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Experimental Study on Characteristic and Effect of Torsion about Spatial Cable

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ABSTRACT

When converting self-anchored suspension bridge with spatial cable from initial construction state to finished dead load state, the main cable between the two saddles would be under certain torsion. An experimental model proportion of 1:15 was determined in the background of Jiangdong Bridge. Based on the model, a hanger tensioning and anchoring system and a measuring equipment for cable configuration were designed. The experiment put forward a concept of azimuth of main cable section, and a set calculation method for twisting angle of main cable section depending on the measurements from the new metrical equipment. A series of model tests were conducted for different bias angles of the sling clamp, different tensioning forces of hanger. And the regularity of the characteristic and effect of torsion is studied. The results indicate that the transverse bias angle of the clamp is the decisive influence factor to the twisting angle in its own main cable section, but almost no effect to other place. The changing of the adjacent clamps is nearly linear. When the tensioning force is small, the twisting angle is closed to terminal value and the torsional stiffness of the main cable is small. When the angle of inclination of hanger is larger (smaller) than the pre-deflected angle of the cable clamp, the cable clamp will cause the main cable section to twist in the positive (reverse) direction. With the gradual increase of the hanger force, the direction of hanger force passes through the center of cross section of the main cable, twisting angle is not changing. For the complication of regularity of torsion about the main cable near the saddles, further studies need to be conducted.

KEYWORDS: spatial cable; overall bridge model test; horizontal pre-deflected angle of cable clamp; measuring equipment for cable configuration; effect of torsion
钢箱梁横隔板弧形切口疲劳裂纹补强方案研究
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摘 要：针对压-压循环可不验算疲劳，横隔板弧形切口母材疲劳为面外反复变形所致等认知，以及探索钢箱梁弧形切口处疲劳裂纹的最优补强方案，以某悬索桥为工程背景，通过交通载荷与病害特征等信息汇集，及ABAQUS有限元软件建立钢箱梁节段的整体模型和构造细节子模型，揭示了横隔板弧形切口疲劳开裂机理，对本桥建议的几种典型补强方案的优劣性进行了分析。研究结果表明：轮载压应力幅耗费压-压循环的横隔板母材疲劳寿命；直接双面加补强钢板的方案对弧形切口起弧点应力有明显改善，但会导致横隔板与U肋连接处应力增大；采用弧形切口优化+双面补强钢板的加固方案对弧形切口及横隔板与U肋连接处应力有明显改善作用，且对补强以外稍远部位应力影响可忽略，补强钢板尺寸可统一，其边缘距U肋宜取30mm，其厚度宜取4mm。

关键词：钢箱梁横隔板；疲劳开裂机理；补强细节尺寸；应力幅

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Reinforcement Scheme about Fatigue Crack in Curved Cut of Transverse Diaphragm of Steel Box Girder
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Abstract: For the recognition that cyclic compressive fatigue needn’t be checked , and damage-fatigue of arc incision of diaphragm is caused by out-of-plane deformation , as well as to exploring the optimal reinforcement scheme of fatigue crack at the curved cut of steel box girder. Take a suspension bridge as the engineering background, by means of collecting information including fatigue detailed, traffic load and disease characteristic, and ABAQUS finite element software to establish the overall model and structural detail sub-model of the steel box girder segment, reveal the fatigue cracking mechanism of the diaphragm-shaped incision, and analyze the advantages and disadvantages of several typical reinforcement schemes proposed by the bridge. some important conclusions can be gained: Pressure
stress amplitude consumes the fatigue life of the base material of diaphragm of cyclic compressive; The method of direct double-sided and reinforcing steel plate has obvious improvement on the stress of arc-shaped incision, but it will lead to the increase of stress at the connection between the diaphragm and U-rib. The reinforcement scheme of arc-shaped incision and transverse diaphragm and U-rib connection has obvious improvement, and the effect of the reinforcing steel plate on the stress of the outside of the reinforcement is negligible, the size of reinforcing steel plate can be unified, the distance of edge to U-rib should take 30mm, and the thickness of reinforcing steel plate should take 4mm.

**key words:** diaphragm of steel box girder; fatigue cracking mechanism; size of reinforcing details; stress amplitude

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干接改湿接简支T梁桥荷载横向分布系数试验研究

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摘要：采用刚接板梁法、刚性横梁法、有限元梁格模型分析法对天津市团泊大桥简支T梁桥的荷载横向分布系数进行计算，通过与实测横向分布系数的对比分析，提出了适用干接改湿接简支T梁桥荷载横向分布系数的计算方法——刚接板梁加权平均值法。

关键词：干接改湿接T梁桥；横向分布系数；刚接板梁法；刚性横梁法；有限元梁格模型分析法

Research on Load Transverse Distribution of Simply-support T Shape Beam Bridge Joining by Dry to Wet Joint

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Abstract: TianJin TuanBo bridge is simply-support T beam bridge joining by dry to wet joint. Calculate it’s load transverse distribution by different methods, such as method of rigid-joint slab, rigid cross beam method and the finite element method of beam grid. Then put forward the applicable method of simply-support T beam bridge load transverse distribution-the weighted average method of rigid connection, through comparing with the results of field test.

key words: simply-support T beam bridge joining by dry to wet joint; load transverse distribution; method of rigid-joint slab; rigid cross beam method; the finite element method of beam grid

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体外束对波形钢腹板简支箱梁自振频率影响分析

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摘 要: 为了分析体外束张拉对波形钢腹板简支箱梁自振频率的影响，进一步解释模型梁的试验结果，基于波形钢腹板简支梁在体外预应力作用下的弯曲振动微分方程，推导波形钢腹板组合箱梁的自振频率解析公式，然后参考模型试验梁，综合考虑预应力张拉和混凝土复杂应力状态下弹性模量的修正，采用数值方法分析结构的自振频率。分析表明: 预应力张拉产生“应力软化”效应引起结构总刚度降低，波形钢腹板组合箱梁结构的频率降低; 对于文中参考的试验模型梁，预应力张拉对波形钢腹板组合箱梁结构的刚度影响较小，在桥梁工程中预应力张拉范围内，预应力张拉对自振频率的影响很小; 另一方面，体外束预应力使得混凝土处于复杂应力状态，材料的弹性模量与单向应力状态下的弹性模量不同，可通过弹性模量和预应力效应的考虑解释模型梁的试验结果。

关键词: 体外束; 波形钢腹板组合箱梁; 简支梁; 自振频率

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Analysis Influence of External Strand on Vibration Frequency of Simply Supported Box Girder with Corrugated Steel Webs

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Abstract: To analyze the impact of external strand to simply supported beam vibration frequency of composite box girder with corrugated steel webs, further to understand the experimental results of the model beam, based on differential equation of flexural vibration of simply supported beam with corrugated steel web under external strand, analytical formula of the vibration frequency of the composite box girder with corrugated steel webs is derived. Then reference model test beam, comprehensive consideration revision of the elastic modulus in the condition of the concrete complex stress state because of prestressed tension, numerical method is used to analyze the natural frequency of the structure. From results, it is indicated that prestressed tension have an impact of stress softening to cause decrease of the total stiffness of the structure. Therefore the vibration frequency of composite
box girder with corrugated steel webs is reduced. But for reference model test beam, prestressed tension has little influence on the stiffness of composite box girder with corrugated steel webs, so in the range of prestressed tension of the bridge engineering, the influence of prestress tension on the vibration frequency is very small. However the concrete is in a complex stress state because of prestressed tension, the elasticity modulus of the material is different from that of the uniaxial stress state’s, thus the test beam’s experimental results can be explained by the consideration of the elastic modulus and the prestressing effect.

**key words:** external strand; composite box girder with corrugated steel webs; simply supported beam; vibration frequency

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温度效应下曲线梁爬移的机理分析

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摘 要：为了明确曲线梁爬移的力学机理，进一步确定温度效应下曲线梁的爬移，利用ANSYS有限元软件建立某曲线梁的实体模型，采用稳态热分析确定各节点的温度即温度场，在此基础上采用一次荷载代替长期反复荷载，主梁横桥向位移代替爬移变形的方法分析温度效应下曲线梁爬移；然后为了进一步说明曲线梁桥的爬移机理，并探讨摩擦力使橡胶支座产生残余变形进而使曲线梁出现横向爬移的过程，利用Combine39单元模拟桥梁爬移时支座变形的累计效应，近似分析温度效应下曲线梁爬移的力学机理。研究表明：温度效应是曲线梁爬移的重要外部荷载原因，灰尘和垃圾堵塞支座空隙、支座材料老化和支座摩擦力是引起曲线梁桥爬移的主要内在因素，通过Combine39单元模拟橡胶支座的摩擦力-残余变形可以近似分析曲线梁爬移的变形累积过程，该方法能定量解释曲线梁桥横向爬移的机理。

关键词：曲线梁；爬移；残余变形；累积效应

中图分类号: U442.5 文献标识码:A

Analysis of the Mechanism of Curved Beam Lateral Deformation under Temperature Effect

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Abstract: To understand the mechanism of the curved beam lateral displacement, further to determine the curved beam lateral displacement under temperature effect, using ANSYS finite element software to establish solid element model of a curved beam, steady state thermal analysis method is applied to analyze temperature field. Based on the analysis, using the primary load instead of the long-term repeated load, transverse displacement of main girder instead of lateral deformation, the curved beam lateral deformation under temperature effect is analyzed. Then in order to further explain the lateral deformation mechanism of curved beam, to discuss the frictional force causing the residual deformation of the rubber bearing to make the lateral deformation of the curved beam, using Combine39 element to simulate cumulative effect of the bearing lateral deformation, the mechanical
mechanism of curved beam under temperature effect is approximately analyzed. It is indicated that temperature effect is an important external load factor of curved beam lateral deformation. The main factors that cause the displacement of curved beam are dust and garbage to clog the gap of bearing, the aging of bearing material and the friction of bearing. The method of using Combine39 element to approximately simulate cumulative effect of the bearing lateral deformation is feasible and this method can be used to explain the mechanism of lateral deformation of curved beam.

key words: curve beam; lateral displacement, residual deformation; cumulative effect
王母渡大桥维修加固经济评价方法
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摘 要：桥梁在服役期常出现病害，为了确保桥梁正常使用，从技术角度探求得到经济、合理、可行的处治措施。采用现行标准对待检测桥梁进行技术状况评定，提出桥梁维修加固经济分析方法。通过工程实例计算表明，王母渡大桥采取维修加固方案比拆除重建方案更经济，是最符合事情情况的处治措施。

关键字：桥梁工程；桥梁检测；技术评定；维修加固；经济评价

The Economic Evaluation Method of Maintenance and Reinforcement for WangMudu Bridge
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Abstract: Bridges are often damaged within the service period. In order to ensure the normal use of the bridge, to explore the economic, reasonable and feasible treatment measures from a technical perspective, we use the current standard to evaluate the technical condition of the bridge, and the economic analysis method of bridge maintenance and reinforcement is put forward. Through project examples, the results show that the maintenance and reinforcement plan of WangMudu bridge is more economical than demolition and reconstruction program, and it is the most suitable treatment measures.

key words: Bridge engineering; Bridge detection; Technical assessment; Maintenance and Reinforcement; Economic evaluation.

