macro perspective, the highway maintenance department can timely adjust the adoption strategy. The researchers took the road surface technical status data from the general highways of the province of Liaoning province from 2015 to 2017 as the research object, taking the length of 1 km as the minimum evaluation unit and the PQI (pavement use performance) as the evaluation index, with the help of a Markov chain. method of prediction, According to the “Technical Assessment Standards for Highway Conditions”, the road performance is divided into five levels of excellent, good, medium, inferior, and poor (ie, the state space of the Markov chain), and the mileage (or percentage) of all grades in 2017 is used as the initial Probability, as the proportion of the number of road segments that are in each state in 2016 in the number of road segments that are in a certain state in 2015, as a one-step transition probability between different states. The one-step transition probability between different states constitutes a one-step transition probability matrix. As a one-step transition probability matrix under the current integrated management level, this probability matrix is used to predict the mileage (percentage) of roads in different provinces of highways in general provinces in Liaoning Province in 2018. In use means of custody in 2015-2016, predicted results compared with 2017 in 2018, concluded that PQI for optimal highway mileage, PQI for good highway mileage, PQI for the highway mileage, PQI in highway mileage, PQI for changes of the highway mileage, with poor maintenance funds for liaoning province highway maintenance

department put forward guidance, to enhance the liaoning provincial trunk highway ordinary countries using performance as a whole.
keywords: transportation; highway maintenance measures; markov Chain; PQI

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基于 SVM 决策树的沥青路面裂缝智能分类算法研究

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摘　要：为实现沥青路面裂缝的智能分类，本文针对采集的沥青路面图像，首先进行基于改进的 Mask 匀光算法，使路面图像光照均匀度一致；其次通过小波变换的方法增强图像的高频系数、弱化背景部分，以增强对比度，提取裂缝目标信息；然后通过形态学操作去除背景纹理噪声及裂缝连接；最后采用 SVM 决策树模型实现沥青路面裂缝图像的智能分类。研究表明，改进的匀光算法较好地实现了图像均匀一致，小波变换与形态学操作能够精确地提取裂缝信息，采用的支持向量机方法识别精度满足标准要求的 90%。

关键词：道路工程；数字图像处理技术；图像分割；SVM 决策树；路面检测

Research on Intelligent Classification of Asphalt Pavement Crack Based on SVM Decision Tree

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Abstract:

In order to realize the intelligent classification of asphalt pavement cracks, this paper firstly based on the improved Mask uniformation algorithm to make the uniformity of the road image uniformity. Secondly, the wavelet transform method is used to enhance the high frequency coefficient and weaken the background of the image. Partly, to enhance the contrast, extract the crack target information; then remove the background texture noise and crack connection by morphological operation; finally, the SVM decision tree model is used to realize the intelligent classification of crack image of asphalt pavement. The research shows that the improved homogenization algorithm achieves uniform image uniformity, wavelet transform and morphological operation can accurately extract crack information, and the support vector machine method uses the recognition accuracy to meet the standard requirement of 90%.

keywords: road engineering; digital image processing technology; image segmentation; SVM decision tree; road surface inspection

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基于现场实测数据的高速公路裂缝形态特征及开裂模式研究

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摘 要：为了分析半刚性基层沥青路面横向裂缝开裂模式，依托江苏多条省管高速公路，采用钻芯取样和逐层铣刨分层观测方法，调查了横向裂缝的分层形态特征和贯穿程度，统计了面层和基层裂缝宽度细部特征，明确了横向裂缝主要开裂模式，分析了开裂成因。结果表明，半刚性基层裂缝呈现下面较宽、上面较窄的细部特征，而沥青面层裂缝则为上面较宽、下面较窄；半刚性基层裂缝基本处于完全贯穿状态，沥青面层裂缝处于顶部部分开裂或完全贯穿状态；横向裂缝开裂模式可分为四种，其中上下发展型开裂模式占比约 80%。基层开裂位置对应面层位置均出现开裂，但面层裂缝扩展方向为顶部到底部，而非传统认为的底部到顶部，因此横向裂缝发展初期应及时养护维修，以防裂缝向下扩展。

关键词：道路工程；半刚性基层；沥青路面；横向裂缝；开裂模式

Research on Morphological Characteristics and Cracking Mode of Expressway Crack Based on Field Measured Data

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（Jiangsu Sinoroad Engineering and Technology Co,.Ltd.）

Abstract:

In order to analyze the cracking mode of transverse crack in semi-rigid base asphalt pavement, relying on several provincial highways in Jiangsu Province, the method of drilling core samples was used, and the surface condition after layer-by-layer milling was observed, to investigate the layered morphological characteristics and penetration degree of transverse cracks. The characteristics of the crack width of the surface layer and the base layer were statistically analyzed, the main cracking mode of the transverse crack was clarified, and the cause of the crack was analyzed. The results show that, the underside of the cracks in the semi-rigid base were wider, and the top were narrower, while the underside of the cracks in the asphalt surface were narrower, and the top were wider. The cracks in the semi-rigid base were basically in full penetration, and the cracks in the asphalt surface were partially cracked at the top or fully penetrated. The cracking mode of transverse crack could be divided into four types, wherein the top-down developmental cracking modes account for about 80%. Cracks occur in the surface layer corresponding to the cracking position of the base layer, but the crack propagation direction of the surface layer is from top to down instead of bottom to up. Therefore, the initial development of the transverse crack should be timely maintained and repaired to prevent the crack propagation to bottom.

keywords: road engineering; semi-rigid base; asphalt pavement; transverse crack; cracking mode

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半刚性基层沥青路面横向裂缝演变规律研究

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摘 要：为了研究沥青路面横向裂缝演变规律，依托江苏省管高速公路历年检测数据，选取部分路段进行精细化跟踪观测，考虑了环境和材料等因素的影响，分析了横向裂缝密度随路龄的演变规律，建立了演变模型，进行了预测分析。结果表明，横向裂缝受低温影响较大；与 AK-13 或 PAC-13 相比，上面层材料采用 SMA-13 时裂缝密度较小；横向裂缝宏观演变规律呈现出初步发展、稳步发展、快速发展的三阶段特征，可以使用结构行为方程进行表征；当路面养护及时时，裂缝发展较慢，方程参数 β 值较小。

关键词：道路工程；沥青路面；横向裂缝；演变规律

Study on the Development Law of Transverse Cracks in Asphalt Pavement with Semi-Rigid Base

Zang Guoshuai, Jin Guanglai , Feng Wenwen
（Jiangsu Sinoroad Engineering and Technology Co,.Ltd.）

Abstract:

To study the development law of transverse cracks, the multi-years crack detection data in Jiangsu Provincial Expressway were analyzed, and the crack number and length were long-term observed for a typical section. Considering the influence of factors such as environment and pavement materials, the development law of transverse crack density with road age was analyzed, and the model was established to carry out prediction analysis using the structural behavioral equation. The results show that the generation and expansion of transverse cracks are greatly affected by low temperature. Compared with AK-13 or PAC-13, the crack density is smaller when SMA-13 is used as the surface layer material. The development law of transverse cracks presents three-stage characteristics of initial development, steady development and rapid development, which can be characterized by structural behavior equations. When the pavement is maintained in time, the cracks develop slowly and the equation parameter of β is small.

keywords: road engineering; asphalt pavement; transverse crack; development law

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“白+黑”路面结构弯沉检测方法适用性研究

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摘　要：为了确定“白+黑”路面的不同弯沉测试方法的适用性和区分度，分别采用贝克曼梁和落锤式弯沉仪进行了相关检测，对弯沉数据进行了统计分析；进行了现场取芯，直接观察了结构内部状态，并和基于 ABAQUS 有限元软件的弯沉测试模拟分析结果进行了对比。结果表明：贝克曼梁代表实测弯沉为 FWD 的 3.5 倍左右，并且数据离散性较高；当路面存在脱空时，FWD 理论弯沉从 60μm 增加到 118μm，而贝克曼梁理论弯沉则从 247μm 急剧增加到 622μm；现场取芯结果表明，贝克曼梁弯沉较大位置处路面存在脱空，而 FWD 弯沉则并无异常，这与力学模拟结果一致。沥青层的黏弹性使得 FWD 动态荷载难以有效传递至水泥层以下，而静态贝克曼梁弯沉则具有较高的区分度，因此建议采用贝克曼梁法进行“白+黑”路面结构的弯沉检测。

关键词：道路工程；弯沉；贝克曼梁；落锤式弯沉仪；有限元

Study on Applicability of Deflection Detection Method for AC Layer on PCC Pavement Structure

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Abstract:

In order to determine the applicability and discrimination of different deflection test methods for AC Layer on PCC Pavement Structure, Beckman Beam and Falling Weight Deflectometer were used for correlation detection, and the deflection data were statistically analyzed. The cores were taken to directly observe the internal state of the pavement structure. This field test results were compared with the simulation analysis results of the deflection test based on ABAQUS finite element software. The results show that the measured deflection of Beckman beam is about 3.5 times of FWD, and the data dispersion is higher. When the pavement has void, the FWD theoretical deflection increases from 60 μ m to 118 μ m, while the Beckman beam theoretical deflection increases sharply from 247 μ m to 622 μ m. The results of the field coring showed that the Beckman beam had a large deflection when the pavement had void, while the FWD deflection did not show an abnormality, which is consistent with the mechanical simulation results. The viscoelasticity of the asphalt layer makes it difficult to effectively transfer the FWD dynamic load to the pavement structure below the cement layer, while the static Beckman beam deflection can have a higher degree of discrimination. Therefore, it is recommended to use the Beckman Beam method to detect deflection in the AC Layer on PCC pavement structure.

keywords: road engineering; deflection; Beckman Beam; Falling Weight Deflectometer; finite element

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基于探地雷达和高速弯沉仪的结构内部状态评价方法

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摘 要：为了准确判别高速公路沥青路面结构内部状态，采用探地雷达和高速激光弯沉仪进行联合检测，分别从结构完整性和结构强度方面，提出了结构内部状态评价方法、评价指标和评价标准，并进行了实例分析。在结构完整性方面，探地雷达实测表明，路面存在不密实、层间接触不良、松散等 3 种隐性病害，可采用路面内部破损状况指数 IPCI 进行评价；在结构强度方面，高速激光弯沉仪检测结果可线性转化为贝克曼梁值，采用路面结构强度指数 PSSI 进行评价。基于 IPCI 和 PSSI 可将路面内部状态分为 4 类：I 级、II 级、III 级、IV 级。研究成果可为路面养护提供决策支持。

关键词：道路工程；探地雷达；高速激光弯沉仪；结构内部状态

Pavement Inner Condition Evaluation Method Based on Ground Penetrating Radar and High Speed Deflectometer

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Abstract:

In order to accurately evaluate the inner pavement condition of the highway asphalt pavement, the ground penetrating radar and high-speed laser deflectometer were used for joint detection. The structural inner condition evaluation method, evaluation index and evaluation criteria were proposed from the aspects of structural integrity and structural strength. The corresponding case studies were performed. In terms of structural integrity, the ground penetrating radar shows that there are three kinds of hidden diseases such as insufficient compaction, poor interlayer contact, and looseness, which can be evaluated by the inner pavement condition index (IPCI). In terms of structural strength, the high-speed laser deflection test results can be linearly converted into Beckman beam values, and the pavement structure strength index(PSSI) can be used for evaluation. Based on IPCI and PSSI, the internal state of the road can be divided into four categories: I, II, III, and IV. Research results can provide decision support for pavement maintenance.

keywords: road engineering; ground penetrating radar; high speed deflectometer; pavement inner condition

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沥青路面裂缝病害的自动识别及增强算法

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摘 要：本文以PaveVision3D（简称Pave3D)多功能路面检测系统所采集的高精度三维路面图像为研究对象，探索高效、高准确率的沥青路面裂缝自动识别及增强算法。首先，结合激光路面三维成像的噪声特点，提出孤点状噪声消除方法，并对图像进行整体校正；其次，利用可调式滤波器组提取路面三维图像中潜在的裂缝区域；再次，为提高路面裂缝空间线性结构的显著性，设计了由球投票和棒投票组成的路面裂缝增强算法；最后，基于数字图像形态学原理，剔除裂缝误判信息，获得最终的识别结果。研究结果表面：提出的算法能够对不同采集条件、形态特征、和几何尺寸的沥青路面裂缝目标进行有效识别，并且具有较高的检测精度及较强的通用性。研究成果为推进沥青路面裂缝的全自动化检测提供实际参考价值。

关键词：沥青路面；可调式滤波器组；裂缝图像增强；张量投票

Asphalt Pavement Crack Detection and Its Enhancement Using 3D Pavement Images

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Abstract:

This paper describes a study to develop effective and accuracy procedures of automated crack detection and enhancement based on 3D asphalt pavement images generated by PaveVision3D (Pave3D for short) system. First, with respect to noises introduced in the 3D scanning systems, a pre-processing procedure is employed to remove spurious noise and rectify the original 3D pavement data. Second, crack saliency maps are segmented from 3D pavement data using steerable matched filter bank. Third, 2D tensor voting is applied to crack saliency maps in order to achieve better curve continuity of crack structure and higher accuracy. Finally, post-processing procedures are used to remove redundant noises or false-positives in processing. The proposed procedures are evaluated over asphalt pavement images with diverse cracks and different collection conditions. The experimental results demonstrates that the proposed method shows a high performance and generalization. Accordingly, the proposed approach can be helpful in automated pavement condition assessment.

keywords: asphalt pavement; steerable matched filter bank; crack maps enhancement; tensor voting

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Network Level Pavement Maintenance Decision-Making Optimization Based on Analytic Hierarchy Process and Integer Programming

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Abstract: The network level pavement maintenance decision-making is a multi-factor and multi-objective problem, it is usually determined based on limited factors and subjective judgment. This paper proposes an optimization model based on the ranking results of road sections and dynamic programming for network level highway pavement maintenance decision-making. Based on the Analytic Hierarchical Process(AHP)theory, this study developed a multi-index model capable of incorporating potential pavement maintenance related factors, considering their relative significance and generating an overall ranking for each road section. A total of five pavement maintenance related indices were considered in the study, including pavement overall quality, pavement structural capacity, pavement age,traffic level and road grade. The optimizations to maximize the overall ratio of benefit over cost in the analysis period through the method of dynamic programming and the method of integer programming. The computing work could be greatly reduced based on the ranking results of road sections in need of maintenance. A case study on the network level highway maintenance decision-making optimization in Jiangsu Province was conducted to illustrate the proposed procedure. The case study clearly demonstrated the applicability and rationality of the optimization model based on the comprehensive ranking of road sections. The results can be used as a guideline for highway agencies in their network level pavement maintenance decision-making process.

Key words: highway, asphalt pavement, network level, maintenance decision-making, analytic hierarchical process, integer programming

基于图像增强算法的混凝土红外缺陷检测研究

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摘 要：针对传统红外检测方法分辨率低、缺陷特征不明显的缺点，将图像增强算法与混凝土红外检测技术相结合，变相提升缺陷处表面温度对于热激励的灵敏程度，以达到缩短检测时间、提升分辨率的目的。本文采用室内试验与增强图像分析的方法对比有无图像增强技术下红外检测技术的分辨率，定量分析红基于图像增强技术的混凝土红外检测方法的分辨率和适用范围。

关键词：混凝土；红外检测；增强图像

Infrared Defect Detection of Concrete Based on Image Enhancement Algorithm

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Abstract:

In view of the shortcomings of the traditional infrared detection method with low resolution and unsharp defect features, the image enhancement technology is combined with the concrete infrared detection technology to improve the sensitivity of the surface temperature at the defect place to heat excitation in purpose of shortening the detection time and improve resolution. In this paper, indoor test and enhanced image analysis were used to compare the resolution of infrared detection with or without image enhancement technology, and quantitative analysis was made on the resolution and application range.

keywords: concrete; infrared detection; enhance image

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大流量高速公路沥青路面中长期养护规划策略的思考

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摘 要：“十三五”期间，江苏省存在相当比例的高速公路沥青路面达到设计寿命的现象，有必要开展中长期养护规划。本文以沪宁高速公路的中长期养护规划为例，在传统养护规划思路的基础上，开展了大流量高速公路中长期养护规划思路的探讨，重点分析并阐述了路面使用性能现状评估方法、路段划分方法和剩余服务年限预估方法等方面。

关键词：高速公路；设计寿命；性能评价；剩余服务年限；养护规划

Thoughts on Medium and Long-Term Maintenance Planning Strategy for Asphalt Pavement of Highway with Heavy Traffic

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Abstract:

During the “Thirteenth Five-Year Plan” period, a considerable proportion of highway asphalt pavements in Jiangsu Province have reached the design life, and it is necessary to carry out medium and long-term maintenance planning. Taking the medium and long-term maintenance planning of Shanghai-Nanjing Expressway as an example, this paper discusses the medium- and long-term maintenance planning ideas of expressways with heavy traffic on the basis of traditional maintenance planning ideas, focusing on the analysis and elaboration of pavement performance evaluation methods, section division methods and residual service life prediction methods.

keywords: expressway; design life; performance evaluation; remaining service life; maintenance planning

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预防性养护导向的路面性能评价及其简化决策方法

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摘 要：本文详细地检查了我国现行《公路技术状况评定标准》路面性能如抗滑能力、行驶质量和结构强度的评价方法和指标，并根据山西路面预防性养护的实际需求，提出了相应的改善方法和指标。在山西大量路面测试数据和国内外成功经验的基础上，本文进一步给出了路面性能的定量评价标准，并在路面预防性养护决策导向下，提出了基于累计频率分布的图示简化方法。

关键词：路面性能评价；横向力系数；平整度；弯沉；预防性养护；累计频率分布

Preventive Maintenance-Oriented Pavement Performance Evaluation and Simplified Decision Method

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Abstract:

This paper reviews the pavement performance assessment methods, including skid resisatnce, ride quality, and structural strength in the current “Highway Performance Assessment Standards,” and provides modified parameters accordingly with respect to the realistic needs for pavement preventive maintenance in Shanxi. Based on the best practices of field pavement testing in Shanxi and successful experiences worldwide, this paper establishes measurable criteria for assessing pavement performance. After examining the field test data, this paper provides a simplified method for preventive maintenance decision in terms of the cumulative frequency distribution.

keywords: pavement assessment; side force coefficient; roughness; deflection; preventive maintenance; cumulative frequency distribution

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静矩标准差和数字图像技术评价沥青路面摊铺均匀性的方法

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摘 要：为了在沥青路面摊铺阶段对混合料均匀性进行实时评价，实时反馈、指导施工，减少离析现象，论文运用数字图像处理技术，通过对摊铺沥青混合料图像进行灰度化、滤波、图像二值化等图像预处理，并通过图像集料颗粒面积比验证预处理准确性；论文以图像中9.5mm以上颗粒静矩标准差评价摊铺沥青混合料数字图像均匀性，通过计算施工现场采集的1085 张摊铺沥青混合料图像静矩标准差进行试验验证并提出数字图像摊铺沥青混合料均匀性评价指标。结果表明本文数字图像处理技术预处理得到的图像中颗粒面积比值与按实际混合料配合比计算的面积比基本相符；通过 min-max 标准化后静矩标准差的值与对应图像进行对比分析，提出了均匀性评价指标，为摊铺沥青混合料离析检测提供一种新方法。

关键词：沥青混合料均匀性。

A Evoluation Method on the Distribution Uniformity of the Paving Asphalt Mixture Based on the Digital Image Processing Technology and Static Moment Theory

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Abstract:

The accurate and timely monitoring of asphalt mixture paving process is critical for reducing segregation and effective construction. In this study, 1085 construction site images were pre-processed by digital image processing techniques (i.e., grayscale, filtration, binarization) to investigate a real-time evaluation method of paving asphalt mixture un during construction process. The sum and standard deviation of the static moment of each particle larger than 9.5 mm was calculated and the min-max normalized standard deviation were utilized to evaluate the paving asphalt mixture distribution uniformity. The result shows that 1) The mix proportion value from the proposed image technique was close to the value from the reality; 2) By comparing the value of min-max normalized static moment standard deviation with the corresponding image, an uniformity indicator has been proposed for evaluation of asphalt pavement uniformity during paving process. The paper provides a new method for paving asphalt mixture segregation detection.

keywords: asphalt mixture distribution uniformity

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基于车道横断面基准线确定的沥青路面车辙多维度评价指标提取研究

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江苏京沪高速公路有限公司 江苏中路工程技术研究院有限公司）

摘 要：为了进行沥青路面车辙状况的精细化评价，解决传统车辙评价仅采用单一车辙深度指标，难以准确反映路面结构的状态，更无法为后期的养护维修方案提供准确依据的问题，进行车辙断面特征精细化评价指标及其提取方法的研究。研究首先确立了进行车辙断面特征精细化评价的多维度评价指标，其次通过对红外线激光车辙检测横断面变形提取机理进行深入分析，在建立基于单车道横断面图形基准线方法确定的基础上，实现了车辙多维度评价指标的提取。研究表明：1)基于研究中提出的确定基准点，连接基准点获得基准线的方法，提出了基于单车道横断面图形的基准线确定方法，通过在高速公路试验段上进行检验证实了方法的可行性；2）对江苏省高速公路的车辙横断面形态进行了汇总分析，总体上归纳为 8 种典型，其中整体压密型的车辙占比最大；3)采用研究中提出的车辙多维度评价指标，精细化的判定高速试验段车辙属于压密性车辙，路面结构仍处于不断压密阶段。

关键词：车辙；多维度评价指标；提取方法；基准线

Study on Extraction of Multi-Dimensional Evaluation Index of Rut Based on the Baseline Determination for Lane Transect

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Abstract:

In order to conduct a refined evaluation of the condition of asphalt pavement ruts, it is difficult to accurately reflect the state of the pavement structure, and it is impossible to provide an accurate basis for the later maintenance and repair plans. Research on refined evaluation index of rut section characteristics. The study first establishes the multi-dimensional evaluation index for the fine evaluation of the characteristics of the rut section, and then analyzes the deformation extraction mechanism of the cross section by infrared laser rut detection. On the basis of the determination of the benchmark line method based on the single-lane cross section, The multi-dimension evaluation index of rut is extracted. The research shows that: 1) Based on the method of determining the reference point and connecting the reference point to obtain the reference line, a reference line determination method based on the single-lane cross-section pattern is proposed, and the feasibility of the method is confirmed by testing on the expressway test section; 2) The cross section of the highway in Jiangsu Province was summarized and analyzed, and it was generally summarized into 8 types of typical models, of which the overall rut proportion of the compact type was the largest; 3) Using the multi-dimensional evaluation index of rut proposed in the study, the refined determination of the high-speed test section rut belongs to the compaction rut, and the road structure

is still in the continuous compaction stage.

keywords: rutting; multidimensional evaluation indicators; extraction methods; baseline

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三维激光在路面宏观纹理检测中的精准性分析

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摘 要：路面宏观纹理作为影响路面抗滑性的主要因素，主要采用铺砂法与激光法进行检测，其中铺砂法受测量人员主观影响大，而国内外基于激光手段检测宏观纹理的研究均未与真实剖面对比来验证真实性，仅仅确定了指标的相关性，忽略了激光检测本身对于路面宏观纹理的影响。所以，本文采用 3D 打印技术制作纵向剖面一致，波长为 0.5mm-50mm 之间不同区段的波形试件，通过横向精度分别为 0.55mm 与 0.15mm 的激光检测设备对试件进行检测，依据点云数据进行三维重构与剖面提取，并与试件设计剖面进行对比分析和相关性指标计算。可以得出，0.55mm 横向精度的激光设备对于 5mm 之上的波长区段检测结果相关性均大于 0.5524，具有较好的相关性，且对于 15mm 之上的区段，检测结果具有强相关性，但高程检测误差较大，且无论误差大小与方向均无规律可循。0.15mm 横向精度的激光设备却拥有更差的检测结果，这说明了激光本身的振动对与宏观纹理的测量不可忽视，而国内外的研究均未对这一误差进行针对性的消除与研究。因此，本文的研究结果可以为未来激光手段检测路面宏观纹理甚至微观纹理的研究与应用提供基础，从而可以更加真实全面地评价路面宏观纹理与抗滑性能。

关键词：三维激光；构造深度；宏观纹理

Precision and Accuracy Analysis of 3D Laser in Macro Texture Detection of Pavement

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Abstract:

As the main factor affecting the slip resistance of pavement, the macro texture of pavement is mainly detected by sanding method and laser method. The sanding method is subjectively influenced by the surveyors. And the domestic and foreign research on macroscopic texture based on laser detection has not been compared with the real profile to verify the authenticity. Only the correlation of the index is determined, and the influence of the laser itself on the macro texture of the pavement is neglected. Therefore, this paper uses 3D printing technology to produce specimen with consistent longitudinal profiles and different wavelengths between 0.5mm and 50mm. The specimens are tested by laser detection equipment with longitudinal precision of 0.55mm and 0.15mm respectively. Based on the cloud data, 3D reconstruction and profile extraction can be proceeded. Then the correlation index can calculate with test piece design profile for the correlation analysis. It can be concluded that the laser device with 0.55mm lateral accuracy has a correlation of more than 0.5524 for the detection of the wavelength segment above 5mm. For the segments above 15mmm, the detection result has strong correlation, but the elevation detection error is large, and the error magnitude and direction are irregular. The laser equipment with 0.15mm longitudinal precision has worse test results. These show that the vibration of the laser itself and can not be ignored for the measurement of the macro texture, but the domestic and foreign research has not

specifically studied and eliminated this error. Therefore, this study can provide a basis for the application of laser detection of pavement macro-texture and even micro-texture in the future research. So that the road surface macro texture and anti-sliding performance can be evaluated more realistically and comprehensively.

keywords: 3D laser; macro texture; texture depth

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基于 U-net 神经网络模型的路面裂缝自动识别

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摘 要：路面裂缝检测是道路养护部门的一项重要工作，然而传统的裂缝检测方法耗时且准确度低。因此，本文提出一种基于 U-net 的迁移模型，通过对模型架构调整，参数微调以让 U-net 神经网络模型实现对路面裂缝精准地自动识别。研究以 DHDV 采集的路面裂缝 2D 激光图像为数据集，首先对激光图像进行裂缝人工标注，并在此基础上通过数据增强进行标注样本扩充，从而构建模型训练原始样本库；在实验及分析阶段，使用不同的学习率和网络深度反复对 U-net 进行训练；最后通过 PR curve 进行模型的稳定性，识别准确度评估。研究结果表明，该分割算法具有较高的准确率 P(90.83%)、召回率 R(89.97%)和 F 值(89.56%)。各项指标均优于 Canny 边缘检测与传统的 Otsu 阈值分割算法。

关键词：U-net；神经网络；DHDV；2D 激光图像；路面裂缝；自动识别

Automatic Identification of Pavement Crack Based on U-Net Neural Network Model

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Abstract:

Traditional crack detection methods are time consuming and have a low accuracy. In this study, transfer learning based U-net model is proposed for automated pavement crack identification by refined architectures and fine-tuning parameters of U-net model. The 2D laser image of the pavement crack collected by DHDV is chosen as the dataset and augmented by pre-processing technique. Subsequently this model is repetitively trained at various learning rate and network depth. Finally, robustness of the model and segmentation accuracy has been evaluated after trained. The results present that the segmentation algorithm has high Precision(90.83%),Recall rate(89.97%) and F-measure Score(89.56%).All the numbers demonstrated that the model has better performance than Otsu segmentation algorithm and Canny edge detection.

keywords: U-net; Neural Network; DHDV; 2D laser image; Pavement Crack; Automatic Identification

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道路沉陷、松散类病害的探地雷达图像解译与分析

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摘 要: 探地雷达是道路检测的重要方法之一，对道路深层病害的识别具有较大的技术优势。为明确道路病害类型和实际范围，本文基于探地雷达剖面检测图，通过复合材料介电模型计算道路病害区域介电常数波动值，提出了一种针对道路沉陷、松散类病害区域的图像模拟方法，分析了道路病害区域介电特性的波动规律，明确了道路沉陷、松散类病害的模拟图像特征与范围。该方法具有一定的工程价值，可以为探地雷达无损检测技术在道路病害智能识别及图像处理方面提供依据。

关键词： 探地雷达；图像模拟

Interpretation and Analysis of Ground Penetrating Radar Images of Road Subsidence and Loose Diseases

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Abstract:

Ground penetrating radar is one of the important methods in road detection area, and has a great technical advantage for the identification of deep road diseases. In order to clarify the type and actual range of road disease, this paper proposes an image simulation method for road subsidence and loose disease areas based on the composite dielectric model to calculate the dielectric constant fluctuation value of road disease area. The fluctuation law of dielectric properties of road disease areas was analyzed, and the characteristics and range of simulated images of road subsidence and loose diseases were clarified. The method has certain engineering value and can provide basis for intelligent detection and image processing of road disease for non-destructive testing technology of ground penetrating radar.

keywords: ground penetrating radar; image simulation

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基于行车安全的车辙养护阈值现状研究

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摘 要：车辙是沥青路面典型病害之一，它的存在降低了行车舒适性和安全性在内的行车性能。车辙养护安全评价及养护阈值评定标准对车辙养护时机判定及养护资金的分配有重要作用。目前基于行车安全的车辙研究仅考虑一维深度，难以从全面的三维视角对车辙横、纵向特征影响进行深入探讨，无法建立真实车辙多维度形貌特征的行车安全理论体系，进而无法满足管理机构考虑行车安全的车辙评价与养护需求。随着高效能、高密度和高精度的先进的三维激光技术引入，突破高解析率车辙三维形貌特征有效提取和构建的瓶颈成为可能。本文从车辙养护评价标准及多维度车辙评价指标、车辙安全评价及养护阈值方法两个方面进行了详细的综述，并提出未来研究建议。未来研究不仅将构建考虑道路横纵坡的高解析率的车辙多维度形貌，同时也将全面高精度地建立针对行车安全的多维度车辙评价方法与养护标准，可对国内外现行车辙养护规范进行完善和修正。

关键词：车辙养护；多维度车辙指标；安全评价；养护阈值；未来研究需求

Research on the Current Status of Rutting Maintenance Threshold Based on Driving Safety

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Abstract:

Abstract: Rutting, one of the distresses in asphalt pavement, is known to be a potential hazard to driving comfort and safety when considering driving performance. The safety evaluation and maintenance threshold of rutting have an important role in determining the timing of rutting and the allocation of maintenance funds. At present, the research on rutting based on driving safety only considers the one-dimensional depth. It is difficult to carry out in-depth discussion on the influence of traverse and longitudinal features from the three-dimensional perspective, thus cannot establish a driving safety theory system based on real vehicular multi-dimensional morphological features. With the introduction of high-efficiency, high-density and high-precision advanced 3D laser technology, it is possible to break through the bottleneck of effective extraction and construction of high-resolution rutting three-dimensional features. This paper gives a detailed overview of the rut maintenance evaluation criteria and multi-dimensional rut indicators, rut safety evaluation and maintenance threshold methods, and proposes future research recommendations. Future research will not only construct the multi-dimensional shape of the rut with high resolution of the horizontal and vertical slopes of the road, but also establish a multi-dimensional rut evaluation method and maintenance standard for driving safety with comprehensive high precision, which can be used for the maintenance of ruts at home and abroad. The specification is refined and revised.

keywords: literature review; rutting maintenance; multi-rutting index; safety evaluation; maintenance threshold; research needs

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Evaluation of Asphalt Pavement Internal Distress Using Three-Dimensional Ground Penetrating Radar

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Abstract: The coupling effect of traffic loads and environmental factors causes damage to the different structural layers within the asphalt pavement, such as transverse cracks, longitudinal cracks and loose materials. These internal distresses will gradually extend to the road surface, thereby accelerating the deterioration of the asphalt pavement structural performance. Three-dimensional ground penetrating radar (3-D GPR) has 21 pairs of antenna channels, capable of detecting the structural condition of asphalt pavement nondestructively, quickly and efficiently. The multi-dimensional radar images (longitudinal, horizontal and cross sections) allow to visualize the internal distresses of the pavement structure. In this paper, 3-D GPR was used to investigate asphalt pavement internal distresses in Guangzhou South China Expressway. The distresses at the asphalt course-base interface, base-subbase interface and subbase-subgrade interface were evaluated and statistically analyzed. Three-dimensional distress ratio (DR3d) and pavement internal condition index (PICI3d) were proposed to assess the internal distress condition of asphalt pavement. The results reveal that DR3d can better reflect the distress condition of the whole pavement structure when compared with the traditional two-dimensional distress ratio (DR2d).