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波形钢腹板组合T梁的力学性能与试验研究

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摘 要: 为探索新型结构波形钢腹板组合T梁的受力性能, 制作了缩尺试验梁, 采用两点对称加载的方式开展了静载破坏性试验, 对试验梁的截面正应变分布、荷载-位移曲线、开裂弯矩、剪应力分布、破坏形态、裂缝分布和发展规律等进行测试。采用ABAQUS软件建立了有限元模型, 进行了加载全过程非线性分析。研究表明: 只布置下翼缘板纵向预应力受力筋的波形钢腹板组合T梁的荷载-位移全过程曲线表现出较明显的弹性、弹塑性和塑性变形阶段, 具有较大的抗弯刚度和良好的抗裂性和延性; 整个加载过程中, 钢腹板与混凝土翼板变形协调, 表现为典型的受弯破坏形态; 剪应力在波形钢腹板组合T梁的腹板中分布均匀, 可不设置弯起筋提供抗剪承载力; 波形钢腹板组合T梁的力学机理明确, 静力性能良好, 具有工程应用前景。

关键词: 组合梁; 波形钢腹板; T梁; 模型试验; 应变分布

中图分类号: TU398.9

Study and Test on Mechanical Properties of Composite T-Girder with Corrugated Steel Webs

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Abstract: In order to analyze the mechanical performances of composite T-girder with corrugated steel webs, a scaled test beam was manufactured, and the static destructive test was completed through symmetrically loading of two concentrated loads. The distribution of normal strains in section, load-displacement curves, cracking moment, distribution of shearing stresses, failure modes, distribution and development of cracks of test beam under loads were tested. The finite element model of test beam is built by the general FEA software ABAQUS, and the overall process of loading is analyzed through nonlinear calculation. The research indicated that the overall process of load-displacement curves of
composite T-girder with corrugated steel webs which only with longitudinal pre-stressed force tendons is arranged on the lower flange plate obviously shows elastic stage, elastic-plastic stage and plastic stage, and the test beam has large flexural rigidity, crack resistance and ductility. The deformations of the steel webs and concrete flange are compatibility in the whole loading process and no visible slip, and show typical bending failure. Shear stresses are evenly distributed in the web of the composite T-girder of corrugated webs, and needn’t set the bending tendons to provide shear bearing capacity. The composite T-girder with corrugated steel webs with clear mechanical mechanism and well static performance has application prospect in project.

**key words:** composite beam; corrugated steel webs; T-girder; model test; strain distribution

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加快推进快速施工桥梁关键技术在中国的研发与应用

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摘要：本文在论述快速施工桥梁技术在美国及欧洲国家发展现状与我国的桥梁工业化发展现状对比的基础上，找出我国快速施工桥梁发展方面的差距，指出中小型桥梁发展快速施工桥梁技术应把钢—混凝土组合结构桥，尤其是高性能多梁式的钢—混凝土组合小箱梁桥作为重要发展方向。并针对存在的问题，提出应加快在快速施工桥梁的结构分析设计理论、结构全寿命的性能、风险分析及控制、施工工艺及质量控制、工厂化预制生产技术及装备、技术标准规范编制等关键技术研究和产业化鼓动政策的建议和制定，推动我国桥梁工业化与信息化的融合发展。

关键词：快速施工桥梁; 钢—混凝土组合结构; 设计; 施工; 规范

Accelerating Study on Key Technologies of Accelerated Bridge Construction in China and Application

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Abstract: This paper described the state-of-art of bridge industrialization development among United States and European countries and China about accelerated bridge construction (ABC) technology and their comparison was finished. Based on the above work, the gap in the field of ABC technology in China was found. It was pointed out that the ABC technology should take the steel-concrete composite structure bridges, especially the high performance steel-concrete composite small multi-box girder bridges as an important development direction in the small and medium span bridges of Chinese bridge
engineering field. Aiming at the existing problems of ABC technology in China, accelerating the study on key technologies of the structural analysis and design theory, the performance of the whole life, risk analysis and control, construction technology and quality control, factory prefabrication production technology and equipment, technical standards or specifications etc. was put forward. The encouragement policy of industrialization in ABC technology was suggested and made to promote the fusion and development of industrialization and informatization of bridges in China.

**key words:** Accelerated bridge construction; steel-concrete composite structure; design; construction; specifications
Experimental Studies on the Mechanical Characteristics of Shear Connectors under Monotonic and Repeated Loads

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ABSTRACT

Shear connector is a key part as the connection of steel beam and flange up and down in composite bridges. Push-out test is adopted to investigate the mechanical characteristics of 12 specimens in 3 types include angle connectors, channel connectors and Twin-PBL connectors by monotonic load and repeated load, such as bearing capacity, load-slip curve, ductility, initial stiffness, stiffness degradation and energy dissipation capacity. The results show that, the ultimate bearing capacity of Channel connectors is better than angle connectors and Twin-PBL connectors. The ductility
of Twin-PBL connector is greater than angle connector and channel connector, and the least one is channel connector. Compared the results of the bearing capacity of all specimens have no significant difference between monotonic loads and repeated loads. The hysteresis curves of the three connectors are full and show good energy dissipation capacity.

**KEYWORDS:** angle connectors; channel connectors; Twin-PBL connectors; monotonic load; repeated load; push-out
波形钢腹板组合梁矮塔斜拉桥受力性能试验研究

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摘 要: 将波形钢腹板箱梁作为矮塔斜拉桥的主梁, 可以综合波形钢腹板组合箱梁和矮塔斜拉桥的优势, 具有降低结构自重、增大桥梁跨径、减小地震反应等优势。本文根据世界上首座单箱三室波形钢腹板矮塔斜拉桥—栗东(Rittoh)桥, 设计了1:2缩尺模型试验梁, 对波形钢腹板组合箱梁矮塔斜拉桥受力性能进行了试验研究。试验结果表明, 体外预应力作用下, 主梁顶板混凝土锚固端处出现应力集中现象, 远离锚固端处正应力横向分布均匀。斜拉索索力作用下, 外侧波形钢腹板剪力值普遍大于内衬波形钢, 同时, 还分析了对称荷载和偏载作用下主梁挠度值, 且试验结果与有限元结果符合较好。

关键词: 波形钢腹板; 矮塔斜拉桥; 模型试验; 体外预应力; 剪力分配

中图分类号: TU441

Experimental Study on Mechanical Behavior of Extradosed Cable-stayed Bridge with Corrugated Steel Webs

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Abstract: Composed of composite beams with corrugated steel webs and extradosed cable-stayed bridge, extradosed cable-stayed bridge with corrugated steel webs can combine the advantages of composite girders with corrugated steel webs and extradosed cable-stayed bridges, thus they have lower structural weight, show large spanning capacity and decrease earthquake response. The experiments that designed in One-half scale model based on the world’s first extradosed cable-stayed bridge with corrugated steel webs that it adopted a three-cell box cross section—Rittoh bridge that on the mechanical performance of the extradosed cable-stayed bridge with corrugated steel webs

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were conducted. Following conclusions can be drawn from the experiments. Under the action of external prestressed, the phenomenon of stress concentration occurs near the anchorage, and uniformly distributed normal stress along the transverse direction far away the anchorage. Under the cable force, shear of the lateral corrugated steel webs is greater than the medial. Besides, the deflection of main beam under the symmetrical load and the partial load were also analyzed. And the results of the model test are in good agreement with the finite elements.

**key words:** corrugated steel webs; extradosed cable-stayed bridge; one-half scale model test; externally prestressed; shear distribution

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崇启大桥钢桥面板抗疲劳分析

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摘 要: 崇启大桥是目前国内最大跨度的钢箱连续梁桥，采用正交异性钢桥面板。由于正交异性钢桥面板为焊接薄壁结构，在服役期内将承受次数极高的轮载作用，其疲劳问题需受重视。本文建立了崇启大桥正交异性钢桥面板板壳有限元模型，分析了关键构造细节在疲劳车辆作用下的应力历程和应力幅值，依据基于Miner准则的累积损伤理论，对关键构造细节进行了抗疲劳分析。结果表明，其面板、纵肋及横肋刚度和关键构造细节的疲劳强度是充分的，在服役期内各主要关键构造细节将不产生疲劳裂纹。

关键词: 崇启大桥; 正交异性钢桥面板; 疲劳

中图分类号: U441.4

Fatigue Analysis of Steel Orthotropic Decks of Chongqi Bridge

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Abstract: Chongqi bridge is the longest-span continuous steel box girder bridge with an orthotropic steel deck in China. Due to the small thickness of the welded deck plate, rib wall and transverse stiffen, out-of-plane bending moments result in high local flexural stresses causing fatigue cracks to develop in the steel orthotropic decks. Aiming at the fatigue problem of the orthotropic steel bridge deck plate, the finite element model of bridge deck plate is established with linear elastic shell elements and the stresses of critical fatigue details were calculated. The fatigue properties of the orthotropic steel deck plate of Chongqi bridge based on the S-N curve method in accordance with Miner rule were analyzed. The results show that the orthotropic steel deck has adequate fatigue strength and no fatigue cracks would occur at the key details under the given fatigue loads.

key words: Chongqi bridge; the orthotropic steel deck plate; fatigue

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钢筋混凝土梁在腐蚀与交变荷载耦合下疲劳性能试验研究

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摘 要: 近海岸线混凝土结构工程承受车辆重复荷载或动荷载的同时也受到大气环境和海洋环境等作用，在交变荷载和腐蚀环境的耦合作用下增加了发生疲劳破坏的概率。本文进行了空气和氯盐环境下钢筋混凝土梁疲劳试验，对试验梁疲劳腐蚀过程、破坏形态和腐蚀疲劳特征进行了分析，研究了不同环境与交变荷载作用下梁的挠度、裂缝等随疲劳次数的变化规律。结果表明，交变荷载和腐蚀环境耦合作用下梁的疲劳寿命极大降低，梁的挠度与裂缝随荷载循环次数不断增加而不断增大，钢筋裂纹疲劳发展过程缩短，属于腐蚀疲劳破坏。

关键词: 钢筋混凝土; 交变荷载; 腐蚀疲劳; 耦合作用; 疲劳寿命

中图分类号: TU375.1

Experimental Study on Fatigue Performance of Reinforced Concrete Beams under Corrosive Environment and Cyclic Load Coupling

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Abstract: In marine environment, reinforced concrete bridge structures, in which concrete subjected to alternating load and chloride ingress, resulting in corrosion of reinforcing bars, induced considerable reduction in the fatigue strength, early deterioration and loss their durability. The reinforced concrete beam fatigue tests in air environment and chlorine salt corrosion environment were carried out. The fatigue corrosion process, the damage mode and corrosion features of the test beams were analyzed and the relationships of deflection, crack and number of cycles in the different environment were given. Results show that fatigue life of the beam were greatly reduced under coupling effect of the alternating load and corrosive environment. The deflection and crack keep growing with the increase of loading cycles. Failure mode of the beam is corrosion fatigue damage.

key words: Reinforced concrete; cyclic loading; corrosion fatigue; coupled effect; fatigue life

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大学生结构设计大赛材料力学性能试验研究

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摘 要：为研究大学生结构大赛采用的白卡纸、竹皮、桐木的力学性能，应用LDS-5电子拉力试验机对222个试件进行轴向拉伸试验，探讨白卡纸、竹皮、桐木三种材料在不同厚度、宽度、长度条件下的受力性能。研究表明：对于白卡纸、竹皮、桐木三种材料，大部分试件发生正截面断裂，极限承载力随着试件宽度的增加而增大。竹皮材料随着厚度的增加，极限承载力的增长幅度呈上升趋势。在厚度和宽度相同的条件下，长度增加，材料出现节点缺陷的概率增大，极限承载能力下降。在对桐木试件进行加载过程中，由于施加的拉力存在偏心，削弱了试件的极限承载能力，对于白卡纸试件，长度改变对试件极限承载力无明显影响。综合强度和减轻结构重量等因素，厚度为0.35mm的竹皮材料最为适合制作拉索构件。最后获得不同材料的弹性模量、极限抗拉强度，为结构设计及有限元结构仿真分析提供较为精确的材料性能依据。

关键词：材料抗拉性能；大学生结构设计竞赛；竹皮；桐木；白卡纸；弹性模量

中文分类号：O346 文献标识码：A

Experimental Study on Mechanical Properties of Materials for Structural Design Competition of University Students

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Abstract: In order to study the mechanical properties of white cardboard, bamboo skin, paulownia, used of the structure of college student competition, use the LDS-5 electronic tensile testing machine to carry out the axial tension test on 222 specimens. Investigate the stress performance of the white cardboard, bamboo skin, paulownia in the condition of different thickness, width and length. The study results show that: most of the test piece fracture along the cross section, ultimate bearing capacity increases with the increase of the width. With the increase of the thickness, the growth range of the ultimate bearing capacity increases with the increase of the thickness. Under the same thickness and width, the length increases, the probability of the node defects increases, and the ultimate bearing
capacity decreases. When loads process the paulownia specimen, the applied force of eccentric weakened the ultimate bearing capacity of the specimen. The length change of specimens had no significant effect on the ultimate bearing capacity of the white cardboard specimens. Comprehensive strength and reducing the weight of structure and other factors, the thickness of the bamboo skin material 0.35mm is the most suitable for the production of cable members. Finally, the elastic modulus and ultimate tensile strength parameters of different materials are obtained, which can provide a more accurate basis for the structural design and finite element simulation analysis.