Key words: asphalt pavement; three-dimensional ground penetrating radar; pavement internal distress condition; three-dimensional distress ratio; pavement internal condition index

地聚合物注浆加固技术在公路唧浆病害处治中的应用

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摘 要：本文通过在国家高速 G30 连霍高速公路永山段应用地聚合物注浆加固技术处治公路唧浆病害的工程实践，探索应用有效的公路唧浆、唧泥病害处治工艺、方法，为公路唧浆唧泥病害处治工作提供参考。

关键词：公路唧浆；新材料；新工艺；探索应用

Application of Geopolymer Grouting Reinforcement Technology in Treatment of Highway Grouting Diseases

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Abstract:

Through the engineering practice of applying geopolymer grouting reinforcement technology in Yongshan section of G30 Lianhuo Expressway to treat highway slurry diseases, this paper explores the effective treatment technology and method of highway slurry and slurry diseases, and provides a reference for the treatment of highway slurry and slurry diseases.

keywords: highway pulping; new materials; new technology; exploration and Application

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绿色养护-水性环氧乳化沥青制备及性能分析

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摘 要：为了满足沥青路面养护修补的需要，采用水性环氧乳液(WE)对乳化沥青的性能进行改性。采用环氧树脂加成反应制备了环氧树脂乳化剂，采用相反法控制并对环氧树脂进行了乳化。采用环氧-多胺类非离子型固化剂对 WE 乳液进行固化，分析了不同温度下 WE 乳液的固化速度。最后将 WE 乳液加入到乳化沥青中，分析了 WE 掺量对乳化沥青性质的影响，并采用荧光显微技术和红外光谱分析了 WE 乳液对乳化沥青的改性机理。

关键词：道路工程；水性环氧；乳化沥青；制备；性能

Preparation and Performance Analysis of Waterborne Epoxy Emulsified Asphalt

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Abstract:

In order to meet the needs of maintenance and repair of asphalt pavement, waterborne epoxy(WE) emulsion was used to modify the performance of emulsified asphalt. Epoxy resin emulsifier was prepared by epoxy resin addition reaction. The epoxy resin was emulsified by the opposite method. Epoxy polyamine nonionic curing agent was used to cure WE emulsion. The curing rate of WE emulsion at different temperatures was analyzed. Finally, the WE emulsion was added to the emulsified asphalt, and the effect of WE emulsion on the properties of emulsified asphalt was analyzed. The modification mechanism of WE emulsion on emulsified asphalt was analyzed by fluorescence microscopy and infrared spectroscopy.

keywords: road engineering; waterborne epoxy; emulsified asphalt; preparation; performance

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不同蒸汽养护恒温温度下预制混凝土箱梁强度、抗裂性能与微观孔结构研究

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摘 要：为研究适用于工程的蒸汽养护恒温温度，本文通过试验箱梁模型，探究了不同蒸汽养护温度下混凝土强度、抗裂性能及微观孔结构差异，得到了适用于工程的蒸汽养护恒温温度。试验结果表明：蒸汽养护恒温温度在 60℃～65℃范围内时，养护结束后混凝土后期强度会出现较大损失，在此养护温度下，混凝土自身抵抗开裂的能力会降低。蒸汽养护恒温温度在 45℃～50℃范围内时，混凝土强度发展较快，养护过程中不产生裂缝，混凝土气孔间距较小，小孔占比较多，相比其他养护下的混凝土更加密实。最终得到适用于工程的蒸汽养护恒温温度为 45℃～50℃。

关键词：预制箱梁；不同养护方式；混凝土强度；抗裂性能；微观孔结构

Study on Strength, Crack Resistance and Micro-Pore Structure of Precast Concrete Box Girder Under Different Steam Curing Temperature

Kang Jian
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Abstract:

In order to study the constant temperature of steam curing suitable for engineering, this paper explores the difference of concrete strength, crack resistance and microscopic pore structure under different steam curing temperatures through the test box girder model, and obtains the steam curing constant temperature suitable for engineering. The test results show that when the steam curing temperature is in the range of 60 ℃～65 ℃, the strength of the concrete will be greatly lost after the curing, and the concrete's ability to resist cracking will be reduced at this curing temperature. When the steam curing temperature is in the range of 45 ℃～50 ℃, the concrete strength develops fast, no cracks occur during the curing process, the concrete pore spacing is small, the small holes account for more, and the concrete is more compact than other concrete. Finally, the steam curing temperature suitable for the project is 45 ℃～50 ℃.

keywords: prefabricated box girder; different curing methods; concrete strength; crack resistance; microscopic pore structure

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绿色养护——新拌水泥乳化沥青胶浆的黏度预测

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摘 要：水泥乳化沥青砂浆作为灌浆被广泛应用于道路与铁道工程中，评估其流变性能是其应用成功的关键。不同沥青与水泥质量比的新拌水泥乳化沥青胶浆（CA 胶浆）具有显著不同的组成，设计其流动性和流变性能并不容易。为此，本文提出了对不同沥青与水泥质量比的 CA 胶浆最小表观黏度的黏度预测模型。在该模型中，模型参数包括最大粒子填充率(ϕm)和调整系数 b。为获得最大粒子填充率，本文提出了水泥沥青复合粒子堆积模型。在该模型中 CA 胶浆的粒子最大填充率由沥青所占水泥-沥青体系的体积分数，沥青颗粒在乳化沥青中的粒子最大填充率，及水泥颗粒在水泥胶浆中的粒子最大填充率决定。同时，确定了阳离子型 CA 胶浆和阴离子型 CA 胶浆黏度预测时所用不同的调整系数 b。该模型能对 CA 胶浆黏度进行简单且可靠的预测。

关键词：CA 胶浆；流变；黏度；粒子最大填充率

Viscosity Prediction of Fresh Cement Asphalt Emulsion Pastes

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Abstract:

Grouting cement asphalt emulsion (hereinafter abbreviated as CA) mortar has been widely used in highway and railway engineering. Assessing their rheological behavior is crucial for the success of a particular application. Fresh CA pastes with different asphalt emulsion to cement mass ratios (AE/C) have significantly different compositions, and design of their rheological properties is not an easy task. The minimum apparent viscosity of CA pastes with different AE/C is predicted by a viscosity prediction model. The model parameters include maximum particle packing density (ϕm) and an adjusting factor b. A predictive model of CA composite particles is proposed, in which the maximum particle packing density of CA pastes can be determined by the maximum particle packing density of cement paste, the maximum particle packing density of asphalt emulsion, and the volume fraction of asphalt in asphalt-cement system. The predictive model requires different adjusting factor b for CA pastes with anionic and cationic asphalt emulsion when the predicted ϕm is used for viscosity prediction. The proposed viscosity prediction equations do offer a simple and reliable method for the viscosity prediction of CA pastes with a wide AE/C range, and can be used to design the rheological properties of CA pastes.

keywords: CA paste; rheology; viscosity; maximum particle packing density

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Green Preservation-Carbon Nanotube Application in Smart Cementitious Materials

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Abstract : Cementitious materials have been commonly utilized as one of the main construction materials for concrete and asphalt in heavy highway, bridge, and building constructions. Concentrated loads could cause concrete or asphalt cracking and delamination, which could be hard to detect and has had long-term impacts on the structure performance. Current methods for detecting distresses in cementitious materials mainly depended on occasional visual inspections and non-destructive detection techniques such as acoustic, ultrasonic, X-ray, and eddy current inspection, which are not in real time and demand significant labors. Therefore, smart cementitious materials with ability to monitor its own health conditions passively become very attractive worldwide. Carbon Nanotubes (CNTs), with a very small fraction, has piezo-resistive effects which has been investigated as a promising solution to enable smart materials to be applied in civil engineering fields to measure strain and stress changes on structures. CNTs could be dispersed in cementitious materials through direct mixing method although it would not effectively disperse the CNTs particles into the cement mortars. The lack of CNTs dispersion effectiveness results in the development of CNTs dispersion methods such as acid surface treatment and surfactant Sodium Dodecylbenzen Sulfonate (NaDDBS) surface modification. Since strong acid poses a danger in the field, NaDDBS surface modification has been a popular dispersion method for carbon nanotube dispersion in smart cementitious materials. However, the NaDDBS surface modification method has a very strict procedure requirement which varies its effectiveness. In this talk, a novel co-polymer dispersion method is introduced to effectively disperse carbon nanotube in smart cementitious materials. Laboratory experiments showed that the developed new method can significantly improve the sensing capability, stability, and consistence for CNTs enabled smart cementitious materials.

Key words: carbon nanotube; smart cementitious materials

Green Maintenance-Facile and One-Step Preparation Carbon Quantum Dots from Biomass Residue and Their Applications as Efficient Surfactants

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Abstract: Using biomass residue as a source of carbon precursors, a pyrolysis method was used to prepare biomass-derived luminescent Carbon Quantum Dots (CQDs). The prepared CQDs exhibited excellent fluorescence and luminescence properties and fluorescence behaviors of CQDs acquired at different pyrolysistemperatures varied. Importantly, the CQDsshowed superior surface activity and the styrene-in-water Pickeringemulsion prepared using the CQDs as nano-sized surfactant was highly stable: the higher the pyrolysis temperature the better the stability of the emulsion. In addition, there was no stratification found in the emulsion which was stabilized by the CQD500（CQDs prepared at 500℃）after holding for 72 hours. This research provided an approach for preparing the surfactants of nano-sized particles in large scale. The CQDs prepared using the proposed method are expected to have a high number of potential applications.

Key words: carbon quantum dots; biomass; nano-sized surfactant; pickeringemulsion; stability

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绿色养护——与沥青胶浆性能相关的矿粉颗粒表征参数

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摘 要：由于现行规范对沥青混合料用矿粉的技术规定有所不足，所采用的常规指标无法细致地反映矿粉作为填料的路用优劣程度，从而弱化了矿粉指标的控制意义。为寻找路用关联度更佳的矿粉控制指标，本文利用激光粒度分析仪获取了五种矿粉的颗粒组成数据，析出不同的颗粒表征参数，评价了它们对沥青胶浆性能的影响程度。结果表明，矿粉颗粒频率分布符合 RRS 关系模型，全面的颗粒表征应包括粒度大小和粒度分布均匀性参数指标，如中位粒度、特征粒度以及离散度；在相同基质沥青和粉胶比条件下，矿粉粒度越小，沥青胶浆低温性能越好，反之粒度增大会提高胶浆高温性能指标，但低温性能指标衰减明显。同时，不同粒度分布的矿粉具有不同粉胶比范围，最大粉胶比受矿粉颗粒分布影响显著；基于同一基质沥青配置胶浆时，使用的矿粉颗粒粒径分布越宽、颗粒离散度越大，沥青胶浆的最大粉胶比应适当降低。推荐在矿粉评价时，积极采用中位粒度、特征粒度和离散度参数作为技术指标，以方便未来矿粉产品的标准化建设。

关键词：矿粉；沥青胶浆；颗粒表征；粒度分布；不可恢复柔量；粉胶比

Green Maintenance-Characterization Parameters of Mineral Powder Particles Related to Asphalt Mortar Properties

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Abstract:

Because of some technical requirement lack of the mineral powder used for the asphalt mixture in current specification, the conventional index cannot reflect the quality of the mineral powder as a filler accurately, thus the controlling significance of mineral powder is weakened. In order to find a better control index of mineral powder with better correlation degree, five kinds of mineral powder were tested by laser particle analyzer, and different particle characterization parameters were obtained to evaluate their influence on the asphalt mortar performance. The results show that the frequency distribution of powder particles is consistent with the RRS model, a comprehensive characterization of particles should include particle size and particle size distribution parameters, such as medium size, characteristic size and dispersion index. Under the same base asphalt and filler-binder ratio, the smaller the particle size of the ore powder, the better the low temperature performance of asphalt mortar. Conversely, the increase of particle size will enhance the high temperature performance index of the mortar, but the low temperature performance index attenuates obviously. At the same time, the maximum filler-binder ratio of asphalt mortar will be affected by the distribution of mineral powder particles. Based on the same base asphalt, the larger the particle size distribution and the larger the dispersion, the maximum filler-binder ratio of asphalt mortar should be reduced. It is recommended that the median particle size, characteristic granularity and dispersion parameter be used as a technical index in the evaluation of mineral powder.

keywords: mineral powder; asphalt mortar; particle characterization; unrecoverable compliance;

filler-binder ratio

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考虑胶浆黏附特性的泡沫沥青冷再生混合料路用性能研究

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摘 要：泡沫沥青胶浆黏附特性对泡沫沥青冷再生混合料路用性能具有重要影响。采用正交设计方法研究了粉胶比，沥青老化程度及老化沥青黏附试验温度 3 个因素对泡沫沥青胶浆与老化沥青黏附特性的影响。其中，利用自研测试设备获取了泡沫沥青胶浆与老化沥青之间的黏附强度，通过极差分析及方差分析查明了 3 个因素的影响程度及每个因素下的最优水平；结合泡沫沥青冷再生混合料干/湿劈裂强度试验确定了混合料的最佳粉胶比。在此基础上，设计了 3 种不同的拌和工艺，采用冻融劈裂，车辙及无侧限抗压强度试验分析了拌和工艺对泡沫沥青冷再生混合料路用性能的影响。结果表明，粉胶比对泡沫沥青胶浆的黏附特性影响最大，其次是老化沥青黏附试验温度，而沥青老化程度的影响最小；泡沫沥青胶浆与老化沥青黏附强度最优水平分别为：粉胶比 2：1，沥青老化程度 85min RTFOT+10h PAV，老化沥青黏附试验温度 50° C。泡沫沥青冷再生混合料最佳粉胶比为 2：1。拌和工艺对冷再生混合料路用性能具有显著影响，即将粗集料及沥青路面铣刨回收的旧料(RAP)与 1/2 泡沫沥青拌和，然后依次加入细集料，矿粉及水泥，最后喷入剩余 1/2 泡沫沥青进行拌和制备所得混合料路用性能最优。