key words: tensile properties of materials; University Design Contest; bamboo; paulownia; white cardboard; elastic modulus

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大件运输通行高速公路桥梁的荷载组合参数探讨

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摘  要: 为分析探讨大件运输过桥时承载力计算有关参数的选取问题，分析了大件运输明显不同于一般汽车设计荷载的特点；根据大件运输的偶然荷载特性，分析和提出了大件运输荷载组合原则；讨论推荐了高速公路桥梁大件运输承载力计算的荷载分项系数取值方法。

关键词: 桥梁工程; 公路大件运输; 荷载组合系数; 横向分配; 动态规划法

Abstract: To discuss about choosing the parameters of bearing capacity with oversize vehicles passing the bridge, this study analyzes the characteristics of designing load of oversize vehicles which are different from the general cars’; according to the characteristics of accidental load of oversize transportation, this research analyzes and proposes the load combination principle of oversize transportation; recommends valve-taking method of partial coefficients for the load of bearing capacity calculation of highway large-scale transportation.

key words: bridge engineering; road heavy transportation; load combination coefficient; transverse allocation; dynamic programming technique

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E-mail:352276628@qq.com
人工制备湿陷性黄土地基下连续墙基础承载特性研究
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摘 要: 为研究湿陷性黄土地基下连续墙基础竖向极限承载特性及浸水后负摩擦力分布特征, 选用石英粉、砂、膨润土、石膏和工业盐制备了人工湿陷性黄土, 对人工制备湿陷性黄土的物理力学特性进行分析; 采用人工制备湿陷性黄土填筑模型试验, 进行地下连续墙基础承载特性试验研究。研究结果表明: 人工制备湿陷性黄土的物理力学参数与天然黄土基本一致, 可用于湿陷性黄土与构筑物相互作用模型试验的相似材料。地下连续墙竖向承载力达到其极限时, 外墙和内墙总侧摩阻力荷载分担比为67%, 确定地下连续墙为端承摩擦型基础。地基浸水湿陷后, 中性点深度比在0.64~0.73之间, 试验结果与桩基浸水试验测试结果较为一致。由于地下连续墙基础具有良好的整体性和防渗性, 芯土不受水的影响, 内墙侧摩阻力与承台土反力能够得以发挥, 有效地阻止墙身附加沉降的继续发展。

关键词: 基础工程; 负摩擦力; 模型试验; 地下连续墙; 人工制备湿陷性黄土

中图分类号: TU47

Experimental Research on Bearing Capacity of Underground Diaphragm Wall in Artificially Prepared Collapsible Loess Foundation
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Abstract: Experimental research on bearing behavior of diaphragm wall foundation was conducted to study the vertical ultimate bearing capacity of diaphragm wall and distribution characteristics of negative skin friction after immersion in collapsible loess foundation. Quartz powder, sand, bentonite, gypsum and industrial salt were chosen to prepare artificial collapsible loess, and its physical and mechanical properties were analyzed, which was utilized as model filling material. The research results show that the artificial loess has a high coherence with natural loess in the view of physical
and mechanical parameters, which could be applied as similar materials to model test of interaction between collapsible loess and structure. When vertical bearing capacity of the diaphragm wall reaches its limit, the load sharing ratio of the outer wall and the inner wall is 67%, and it comes to the conclusion that the diaphragm wall is a kind of end-bearing friction foundation. The range of neutral point depth ratio is from 0.64 to 0.73, which is in good agreement with the test result of immersion test of pile foundation. Because diaphragm wall foundation has good integrity and anti-permeability, core soil is not affected by water, and side friction of inner wall and the reaction force of bearing-stage soil could be exerted, which prevents the development of additional settlement of wall body effectively.

key words: foundation engineering; negative skin friction; model test; diaphragm wall; artificially prepared collapsible loess

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耗能中央扣在大跨度悬索桥抗震设计中的创新应用

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摘要：以雅康高速公路泸定大渡河特大桥为研究背景，建立该桥的空间动力计算模型，采用非线性时程分析方法研究了刚性中央扣、柔性中央扣和耗能中央扣三种形式对结构抗震性能的影响。耗能中央扣首次将防屈曲钢支撑构件应用于悬索桥，利用钢材良好的滞回耗能性能消耗地震输入能量，保护桥梁主体结构免遭破坏。研究结果表明耗能中央扣的综合性能大大优于传统的刚性中央扣和柔性中央扣，是适用于高烈度地震区大跨度悬索桥的一种理想的中央扣形式。

关键词：悬索桥；耗能中央扣；防屈曲钢支撑；延性抗震；减震设计；非线性时程分析

Application of Energy-consuming Central Buckle in Seismic Design of Long-span Suspension Bridge

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Abstract: Based on the Luding Dadu River super Bridge of Yakang Expressway, the spatial dynamic model of the bridge is established, and the influence of different forms of central buckle: rigid central buckle, flexible central buckle and energy-consuming central buckle on the seismic performance of the structure is studied with nonlinear time-history analysis method. In the energy-consuming central buckle, the anti-buckling steel support structure will be applied for the first time to the suspension bridge, the seismic energy input will be dissipated because of the hysteretic energy dissipation characteristic of the steel, thus protecting the main structure of the bridge from damage. The results show that the comprehensive performance of energy-consuming central buckle is much better than that of traditional rigid central buckle and flexible central buckle, it is an ideal central buckle form for long-span suspension bridge in high-intensity seismic zone.

key words: suspension bridge; energy-consuming central buckle; anti-buckling steel structure; ductility seismic; design of seismic reduction; nonlinear time-history analysis

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Composite Bridge Design and Pile Freeze Back Test in Cold and High-altitude Permafrost Regions

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ABSTRACT

After sixty years service of Qinghai-Tibet Road, highway joining Golmud and Lhasa was about to build. The design scheme for bridge constructed in cold and high-altitude environment needed to be analyzed. Given the complicated geological and ecological conditions plus high seismic-risk, steel-concrete composite bridge was recommended. An integral concrete-steel composite girder (ICG) scheme for permafrost region application was proposed, whose highlights mainly included mill-fabrication, overall-girder-erection, fast construction, less labour consumed by cast-in-situ. Field test for pile freeze back in permafrost region was carried out to investigate the solid bond formation time. Freeze back test was in the backdrop of the construction of Chala Ping Bridge. Pile freeze back field test could be a practical reference for the small-span bridge construction schedule drafting in
permafrost region.

**KEYWORDS:** composite bridge; steel I girder; permafrost region; frozen ground; pile freeze back
奇龙大桥独塔钢混结合梁斜拉桥施工主要技术
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摘 要: 本文以佛山奇龙大桥为例,介绍了一座主跨260m的独塔钢混结合梁斜拉桥的主要施工技术，包括主墩软弱地质条件下大直径桩基、深基坑大体积承台、高142m索塔、主跨钢箱梁安装等施工技术的改进、创新和钢混结合段、边跨混凝土梁、斜拉索安装等工艺的优化，同时运用成熟、先进的理论分析计算和科学的监控量测手段，在确保质量、安全的前提下创新了思路，缩短了工期，节约了资源投入，为类似桥梁施工提供了有益的借鉴和参考。

关键词: 独塔; 钢混; 斜拉桥; 施工技术

The Main Construction Technology of Single Pylon Steel Concrete Cable-stayed Bridge of Qilong Bridge
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Abstract: This paper takes Foshan Qilong bridge as an example, showing the main construction technology of single pylon steel concrete cable-stayed bridge with a main span of 260m, including the improvement and innovation of the construction technology of large-diameter pile foundation under the soft foundation of the main pier, large pile cap of deep foundation pit, 142-meter-high tower, the installation of steel box girder of the main span, and the optimization of the process of steel-concrete section, the concrete beam of the side, the installation of oblique cable. At the same time, using matured and advanced theoretical analysis and scientific monitoring means of measurement, shorten the construction period and saved resources under the premise of ensuring quality and safety of innovative ideas, and for similar bridge construction provides a useful reference and reference.

key words: single tower; steel-concrete; Cable-stayed bridge; construction technique

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Optimization of Ship Scheduling for CO$_2$ Emissions Minimization with Uncertain Berthing Times

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ABSTRACT

This paper deals with an optimizing ship schedule problem to minimize the total cost and CO$_2$ emissions during the whole shipping transit time considering uncertain berthing times. Increased port congestion and infrastructure constraints can impede the reliability and sustainability of liner services. Previous researches have been applied queuing theory to analyze ports’ congestion problem, ship arrivals generally follow Poisson’s distribution, which can be used to calculate the uncertain queuing times. We establish a ship scheduling optimization model including uncertain berthing times calculated by queuing methodology. The proposed problem is formulated as a mixed-integer linear programming model which applying ship arrivals as multi-server first-come-first-served law. Experiments on the container service routing show that the validity of modified model in minimizing vessel emissions and total cost, which can be solved efficiently by MATLAB.

KEYWORDS: Liner shipping; CO$_2$ emissions; Queuing theory; Port congestion; Uncertainty
Design and Analysis for Prestressed Concrete Cable-stayed Bridge

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ABSTRACT
This paper is a design of a prestressed concrete cable-stayed bridge. According to the design requirements, the design scheme of a prestressed concrete cable-stayed bridge, a prestressed concrete continuous rigid-frame bridge and a top-bear arch bridge are put forward according to the principle of safety, durability, application, environmental protection, economy and aesthetics. Considering the advantages and disadvantages of various schemes, the prestressed concrete, double cable plane, single-pylon cable-stayed bridge is taken as the recommended design scheme. Through computer modelling and structural analysis, the effect under the action of dead load and live load is calculated, Then the author designed the arrangement of the prestressed steel in the beam and checked the intension, stress, living load distortion of key sections. The results show that the internal force distribution is even and meet the requirements of the assignment, which means that the design scheme is reasonable.

KEYWORDS: prestressed concrete; single-pylon cable-stayed bridge; rational dead load state; structure analysis
钢桥厚边U形肋的研究与创新

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摘 要：钢桥正交异性板结构因其自重轻、刚度大已成为钢桥桥面的主要结构形式；正交异性板结构钢桥面体系在国内外得到广泛的应用。正交异性板结构在经历了大规模使用不久，陆续出现了桥面板结构开裂，尤其以纵向U形肋与顶板的角焊缝开裂为甚，且修复困难，严重影响了桥面板的使用寿命！针对正交异性桥面板出现的疲劳裂缝病害，研究开发新型厚边U形肋，通过对U形肋边缘进行局部加厚，从而增加U形肋和顶板的焊缝尺寸，改善焊缝偏心受压，可以大幅度提高桥面板的抗疲劳性能。

关键词：钢桥；正交异性板；焊缝疲劳开裂；端部增厚U形肋

中图分类号: U443.35

Research and Innovation on the Thickened Edge U Rib of Steel Bridge

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Abstract: The orthotropic plate of steel bridge has been the main structure of the steel bridge deck because of its light weight and big raideur; the orthotropic plate steel deck system both at home and abroad to get a large number of applications.

Shortly after a large-scale use orthotropic plate structure, Structural cracks appeared in succession the bridge panel, Especially with the Angle of the vertical u-shaped frame and roof to welding crack, seriously affect the service life of the bridge deck.

In view of the orthotropic bridge deck, the fatigue cracks in the research and development of new thick edge u-shaped frame, through the study of the local thickening of u-shaped frame edge, thereby increasing the weld dimension is u-shaped frame and roof, improving weld eccentric compression, can greatly improve the anti-fatigue performance of bridge deck.
key words: Steel bridge; The orthotropic plate; weld Fatigue cracking; the thickened edge U rib

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Numerical Analysis on the Mechanical Performance of I-section Steel-concrete Composite Girder Bridge

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ABSTRACT

Using an I-section steel-concrete composite girder bridge as the engineering background, with help of the numerical model created by ANSYS finite element software, this essay discusses the mechanical properties of the structural system under the condition of the second phase dead load and the vehicle load. The result shows that huge main tensile stress is produced on the concrete bridge deck at the bearing position, because of the negative bending moment. Transverse stress of the concrete bridge deck under the second phase dead load makes little contribution to the main tensile stress. The transverse stress of the concrete bridge deck under the vehicle load cannot be ignored. I-section girder equivalent stress is generally low under the two conditions, containing enough safety storage. The stress level of the frame members including truss beams and stiffened ribs is low, except that there are still some parts have stress concentration, and it deserves more researches.