关键词：道路工程；泡沫沥青冷再生；正交设计；泡沫沥青胶浆；黏附特性；拌和工艺

Performance Evaluation of Cold Recycled Mixture with Foamed Asphalt Considering Adhesive Properties of Mastics

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Abstract:

The adhesive properties of foamed asphalt mastics have a significant effect on the performance of cold recycled mixture with foamed asphalt (CRMFA). The influence of filler-asphalt ratio, aging degree and temperature of aged asphalt on the bonding properties between the foamed asphalt mastics and aged asphalts was investigated based on orthogonal design method. The bonding strength between the mastics and aged asphalts were obtained using a self-developed testing equipment. The impact of the three factors and the optimal level of each factor were determined using methods of range analysis and variance analysis. The optimal filler-asphalt ratio was obtained with a combination of the dry/wet indirect tensile strength (ITS) test of the CRMFA. Then, three different mixing processes of CRMFA were proposed, and the performances of the samples produced by different mixing processes were investigated based on freeze-thaw tensile strength, wheel tracking and unconfined compressive strength tests. The results show that the adhesion properties of foamed asphalt mastics are most affected by filler-asphalt ratio, followed by temperature of aged asphalt, while the aging degree exhibits the minimal effect. The optimal levels of the three factors affecting the bond strength between the mastics and aging asphalts are 2:1 of filler-asphalt ratio, 85min RTFOT+10h PAV aging degree of asphalt, and 50° C of aged asphalt

temperature, respectively. The optimal filler-asphalt ratio 2:1 is determined based on the dry/wet ITS test. Comparing with the performances of samples produced by the three different mixing processes, it is found that the mixing process displays a significant influence on the performances of mixtures. The mixing process that blending coarse aggregates together with RAP firstly, then adding fine aggregate, mineral powder and cement in turn, at last adding remaining asphalt for last mixing is the best process.

keywords: road engineering; cold recycled asphalt with foamed asphalt; orthogonal design method; foamed asphalt mastic; adhesive property; preparation process

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Hydration, Mechanical and Deformation Behaviors of Cement-Based Materials with the Incorporation of Superabsorbent Polymers

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Abstract : Superabsorbent Polymer (SAP) is attracting great concerns in cement-based materials. This study investigated the hydration characteristic, autogenous shrinkage behaviors, mechanical properties and microstructure of SAP cement-based materials. Furthermore, the influence mechanism of SAP on the properties of cement-based materials is also discussed. The effect of SAP on the hydration heat and autogenous shrinkage behavior of cement mortar was studied by utilizing TAM AIR technology and non-contact autogenous shrinkage test method. The microstructure of cement mortar was analyzed by employing scanning electron microscopy (SEM). The results show that the peak rate of hydration heat decreased with the addition of SAP and the occurrence time was also delayed. The more the content of SAP, the larger the total hydration heat of cement-based materials. SAP can significantly reduce the autogenous shrinkage when the content ranged from 0.25% to 0.5%. Besides, the large size of SAP particles could become a stress defect in cement-based materials when it absorbed some water, and the interfacial transition zone between the SAP particles and the surrounding hydration products was also weak. Therefore, the strength of the material was inversely proportional to the content of SAP.

Key words: superabsorbent polymer (sap); mechanical properties; hydration heat; autogenous shrinkage

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绿色养护——乳化沥青冷再生混合料的配合比优化设计研究

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摘 要：乳化沥青冷再生技术在国内已经取得了规模化的应用，但乳化沥青冷再生混合料的配合比设计仍存在周期长，与混合料服役性能相关性差的问题。本文通过经验法（裹附试验）与实测法（性能试验）相结合的方式，并引入了与实际路面压实更为接近的旋转压实方法，进行冷再生混合料最佳用水量和最佳乳化沥青用量确定。提出了基于裹附试验的最佳外加用水量确定、基于沥青膜厚的最佳乳化沥青用量预估，以及基于旋转压实一次成型的最佳用水量与最佳乳化沥青含量确定等环节的冷再生混合料配合比快速设计体系，并且通过室内试验证实了该方法的可行性。文中所得到设计方法简化了设计流程，增强了设计的实用性，对冷再生混合料施工具有很强的指导意义。

关键词：道路工程；乳化沥青冷再生混合料；配合比设计；旋转压实

Research on Optimized Design of Mix Ratio of Emulsified Asphalt Cold Recycled Mixture

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Abstract:

Cold recycling technology of asphalt pavement by asphalt emulsion has been successfully applicated in China. However, the mixture design method of cold recycled asphalt mixture still has a long period and poor correlation with the in-service performance of the mixture. In this paper, the combination of the empirical method (wrap test) and the laboratory test method (performance test) is adopted. The rotary compaction method which is closer to the actual road surface compaction is introduced in the compaction. The optimum water content and optimum emulsified asphalt dosage for cold recycled mixture is determined. A rapid design system for cold recycled asphalt mixtures, based on the determination of the optimum additional water consumption by wrap test and the prediction of the optimum emulsified asphalt dosage based on the thickness of asphalt film, as well as the determination of the optimum water consumption and the optimum emulsified asphalt dosage by one-step rotary compaction is formed. Furthermore, the feasibility of the method was verified by laboratory tests. The design method obtained in this paper simplifies the design process, enhances the practicability of the design process, which will be helpful for the construction of cold recycled asphalt mixture.

keywords: road engineering; recycled asphalt mixture; mixture design; rotary compaction

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Triaxial Tests of Subgrade Soil Treated by Superabsorbent Polymer (SAP)

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Abstract: Superabsorbent polymer (SAP) is attracting great concerns in civil engineering materials, especially in cement concrete. However, the use of SAP in soil treatment is seldomly studied. This study investigated the dynamic modulus and damping ratio of subgrade soil treated with different content of SAP by conducting some dynamic triaxial compressive tests. Triaxial tests were conducted for soil with the optimal moisture content. The findings from compaction tests showed that SAP decreased the maximum dry density, while played no effect on the optimum moisture content. Test results show that at the same content of SAP, with the increase of confining pressure, the dynamic modulus increased while the damping ratio decreased. SAP slightly decreased the dynamic modulus while significantly increased the damping ratio.

Key words: Superabsorbent polymer (SAP); Triaxial test; Dynamic modulus; Damping ratio; Optimal moisture content

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聚醚型聚氨酯注浆材料强度的影响因素

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摘 要：采用一步法制备聚氨酯注浆材料，研究了原料合成中五种主要助剂，催化剂、交联剂、稳泡剂、阻燃剂和发泡剂，对成品的抗压与抗拉强度的影响。结果表明：聚氨酯材料的抗压强度受催化剂掺量的影响较小，其抗拉强度随着催化剂掺量的增加逐渐增大并趋于稳定；在适量的范围内，交联剂的用量越多，聚氨酯材料的抗压和抗拉强度越高，当超出适量范围时，聚氨酯材料的抗压和抗拉强度降低；稳泡剂对聚氨酯材料的抗压强度影响不大，在适量的范围内，增加其用量可以提高聚氨酯材料的抗拉强度，而用量过大会导致抗拉强度大幅下降；阻燃剂存在一个最佳掺量，低于或高于这个掺量聚氨酯材料的抗压和抗拉强度都会有明显下降；发泡剂的用量越多，聚氨酯材料的抗压和抗拉强度越低。最后根据成分影响分析，设计出符合 CJJ/T 260-2016 技术要求的聚醚型聚氨酯材料。

关键词：道路工程；聚氨酯；力学强度；影响因素

Influencing Factors of Strength of Polyether Polyurethane Grouting Material

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Abstract:

Polyurethane grouting material was prepared by one-step method in this paper. The effects of five main additives, which are catalyst, crosslinking agent, foam stabilizer, flame retardant and foaming agent, on the compressive and tensile strength of the material were studied. Results show that the compressive strength of polyurethane material is less affected by the amount of catalyst, while tensile strength increases gradually and tends to be stable with the increase of the dosage; Within the appropriate range, the more crosslinking agent used, the higher the compressive and tensile strength of polyurethane materials will be. However, if the amount of crosslinking agent exceeds the appropriate range, both compressive and tensile strength of polyurethane materials will decrease; Foam stabilizer has little effect on the compressive strength of polyurethane materials, within a proper range, increasing its dosage can improve the tensile strength of polyurethane materials, but excessive dosage will lead to a significant decrease to the tensile strength; There is an optimum content for flame retardant, and the compressive and tensile strength of polyurethane materials will decrease obviously when the content of flame retardant is lower or higher; The more the amount of foaming agent added, the lower the compressive and tensile strength of polyurethane materials will be. Finally, the polyether polyurethane material which meets the technical requirements of CJJ/T 260-2016 was designed according to the composition analysis.

keywords: road engineering; Polyurethane; mechanical strength; influence factors

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Green Maintenance-Study on the Effect of Cationic Emulsifier to the Performance of Asphalt

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Abstract: The objective of this experimental work is to investigate the effect of the cationic emulsifier on the ductility, penetration, saturates, aromatics, resins and asphaltenes (SARA) components and viscosity-temperature characteristics of three matrix asphalts. Asphalt emulsions were prepared by means of the asphalts emulsified by one kind of cationic emulsifier. The results show that the magnitude of the penetration at 25 oC and ductility at 15 oC of asphalts increases and decreases respectively as the emulsifier content in the emulsions increases from 0 wt% to 5.0 wt%. The asphaltenes content of emulsion residues is a little higher than that of corresponding matrix asphalt. However, the content of saturates, aromatics, and resins of emulsion residues does not reflect obvious trend. With the emulsifier content increasing from 0 wt% to 5.0 wt%, the viscosity of Karamay AH-90 decreases at temperatures in the range from 60 oC to 80 oC and changes slightly when the temperature is above 80 oC. However, the viscosity of Gaofu AH-90 increases at temperatures from 60 oC to 90 oC and almost remains unchanged when the temperature range between 90 oC and 150 oC. The change of the viscosity for Zhonghai AH-90 is insignificant.

Key words: Asphalt emulsion; Cationic emulsifier; Residue; Saturates, aromatics, resins and asphaltenes (SARA) components; Viscosity-temperature characteristics

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Experimental Study on Aggregate Optimization of Epoxy Wearing Coarse

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Abstract: The aggregate image measurement system（AIMS） and digital image processing technology (DIP) was used to quantify the shape features such as contour shape, angularity and surface texture. Four kinds of aggregates such as basalt, granite, limestone and diabase were quantitatively studied. Base on the analysis, a secondary indicator evaluation system was established to evaluate the skidding resistance. The results had shown that the acicularities of four aggregates were similar.The roundness and sphericity of basalt and diabase were closer to 1, and the corresponding skidding resistance was better than granite and limestone; limestone had the highest angular value, followed by granite, and finally basalt and diabase. The angle value of limestone was the highest value, followed by granite. The higher the surface texture index, the better the superficial texture performance, and then the more rough surface roughness. The comprehensive evaluation index values of shape characteristics of four aggregates were calculated. It was pointed out that basalt was the most ideal type of wearing aggregate, followed by diabase, and it was verified by engineering tests. Basalt was an excellent aggregate of skidding resistance.

Key words: road engineering; epoxy wearing coarse; aggregate; shape characteristics

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Real-Time Detection of Foreign Object Litter on the Expressway Using Yolo Model

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Abstract: Foreign Object Litter (FOL) are obstacles or debris scattered by passing vehicles on expressways, which may cause chaos, block the traffic and even cause traffic accidents. For administrators of the freeway, it takes vast amounts of labor power and financial resources to patrol for FOL that can appear anytime at any place. We present a new approach to Foreign Object Litter detection by developing a deep learning algorithm YOLO to achieve real-time monitoring of the expressway. YOLO model is emerging as a fast and robust tool for object detection. We improve the YOLO method as FOL-YOLO to make it more sensitive to common FOL to enhance detection accuracy. We make two main optimizations on FOL-YOLO networks. One is reducing the size of the convolution kernel; the other is adding connections between different feature layers. To get enough images to train the networks, we use synthetic images and self-taken images to construct the FOL image database. Furthermore, the development system has been field tested on the smart FOL detection robot platform-FOLobot which is a road vehicle with semi-automated driving capabilities using GPS and tracking system. We made the field test on the first photovoltaic expressway of the world in Jinan, Shandong Province of China. The FOL-YOLO model can arrive at an accuracy rate of 95% in the closed test.

Key words: Expressway patrol; Obstacles detection; Foreign Object Litter; Deep learning; FOL-YOLO model

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老化 SBS 改性沥青混合料性能再生及评价指标优化

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摘 要：为对老化 SBS 改性沥青混合料进行再生，实现二次利用，完善旧料（RAP）再生工艺，本文选取四种再生方式进行对比研究。首先利用沥青混合料车辙试验、弯曲试验、冻融劈裂试验比较不同方式对再生料路用性能影响，进而确定四种再生方式下 RAP 的最大掺量。然后，对汉堡试验性能评价指标进行分析，探讨其存在的不足，并提出新的评价因子验证再生料路用性能。试验结果表明：不同再生方式制备的再生混合料随着 RAP 掺量的增加，路用性能变化趋势差异较大，其中方式Ⅳ对再生料的低温性能最有利，方式Ⅲ对再生料的水稳性能最有利；四种再生方式的 RAP 最大掺量依次为：39.5%、36.4%、43.7%、43.8%。此外，车辙稳定度 RS 作为汉堡试验时高温性能的评价因子具有一定的可行性，可以用来直观比较不同再生方式下 RAP 掺量对再生沥青混合料性能的影响程度，进而确定各方式下高温性能的优劣。

关键词：道路工程；SBS 改性沥青；再生方式；评价指标；掺量

Performance Regeneration and Evaluation Index Optimization of Aged SBS Modified Asphalt Mixture

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Abstract:

In order to regenerate the aged SBS modified asphalt mixture, realize the secondary utilization, and improve the regeneration process of the Reclaimed Asphalt Pavement, four kinds of regeneration methods for comparative study were selected in this paper. Firstly, the rutting test, bending test and freeze-thaw split test of asphalt mixture were used to compare the influence of different ways on the pavement performance of the recycling mixture, and then the maximum content of the PAR under the four regeneration ways was determined. After that, the existing defects of performance evaluation index in Hamburg test were discussed and analyzed, and a new evaluation factor was proposed to verify the road performance of recycling mixture. The results show that the recycling mixture prepared by different regeneration ways with the increasement of dosage of RAP, the variation trend of pavement performance difference obviously. Moreover, way Ⅳ is the most favorable to the low temperature performance and way Ⅲ is the best for water stability performance of recycling mixture. The maximum RAP content of the four regeneration methods is 39.5%, 36.4%, 43.7% and 43.8% respectively. In addition, Rutting Stability is feasible as an evaluation factor of high temperature performance in Hamburg test. It can be used to directly compare the influence of RAP content on the performance of recycled asphalt mixture, and then determine the advantages and disadvantages of high temperature performance under different regeneration modes.

keywords: road engineering; SBS modified asphalt; regeneration methods; evaluation index; content

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基于性能评估的水泥就地冷再生关键技术应用研究

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摘 要：为了研究水泥就地冷再生铣刨料基层抗裂性能，本文基于性能评估试验，采用应变特性对比分析不同水泥剂量及新旧混合料的干、温缩性能，研究结果表明温缩应变与温度有很高的相关性，温缩系数随着温度降低而减小，同时随着水泥用量的提高，平均温缩系数先增大后减小，5%水泥剂量的旧混合料温缩性能较好，且在再生混合料应用过程中，应尽量增加粗集料用量，增强再生混合料的抗温缩性能；对于铣刨旧料再生基层，施工过程中失水率控制在3.5%左右时，其干缩应变较小，能够有效的较少早期干缩裂缝。