KEYWORDS: I-sectionsteel-concretecompositegirder; mechanical properties; finite element; numerical analysis
Study on Calculation of Transverse Distribution Coefficient of I-section Steel-concrete Composite Bridge

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ABSTRACT

With a 4x30m I-section steel-concrete composite bridge as the background, this paper adopted finite element analysis software ANSYS and MIDAS CIVIL to make numerical simulation of the whole bridge and obtain load transverse distribution coefficient at mid-span. Then compare the results of two finite element models, and find that the relative error of the result is little. By comparing the calculation results of five commonly used methods with that of finite element analysis, the rigid jointed plate method is recommended to be a suitable theory to calculate transverse distribution coefficient of I-section steel-concrete composite bridge.

KEYWORDS: I-section steel-concrete composite bridge; transverse distribution coefficient; calculation theory; numerical analysis
Study on Bridge Detection Technology and Practical Application

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ABSTRACT

Based on the present situation of bridge detection technology, this paper briefly introduces the main contents and evaluation methods of bridge structure detection, makes a comprehensive evaluation of bridge detection technology, and introduces the development prospect of bridge detection technology. By the case of a bridge detection, this paper display how to use the comprehensive analysis method to evaluate the index of bridge, and the relationship between these indexes and the safety of the bridge. Finally, make bridge safety rating according to the evaluation results.

KEYWORDS: Bridge test; Detection technology; Damage theory; Evaluation method; Bridge Safety
基于ANSYS考虑收缩徐变的索力变化分析
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摘要: 斜拉索于斜拉桥受力体系中处于重要地位，混凝土收缩徐变效应对索力的影响不可忽略。本文根据我国JTGD62规范计算收缩应变和徐变系数，结合ANSYS二次开发工具APDL语言进行编程，修改LINK180单元弹性模量考虑非线性效应以准确施加索力。采用降温模拟收缩作用，CREEP准则描述徐变作用，建立全桥空间杆系模型。与MIDAS/CIVIL计算结果对比可知，此方法计算结果可靠，且耗时更短，同时索力损失值不可忽略。

关键词: 斜拉索；收缩应变；ANSYS；CREEP准则；MIDAS/CIVIL

Analysis of Cable Force Change Considering Shrinkage and Creep in ANSYS

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Abstract: Oblique cable is important in the stress-bearing system of cable-stayed bridge. The influence of shrinkage and creep effect on cable force can not be neglected. In this paper, according to the calculation method of China JTGD62 standard of shrinkage strain and creep coefficient, combined with ANSYS secondary development tool APDL language programming, modify the elastic modulus of the LINK180 unit to accurately apply the cable force. Using the cooling effect to simulate shrinkage, and CREEP criteria to describe the creep effect, set up the bridge space rod Model. Compared with the calculated results of MIDAS / CIVIL, this method is reliable and time-consuming, and the cable loss can not be neglected.

key words: oblique cable; shrinkage strain; ANSYS; CREEP criterion; MIDAS / CIVIL

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杭瑞高速公路北盘江大桥钢桁梁纵移悬拼施工

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摘 要: 杭瑞高速公路北盘江大桥由云贵两省合作共建，全长1341.4米，桥面到谷底垂直高度565米，相当于200层楼高——这也是世界最高的大桥。同时，大桥东、西两岸的主桥墩高度分别为269米和247米，720米的主跨，在同类型桥梁主跨的跨径中排名世界第二。工程首次在山区大跨度钢桁梁斜拉桥施工中，运用了纵移悬拼技术对钢桁梁节段进行吊装。

关键词: 钢桁梁; 纵移悬拼

中图分类号: U238

Steel Truss Girder Hangrui Highway Longitudinal Movement of Beipanjiang Bridge Cantilever Construction

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Abstract: hangrui highway Beipanjiang bridge by two cooperation of Yunnan and Guizhou Province, a total length of 1341.4 meters, the bridge deck to the bottom of the vertical height of 565 meters, equivalent to 200 storeys high, which is the world's highest bridge. At the same time, Ohashi To and west sides of the main pier height was 269 meters and 247 meters, 720 meters of the main span, the span in the same type of bridge main span of ranked second in the world. For the first time in the construction of large span steel truss cable-stayed bridge in mountain area, the longitudinal cantilever erection technique is used to segment the steel truss girder.

key words: steel truss girder; longitudinal cantilever

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Experiment Research on Influence of Transverse Rebar Direction on Flexural Cracking Behavior for RC

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ABSTRACT

The cracking behavior of flexural reinforced concrete (RC) members, such as bridge beams and slabs, is an important issue in the design for the serviceability limit state. It also has a significant effect on load carrying behavior. This paper deals with the influence of transverse reinforcement direction on the cracking behavior. In experimental investigation, 18 RC slab-strips were used to study the flexural cracking behavior in the presence of T-reinforcement. The T-reinforcement direction was considered as another factor. The influence of the T-reinforcement direction on the crack pattern was described qualitatively. Three concrete types, i.e., normal, high-strength and light-weight concrete were used to qualitatively study the effects of the concrete properties. In the results, the average crack spacing and maximum crack width were compared with values predicted by DIN 1045-1. The relations between the average crack spacing, the maximum crack width, and the stress in the reinforcement were also analyzed. The results indicate that the T-reinforcement direction has a complicated effect on the crack spacing and crack width for different types of concrete. Moreover, the T-reinforcement direction also affects the growth rate of crack width.

KEYWORDS: Structure experiment; reinforced concrete; bridge slab;
transversereinforcement; crack behaviors

**Abstract:** Steel reinforcement in concrete beams and slabs is a common feature in various forms of bridge structures, such as beams and bridge decks. The nature of cracks is a crucial issue under the condition of ultimate state. The nature of cracks significantly affects the load-deformation performance. This study employed a four-point loading structural test method to investigate the effect of transverse reinforcement direction on crack behavior for 18 reinforced concrete slabs. The transverse reinforcement direction was considered as an independent parameter, and the concrete type was regarded as an influencing factor, including普通混凝土, lightweight concrete, and high-strength concrete. The experimental results were compared with the calculation results from German DIN1045-1. The relationship between the flexural reinforcement stress and average crack spacing and maximum crack width was analyzed. The experimental and analytical results showed that the transverse reinforcement direction had a complex influence on crack spacing and width, and this influence was related to the type of reinforced concrete. Furthermore, the test results indicated that the transverse reinforcement could suppress the crack width.

**Author Introduction:** Dagunag Han

**Research Field:** Development of approaches to build models and to improve construction and FM processes. Advancing the capability and application of BIM with reality capture and simulation, such as TLS, FEM and sensors to represent information model and monitor safety.

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Mechanism and Countermeasures of Longitudinal Cracks During Construction of PC Box Girder Bridges Constructed by MSS

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ABSTRACT

Serious longitudinal cracks have occurred in bottom slab at cantilever stage during construction of PC box girder bridges by MSS (movable scaffolding system), this paper is devoted to studying the cracking mechanism and countermeasures. A 3D finite element model of a PC box girder constructed by MSS was built using ABAQUS to analyze the causes for the cracks, and the accuracy of the FE model was verified on the basis of field test results of stress in the bottom concrete slab. Analytical and test results indicated that the maximum transverse stress on the lower edge of the bottom slab under combined effect of all loads is about 6.8 MPa (tensile), and the main reason leading to the cracks is the
great transverse stress caused by post tension of the centrally arranged longitudinal tendons, especially by tension of tendons in the web plate. Countermeasures to prevent or reduce the cracks were proposed and compared, results showed that the transverse stress in the bottom concrete slab can be significantly reduce by setting transverse tendons, thus preventing the cracking. The stress distribution is changed to some extent by the other proposed measures, but the cracks can not be completely avoided.

**KEYWORDS:** longitudinal cracking; box girder bridges; movable scaffolding system; countermeasures
桥头搭板脱空断裂机制及处置技术讨论

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摘  要：桥头搭板脱空断裂是高等级公路的常见病害，该病害将造成桥头跳车，严重影响行车安全和舒适性。本文对桥头搭板的脱空断裂机制、判定评价标准以及处置技术进行分析，从材料选择、浆液选择以及施工工艺方面讨论了桥头搭板脱空断裂的注浆加固处置技术。桥头搭板注浆技术既可永久消除地基和路基沉降以阻止或消除搭板脱空，又能保持桥头搭板长期处于稳定的工作状态，具有很好的加固效果。

关键词：桥头搭板；脱空；断裂；机制；注浆加固

Discussion on Bridge Vibration Mechanism and Dispatching Technique

Abstract: The void and breakage of lap plate on bridgehead is one of the main damages of highway, this damage will cause vehicle bump at bridgehead and affect the safety and comfort of driving seriously. In this paper, the void mechanism and breakage of lap plate, evaluation standard and disposal technology is analyzed, and discusses grouting strengthening technology on the choice of materials, grout, and the construction technology. Grouting strengthening technology should eliminate foundation and embankment settlement permanently to prevent or eliminate lap plate void, and can keep the lap plate working in stable condition for a long time, has the very good reinforcement effect.

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摘 要: 为满足昌九高速改扩建项目涵洞部分设计建造的要求, 本文首次提出了一种构造独特的涵洞装配式八字墙洞口形式, 并利用ANSYS有限元软件建立三维实体模型对其结构进行了精确的受力分析, 得到了可适用于昌九高速改扩建项目中的扶壁式钢筋混凝土挡土墙结构形式, 及其各预制节段的最优尺寸和配筋。设计方案大幅度缩短了施工工期, 给昌九高速改扩建项目带来了可观的经济效益, 值得推广应用。

关键词: 装配式涵洞洞口; 八字翼墙; 悬臂式钢筋混凝土挡土墙; 扶壁式钢筋混凝土挡土墙

The Design Research of Box Culvert Prefabricated Hole
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Abstract: In order to satisfy the culvert design and construction requirement of “Chang Jiu Highway reconstruction project”, this paper firstly proposed a unique form of fabricated culvert wing wall. Three-dimensional models will be made by ANSYS for accurate structural analysis. As the result, the buttress reinforced concrete retaining walls with optimized size and reinforcements are obtained. The solutions can be generally used in the “Chang Jiu Highway reconstruction project”. This design scheme greatly shorter the construction time and brought considerable economic benefits to the “Chang Jiu Highway reconstruction project”. Therefore the wing wall structure form is worthy of popularization and application.

key words: fabricated culverts hole; wing wall; Cantilevered reinforced concrete retaining wall; buttress reinforced concrete retaining wall.
灌浆波纹管连接预制拼装RC墩柱-承台节点抗震试验研究

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摘要: 预制拼装钢筋混凝土(RC)墩柱与承台连接节点的关键构造及其抗震性能是强震区应用预制装配技术需要解决的关键问题。本文将灌浆金属波纹管连接锚固钢筋新技术应用于预制拼装墩柱-承台节点连接，并开展预制拼装节点的拟静力往复加载试验研究。通过对比分析拟静力往复加载试验中的预制拼装RC墩柱-承台节点与现浇节点的损伤演化过程、失效模式和非线性力学行为，评价了基于灌浆金属波纹管锚固连接的预制拼装RC墩柱-承台节点的抗震性能。研究结果表明：基于高强砂浆灌浆金属波纹管锚固连接的预制拼装RC墩柱-承台节点与现浇墩柱-承台节点在抗侧强度、位移延性和耗能能力等方面的抗震性能指标基本一致；预制拼装RC墩柱-承台节点的损伤主要发生在柱底接缝处和墩柱底部塑性铰区域，承台内预埋波纹管锚固钢筋未发生粘结滑移破坏；灌浆金属波纹管锚固钢筋连接技术可应用于强震区预制墩柱与承台的拼装连接。

关键词: 灌浆金属波纹管; 预制拼装桥墩; 抗震性能; 拟静力试验

Seismic Testing of Precast RC Bridge Column-pile Cap Joints Connected with Corrugated Grouted Duct

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Abstract: Construction detail and seismic performance are the key problems for the precast RC bridge column-pile cap joints used in seismic regions. The new technology of reinforcement bars anchored with corrugated grouted duct is used for prefabricated bridge column-pile cap joints, and the quasi-static cyclic tests were performed on the precast joint. Damage evolution process, failure mode and nonlinear behavior of precast and cast-in-place bridge column-pile cap joints during the quasi-static cyclic testing was comparably analyzed, and the seismic performance of precast and cast-in-place RC bridge column-pile cap joints were evaluated. It is concluded that the seismic performance of the
precast and cast-in-place bridge column-pile cap joints is coincident in the main seismic performance index such as lateral strength, displacement ductility, energy dissipation character and residual displacement. The main damage of precast bridge column-pile cap joint occurred on the seam and plastic hinge regions, bond-slip failure was found during the testing. Anchored reinforced bars with corrugated grouted duct can be used in precast bridge column-pile cap joints for seismic regions.

**key words:** corrugated grouted metal duct; precast bridge column; seismic performance; quasi-static testing

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The Influence of Soil Surround the Caisson Cutting Edge to Excavation and Sinking
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Abstract: In the process of excavation and sinking of the caisson, the bearing capacity of the soil surround the caisson cutting edge is the key factor of the excavation settlement and the limit of mud height. This article is based on the finite element numerical simulation, with cohesive force and Angle of internal friction as variables, analyzed the impact on the excavation of the open caisson sinking. Analysis the influence factors of the internal friction Angle as the main. At the same time, through curve fitting of Angle of internal friction, the excavation settlement and mud height to the change of the relations, and determined the limit mud height of this calculation model.

key words: caisson sinking; mud height; settlement
中承式劲性骨架拱桥施工过程稳定性分析
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摘  要：劲性骨架拱桥的一般采用缆索吊装斜拉扣挂法施工，其稳定性问题尤为关键。本文针对某拱桥，利用Midas/civil建立从扣塔施工、悬臂拼装到成桥的全部过程的空间有限元模型，计算各工况下的结构稳定性系数。本文通过扣塔稳定性的计算，对扣塔提出改进意见直至满足要求；提出增强外包混凝土阶段稳定性措施；计算浪风索的对拱肋稳定性的影响。结果显示，该桥各施工阶段的稳定性系数均满足规范要求，浪风索的设置对拱肋吊装阶段稳定性有显著影响。

关键词：劲性骨架；中承式拱桥；Midas/civil；稳定性

中图分类号：U238

Stability Analysis of the Construction Process of Half Through Stiff Skeleton Arch Bridge
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Abstract: In general, the construction of the arch bridge with cable hoisting cable is adopted, and the stability of the arch bridge is becoming more and more important. In this paper, a finite element model of the whole process of buckling tower construction, cantilever assembly to completed bridge is built by using Midas/civil for an arch bridge, and the structural stability coefficient under each operating condition is calculated. Through the calculation of the stability of the buckle tower, the improvement suggestion is put forward to meet the requirement, the measures to enhance the stability of the outsourcing concrete stage are put forward, and calculate the impact of the wind cable on the stability of the arch ribs. The results show that the stability coefficient of the bridge in each construction stage can meet the requirements of the specification, and the setting of wave cable has a significant influence on the stability of arch rib.
**key words:** Stiff skeleton; Half through arch bridge; Midas/civil; Stability

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港珠澳大桥钢箱梁制造自动化关键技术研究与应用
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摘 要: 本文以港珠澳大桥为工程背景，阐述了钢箱梁制造的技术和管理挑战，基于创造性提出并实践的钢箱梁板单元全自动生产线理念，从钢箱梁U形肋加工、板单元自动化组装及焊接技术、U形肋角焊缝相控阵检测技术、焊接数据管理系统等方面，介绍在港珠澳大桥钢箱梁制造过程中研究、应用的达到国际领先水平的自动化技术和装备，成果促成了全球首条钢箱梁板单元制造自动化示范生产线的诞生，对推进钢结构桥梁建设、打造桥梁建设品质工程、推动桥梁建设转型升级、“一带一路”具有重要的推动意义。

关键词: 港珠澳大桥；钢箱梁；自动化制造；创新

中图分类号: U238

Research and Application of Steel Box Girder Manufacturing Automation Technology in Hong Kong-Zhuhai-Macao Bridge Project
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Abstract: In the background of the Hong Kong-Zhuhai-Macao Bridge engineering, the technical and managerial challenges of steel box girder fabrication are described in this paper. Based on the creative concept and practice of automatic production line of steel box girder, the automation technology and equipment used in the steel manufacturing process which have reached the international advanced level are introduced in this paper. The main points are U-shaped ribs processing, automatic assembly and welding technology, fillet weld of U-shaped ribs phased array detection technology, and welding data management system. The results of the study led to the birth of the world's first automatic production line of steel box girder. This achievement is of great significance to promote the construction of steel bridge, the transformation and upgrading of bridge-building and “one belt and road initiative” and improve the quality of bridge construction.

key words: Hong Kong-Zhuhai-Macao Bridge; Steel Box Girder; Automated Manufacture; Innovation

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Establishment and Damage Analysis for Steel Deck Pavement Composite Beam Fatigue Model

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ABSTRACT

Different from high-grade asphalt pavement, steel bridge thin layer pavement share traffic load with orthotropic steel deck pavement and its fatigue damage is related to the latter. Based on deformation characteristics of orthotropic steel deck pavement, we established a corresponding composite beam fatigue test model. Based on damage mechanics, we put up with a steel bridge composite beam fatigue damage model. Through steel deck pavement composite beam fatigue experiments, composite beam fatigue damage equation was established. Results show that the fatigue damage test model can well reflect local mechanics response of steel deck pavement; composite beam made of different paving materials have different damage rules: stiffening pavement system has the smallest fatigue damage rate, modified asphalt SMA has the biggest fatigue damage rate and epoxy asphalt concrete has a middle level.

KEYWORDS: Steel Deck Pavement; Composite Beam; Fatigue Experiment; Damage Variable; GussAsphalt
The Study of Temperature Control on Large Concrete Cap of Shanghai-Nantong Bridge

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ABSTRACT

The temperature and crack control are essential in the concrete casting of large bridge cap, the selection of construction materials, casting method, cooling treatment method and maintenance method are utilized during the cap casting of # 28 pier of Shanghai-Nantong Bridge. The temperature were monitored during the construction and no crack was observed when the construction was finished. In the paper, the temperature was recorded and analyzed, It is concluded that the temperature difference between the inner side and the outer side of the cap depends on the highest temperature and the time difference between the peak temperature of core and surface of the cap. To eliminate the influence of the temperature on cracks, the concrete with various hydrating rates were used for the casting.

KEYWORDS: concrete casting; cap; crack; temperature difference between the inner side and the outer side of the cap; time difference between the peak temperature of core and surface of the cap.
高墩大跨连续刚构桥承台大体积混凝土水化热研究

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摘 要: 为研究高墩大跨连续刚构桥承台大体积混凝土水化热效应和控制措施，文章选取广东省龙川至怀集高速公路蛇背大桥为实例，对主墩承台进行水化热仿真计算，施工过程中进行温度监测，对比分析仿真计算结果和实测数据，结果表明: 承台大体积混凝土浇筑后36-42h水化热效应最大，温度可达70℃，采用钢制管道冷水等措施可有效降低承台水化热效应，防止有害裂缝的产生。

关键词: 桥梁工程; 水化热; 仿真分析; 大体积混凝土; 温度应力

Study on Hydration Heat of Mass Concrete Caps of Long-span Continuous Rigid Frame Bridge with High-rise Piers

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Abstract: Hydration heat control methods of mass concrete for caps of long span continuous rigid frame bridge with high-rise piers were investigated. In this study, Guangdong Longchuan to Huaiji expressway Shebei bridge has been selected as an example. A thermal simulation of hydration heat was performed on the main pier, and the temperatures in the construction process were monitored. The simulation results were compared with the measured data. The comparison results revealed that the hydration heat effect took place most significantly after 36 to 42 hours after pouring, and the temperature can reach up to 70 °C. It is shown that methods such as using cold water can effectively reduce the hydration heat effect of the bearing platform, which could prevent the occurrence of harmful cracks.

key words: bridge engineering; hydration heat; simulation analysis; mass concrete; temperature stress

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混凝土斜拉桥换索施工控制新方法研究与探讨

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摘 要：通过调研当代混凝土斜拉桥新建、换索工程，对近年来斜拉桥换索施工控制方法的国内外研究成果进行了简要综述，目前使用较为成熟的控制方法是“主梁线形和结构内力双控”的方法，代表了当前施工控制研究领域的较高水平。而现场施工过程中，往往存在主梁线形、内力无法同步与理论吻合的情况，对现场施工指导产生影响，更有甚者导致成桥状态与设计存在较大偏差。本文通过有限元模拟分析换索施工实际过程，在原有施工控制理念的基础上，以交通部重点工程“重庆市涪陵长江大桥换索施工项目”为依托进行分析研究和探讨，提出了换索施工控制过程中，以单塔拉索覆盖主梁长度为标准，将主梁大致等分为三段，并以主塔向两侧延伸方向“前三分之一采用线形控制为主、中间三分之一采用线形和内力双控、后三分之一采用索力控制为主”的新控制方法，供广大同行一起探讨。并通过该工程实例分析验证，该控制方法可很好的符合换索后主梁线形、结构内力等设计参数指标，研究成果可为换索施工控制提供理论参考和现场指导。

关键词：混凝土斜拉桥;换索施工;施工控制新方法;主梁线形;结构内力

中图分类号: U446

Research and Discussion on a New Method for Cable Replacement Construction Control of Concrete Cable-stayed Bridge

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Abstract: Based on the research on the construction of new concrete cable-stayed bridge and cable replacement, made a survey on the domestic and foreign research achievements of cable-stayed bridge construction control methods in recent years, in present, the more mature method is the double control of internal force of structure and main beam alignment, it represents the high level of the current construction control research. But in the process of construction, the main beam alignment and internal force can't be synchronized with the theory, it will impact on site construction guidance,
What's more, it will cause a large deviation between the bridge state and design state. In this paper, finite element method is used to analyze the actual process of cable replacement construction, on the basis of the original construction control concept and the analytical study of the key project of Ministry of communications, Chongqing Fuling, Yangtze River bridge cable replacement construction, put forward a new control method that take the length of single tower cable as the standard, divided the main beam into three sections, "the first 1/3 uses linear control, the second is linear and the internal force is double controlled, and the latter is mainly controlled by the cable force in the latter 1/3" for the main tower extends to both sides In the process of cable replacement construction control, and discuss with the majority of peers. Through to the engineering example analysis, the control method can well accord with the parameters of the main beam alignment, the internal force of the structure and so on, the research results can provide theoretical reference and guidance for the construction control of cable replacement.

**key words:** concrete cable-stayed bridge; cable replacement construction; new method for construction control; main beam alignment; internal force of structure

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单层桥面公轨两用混凝土连续刚构桥试验研究与评定

姜宏维1,2，向勇2

摘 要：目前，随着城市交通量日益增大，为更好的缓解交通压力，越来越多的桥梁在建设时采用公轨结合两用的方式。本文以重庆市鱼洞长江大桥为例，针对国内外极少数公轨两用单层桥面混凝土连续刚构桥，介绍了桥梁的基本概况及运营荷载，并对桥梁成桥后的承载力试验进行现场测试及分析研究，对桥梁设计、成桥状态承载能力给予准确的评价。同时为今后同类桥梁设计提供相关参考数据，也为今后同类型桥梁试验研究及评价提供借鉴和参考。

关键词：同层桥面；公轨两用；连续刚构桥；承载能力；荷载组合；试验研究

中图分类号: U238

Experimental Research and Evaluation of Single Deck Combined Highway and Railway Concrete Continuous Rigid Frame Bridge

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Abstract: At present, with the increasing urban traffic volume, in order to better ease the traffic pressure, more and more bridges in the construction of the combination of highway and railway.