关键词：应变特性；就地冷再生；温缩应变；温缩系数；干缩应变；干缩系数

Research on Key Technology of Cement In-Situ Cold Regeneration Based on Performance Evaluation

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（Jsti）

Abstract:

In order to study the crack resistance of the cold-recycled milled base material in cement, this paper based on the performance evaluation test, using strain characteristics to compare the dry and shrinkage properties of different cement dosages and new and old mixes. The results show that the temperature shrinkage strain and temperature are very high. With high correlation, the temperature shrinkage coefficient decreases with the decrease of temperature. At the same time, with the increase of cement dosage, the average temperature shrinkage coefficient increases first and then decreases, and the old mixture of 5% cement dosage has better temperature shrinkage performance. In the application process of recycled mixture, the amount of coarse aggregate should be increased as much as possible to enhance the temperature and shrinkage resistance of the recycled mixture. For the reclaimed base of milled old materials, when the water loss rate is controlled at about 3.5% during construction, the shrinkage is dry. The strain is small and can effectively reduce the early shrinkage cracks.

keywords: Strain characteristics; Cold regeneration; Shrinkage strain; Coefficient of temperature shrinkage；Dry shrinkage strain；Dry shrinkage factor

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Precision Uplift Rehabilitation by High Polymer for Differential Settlement of Ballastless Track Structure

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Abstract: The concrete slab ballastless track is an advanced track structure with high stability and integrity. However, when the foundation of ballastless track appears large differential sunken deformation, compared with ballast track which can be restored by increasing the ballast under the sleepers simply, the smoothness of concrete slab ballastless track can only be restored by adjusting the thickness of the base plates of fastener system accordingly. But if continuous sunken deformation exceeds specified adjustable range of fastener system, the smoothness of concrete slab ballastless track cannot be restored timely and completely, and then the speed of passing trains has to be limited to ensure the safety. To solve this problem without disturbing the regular operation of the railway lines, we systematically studied a complete set of new quick uplift rehabilitation technology through a series of indoor reduced scale tests and field full scale simulations with real concrete slabs and combined with practical application. Results indicated this technology can restore the smoothness of sunken concrete slab ballastless track quickly and accurately. These will provide valuable references for the rehabilitation of sunken concrete slab ballastless structure.

Key words: grouting; uplift; concrete structure; ballastless track; rehabilitation

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Green Preservation-Better Road Cleaner Air: Sustainable Asphalt Pavement Preservation Strategy Assessment

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Abstract: Preserving pavement early in its life can maintain the surface condition at minimal cost. Federal Highway Administration (FHWA) estimates that every $1 spent on pavement preservation can delay or eliminate the need to spend $6 to $10 on rehabilitation or reconstruction in the future. This research extends the benefit of preservation strategy to environmental gains. The study looks at quantifying environmental impact of asphalt pavement presentation throughout its lifecycle, including construction and in-service stages. Preservation strategies considered in this study include thin overlay, chip seal and crack seal. The carbon dioxide (CO2) emission models are based on motor vehicle emission simulator and pavement roughness models with long-term pavement performance program. The research indicates that an improved surface condition results in not only smooth pavement but reduce pollution emissions even considering the original treatment application stage emissions. The reductions of carbon dioxide emission can be as great as 0.4 million kilograms depending on the traffic volume, pavement types, and application time.

Key words: green; sustainable; pavement preservation

基于 AHP-SWOT 的公路废弃物资源化发展战略研究

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摘 要：随着公路系统的新陈代谢，大量废弃物给城市的资源与环境协调发展带来了巨大压力，以沥青路面再生技术为路径的公路废弃物资源化符合循环经济的理念，是我国公路建设迈向生态文明的必然选择。文章通过 AHP-SWOT 对上海公路废弃物资源化发展战略进行实证分析，发现当前形势下其优势和机遇较为明显，确定以 SO 策略为核心的推广战略为最佳选择，并提出一系列配套发展策略，为推动上海公路废弃物资源化提供参考。

关键词：资源化

Research on the Developing Strategy of Highway Waste Recycling in Shanghai Based on AHP-SWOT

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Abstract:

With the metabolism of highway system, a large amount of waste brings great pressure to the coordinated development of urban resources and environment, and highway waste recycling based on asphalt pavement recycling technology conforms to the concept of circular economy, which is the inevitable choice for China's highway construction to move towards ecological civilization. Through AHP-SWOT, this paper makes an empirical analysis of the development strategy of highway waste recycling in Shanghai, finds that it has obvious advantages and opportunities under the current situation, determines the promotion strategy with SO strategy as the core as the best choice, and puts forward a series of supporting development strategies to provide reference for promoting the highway waste recycling in Shanghai.

keywords: recycling

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Research on Reference Indicators for Sustainable Pavement Maintenance Cost Control Through Data Mining

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Abstract: Maintenance management has become increasingly important in the development of highways and government investment, but the shortage of funds is still a serious problem. When the administrative department reviews expense, the existing evaluation methodology cannot be applied to the current national condition and its calculation process is too complicated. Therefore, in order to improve this situation, this paper analyses various factors affecting maintenance costs, and obtains the quantitative relationship between the six main influencing factors such as traffic volume, using time, location, the number of lanes, overlays, and major rehabilitation. Based on regression analysis, an accuracy-based and cost-oriented control methodology is proposed, which can be dynamically updated according to the market conditions. This method is built on the data of 18 typical highways in Guangdong Province, China. The control reference indicators consist of a set of models and confidence intervals, and the actual cost needs to meet the corresponding requirements. In addition, the expenditure characteristics of rehabilitation and reconstruction in China are summarized. Experiments showed that this methodology can be used to guide cost planning and capital allocation in sustainable maintenance and achieved good results in application, making it worthwhile to promote them in other areas.

Key words: pavement maintenance management; routine maintenance; cost control; factors analysis; data mining

基于不同养护方式的高速公路沥青路面性能预测模型

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摘 要：我国高速公路网络日趋完善，养护维修工作越来越重。科学的养护维修不仅要做到节约资金,更要保障道路的服务水平,利于行车安全。本文整理了江苏省高速公路性能数据，主要提出了一个基于养护措施，交通量，路面当前性能状况进行高速公路沥青路面各性能指标预测的模型，有一定的准确度与实际意义，并已应用于江苏省路面网级决策管理系统。

关键词：性能预测；预测模型；路面养护管理

Prediction Module of Asphalt Pavement of Highway Under Different Maintenance Condition

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Abstract:

With the gradual improvement of highway network construction in China, the volume of maintenance of road is higher and higher. Scientific maintenance and repair not only saves money, but also guarantees the road service level and facilitates driving safety. This paper sorts out the performance data of expressway in Jiangsu Province, and proposes a model for predicting the performance indexes of asphalt pavement of highway based on maintenance measures, traffic volume and current performance of pavement. It has certain accuracy and practical significance and has been applied in road network level decision management system of Jiangsu Province.

keywords: performance predictive; predictive model; pavement maintenance management

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预防性养护雾封层技术研究现状与进展

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摘 要：为有效防治沥青路面早期病害，延长沥青路面使用寿命，给预防性养护雾封层技术的研究及推广应用提供理论指导与技术支持，通过对国内外预防性养护雾封层技术的研究成果进行梳理总结，分析研究了雾封层的技术特性，评价了雾封层技术的适用性，探索了雾封层研究的新技术，提出了国内外现有雾封层技术存在的主要问题，并展望了雾封层技术未来发展趋势和研究方向。

关键词：道路工程；预防性养护；雾封层；技术特性

Research Status and Development of Preventive Maintenance Fog Sealing Technology

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Abstract:

In order to effectively prevent the early damage of asphalt pavement, extend the service life of asphalt pavement, provide theoretical guidance and technical support for the research and popularization of preventive maintenance fog seal technology, and sort out the research results of preventive maintenance fog seal technology at home and abroad. In summary, the technical characteristics of the fog seal layer were analyzed and analyzed, the applicability of the fog seal layer technology was evaluated, the new technology of the fog seal layer research was explored, and the main problems existing in the existing fog seal layer technology were put forward. The future development trend and research direction of fog sealing technology.

keywords: road engineering; preventive maintenance; fog sea; technical characteristics

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水泥再生结合料在农村公路冷再生技术改造中的应用探索

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摘 要:本文从工程实践角度，结合县乡公路改造实例，用水泥作为再生结合料，探索农村公路大修工程应用冷再生技术。通过检测数据分析，创造性提出一系列农村公路冷再生技术参数和施工工艺；经过工程运营，就地冷再生技术质量可靠，经济适用，技术可行，施工简便，在农村公路领域具有良好的使用前景。

关键词:水泥再生剂；就地冷再生；农村公路；技术改造

Application of Cement Regenerative Binders in Rural Highway Cold Regeneration Technology

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Abstract:

Abstract: this article from the point of view of engineering practice combined with county and township highway reconstruction examples. In this paper, cement is used as recycled binder to explore the application of cold regeneration technology in rural highway overhaul engineering. Through the analysis of testing data, a series of technical parameters and construction technology of cold regeneration of rural highway are put forward creatively. After engineering operation, the on-site cold regeneration technology is reliable in quality, economical and applicable, feasible in technology and simple in construction. It has a good application prospect in the field of rural highway. Key words: on-site Cold Regeneration of cement Regenerative Agent in Rural Highway Technical Reconstruction.

keywords: on-site Cold Regeneration of cement Regenerative Agent in Rural Highway Technical Reconstruction

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green reservation 地铁荷载下隧道注浆对地面振动的影响

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摘 要：为研究地铁隧道注浆加固后土体力学性能的改变对列车运行引起地面振动的影响，采用有限元分析方法，建立了土体-隧道二维计算模型，分析了在不同隧道埋深及荷载频率下，注浆结石体强度与注浆范围对地面振动加速度反应的影响。计算结果表明：不同隧道埋深下注浆体强度与范围对地面反应的影响规律大致相同；荷载频率对计算结果影响很大，10Hz-30Hz 低频荷载频率下，注浆体强度与注浆范围对地面加速度反应的影响较小；50Hz 荷载频率下，地面最大加速度反应与注浆效果近似成正比，且整体趋势随着注浆范围的增大而增大；70Hz 与 90Hz 荷载频率下，注浆体强度与范围对地面反应的影响存在很强的非线性。研究结果表明，在地铁动力反应分析中，隧道注浆的影响不可忽略，计算时应详细考虑注浆结石体强度与注浆范围的影响。

关键词：地铁隧道；列车荷载；注浆；地面振动

Green Reservation Effects of Tunnel Grouting on Ground Vibration Under Subway Load

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Abstract:

Abstract: In order to research the influence of subway induced vibration on the ground caused by the change of soil mechanical properties after grouting in subway tunnel, a two-dimensional calculation model of soil-tunnel was established by using finite element analysis method. The effects of grouting strength and range on ground vibration under different tunnel depths and load frequencies were analyzed. The calculation results show that : the influence of grouting strength and range on ground vibration under different tunnel depths is roughly the same; the load frequency has a great influence on the calculation results, it is little impact of grouting strength and range on ground acceleration response at 10Hz-30Hz load frequency; the maximum acceleration response on the ground is approximately proportional to the grouting strength and has the same trend with grouting range at 50Hz load frequency; there is a strong nonlinearity between the strength and range of grouting on the ground response. The research indicates that the influence of grouting in tunnels should not be neglected and should be considered in detail in the dynamic response analysis of the subway.

keywords: Subway tunnel; Train load; Grouting; Ground vibration

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Fundamental Engineering Properties of Asphalt Mixtures for Heavy Duty Asphalt Pavements

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Abstract: The rapid development of premature failures of the asphalt pavements has been found in heavy duty use areas in Taiwan. These premature deteriorations were commonly caused by rutting and shoving. It is imperative to design and develop heavy duty asphalt concrete for the rut-resistant and durable asphalt pavements. However, due to material and climate variations, the utilization of aggregate gradation and modified asphalt binder must be investigated using local materials and specifications. The objectives of the investigation were to characterize the fundamental engineering properties in terms of mixture type and aggregate size for the heavy duty asphalt mixtures. The laboratory results shows that the dense grade asphalt concrete (DGAC) had the better performance in indirect tensile strength and resistance to raveling as compared to the porous asphalt concrete (PAC) and stone mastic asphalt (SMA) mixtures. In addition, the fundamental properties of DGAC incorporating steel slag appeared to be comparable with those of the DGAC containing limestone aggregate. In terms of moisture-induced damage, the retained strength ratios displayed that all heavy duty asphalt mixtures investigate in this study met the minimum requirement of 80% regardless of mixture gradation and aggregate type. On the basis of the results of wheel tracking test, the PAC showed the better resistance to rutting within the initial number of cycles because of stone on stone interlock, but appeared to develop higher rutting depth rate for further increases in number of cycles compared to the DGAC and SMA. The higher mixture viscosity ($\eta 0$) calculated from Burgers model represented the better cohesive strength within the asphalt mixture, resulting in the slower rate of rutting development. It was found a positive linear correlation between mixture viscosity and number of loading cycles at the rutting depth of 12.5 mm with the R2 value of 0.983 as including the DGAC and SMA mixtures.

Key words: heavy duty asphalt mixture; mixture viscosity; burgers model; rutting

Interface Reinforcement Technique of Asphalt Pavement Pothole Patching

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Abstract: Interface failure of pothole patching is a major distress in asphalt pavement maintenance. To find an effective method to mitigate it, an interface reinforcement technique using non-woven fabric was proposed and evaluated based on numerical simulation and experimental research. Firstly, a three-dimensional finite element model of pothole patching structure was conducted to clarify the stress state of pothole patching interface. Then an interface reinforcement technique was put forward to improve the stress state in the interface. Lastly, experimental tests were designed and carried out to assess bonding performance between non-woven fabric and pavement, fatigue and fracture performance of the patching interface, which shows the reinforcement technique has obviously active effect to the repair of pothole interface.