This paper takes Chongqing Yudong Yangtze River bridge as an example, for a handful of domestic and foreign single deck combined highway and railway concrete continuous rigid frame bridge, introduces the basic situation and operation load of the bridge, and carries on the field test and the analysis to the bearing capacity test of the bridge after the completion of the bridge, give a accurate evaluation to the bridge design and the bearing capacity of the bridge. At the same time provide relevant reference data to similar bridge design for the future, and provide reference for the same type bridge in the future experimental research and evaluation also.

key words: single deck; combined highway and railway; continuous rigid frame bridge; carrying capacity; load combination; experimental research
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坭洲水道桥超大体积混凝土生产质量及出机温度保证措施

The Research about Measures which Could Ensure Production Quality of Extra Large Volume Concrete and Concrete Out-of-mixer Temperature, Case Study: Nizhou Waterway Bridge

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摘 要：虎门二桥坭洲水道桥超大体积混凝土质量控制为施工过程的重难点之一，其中单次浇筑混凝土超18000m³，本文主要从混凝土配合比设计，原材料“先检后用”的体系控制，保证混凝土入模温度不大于28℃降温采取的措施，以及生产过程中的质量控制等几个方面介绍超大体积混凝土的质量控制。

关键词：混凝土；超大体积；入模温度；降温措施；先检后用
High Precision Intelligent Total Station in River Crossing Elevation Measurement of "Humen" Bridge

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Abstract: The article describes the new method of high precision intelligent total station measurement during river crossing elevation measurement. This method overcomes the problems of human observation, atmospheric refraction, and other factors that affect the accuracy of measurements. It has been successfully applied in the second-order river crossing elevation measurement of "Humen" Bridge, and has practical application and reference value for similar conditions.

Keywords: Intelligent total station; Second-order river crossing elevation measurement; Triangular elevation measurement; Automatic observation
泥浆循环时间对砂土与黏性土中单桩承载特性的影响研究

Bearing Capacity of Single Pile in Sand and Cohesive Soil Considering the Mud Circulation Time

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摘 要: 钻孔灌注桩施工时常采用泥浆护壁，桩身表面形成的泥皮影响单桩的承载性能，而泥皮受泥浆循环时间及桩周土性质等因素影响。基于实际工程中泥浆护壁现场施工，对黏性土中4根泥浆循环时间不同的钻孔灌注桩进行室内模型试验，分析泥浆循环时间对模型桩承载性能的影响，并与砂土中相同试验进行对比。试验结果表明：黏性土中泥浆循环6小时、12小时和18小时后，模型桩的极限承载力分别缩减为泥浆循环5分钟时的75.00%，68.75%，62.50%，而砂土中4根模型桩的极限承载力基本不变，泥浆循环时间对黏性土中模型桩的极限承载影响更大；泥浆循环时间会影响桩端阻力和桩侧阻力的大小，随着泥浆循环时间延长，桩侧阻力非线性减小；由于黏性土的渗透性小于砂土，导致泥浆循环更容易在黏性土孔壁形成泥皮，减小孔壁摩擦，使黏性土中桩侧阻力受泥浆循环时间的影响比砂土大。

关键词:桩基; 泥浆循环; 砂土; 黏性土; 承载特性
腐蚀与疲劳作用对带损伤混凝土梁弯曲性能的影响

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摘 要：在役钢筋混凝土桥梁通常为带裂缝工作状态，而处于腐蚀环境下的桥梁又会经受车辆等重复荷载的作用，在腐蚀与荷载作用下耐久性能极大降低。本文通过6根钢筋混凝土梁的持续荷载试验和腐蚀与疲劳试验，研究了钢筋混凝土梁在持续荷载作用下的长期挠度以及在不同腐蚀与疲劳工况下的寿命、破坏形态、挠度增长及裂缝开展等性能。结果表明，在持续荷载作用下混凝土梁的挠度持续增长，梁内掺入氯盐对挠度影响不明显，但由于钢筋产生锈蚀其疲劳寿命减少较多，腐蚀与疲劳交替作用促进了梁内钢筋的锈蚀，对梁的疲劳寿命影响较大，挠度损伤和裂缝损伤累积等疲劳性能都有所降低。

关键词：钢筋混凝土梁；腐蚀；疲劳寿命；疲劳性能

中图分类号：TU375.1

Influence of Corrosion and Fatigue on Bending Performances of Damaged Concrete Beams

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Abstract: In-service reinforced concrete bridges are usually in cracked working conditions. In the corrosive environment, the bridge will withstand the repeated load such as vehicles. The durability of concrete structure will be greatly reduced under the action of corrosion and load. This article has studied the lifetime, failure modes, deflection and crack growth performance under different corrosion and fatigue working conditions through the corrosion and fatigue test on six reinforced concrete beams, as the long-term deflection through the long-term test. The result indicates that the deflection of beams will keep growing under the long-term load. The chloride salt in beam has little influence on the deflection, but it will shorten the fatigue lifetime for the corrosion of steel bars. Moreover, the corrosion environment can accelerate the rustiness of the beam bar and reduce the fatigue lifetime, as
well as the deflection damage and crack damage accumulation and other fatigue performance.

**key words:** reinforced concrete beam; corrosion; fatigue lifetime; fatigue performance

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基于金属磁记忆的钢筋混凝土锈蚀检测试验研究
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摘  要: 金属磁记忆属于无损检测技术, 能够对铁磁性材料(如钢筋)进行有效评估及早期损伤预测, 至今已在工程中得到部分应用, 其中定量分析仍是重点和难点。因此, 本文设计了两组不同锈蚀参数的试件, 在经过相应锈蚀程度后, 分别采取两种扫描方式 (切向扫描和法向扫描), 获取试件周围的磁信号; 然后通过数据分析, 对试件的锈蚀情况进行判断, 并提出相应的数据规律; 最后, 基于“磁力线分布图”, 对试验现象进行解释。试验结果表明: 当锈蚀达到一定程度时, 切向扫描的x-Bx曲线会出现“相交点”, 且两“相交点”间的距离接近于设计锈蚀宽度; 法向扫描的部分z-Bx曲线会出现“反转点”; 经提取的“反转点”x-z0曲线呈“倒U形”, 利用锈蚀度C与曲线最大值z0max和曲线中z0≠0的区域宽度W呈线性的关系, 推导出定量计算公式。本文试验可为钢筋锈蚀的无损检测提供新思路, 并对金属磁记忆技术定量分析研究带来重要意义。

关键词: 钢筋混凝土; 锈蚀检测; 金属磁记忆; 自发漏磁

中图分类号: U448.34

Experimental Study on Corrosion Detection of Reinforced Concrete Based on Metal Magnetic Memory

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Abstract: The metal magnetic memory belongs to the non-destructive technology. It can effectively evaluate the ferromagnetic material like rebar, and predict the early damage. Until now, it has been applied in some projects, but the quantitative analysis is still the focus and difficulty. Therefore, two groups of specimens with different corrosion parameters were designed in this paper. When the corresponding degree of corrosion had been completed, two modes of scanning (tangential and normal scanning) were adopted to obtain the magnetic signal around the specimens. Then via the analysis
of the data, the conditions of the corrosion were judged, and the corresponding rules were proposed. Ultimately, based on the magnetic field distribution map, the phenomenon of the test was explained. The test results showed that when the corrosion reached a certain extent, the tangential scanning curves x-Bx appeared the "intersection", and the distance between the two intersections of each curve became close to the designed width of corrosion. Some normal curves z-Bx appeared "inversion point" while the extracted "inversion point" curve x-z0 was the "inverted U-form". With the increase of corrosion, the maximum value z0max and the width of z0≠0 area W in the curve would change linearly with the corroded degree C. This paper can provide a new idea for the non-destructive testing of steel corrosion. Furthermore, it is of great significance for the quantitative analysis of the metal magnetic memory technology.

key words: reinforced concrete; corrosion detection; metal magnetic memory; self-magnetic flux leakage

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Bearing and Deformation Behavior of Vertically Loaded Single Batter Piles in Sand

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ABSTRACT

Understanding the behavior of vertically loaded batter piles and predicting the capacity and the settlement of batter piles subjected to pure vertical loading are important topics in foundation design. In order to delineate the significant variables affecting the behavior of single batter pile in sand, a testing program comprising 9 series tests was conducted. The tests were conducted on model PVC pile installed in medium dry sand to an embedded depth-to-diameter ratio, L/D, vary from 15 to 50 and with various inclined angles of 0°, 5°, 10°, and 15°. The influences of inclined angle and L/D ratio on pile head horizontal displacement, settlement and vertical ultimate bearing capacity were investigated. And also, the behavior of batter piles was compared to that of vertical piles. The test results indicate that: (1) The settlement of batter pile subjected to vertical load is greater than that of vertical pile, the bigger the inclined angle as well as the larger the L/D ratio, the greater the settlement for batter pile over the vertical pile. (2) The horizontal displacement caused by vertical load for the batter pile is closely related to the inclined angle and the ratio of L/D. The bigger the inclined angle as well as the larger the L/D ratio, the greater the horizontal displacement. A big inclined angle as well as a big ratio of L/D will result in a knee point on the load-settlement curve for batter pile, and the bigger the inclined angle and the L/D ratio, the smaller the vertical load corresponding to the knee point. (3) The inclined angle has a significant effect on the ratio of vertical ultimate bearing capacity and settlement of the batter piles with respect to the vertical piles, while the effect of the L/D ratio is less significant. A bigger inclined angle will result in a smaller ratio of bearing capacity and a larger ratio of settlement.

KEYWORDS: Batter pile; Model test; Inclined angle; Embedded depth-to-diameter ratio; Bearing capacity ratio; Settlement ratio
混凝土构件裂缝深度的超声波检测与分析

关孝文

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摘 要: 在工程结构无损检测多种可行的方法中, 超声波方法是一种最广泛和成熟的用于混凝土质量的无损检测技术, 在国内外均得到了十分广泛的应用。在工程检测中混凝土构件裂缝深度的判定往往也是借助于超声波检测这种手段来完成的。通过对裂缝深度的检测以及对裂缝深度的评定, 我们可以判断出造成构件裂缝的成因, 评估结构的安全性, 并制定相关的修复及加固方案。本文将介绍超声波单面平测法在混凝土构件裂缝深度检测中的应用及一些体会。

关键词: 无损检测; 超声波; 单面平测法

中图分类号: U443

Ultrasonic Testing and Analysis for the Depth of Concrete Structures

Crack

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Abstract: In a variety of feasible engineering structures non-destructive testing method, ultrasonic method is one of the most extensive and mature non-destructive testing techniques for concrete quality and a very wide range of applications at home and abroad. Concrete Crack depth determination in the detection of the works is also often the help of this means of ultrasonic testing to complete. Detection of crack depth and crack depth assessment, we can determine the cause of Crack causes, assess the safety of the structure, and develop repair and reinforcement program. This article describes the measurement method of ultrasound-sided flat crack depth detection in concrete structures in applications and some experience.

key words: destructive testing; ultrasonic wave; single level measurement method

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钢管混凝土拱桥拱肋节段吊装过程温度效应分析

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摘要：钢管混凝土拱桥拱肋安装过程中在整体温度变化和日照温度变化作用下的线形及应力影响不可忽略。以贵州香火岩特大桥为例，对拱肋安装过程中整体温度变化和日照温度变化作用下的结构变形、拱肋应力及温度场分布进行研究。结果表明：季节性整体温度作用效应是线性的，结构应力和线形随温度变化而发生线性变化；日照作用下，拱肋因不均匀温度场而发生不均匀变形，对拱肋轴线及高程产生重要影响；缆索吊装系统因温度变化产生的挠度变化会影响拱肋对接高程。拱肋吊装过程温度效应显著。实测拱肋高程及轴线随着温度变化而产生周期性的波动，在拱肋节段安装时可以采取两岸相互参照并结合桥位温度情况进行理论计算对温度效应加以修正。

关键词：钢管混凝土拱桥；缆索吊装；温度效应

中图分类号：U445

Temperature Effect Analysis of CFST Arch Bridge During Arch Ribs Installation

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Abstract: During arch ribs installation, the stress and deformation effects of CFST arch bridge under the overall temperature change and sunlight temperature change cannot be neglected. Taken the Xianghuoyanbridge in Guizhou as a study object, construction steel tube stress, structural deformation and temperature distribution under the overall temperature change and sunlight temperature change were in-depth studied. The results show that seasonal overall temperature effect is linear, structural stress and deformation change linearly with temperature. Under the action of sunlight temperature change, the arch ribs have nonuniform deformation due to the uneven temperature field, which have important influence on the arch rib axis and elevation. The deflection of cable hoisting system due
to temperature change will affect the height of arch rib butt joint. The temperature effect of arch ribs lifting process is remarkable, and the elevation and axis of measured arch ribs fluctuate periodically with the change of temperature. The temperature effect can amended by cross-cross-referencing and calculation of the temperature effect based on bridge temperature observation in the section of the installation of the arch.