Key words: pothole patching; numerical simulation; experimental research; non-woven fabric; interface reinforcement

SBS 改性沥青储存稳定性的实时检测方法与机理研究

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摘 要：苯乙烯-丁二烯嵌段共聚合物(SBS)改性沥青由于相对优良的高低温性能在沥青路面中得到广泛应用。SBS 的结构、SBS 的掺量、热存储过程中 SBS 与沥青的离析都会影响 SBS 改性沥青的性能。通过对沥青分层样品中 SBS 含量的精确测量可以对改性沥青的离析进行准确的评估，可以有效地对改性沥青的质量进行监控，改善沥青路面施工质量。本工作利用电位滴定精确计量 SBS 中碳碳双键的加成反应，实现了对改性沥青中 SBS 含量的精确测定。电位滴定可以及时准确地检测 SBS 的掺量，真实地反映改性沥青的离析过程和离析结果，直接评价 SBS 改性沥青的贮存稳定性，而不是间接测定软化点。同时，电位滴定可以实时监控热储存过程中沥青样品 SBS 掺量的变化，揭示改性沥青和 SBS 的热降解过程。

关键词：改性沥青；SBS 掺量；定量检测；电化学分析；电位滴定

Study on Real-Time Testing Method and Mechanism of Storage Stability of SBS Modified Asphalt

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Abstract:

Styrene-butadiene-styrene triblock copolymer (SBS) modified asphalt has been widely used in asphalt pavement due to its relatively good high and low temperature properties. The structure and content of SBS, the segregation of SBS and asphalt during hot storage will affect the performance of SBS modified asphalt. The segregation of modified asphalt can be accurately evaluated by the accurate measurement of SBS content in asphalt stratified samples. The quality of modified asphalt can be monitored effectively and the construction quality of asphalt pavement can be improved. In this work, the addition reaction of carbon-carbon double bonds in SBS was accurately measured by potentiometric titration, and the accurate determination of SBS content in modified asphalt was realized. Potentiometric titration can detect the amount of SBS in real time and accurately reflect the segregation process and segregation results of SBS modified asphalt, which directly evaluate the storage stability of SBS modified asphalt rather than indirectly determine the softening point. In addition, potentiometric titration can monitor the change of SBS content in asphalt samples during hot storage, and reveal the thermal degradation process of modified asphalt and SBS.

keywords: Modified asphalt; BS content; Quantitative detection; Storage stability Potentiometric titration

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Laboratory Investigation of Physical Performance and Chemical Characteristics of Warm Mix Asphalt Binders

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Abstract: Due to the environmental benefits and advantages in energy conservation, warm mix asphalt (WMA) technologies have become increasingly popular in recent years around the world. The objective of this study was to investigate the performance in laboratory and chemical compositions of the three WMA binders mixed with M-1, WB-2 and WB-3, respectively. The testing procedures including penetration tests, softening point tests, rotary viscosity (RV) tests and Fourier transform infrared spectroscopy (FT-IR) analysis were performed to determine the influences of the three additives on asphalt binders. The test results indicated that the WMA additives had a significant influence on the physical performance of asphalt, such as penetration, softening point and rotary viscosity. Also, the rotary viscosity was not the single index to determine the mixing and compaction temperature of WMA binders since the WB-3 increased the viscosity. The chemical investigation conducted using FT-IR analysis showed that the effect of M-1, WB-2 and WB-3 on the asphalt may be mainly physical not chemical modification, there was no chemical bond cracking or recombination found in the FTIR spectra. The change of the density of asphalt component may be the most effect of WMA additives on the base asphalt. By analyzing the integral spectral peak area calculation, the change trend between the area ratio of the aromatics base absorption peak to rotary viscosity was found the same, which could be due to the fact that the aromatics has impact on the rotary viscosity directly in the three WMAs.

Key words: warm mix asphalt; warm mix additive; physical performance; Fourier transform infrared spectroscopy

桥梁结构动力性能测试及注意事项

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摘 要：结合工程实例，明确了梁桥动力性能评价指标和动载试验激励源的确定，研究了结构动力性能测试原理及评价方法，总结了动力测试注意事项。为桥梁结构动力测试提供了一定参考。

关键词：桥梁动力性能

Bridge Structure Dynamic Performance Test Ad Matters Needing Attention

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Abstract:

Combining with engineering examples, the evaluation index of dynamic performance and the determination of excitation source of dynamic load test of beam bridge are clarified, the principle and evaluation method of structural dynamic performance test are studied, and the matters needing attention in dynamic test are summarized. It provides a reference for dynamic testing of bridge structures.

keywords: bridge dynamic performance

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HTRCS 侧面加固混凝土偏压柱试验研究及承载力计算分析

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摘 要：通过 6 根 HTRCS（超强高韧性树脂钢丝网混凝土）侧面加固钢筋混凝土柱偏心受压试验，研究加固后钢筋混凝土偏压柱在不同加固方式、大小偏心作用下的破坏特征和受力性能，对柱截面应变、开裂荷载以及极限承载力等进行分析。试验结果表明：HTRCS 加固是一种有效的加固方法，能够显著提高钢筋混凝土柱的极限承载力；同时，HTRCS 加固还能够极为有效地提高大偏心受压柱的抗开裂能力；特别对于远轴侧加固的大偏心柱和近轴侧加固的小偏心柱，HTRCS 加固能够充分发挥加固层材料的优良特性，加固效果最优。根据试验分析结果，采用普通混凝土等效矩形应力图和树脂混凝土等效梯形应力图简化计算，提出了 HTRCS 加固钢筋混凝土偏压柱的承载力计算公式。计算结果与试验值吻合较好，可为后续研究及工程应用提供理论依据。

关键词：偏压柱；加固；HTRCS；极限承载力；计算公式

Experimental Study and Analysis of Bearing Capacity of Concrete Columns Strengthened by HTRCS on Side

Wang Wendong ; Yang Yongqing ; Li Xiaobin ; Zhao Gangyun ; Yan Meng
（Southwest Jiaotong University ; Southwest Jiaotong University ; Southwest Jiaotong University）

Abstract:

An experimental study of eccentrically loaded reinforced concrete columns strengthened by HTRCS on side is presented. This paper studies the damage characteristics and mechanical properties of reinforced concrete column under different reinforcement methods and eccentricity, and analyzes the strain of column section, cracking load and ultimate bearing capacity. The experimental results indicated that HTRCS reinforcement is an effective method, which can significantly improve the ultimate bearing capacity of the reinforced concrete column. In addition, HTRCS reinforcement can greatly improve the anti-cracking ability for large eccentric columns. Especially for the large eccentricity column reinforced by the far axial side and the small eccentricity column reinforced by the near axial side, the HTRCS reinforcement can give full play to the excellent properties of the reinforced material, and the strengthening effect is the best. The equivalent rectangular stress diagram of normal concrete and the equivalent trapezoidal stress diagram of resin concrete were used to simplify the calculation. Based on the results of the test, the formula for the load-bearing force of reinforced concrete columns strengthened by HTRCS. The calculated results have good agreement with the test results. It can provide a theoretical basis for follow-up studies and engineering application.

keywords: eccentric compression column; strengthening; HTRCS; ultimate bearing capacity; computational formula

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跨线桥转体施工监控的研究进展及展望

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摘 要：随着我国交通建设的不断发展，桥梁跨既有线路交叉立体施工日益频繁，为避免对既有线路运营的影响，实现不间断交通及快速施工，转体法具有其独特的优势。为了促进转体法技术在桥梁快速施工中的应用，对近几十年来转体法的广泛应用及进展进行了总结。重点介绍了转动体系局部受力分析方法、转体平衡确定方法、转体施工控制、施工风险控制等最新研究成果。研究表明：转动系统的局部应力分布规律难以准确把握，现有的计算模型均存在一定的简化；相比较现场承重试验，基于应变测试的不平衡力矩的预估方法具有一定的可行性，但是需要控制测试的精度；转体法施工的线形控制采取位移和应力“双控”的方法；下部结构的控制应以局部受力复杂区域为主；通过控制关键参数采用最小二乘法进行误差分析能较好地确保合龙的精度；转体法在跨线桥快速施工领域应用前景较好。

关键词：桥梁工程；快速施工；转体法；施工控制

Study Progress and Outlook of Swivel Rapid Construction Monitoring Technology in Flyover Bridge

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Abstract:

With the development of the construction in China, bridge construction cross the existing lines has increased frequently. To avoid the impact on existing lines and to achieve uninterrupted traffic rapid construction, the Swivel Construction has its unique advantages. In order to promote the application of swivel technology in rapid construction, the wide spread applications and progresses recently of the technology was concluded. Local force analysis of rotating system, rotation balance, and swivel construction control, the local stress distribution is hard to get and calculation models simplified. Compared with the on-site load test, unbalanced torque estimation method based on stress test is feasible. Swivel construction adopts the “double control” method of displacement and stress; The construction control of the substructure should focus on the complex areas of local stress. There are many factors that can affect the swivel construction. Least square method can better keep the accuracy of the collapse. Reasonable risk control measures can effectively guarantee the safety of construction. The swivel bridge has a good application prospect in the field of flyover bridges..

keywords: Bridge Engineering; Rapid Construction; Swivel Construction; Construction Control

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基于柔性导电涂料的混凝土桥梁裂缝变化规律研究

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摘 要：本文首先介绍了基于柔性导电涂料进行混凝土桥梁裂缝监测的基本原理，而后指出利用其进行混凝土桥梁裂缝监测具有分布式、全过程、对温度等环境因素不敏感以及成本低廉等突出优点，特别适合在量大面广的混凝土桥梁上进行推广应用。通过对两座混凝土桥梁在不同时间跨度下实测数据的分析，发现桥梁混凝土裂缝在温度与超载作用下会出现频率不同的、反复开裂、缩小甚至闭合的变化规律，指出这种现象将严重影响结构耐久性与使用寿命，但又是经常性检查与定期检查难以发现的损伤现象，指出需要研究更为合理的桥梁检测制度的必要性。

关键词：混凝土桥梁；裂缝监测；导电涂料

Research on the Variation of Concrete Bridge's Crack Based on Flexible Conductive Paint

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（NanJing Tech University ; Jiangsu Delauney Information Co.,ltd. ； Jiangsu Delauney Information Co.,ltd. ； Jiangsu Delauney Information Co.,ltd.）

Abstract:

The principle of crack monitoring of concrete bridge based on conductive paint is introduced. The technology is suitable for monitoring widely used concrete bridges because it is accessible to the whole monitoring process and sensitive to crack while not sensitive to environment such as temperature and has distributed layout and low cost. Through the analysis of the monitoring data of two concrete bridges under different time spans, it is found that concrete bridge cracks repeatedly expand, shrink or even close with different frequency under the action of temperature and overload, which seriously affect the bridge's structure durability and service life. This rule can be easily ignored during regular and periodic inspection, so it is necessary to develop a more reasonable bridge detection system.

keywords: concrete bridge; crack monitoring; conductive paint

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基于 WIM 数据的泰州大桥交通量及交通荷载分析

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摘 要：交通状况是影响路面服务性能和路面使用寿命的重要因素之一。为了准确掌握泰州大桥的交通量及车辆荷载分布状况，选取实测的主桥动态称重（WIM）数据，首先统计了泰州大桥的日均交通量，对比分析了泰州大桥的车道分布概率，然后进一步分析了分车道分车型的分布概率，并对泰州大桥主桥的轴载谱进行了分析。结果表明：泰州大桥交通量以 2 轴车为主，占比达到 80%以上，主线收费站拆除后主桥交通状况更为不利，轴载＞10t 的车辆占比达到 16.8%，应限制超载车辆通行。

关键词：桥梁工程；WIM；交通量；轴载

Traffic Volume and Load Analysis of Taizhou Bridge Based on WIM Data

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Abstract:

Abstract: Traffic condition is one of the important factors affecting pavement service performance and pavement service life. In order to accurately grasp the traffic volume and vehicle load distribution of Taizhou Bridge, the measured dynamic weighing (WIM) data of the main bridge are selected. First, the daily traffic volume of the Taizhou Bridge is counted, the lane distribution probability of the Taizhou Bridge is compared and analyzed, then the distribution probability of the lane and vehicle types is further analyzed, and the axle load spectrum of the main bridge of the Taizhou Bridge is analyzed. The results show that the traffic volume of Taizhou Bridge is dominated by 2-axle vehicles, accounting for more than 80%. The traffic condition of the main bridge is more disadvantageous after the main toll station is dismantled. The proportion of vehicles with axle load > 10 t is 16.8%. The traffic of overloaded vehicles should be restricted.

keywords: bridge engineering; WIM; traffic volume; axle load

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基于金属磁记忆的钢筋弹性与屈服阶段内力检测方法研究

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（重庆交通大学）

摘 要：钢筋作为土木工程中常用材料，对于服役过程中其内部拉力检测十分重要。现有的检测技术和方法还不能做到对钢筋拉力完全有效的检测和评价。本文基于金属磁记忆检测技术，采用定点监测与顺筋扫描的方法，研究了不同直径钢筋表面的金属磁记忆信号随内部拉力的变化规律。结果表明，自发漏磁信号切向分量曲线上极值点对应的拉力与屈服阶段拉力比值总体上接 65%，且随着钢筋直径的增大而减小。SMFL 切向分量曲线的一阶导数在弹性阶段与屈服阶段分别会出现数值较大的峰值。为了定量检测拉力，本文还定义了“力致波动参数”，该指标反映了磁信号切向分量大小沿顺筋方向波动的幅度，在钢筋线弹性阶段内与拉力成线性关系，直线斜率随直径增大而增大。结合钢筋 SMFL 信号在弹性和屈服阶段变化特征以及“力致波动参数”与拉力之间的斜率，为实际工程钢筋拉力检测提供了新的方法与思路，具有良好的应用前景。

本文通过分析金属自发漏磁信号，提出了可以用于钢筋内部拉力检测的无损检测方法。钢筋表面漏磁场强度随其拉力的变化规律表明，SMFL 信号的曲线在钢筋拉力达到屈服强度 65%是会出现明显极值点，其一阶导数在弹性和屈服阶段出现明显峰值。在探究漏磁场强度在不同拉力下随钢筋轴向位置的变化试验中，提出了一种反映 SMFL 沿钢筋轴向波动的参数，通过该参数与拉力之间的线性关系可以定量计算拉力。

关键词：金属磁记忆；钢筋拉力检测；弹性阶段；屈服阶段

Research on Internal Force Detection Method of Reinforcement Elasticity and Yield Stage Based on Metal Magnetic Memory

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Abstract:

As a commonly used material in civil engineering, steel bars are very important for the internal tensile testing during service. The existing testing techniques and methods are not able to fully detect and evaluate the tensile force of the steel bars. Based on the metal magnetic memory detection technology, the method of fixed point monitoring and rib scanning is used to study the variation of metal magnetic memory signal with internal tensile force on the surface of steel bars with different diameters. The results show that the ratio of the tensile force to the yield at the extreme value of the tangential component curve of the spontaneous magnetic flux leakage signal is 65%, and decreases with the increase of the diameter of the steel bar. The first derivative of the SMFL tangential component curve will have a large numerical peak in the elastic phase and the yield phase, respectively. In order to quantitatively detect the tensile force, this paper also defines the “force-induced fluctuation parameter”, which reflects the amplitude of the tangential component of the magnetic signal fluctuating along the direction of the rib. It is linear with the tensile force during the elastic phase of the rebar, and the slope of the line varies with the diameter. Increase and increase. Combined with the variation characteristics of the elastic SMFL signal in the elastic and yielding

stages and the slope between the force-induced fluctuation parameters and the tensile force, it provides a new method and idea for the actual engineering steel tensile force detection, and has a good application prospect.