**key words:** CFST arch bridge; cable-stayed suspension supporting; temperature effect

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Fatigue of Orthotropic Steel Deck of a Suspension Bridge in China: 
Cracking Characteristics, FE Analysis and Field Test

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ABSTRACT
Fatigue cracking of orthotropic steel bridge deck is one of the most difficult issues in the field of bridge engineering. In this paper, the cracking characteristics of orthotropic steel deck in a suspension bridge in China have been introduced and classified, indicating that the most serious cracking occurred
in the cutouts of transverse diaphragms, which accounts for 77% of the cracks in the whole bridge. Fatigue stress analysis of a crack-free diaphragm was conducted with various longitudinal and transverse wheel load positions, of which the results were verified by field test of the existing bridge. The results show that there are two stress concentration zones (zone A and zone B) in the cutout of the diaphragm, cracking tends to occur in the zone A, where the stress under local wheel loads is always compressive and the absolute value is the biggest. The out-of-plane stress caused by eccentric loading of the diaphragm is very small relative to the principle stress under local vehicle loads. The direction of crack propagation is almost perpendicular to the direction of the principal compressive stress. Results of FEA and tests also indicate that the influence scope of local wheel loads does not exceed the spacing of two adjacent diaphragms.

**KEYWORDS:** fatigue; orthotropic steel deck; cracking characteristics; FE analysis; field test
公路钢-混组合结构桥梁发展应用综述

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摘 要：通过介绍钢-混凝土组合结构在桥梁中的应用发展历史，结合组合结构桥梁技术发展情况，介绍了2015年发布的《公路钢-混组合桥梁设计施工规范》JTG/T D64-01-2015和《公路钢结构桥梁设计规范》JTG D64-2015编制情况，以及在我国“加强推进公路钢结构桥梁建设”技术政策背景下组合结构桥梁的推广应用情况，提出了在推广应用中一些值得关注的主要风险问题。

关键词：钢-混组合桥梁；历史；规范；推广应用

Summarization of Highway Steel-concrete Composite Bridge Development and Application

Abstract: Through the introduction of the historical development of the application of steel-concrete composite structure in the bridge, combined with the technology development of the composite bridge, introduces the specifications released in 2015 "Specifications for design and construction of highway steel-concrete composite bridge" JTG/T D64-01-2015 and " Specifications for design of highway steel bridge " JTG D64-2015 , as well as in our country to strengthen the application the combined bridge structure background of promoting highway steel bridge construction technology policy, put forward in the application of some main risk problems worthy of attention.

key words: Steel-concrete composite bridge; history; specification; application
Study the Demolition Cable Sequence of Large-span CFST Arch Bridge with Asymmetrical Closure

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Abstract: Authors used finite element analysis software to establish demolition cable construction stage 3D model of large-span CFST arch bridge which is a 300m span Bridge with asymmetrical closure in Xiang Huo Yan under construction in China. Analysis of the main arch about stability factor $\lambda_j$, displacement variation $d_j$, stress distribution $\sigma$ and the safety factor of buckle cable $\gamma_j$ studied five kinds of cable dismantling plan with exhaustive method. The results show that the demolition cable sequence influence on the stability of the main arch was not significant and dismantling cable with the sequence arch top to foot is more advantageous to structure construction phase stress and safety, and provide reference for similar bridge construction.

key words: CFST arch bridge; buckle cable demolition; construction stage; stability; stress redistribution

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基于金属磁记忆技术钢筋混凝土试块应力状态的试验研究

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摘 要：钢筋是钢筋混凝土结构中最主要的承重材料之一，及时、准确且无损地检测出桥梁结构内部钢筋绝对应力状态以掌握其损伤程度，对桥梁整体承载能力的评定具有重大工程意义。尽管在实际工程中也有一些钢筋应力的检测方法，但大多数都是对结构有破坏性的，因此急需一种全新且快速的对钢筋绝对应力进行无损检测的方法。本文利用金属磁记忆技术对不同应力状态下光圆钢筋、钢筋外包混凝土表面附近的磁感应强度进行了系统的检测，结果表明：光圆钢筋与钢筋外包混凝土在各个应力状态下磁感应强度曲线变化有很大的相似性，不同的是，由于受外包混凝土收缩应力等的影响，钢筋外包混凝土后的磁感应强度曲线表现出一定的波折性。但在各个应力状态下，磁感应强度曲线的突变情况仍然清晰可辨。本文成果对于后续钢筋混凝土梁乃至实桥基于金属磁记忆钢筋应力检测技术研究奠定了良好的基础。

关键词：应力检测；金属磁记忆；钢筋混凝土；无损检测

中图分类号：TU502

Experimental Study on Stress State of Reinforced Concrete Block Based on Metal Magnetic Memory

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Abstract: Reinforcement is one of the most important load-bearing materials in reinforced concrete structures. Detecting the absolute stress working condition of the reinforcement inside the bridge structure timely, accurately and un-destructively is aimed at grasping the degree of damages. It is of great engineering significance for the evaluation of the overall bearing capacity of the bridge. But most of methods of testing the stress in the actual engineering are destructive to the structure. So there is a need for a new and rapid method for non-destructive testing of the absolute stress of the reinforcement. In this paper, the magnetic flux density of plain round bars and the concrete packaging steel bars...
outside under different stress conditions was systematically detected by metal magnetic memory technology. The results showed that, The magnetic induction strength curves of the reinforced concrete and the reinforced concrete are very similar in the stress state of the reinforced concrete. The difference is that the magnetic induction strength curve of the reinforced concrete after concrete is affected by the shrinkage stress of the concrete. But in each stress state, the magnetic induction curve of the sudden change is still clearly visible. The results of this paper have laid a good foundation to the stress detection technology for the reinforced concrete beams and even the real bridge based on the metal magnetic memory.

**key words:** stress detection; Metal Magnetic Memory; reinforced concrete; non-destructive detection

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Influence Factor Analysis for Stiffening Girder Bridge Line of Concrete Self-anchored Suspension Bridge

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ABSTRACT

Through finite element numerical simulation analysis, take a concrete self-anchor suspension bridge with a main span of 156m as the engineering background, the influence factors effecting on its stiffening girder bridge line are summarized and analyzed in this paper. And the parameter sensitivity analysis of concrete elastic modulus, bulk density and unstressed length errors of suspender are calculated. The results show that there is long-term effect of concrete shrinkage and creep on the stiffening girder bridge line. It is proposed raising the loading age of the concrete of stiffening girder and ten years of concrete shrinkage should be considered to determine the stiffening girder bridge line at least. The empty cable shape of the main cable and the unstressed length of suspender play a decisive roles on the concrete self-anchored suspension bridge in the completion line. Unstressed length of suspender errors are the most sensitive to the stiffening girder bridge line compared with bulk density and elastic modulus errors of concrete stiffening girder.

KEYWORDS: Concrete self-anchor suspension bridge; Stiffening girder; Bridge line; Influence factor; Parameter sensitivity analysis
Study on Mechanical Analysis of Prestressed Concrete Curved Bridges

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ABSTRACT

Within the progressive expansion of urban traffic and highway, horizontally prestressed curved box girder bridges have become reliable and sustainable solutions for nowadays highway system and urban interchanges. Due to complex geometrical properties of curved girders, the prestressed concrete curved box girders are more complicated than straight bridges. Hence, more researches have been conducted for the purpose of determining a clear and good understanding of mechanical properties and behaviours of the curved bridges. The current study has also based on the engineering backgrounds of designed prestressed concrete curved box girders in order to investigate mechanical properties by modifying structural parameters when curved bridges are only subjected to static loads.

Based on the performance of finite element analysis, the static analysis of different bridges with variable parameters has been carried out in order to compare mechanical properties of prestressed concrete curved box girders. Results have shown that displacements and stresses of aforementioned curved box girders under dead loads and prestressed loads are exponentially deformed as the curved radius is changed but they are linearly deformed as the height of box girder is modified.

According to finite element method results, characteristics and mechanical behaviours of prestressed curved box girders can be summarized in two deformations divided as the variation of the
radius is an exponential function. However, the variation of height is a linear function.

**KEYWORDS:** Curved box girders; Prestressed Concrete; Finite Element Analysis; Static Analysis
可接入扩展公路桥梁的网级监测平台集成与实现
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摘  要: （路）网级公路桥梁监测平台以“点多面广”为主要特征。由于接入了大量不同标准的项目级桥梁监测系统，平台在兼容性、响应能力及稳定性方面受到了很大的挑战。本研究采用了私有云架构的IDC 支撑体系和优异的平台传输模式，并首次在交通行业运用了大数据缓存分发技术，最终成功解决了平台的扩展公路桥梁无缝动态接入与快速响应难题。其自主开发的平台可对网级受测桥梁实施实时监控并预警，为桥梁安全提供保障，其独特的分级数据访问控制功能也为省、市、县不同级别政府、道路交通管理部门、以及科研工作者提供查询便利。

关键词: 桥梁监测; 路网级桥梁; 监测平台; 大数据; 云技术

中图分类号: U446

Realization and Integration of Accessible Network Monitoring Platform on Highway Bridge

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Abstract: The monitoring platform of (Road) network level highway bridges has the main characteristics of extensive and comprehensive. Since successive bridge monitoring systems of project levels with different standards are accessed to the platform, the monitoring platform has faced a great challenge in stability, response ability and compatibility. In this study, the private cloud architecture IDC supporting system and the excellent platform transfer mode are adopted. Also, the technology of data caching distribution is initially introduced in the transport industry field. Problems of seamless dynamic access and rapid response of the extension of highway bridges are successfully solved. The self-developed platform can perform real-time monitoring and early warning on network level tested bridges and provide guarantee for bridge safety. Its unique hierarchical data access control function can provide different level of governments, provincial, city and county road traffic management
departments, as well as scientific researchers for convenient querying.

**key words:** bridge monitoring; network-level bridge; monitoring platform; big data; cloud technology

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基于不同超重规定的重车荷载特性及效应研究

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摘 要: 为获取超重车荷载构成特性以及重车并行过桥产生的荷载效应，收集了美国加州历时3年实测WIM数据，根据美国联邦政府和加州交通厅超重规定，将超重车分为三类，对比分析了三类超重车辆分布及荷载构成特点。基于随机过程理论建立了多车道车辆并行荷载效应计算模型，分别计算第II类超重车和加州超重车最大荷载效应，结果表明两类超重车起控制作用的荷载相同；与中美规范对比显示，由超重车引起的最不利荷载约为规范值的1.5倍，因此在桥梁设计和评估工作中，应充分考虑重车过桥对桥梁结构的影响。

关键词: 超重模型; 荷载特性; 荷载效应; 车辆并行

中图分类号: U442.5 文献标识码:A

A Study on the Configurations of Overload Trucks and Their Load Effects Based on Different Overload Provisions

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Abstract: In order to analyze the characteristics of overload truck configurations and the load effects induced by heavy trucks running on bridge lanes simultaneously, 3-year of WIM data was collected from California in USA and three classifications of overload truck were defined based on provisions issued by Federal Government and Caltrans separately, then the similarity and difference were analyzed in distribution characteristics of the three types of overload trucks. A new model was proposed for the computation of the multiple load effects considering real space of trucks loading on bridge; The maximum load effects were calculated of overload truck type II and CA-overload truck respectively, and the results indicate the same dominant truck loads. Compared with JTG and AASHTO specifications, the severest load effects are 1.5 times those values specified. It is more reasonable to take the overload truck effect into account for bridge design and evaluation.
key words: overload provision; characteristics of truck load; load effect; multiple trucks

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Research on Damage Identification of Bridge Based on Digital Image Measurement

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ABSTRACT

With the progress of society and the development of science, the number of bridges is increasing. All countries are facing the peak of the bridge maintenance and repair. In recent years, the number of the damage bridge due to excessive deformation gradually increased, which caused significant property damage and casualties. Hence health monitoring of the bridge structure is particularly important. The damage detection and identification are the core of the health monitoring, and they can be used to evaluate bridge's health status and give reasonable repair maintenance advices. In the means of bridge damage identification, deflection measurement is one of the important components. The current conventional deflection measurement methods, such as total station, connected pipe, GPS, etc., have many shortcomings as low efficiency, heavy workload, low degree of automation, operating frequency and working time constrained. GPS has a low accuracy in the vertical displacement measurement and cannot meet the dynamic measured requirements of the current bridge engineering. This paper presents a bridge health monitoring technology based on digital image measurement method in which the measurement accuracy is sub-millimeter level and can achieve the 24-hour automatic non-destructive monitoring for the deflection. It can be concluded from this paper that it is feasible to use digital image measurement method for identification of the damage in the bridge structure, because it has been validated by the theoretical analysis, the laboratory model and the application of the real bridge.