In this paper, by analyzing the spontaneous magnetic flux leakage signal of metal, a non-destructive testing method that can be used for the internal tensile force detection of steel bars is proposed. The variation of the magnetic field strength of the steel surface with the tensile force indicates that the curve of the SMFL signal has a significant extreme point when the tensile force reaches 65% of the yield strength, and the first derivative has a distinct peak in the elastic and yielding stages. In the experiment to investigate the variation of the leakage magnetic field strength with the axial position of the steel bar under different tensile forces, a parameter reflecting the axial fluctuation of the SMFL along the steel bar is proposed. The linear relationship between the parameter and the tensile force can be used to quantitatively calculate the tensile force.

keywords: metal magnetic memory; tensile force detection; elastic stage; yield stage

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浅谈施工安全管理

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摘 要：“安全生产”是施工单位和施工项目在进行生产经营活动中的一项必不可少的重要工作内容。安全工作的成败决定单位的前途和命运，良好的安全环境，可以给单位带来社会信誉和经济效益，国家和集体财产免遭损失，职工生命安全得到保障。否则就会给单位带来巨大损失。

关键词：施工安全；管理

On Construction Safety Management

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Abstract:

"safe production" is an essential and important work content of construction units and construction projects in the production and operation activities. The success or failure of the security work determines the future and destiny of the unit. A good security environment can bring social credibility and economic benefits to the unit. The state and collective property are protected from losses and the safety of workers 'lives is guaranteed. Otherwise it will cause huge losses to the unit.

keywords: construction safety; management

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厦蓉高速公路改扩建工程交通组织方案研究

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摘 要：山区高速公路已步入改扩建期间，改扩建施工势必会影响原有交通。依托厦蓉高速漳龙段改扩建工程，针对山区高速公路改扩建工程特点提出与其适应的交通组织方案，保证道路通行能力和行车安全。

关键词：高速公路；改扩建工程；交通组织

Study of Traffic Organization for Reconstruction and Expansion of Xia-Rong Expressway

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Abstract:

Mountainous expressway has entered the period of reconstruction and expansion, and reconstruction and expansion will certainly affect the original traffic.Combining Zhanglong section of Xia-rong expressway reconstruction and expansion project,according to the characteristics of mountainous expressway,a traffic organization plan adapted of it is put forward to ensure road capacity and traffic safety.

keywords: expressway; reconstruction and expansion project; traffic organization

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Object-Oriented Road Information Recognition Based on RS and GIS

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Abstract: In recent years, with the rapid development of technology, the resolution of satellite remote sensing images has been significantly improved. The road information extraction from high resolution images has the characteristics of short cycle, fast speed and rich details. Urban road network in remote sensing image is a very important transportation infrastructure, and is also the main source of geographic information and basic data for application. The extraction of road information is of far-reaching significance to GIS data acquisition, remote sensing image understanding, mapping and spatial database updating. Automatic road extraction is an important research field of remote sensing image recognition. It has important application value for the development of geographic information technology to realize automatic, intelligent, reliable and accurate road extraction. Based on the characteristics of road radiation, geometry, topology and background in remote sensing images, this study extracts the information of roads that are still intact after the earthquake by setting empirical parameters and multi-scale segmentation combined with image features. Then overlay the GIS road vector map of the area to interpret the damaged road.

Key words: Road extraction, multi-scale segmentation, GIS Road Vector, Damaged road

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公路行道树智能攀爬采伐、修枝机器人

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山东省临沂市费县公路管理局　山东省临沂市费县公路管理局）

摘 要：在公路保畅工作中，对枯死的大型行道树进行采伐时，需要封闭交通从而造成道路临时阻断，且采伐过程存在费时费力，安全隐患较多等问题。对此，研发了智能攀爬采伐、修枝机器人。机器人通过电池提供动力，6 个棘轮以恒定压力和树干表皮接触，通过电机带动棘轮旋转实现机器人整体沿树干上下运动，机器人上安装的锯齿通过旋转组件的动作可以实现竖直和水平两种锯木作业方式。上升过程中，锯齿呈竖直状态并在旋转支撑系统的作用下围绕树干旋转，锯断树木的枝杈，在接近树干顶部或者树干直径小于机器人作业参数时，旋转组件动作将锯齿调整为水平作业状态，机器人进入下降阶段，下降过程中以节点式停留的方式将树木的主干分段横切锯断，从而完成伐树作业。此过程可以设置参数自主智能运行或者遥控作业，代替人工爬树完成采伐任务，以消除安全隐患，提升采伐效率，有效缩短封闭交通的时间。

关键词：公路；智能；采伐；机器人

Road Tree Intelligent Climbing Logging and Pruning Robot

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Abstract:

In the work of highway smoothness, when cutting dead large roadside trees, it is necessary to close the traffic and cause temporary road blockade, and the cutting process is time-consuming and laborious, and there are many potential safety hazards. In this regard, an intelligent climbing and cutting and pruning robot has been developed. The robot is powered by batteries. Six ratchets are contacted with the trunk epidermis under constant pressure. The ratchet is rotated by motors to realize the overall movement of the robot along the trunk. The sawtooth installed on the robot can achieve vertical and horizontal sawing operations through the action of rotating components. In the process of ascending, the sawtooth rotates vertically around the trunk under the action of the rotating support system, and saws the branches of trees. When approaching the top of the trunk or the diameter of the trunk is less than the operating parameters of the robot, the action of the rotating component adjusts the sawtooth to the horizontal operating state. The robot enters the descending stage, and in the descending process, the trunk of the tree is segmented and transverse in a nodal way. Cut and saw to complete the cutting operation. This process can set parameters for autonomous intelligent operation or remote control operation, instead of manual tree climbing to complete the cutting task, in order to eliminate hidden safety hazards, improve cutting efficiency, and effectively shorten the time of closed traffic.

keywords: highway intelligent logging robot

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公路三级减震防撞护栏

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摘 要：为了保障公路的行车安全，高等级公路全段或者低等级公路的危险路段都安装有防撞护栏，其主要作用是防止失控车辆冲出公路，使车辆回复到正常行驶方向，避免二次事故发生，保障车辆安全，降低司乘人员的伤害。针对目前常用防撞护栏的不足之处，研发了公路三级减震防撞护栏，该护栏采用旋转的柔性滚轮接受车辆的直接撞击，滚轮通过弹簧组件的作用可以实现横向及纵向的移动和复位，从而转嫁撞击力度和撞击角度，缓解瞬间冲击力，柔性引导失控车辆，更好的保护司乘人员，降低事故损失。在滚轮受到车辆撞击发生旋转时，滚轮内部安装的永磁发电机发电，触发信号发射器向监控中心发射报警信号，并和监控摄像的屏幕切换进行关联，第一时间掌握事故现场情况以快速精准部署救援，提升公路安全综合保障能力。

关键词：公路；三级减震；护栏

Three-level Shock Absorption and Collision-Proof Guardrail for Highway

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Abstract:

Order to ensure the traffic safety of highway, anti-collision barriers are installed in all sections of high-grade highway or dangerous sections of low-grade highway. Its main function is to prevent out-of-control vehicles from rushing out of highway, to make the vehicles return to normal driving direction, to avoid secondary accidents, to ensure vehicle safety, and to minimize the degree of injury of passengers. In view of the shortcomings of the current commonly used anti-collision barriers, a three-level anti-collision barrier for highway is developed. The barrier adopts a rotating flexible roller to accept the direct impact of vehicles. The rollers can move and reset horizontally and longitudinally through the role of spring components, thus transferring the impact force and angle, alleviating the instantaneous impact force, flexibly guiding out-of-control vehicles, and better protecting department. Take the personnel to reduce the accident losses. When the roller is rotated by vehicle impact, the permanent magnet generator installed inside the roller generates electricity, triggers the signal transmitter to send an alarm signal to the monitoring center, and correlates with the screen switch of the surveillance camera, grasps the accident scene at the first time to deploy rescue quickly and accurately, and enhances the comprehensive support ability of highway safety.

keywords: highway three-level shock absorber guardrail

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基于追尾碰撞的液罐车罐体变形失效的仿真研究

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摘 要：为了研究罐车碰撞事故中罐体结构损伤变形机理，并分析罐体失效泄漏规律以控制罐车碰撞危害。以客车与罐车的正面追尾碰撞为研究对象，分析不同条件下罐体碰撞的变形失效情况。运用 Hyper Mesh 软件建立两车的有限元模型，并导入 LS-DYNA 求解器，计算模拟出两车碰撞过程的能量变化及罐体结构变形等情况，分析了不同冲击载荷和液体属性对罐体碰撞的应力分布，位移变化以及损伤变形演变的影响。结果表明：相同接触位移下，初始撞击速度越大，罐体的变形量越大；同一碰撞速度下，变形位移量与接触位移呈正相关。根据位移云图判断罐体失效范围，得出罐体在充液比为 0.9 时的临界破裂速度为 43km/h。最后根据罐体失效单元网格计数，估计出液体泄漏速率和泄漏量。

关键词：危险货物运输；有限元模型；碰撞仿真；罐式车辆；追尾碰撞

Simulation Study on Deformation Failure of Liquid Tank Truck Based on Rear-End Collision

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Abstract:

In order to study the damage and deformation mechanism of tank structure in tank truck collision, researching the rear-end collision between passenger car and tank truck, the damage of tank body after collision under different conditions was analyzed. The deformation and failure of tank body at different collision velocities were analyzed in this paper. The finite element model of two vehicles was established by Hyper Mesh software, and the LS -DYNA solver was introduced to calculate and simulate the energy change and tank structure deformation. This paper analyzed the impact of different impact loads and liquid properties on the stress distribution, displacement change and damage deformation evolution of tank body collision, probed into the damage evolution trend of tank body after structural failure. The results showed that the greater the initial impact velocity, the greater the deformation of tank body. At the same collision velocity, the deformation displacement was positively correlated with the contact displacement. According to the displacement cloud diagram, the failure range of tank was determined, and the critical rupture velocity of tank at the filling ratio of 0.9 was obtained as 43km/h. Finally, the liquid leakage rate and leakage quantity were estimated according to the tank failure cell grid.

keywords: dangerous goods transport; finite element model; collision simulation; tank vehicles; rear-end collision

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基于无人机影像的灾后快速评估系统研究

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摘 要：在分析当前公路地质灾害后主要的评估方式后，提出影像评估法框架。并对框架的核心内容即影像评估法的不同适用场景进行了阐述和不同适用场景的方案对比，对关键算法进行了说明，可为后续搭建灾后快速应急平台提供支撑。

关键词：无人机影像；快速评估；应急

Research on Rapid Post-Disaster Assessment System Based on Unmanned Aerial Vehicle Image

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Abstract:

After analyzing the main assessment methods of highway geological hazards at present, the framework of image evaluation method is proposed. The core content of the framework, i.e. different application scenarios of image evaluation method, is expounded and the schemes of different application scenarios are compared,and the key algorithms are explained, which can be used as a support for the subsequent construction of a rapid post-disaster emergency platform..

keywords: unmanned aerial vehicle image; rapid assessment system; emergency

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Analysing the Robustness of Hazmat Interdependent Network Under Emergency of Hazmat Transportation

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Abstract: For researching on the emergency accident of hazmat transportation, we analyse the impact of robustness of hazmat interdependent network which consists of hazmat physics network and hazmat flow network. This paper focuses on building simulation model of failure percolation process, and analysing the different parameters impact, including limitation value, the number of hazmat transportation, node bearing capacity coefficient, the number of emergency accidents of hazmat transportation. Through simulating with the hazmat interdependent network of Pengzhou city, we could get the results of network connectivity and the livability of hazmat transporting to judge the robustness strength of it. Simulation results show that the node bearing capacity coefficient has a great impact on the robustness of hazmat interdependent network. Especially when the value of limitation is low and there are more emergency accidents of hazmat transportation, increasing node bearing capacity coefficient could effectively improve it robustness. When the current system has less hazmat transportation, the less emergency accidents of hazmat transportation, and the higher limitation value, the robustness of hazmat interdependent network is stronger.

Key words: hazmat transportation; interdependent network; robustness; emergency accident; simulation

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The Interaction Effects of Weather and Roadway Characteristic Factors on Freeway Monthly Crash Counts

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Abstract: How the weather factors affect freeway crash frequency has been investigated by many studies. However, most of them assumed the relationship between crash frequency and weather factors are independent from other risk factors and rarely no studies have conducted to explore the interaction effect between roadway characteristics and weather factors.To comprehensively quantify the interaction effects contributing to crash occurrence, the interaction terms of various weather factors and roadway characteristics factors are introduced as the explanatory variables in the freeway crash frequency model. The data obtained from Kaiyang Freeway, Guangdong Province, China, are used for the empirical analysis and due to the great variation of meteorological data among months in this area, the data would be aggregated and analyzed by month in this paper. As for the methodology, Poisson model, Bayesian spatial model and Bayesian spatio-temporal model are adopted and compared in this paper. The model results show that there are significant spatial and temporal effects in crash frequency and the spatial-temporal model fits the crash data best. Significant interaction effects are found in steep slope indicator and wind speed, steep slope indicator and precipitation, steep slope indicator and visibility as well as curve segment indicator and precipitation.

Key words: freeway safety; weather condition; roadway characteristic factors; interaction effect; spatio-temporal correlation

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Mechanical Ice Removal Equipment for Winter Road Maintenance in Northern American: A Feasibility and Importance Review

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Abstract: In the northern American (U.S. and Canada), current methods used for winter road maintenance include snow plows, snow melts and abrasives. These methods hold considerable limitations that lead to increased costs. 22 million tons of melting salts are scattered each year in the U.S., leading to a 1.4 billion dollar annual national salt cost, on material alone. Snow melts have severe toxicity implications affecting soils, ground and surface water, vegetation, aquatic wild life, vehicles, and infrastructure. In recent years, mechanical ice-breaking/snow-removal equipment emerges as a revolutionary solution to replace traditional, methods for winter road maintenance. However, the feasibility of implementation of mechanical ice removal system in the northern American remains elusive. Therefore, we conducted a review study aiming at investigating the feasibility and importance of using mechanical ice removal system for winter road management in the northern American. Mechanical ice removal system is compared with traditional ice removal methods in terms of efficiency and effectiveness, capability, cost, and environmental impact. The design principles of mechanical ice removal equipment are discussed. The manufactures and current status of development of mechanical ice removal equipment in the U.S. are reviewed.

Key words: Mechanical ice-breaking/snow-removal system; winter road management; environmental impact

基于云模型计算的长下坡货车动态风险预警模型研究

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摘 要：为提高长大下坡路段大货车的行驶安全性，本文建立了基于云模型计算的长大下坡道路风险预警模型，以此对长大下坡路段大货车的安全性进行评估。模型从人、车、路角度分析长下坡事故类型，建立长下坡货车动态风险预警指标体系。提出指标阈值划分方法，采用熵权法进行各指标权重计算，采用云模型发生器实现定性到定量的转变过程，进而对综合评价风险指标进行等级划分。最后以G5京昆高速某长下坡路段试验车辆A、B时段实测数据为例，对长大下坡路段货车动态风险进行评估，并采用亿车公里事故率进行验证。结果表明：基于不确定性分析的长大下坡路段行车风险预警模型可以有效实现车辆在长大下坡路段行车风险等级定性判断，从而达到短临预警的目的。

关键词：道路工程；风险预警；长大下坡；云模型；云发生器

Research on Driving Risk Early Warning of Long Slope Downhill Section Based on Cloud Model

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Abstract:

In order to realize safety assessment for vehicles operating and improve the driving safety of vehicles on long Slope downhill sections, thus road risk warning model is established. By analyzing the three categories of indicators based on persion, vehicles, and roads. Providing a feasible early warning method for road vehicles. The weights of each index are calculated by using the AHP method and group decision theory. The cloud model is used to establish the index threshold division through the qualitative to quantitative transformation process. Finally, the risk index level is evaluated by taking the measured data of the test vehicles A and B at a long downhill section of the G5 Jingkun Expressway as an example. The results show that the early warning model of the traffic risk of the long slope downhill section based on the uncertainty analysis can effectively realize the qualitative judgment of the vehicle's risk level in the long downhill section, thus achieving the short-term warning.

keywords: risk warning; Long Slope Downhill Section; cloud model; cloud generator; road engineering

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恐惧缺失与机动车事故防控研究

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摘 要：本文以机动车驾驶人为研究对象，对驾驶人驾驶相关行为能力与机动车事故开展相关研究。认为驾驶人因各种因素而出现的一些不同程度的驾驶相关行为能力缺陷是一种自然现象，尽管这是一种重要的风险因素，但其本身并不是引发事故的关键性因素。如果驾驶人因对这种风险因素缺乏足够的认知而丧失应有的理性恐惧，则有可能引发驾驶人错误的驾驶行为，并在错误驾驶行为与某些行为能力缺陷的双重因素下而引发事故。
本文强调提高驾驶人对自身风险的认知度，激发驾驶人自我保护的本能是一种值得推广的预防和控制机动车事故的有效手段。

关键词：恐惧缺失；驾驶相关行为能力；机动车事故

Research on Fear Absence and Motor Vehicle Accident Prevention and Control

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Abstract:

In this paper, motorist as the research object, the driver driving related behavior ability and motor vehicle accident related research. It is believed that it is a natural phenomenon for drivers to have some driving related behavior defects of different degrees due to various factors. Although this is an important risk factor, it is not the key factor to cause accidents. If the driver loses the rational fear due to the lack of sufficient cognition of this risk factor, it may lead to the driver's wrong driving behavior. Accidents are caused by the double factors of wrong driving behavior and some behavioral ability defects.

This paper emphasizes that it is an effective way to prevent and control motor vehicle accidents to improve drivers' awareness of their own risks and stimulate their instinct of self-protection.

keywords: fear absence; driving related behavioral ability; motor vehicle accident

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浅谈治理路域范围内非法耕种占地行为

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摘 要：高速公路路域范围内非法占地耕种行为不仅破坏了公路绿化、妨碍路容路貌，且种菜人员频繁横穿公路，极易引发交通事故造成重大人员和财产损失，同时给高速公路运营管理单位带来法律责任纠纷。本文通过对非法占地耕种行为的治理予以简要总结，以供同类高速公路运营单位参考。

关键词：高速公路

A Brief Talk on the Behavior of Illegal Cultivation and Land Occupation in the Range of Governance

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Abstract:

Illegal land-occupying cultivation in Expressway area not only destroys highway greening and obstructs road appearance, but also frequently crosses the highway by vegetable planters, which is easy to cause traffic accidents and cause significant loss of personnel and property, and at the same time bring legal liability disputes to expressway operation and management units. This paper briefly summarizes the management of illegal land occupation and cultivation behavior for reference by similar Expressway operators.

keywords: Highway

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Road Transport Policy and Traffic Management in Nigeria

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Abstract: The effectiveness of road transportation relies heavily on several factors and the attitude of the road driver to traffic engineering, control and management requirement. It is in the light of the above consideration and context that this study; Road Transport policy and Traffic management in Nigeria, Directorate of Road Traffic Service (DRTS) Federal Capital Territory Abuja in Perspective can conveniently be situated. The study brings into focus for better appreciation, the important roles of the traffic officers in driving test licenses, road worthiness test, enlightenment campaign activities, highway patrol, revenue generation etc which are all important elements in actualizing the policy thrust of the country' s transport policy of adequacy and safety using both primary and secondary sources of data collection with simple percentage method of analysis and system theory as theoretical underpinning. Conclusion and far reaching recommendations were drawn in the light of the findings with the hope that such will shape the transportation policy process of government.

Key words: policy; transport; management; traffic; highway

高性能可移动钢护栏设计及碰撞仿真研究

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摘 要：本研究依托经实车碰撞试验验证、防护等级满足 A 级的高性能金属护栏进行二次开发，开发一种防撞性能好、安装拆移简便、对既有道路损害较少、具备良好复用性和回收性，可作为永（久）临（时）综合利用功能的高性能可移动钢护栏。在不改变原有护栏的受力结构的基础上，优化护栏的安装、连接细部构造，使护栏便于安装、拆卸；优化护栏的底部构造，设置活动滚轮，使护栏便于转运，使优化后的护栏作为临时设施使用时仍具备满足 A 级的防撞性能，并运用有限元软件进行碰撞仿真实验验证其防护性能。

关键词：钢护栏；可移动；数值模拟；防撞性能

Study on Design of Movable Steel Guardrail with High Performance and Collision Simulation

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Abstract:

In this study, the secondary development of movable metal guardrails high-performance, which has been verified by real vehicle crash test and meets the requirement of Grade A in protection level, was applied. The developed movable guardrail can be utilized comprehensively as permanent or temporary facilities with many merits including convenience of installation and removal, less negative effects on existing roads, and good crashworthiness, reusability & recycling. To simplify the process of the installation and demolishment, the structure of guardrail connection parts was optimized on the basis of retaining the original stressed structure. Rollers were installed at the bottom of the guardrail, which makes the guardrail movable as a temporary facility. A collision simulation experiment is conducted based on finite element model (FEM) to ensure that the requirement of Grade A can still be met by the optimized guardrail.

keywords: steel guardrail; movability; numerical simulation; crashworthiness

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高速公路弯道路段载重汽车的理论限速值研究

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摘 要：针对载重汽车在高速公路弯道路段发生侧滑及侧翻事故的可能性较大、伤亡率较高的现状，本文以传统刚性载重汽车力学模型为基础，对该模型进行了修正，提出了考虑刚柔耦合效应的载重汽车力学模型，通过受力分析推导出高速公路弯道路段载重汽车不发生侧滑、侧翻的平衡条件，提出并分析了弯道路段载重汽车瞬态转向侧滑模型和侧翻模型，探讨了载重汽车瞬态转向安全行驶条件，进而总结出了载重汽车在高速公路弯道路段的理论限速值，为载重汽车安全行驶研究提供理论基础。

关键词：弯道路段；载重汽车；侧滑；侧翻；限速值

Research on Limiting-Velocity of Truck on Curved Section of Freeway

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Abstract:

Aiming for the current situation about the probability of truck side-slip and rollover accident on curved section of freeway is big, and the casualty rate is high, this paper corrects a mechanical model on the basic of the traditional rigid truck mechanics model and puts forward the truck mechanics model considering the coupling effect of rigidity and flexibility. Combining with the balance condition about that truck would not happen side-slip and rollover accident on the curved section of freeway, this paper puts forward and analyzes the truck transient steering security model on freeway, investigation the truck transient steering safe driving conditions, and summarizes the theoretical limiting-velocity of truck on curved section of freeway, which could provide the theoretical principle for the research on running safety of the truck.

keywords: curved section; truck; sideslip; rollover; limiting-velocity

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浅谈智慧高速综合管理平台在应急处置中的应用

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摘 要：为切实提高高速公路突发事件应急处置效率，自主研发智慧高速综合管理平台，通过建立时间轴，将调度过程由线下转为线上，同时对异常路况信息，现场视频、照片，车载设备回传的视频等信息进行融合，实现路网监测可视化、应急处置可视化，打造高速公路全方位、可视化的应急调度体系，弥补道路视频盲区、应急调度滞后的短板。

关键词：高速公路；路网监测；应急调度；可视化

Application of Intelligent High-Speed Integrated Management Platform in Emergency Disposal

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Abstract:

In order to effectively improve the efficiency of expressway emergency response, we independently develop intelligent high-speed integrated management platform. By establishing a time axis, the dispatching process can be changed from off-line to on-line. At the same time, information such as abnormal road condition information, on-site video, photographs, video returned from vehicle-mounted equipment can be fused to realize the visualization of road network monitoring and emergency response, and to build a complete expressway. The orientation and visualization emergency dispatching system can make up for the blind area of road video and the lag of emergency dispatching.

keywords: expressway; road network monitoring; emergency dispatch; visualization

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高速公路出口区连续动态交通流风险评估方法

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广东省路桥建设发展有限公司）

摘 要：为了建立高速公路出口区域连续动态交通流风险计算模型，用三台无人机同时对高速公路出口区域 700 米范围进行高空垂直俯拍，获取出口区域动态交通流运行状态。提取视频中的车辆行驶轨迹，分析不同区域不同车道的交通流运行特征，包括平均速度、速度标准差、加速度、TTC 四项指标。从风险的定义出发，考虑事故发生的概率以及其后果的严重程度，提出了一种新的交通安全风险计算方法。采用速度变异系数与 v/c 比率来表征事故发生概率，采用速度的大小表示事故后果的严重程度。基于 TTC 数据对模型参数进行标定，结果表明，变异系数对风险影响最大。通过实际数据验证，该模型可用于连续的动态交通流的风险计算。

关键词：交通安全；风险评价；高速公路；出口区域

Risk Evaluation Model of Dynamic Traffic Flow at Freeway Exit Area

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Abstract:

In order to establish a risk assessment model for freeway diverging segments three drones were used at the same time to shoot the freeway. The length of the shooting range was 700 meters. Vehicle trajectories were extracted from the video, and traffic flow characteristics of different lanes in different segments were analyzed. The parameters include average speed, standard deviation, acceleration and TTC were analyzed. Based on the definition of risk, the probability and the severity of the accident were considered, a new method for calculating traffic safety risk was proposed. Coefficient of variation of speed, v/c ratio are used to represent the probability of accidents. The magnitude of speed was used to indicate the severity of the accident. TTC was used to calibrate the model parameters. The model results showed that the coefficient of variation had the greatest impact on the risk. The model was validated by actual data. The results showed that the model can be used to calculate the risk of dynamic traffic flow.

keywords: Traffic Safety; Risk Assessment; Freeway; Exit Area

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福建省高速公路工程建设信息化监管研究

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摘 要：利用互联网技术与高速公路建设行业有机结合，采用“1 个平台+N 个子系统+N 个单位”的建设模式，开发应用福建省高速公路建设监管一体化平台，将全省各在建高速公路项目的基础信息、重点工点影像、关键数据（试验数据、拌和数据、预应力张拉数据等）等内容集中从线下转移到线上，形成工程建设数据集中管控；对施工数据、图像等的采集、统计、分析，数据实时智能预警监控，提升了工程建设监管的针对性、有效性和即时性，服务“建管养”一体化和全寿命周期管理。该一体化平台应用广泛并取得了良好的效果。

关键词：高速公路；建设；信息化；监管；一体化平台

Study on the Informatization Supervision in Fujian Expressway Construction

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Abstract:

The Fujian Expressway Construction Supervision Integration Platform is developed and applied by using a construction model “One Platform + N Subsystems + N Companies”, which is organically combined Internet technology and expressway construction industry. And the basic information, image of key sites and key data (including the experimental data, the mixing data, and the prestress tension data) of whole expressway projects in Fujian are uploaded and centrally managed. Through the collection, statistics and analysis of construction data and images, and real-time early warning of unqualified data, the pertinence, effectiveness and promptness of construction supervision is promoted. The integration of Construction-Management－Maintaining and the life-cycle management is served. The integration platform is widely applied and excellent results are obtained in practical applications.

keywords: expressway; construction; informatization; supervision; integrated platform

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基于无人机低空遥感技术的公路水土保持监测应用研究

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摘 要：无人机低空遥感技术尚未在公路建设水土保持工作中形成统一、有效的方法和标准，其应用尚处于起步阶段。本研究以四川省某山区高速公路为例，利用低空航拍手段获取基础数据，提取相关水土保持要素，开展基于时间序列的公路建设期间的监测分析。首先，针对研究区域规划飞行航线，获取低空航片后进行数据预处理，生成 DOM 和 DEM 成果。其后，从 DOM 和 DEM 成果中识别施工扰动面、永久工程和临建区工程，以及各项水土保持措施、土石方开挖填筑量等水土保持相关因子，提取各要素类型、分布位置、长度、面积及体积等水保措施信息。其研究结果表明，在公路建设期间实施低空遥感监测，该方法快速、精准、直观、高效，方法简单实用，为施工期间公路水土保持工作的监测和监管提供了有效技术支撑。

关键词：无人机低空遥感技术；公路水土保持监测；应用研究

Application Research of Highway Soil and Water Conservation Monitoring Based on UAV Remote Sensing Technology

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Abstract:

Unmanned aerial vehicle (UAV) remote sensing technology has not yet formed a unified and effective method and standard for soil and water conservation in highway construction, and its application is still in its infancy. Taking a mountain expressway in Sichuan Province as an example, this study uses aerial photography to obtain basic data, extract relevant elements of soil and water conservation, and carry out monitoring and analysis of relevant elements during highway construction based on time series. Firstly, according to the research area planning flight route, the aerial photographs are acquired and data preprocessing is carried out to generate DOM and DEM results. Subsequently, from DOM and DEM results, the disturbance surface of construction, permanent engineering and adjacent construction projects, as well as various soil and water conservation measures, earthwork excavation and filling volume and other soil and water conservation related factors are identified, and the information of each element type, distribution location, length, area and volume is extracted. The results show that the implementation of remote sensing monitoring during highway construction is fast, accurate, intuitive and efficient, and the method is simple and practical, which provides effective technical support for monitoring and supervision of Highway Soil and water conservation work during construction.

keywords: UAV remote sensing technology；soil and water conservation monitoring during highway construction；application research

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基于电子文件管理的公路建设项目信息不对称问题研究

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摘 要:《建设项目电子文件归档和电子档案管理暂行办法》等规章施行后，电子文件在建设项目领域的应用必不可少、研究迫在眉睫。电子文件真实性管理与信息不对称现象之间的根本对立，表明基于电子文件管理解决信息不对称问题的可行性。科学获取信息是降低信息不对称程度的直接方法。自动采集与人工采集信息交互对照，多媒体、超文本电子文件具有的多维全程性、动态全息性，元数据对动态过程的静态映射等途径和方法的系统研究应用，有效解决了公路建设项目管理信息不对称问题。

关键词：电子文件

Research on Information Asymmetry of Highway Construction Project Based on Electronic Document Management

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Abstract:

The Interim Measures for the Filing of Electronic Documents and the Management of Electronic Archives in Construction Projects establishes the administrative effectiveness of electronic documents in the field of construction projects, making the applied research of electronic documents extremely urgent. The fundamental opposition between the authenticity management of electronic documents and the phenomenon of information asymmetry illustrates the feasibility of solving information asymmetry by electronic document management. Scientific access to information is a direct way to reduce the degree of information asymmetry. Systematic research and application of automatic acquisition and manual acquisition of information interaction multidimensional full-scale and dynamic holographic of multimedia, hypertext electronic files, and static mapping of metadata to dynamic processes, can effectively solve the information symmetry issue in highway construction project management.

keywords: electronic

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圭嘎拉高海拔隧道施工人员体力劳动强度评价

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摘 要：为探究圭嘎拉高海拔隧道施工人员体力劳动强度水平，评价施工工序劳动强度。选择圭嘎拉隧道进口段（海拔 4300m）及 1#斜井段（海拔 4560m）的施工人员作为测试对象，分别测量并计算不同工序下施工人员的心肺功能指标(心率、血氧饱和度)和劳动强度指数。测试结果表明，260m 的海拔高差造成的施工综合劳动强度指数差异具有统计学意义（P<0.05）。钢筋绑扎是所测施工工序中劳动强度最大工序，该工序下施工人员的心肺功能指标及平均能量代谢率都出现超过卫生限值的情况。

关键词：高海拔隧道；体力劳动强度；心肺功能指标；劳动强度指数

Evaluation on Physical Labor Intensity of Guigala High-Altitude Tunnel Constructors

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Abstract:

In order to explore the physical labor intensity level of Guigala high-altitude tunnel constructors and evaluate the labor intensity of construction process. The constructors in the entrance section(4300m above sea level) of Guigala tunnel and 1 # inclined section(4560m above sea level) were selected as test objects. The cardiopulmonary function index (heart rate, oxygen saturation) and labor intensity index of the constructors in different working procedures were measured and calculated respectively. The test results show that the difference of comprehensive labor intensity index of construction caused by altitude difference of 260m has statistical significance (P < 0.05).Reinforcement binding is the most labor intensive process in the measured construction process. Under this process, the cardiopulmonary function index and average energy metabolic rate of the constructors exceed the sanitary limit.

keywords: high-altitude tunnel; physical labor intensity; cardiopulmonary function index; labor intensity index

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