KEYWORDS: digital image measurement; bridge structure; damage identification; health monitoring
Risk Assessment for Operation Safety in Continuous Rigid Frame Bridge 
Using BDS Fusion Monitoring Technology

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ABSTRACT
The Real Time BeiDou Navigation Satellite System (BDS) has evolved into a reliable technique to detect both the three-dimensional magnitudes and frequencies of displacement of structures. BDS technology is exactly what monitoring needs for the bridge deformation. Also, the oscillations and damage severity can be evaluated and classified according to the dynamic bridge characteristics obtained from BDS. The intention of the present work is to demonstrate the use of BDS to provide data for the assessment of existing structures safety. The raw data were collected continuously over a period of 24 h at a minimum rate of 1 Hz. The collected data include traffic flow (for load estimation) and environment factors (such as wind speed, wind direction, relative humidity and temperature). The vibration frequencies are also measured from BDS data and compared with those given in the literature. The results of all the experiments proved to be very encouraging, and showed that the performance of BDS as it has developed in recent years, and that the BDS is reliably in quantifying both environmental induced bridge vibrations and high-frequency transient motion caused by vehicle loading, in particular changes of mass associated with changes in traffic loading are observed, providing the ability for verification and/or improvement of bridge design and modelling.

KEYWORDS: Bridge Detection; BeiDou Navigation Satellite System (BDS); Monitoring; Structural health monitoring
A New Method to Determining Cable Tension in Condition Assessment of Existing Suspension Bridges

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ABSTRACT

Cable tension of suspension bridge which decreases live-load deflection through its gravity stiffness under dead load is the key mechanical index for structural condition assessment and performance evaluation. Because of suspension cable’s erection errors and/or cable’s additional deformation caused by diseases of cables, anchorages, saddles and etc. actual cable tension of an existing suspension bridge is generally dissimilated the reasonable designing one. The key and primary work in condition assessment of old suspension bridges is to determining actual cable tension according to bridge’s real condition. In this paper, back analysis method which to calculate actual tension of suspension cables in servicing stage is put forward. Considering the cable’s balance equations, back analysis theory and analysis flow for condition assessment is presented. Using back analysis method, the cable tension is calculated for a 180m span suspension bridge, and theoretical solutions of whole bridges under live loads are gotten which according to its current state. Compared with results calculated according designing parameters and measured results, influence of initial tension errors to cable’s deflection and stress is analysed. It’s shown the back analysis method to calculate initial tension force of suspension cable has advantages of high precision and manœuvrability. It has reference value
for calculation cable’s initial tension force in job of condition assessment of suspension bridge.

**KEYWORDS:** Suspension bridges; Condition assessment; Back analysis method; Cable tension; Finite element method
基于动态监测的中小型混凝土桥梁安全评估技术研究

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摘 要：对中小型混凝土桥梁结构进行长期监测，从主梁挠度、应变及裂缝宽度变化进行分析，进而进行评估。

关键词：桥梁工程；安全评估；动态监测；混凝土桥梁

中图分类号：U447

Research on Safety Evaluation of Medium and Small Span Concrete Bridges Based on Dynamic Monitoring
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Abstract: Long term monitoring of small and medium span concrete bridges are taken, and structural deflection, strain and crack width are analyzed and evaluated.

key words: bridge engineering; safety evaluation; dynamic monitoring; concrete bridges

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A Computer-vision-based Crack Segmentation and Measurement Algorithm for Concrete Bridges

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ABSTRACT

Bridge crack detection is one of the key procedures of bridge inspection. Conventionally, cracks are located and measured by experienced engineers. However, this method has low efficiency and is time-consuming, especially for large and complex bridges (Bu et al., 2015). This paper focuses on concrete bridge crack segmentation and measurement, and proposes a straightforward computer-vision-based algorithm to extract and calculate crack information from raw images. Firstly, raw images were pre-processed by mathematical morphological (MM) operations; secondly, binary segmentation images were created using a fixed threshold; thirdly, non-crack components were filtered by studying their size and geometry, then a sewing method was introduced to ensure crack integrity; finally, the length, width and angle of cracks could be computed, using simple approximation. This algorithm produced good results, using indoor crack images to calibrate the measuring accuracy as well as using previous bridge inspection images to demonstrate the capability of using this algorithm on site. Two possible applications of this algorithm are discussed in the paper.

KEYWORDS: computer vision; crack segmentation; bridge inspection; mathematical morphology
施工缺陷对PC梁力学性能影响研究
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摘 要: 为研究施工缺陷对PC梁极限承载力、强度和刚度等力学性能的影响,本文以数值方法模拟了底板混凝土缺损、腹板混凝土缺损、胀模和立模偏差等四种实际施工缺陷,数值结果包括梁体极限承载力、应力和刚度变化,并将各类施工缺陷的数值模拟结果与无缺陷梁进行了对比研究。研究结果表明:1)各类施工缺陷对梁体极限承载力的影响程度较小,但是对开裂、挠度以及刚度存在不同程度的影响。2)各类施工缺陷对梁体强度影响主要集中在梁体钢筋屈服后。3)仅底板混凝土缺损对梁体刚度影响较大。

关键字: 预应力混凝土梁; 极限承载力; 施工缺陷; 刚度; 应力; 开裂荷载

Mechanical Properties of PC Girder with Constructional Defects
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Abstract: In order to study mechanical properties like ultimate load capacity, strength and flexural rigidity for PC girders with constructional defects, this paper conducted numerical simulation for four constructional defects on the girder: sectional loss on the soffit (SLS), sectional loss on the web (SLW), excessive concrete on the soffit (ECS) and vertical deviation of inner mold (VDIM). The numerical results include loading capacity, stress and deflections. With the comparison of the results for the numerical models with and without constructional defects, the following conclusions have been made: 1) All types of construction defects have lesser degree of impact on the ultimate bearing capacity of the beam, but there are different degrees of impact on crack, deflection and stiffness. 2) All constructional defects have obvious effects on the strength of the girder mainly after the reinforcement yielding. 3) SLS is the mere defect that indicates significant effects on flexural rigidity of the girder.

key words: PC girder; Ultimate load capacity; Constructional defects; Stress; Flexural rigidity; Cracking load
基于金属磁记忆的镀锌钢绞线腐蚀检测试验研究

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摘 要：针对常规技术难以检测镀锌钢绞线拉索内部腐蚀的问题，结合金属磁记忆理论在铁磁性材料早期缺陷无损检测方面的优势，提出了基于金属磁记忆（MMM）技术的镀锌钢绞线拉索腐蚀检测新方法。设计了8个钢绞线试件，运用电化学加速腐蚀方法对试件进行不同程度的腐蚀，利用霍尼韦尔HMR2300三维磁强计传感器采集钢绞线试件腐蚀后的金属磁记忆漏磁信号，研究漏磁信号的变化特征，分析漏磁信号和拉索试件腐蚀之间的关系。试验结果表明：在试件腐蚀区域漏磁信号出现明显变化，切向分量曲线出现极大值，法向分量曲线出现极大值和极小值且过零点；在试件中间腐蚀区域漏磁信号切向梯度曲线过零点，漏磁信号法向梯度曲线出现极小值；随着拉索试件腐蚀程度的增加，漏磁信号强度也相应增加；通过对试件腐蚀后的漏磁信号分析，可以较为准确判别钢绞线试件腐蚀位置及范围。该试验验证了金属磁记忆检测技术作为检测钢绞线腐蚀技术的可行性。

关键词：钢绞线；腐蚀检测；金属磁记忆；HMR2300；漏磁信号

中图分类号：TG172.9

Experimental Study on Corrosion Detection of Galvanized Steel Strands Based on Magnetic Flux Leakage Characteristics of Metal Magnetic Memory

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Abstract: Some conventional technologies found it difficult in detecting internal corrosions of the galvanized steel strands. Aimed at the problem in galvanized steel strands, a new method based on Metal Magnetic Memory (MMM) technology was proposed combined with the advantages of the early defect detection of ferromagnetic materials. Eight pieces of specimens were designed. The experiment was carried out by using electrochemical corrosion method to accelerate the process. Via the Honeywell HMR2300 three-dimensional magnetic sensor, the Magnetic Flux Leakage signals of...
the specimen with different degrees of corrosion could be obtained. Then, the variation characteristics of the signals were studied, and the relationship between the signals and the corrosions were analyzed. The test results showed that the magnetic signals changed substantially in the corroded region. In other words, there would be a maximal value in the curve of the tangential component while a zero point in the normal component. Besides, there would be a zero point in the gradient of the tangential component while a minimum value in the gradient of normal component. With the corrosion degree gradually increasing, the intensity of the magnetic signals increased correspondingly. Via the analysis of the signals after corrosion, the corrosion position and range of the Steel Strands specimen could be relatively accurately identified. The test verified that the MMM technology could be a feasible method for the detection of the cable corrosion.

**key words:** steel strands; corrosion detection; Metal Magnetic Memory; HMR2300; Magnetic Flux Leakage signals
Performance Improvement for Semi-TCP by Rate Control

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ABSTRACT

This paper studies the rate control algorithm to improve the performance of Semi-TCP, which adopts a buffer-based hop-by-hop congestion control mechanism. We first analyze the impact of the buffer-based sending strategy on the medium contention and interference. We find that this sending strategy is too aggressive to increase the throughput, and we find the significance of the source in rate control. Based on our analysis, we further proposed a binary search based rate control to improve Semi-TCP. Simulation results show the effectiveness of the proposed algorithm in improving the end-to-end throughput and delay.
Spatial Failure Probability Analysis 1 of Reinforced Concrete Beams
Considering the Influence of Crack and Corrosion Unbalanced

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ABSTRACT

The paper aims to study the reliability and durability of RC structure caused by chloride ion erosion. First, based on the accelerated corrosion test of RC beams, the pit shapes and the failure modes of corroded reinforcement are analyzed statistically, meanwhile, the cross-sectional area model is studied considering the uniform corrosion and the pitting corrosion occur simultaneously. Second, the relationship between the crack width or chloride diffusion coefficient and the resistance of RC beam is established. Then the scale of fluctuation of the protective layer thickness and the compressive strength of concrete are estimated by the semivariogram function method. Final, the calculation model of structural resistance is discussed under the influence of longitudinal reinforcement with different corrosion degree in the same RC beam, and the time-spatial-varying degradation model of RC beam resistance and the model of RC beam failure probability are built. The results show that when the spatial variability of the parameters are considered, the failure probability of RC beam considering the effect of the crack in the design’s working life is 17.89% higher than that without considering...
the effect of crack. Simultaneously, considering the spatial variability of the parameters, the failure probability of RC beam increased by 31.37% than that without consideration. Random field parameter analysis shows that appropriate choice of the element size to consider the spatial variability of the material properties and structural dimensions is very important for the safety evaluation of RC beam. The failure probability of RC structure in the tidal environment and the splash environment are 4.83% and 6.85%, respectively, which increased by 20.15% and 70.40% compared with structure in the marine atmospheric environment. Therefore, during the design working life of RC structure, corrosion protection measures should be done well to reduce the damage of the structure durability due to the chloride ion erosion.

**KEYWORDS:** RC beams; Failure probability; Cross-sectional area; Crack; Corrosion unbalance; Spatial variability
Sensor Fault Diagnose Method Based on GLRT

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Abstract: A new generalized likelihood ratio test threshold setting method is proposed based on the problems of damage false alarm and high false alarm rate caused by sensor fault in bridge structure health monitoring system. Firstly, several groups of health-structured and well sensor data are assumed, the number of reference samples of each generalized likelihood ratio test is 1, the rest is the quantity of test samples, each group has the same quantity of sensors, the generalized likelihood ratio matrix is constructed; Secondly, the log likelihood ratio of every sensor in the generalized likelihood ratio matrix is statistics analyzed and get the threshold. Finally through the set threshold to determine sensor failure or not. The Simply Supported beam of numerical example and actual calculation example result show that the threshold can correctly identify whether the sensor is fault or not in bridge health monitoring system, thus providing a new method for the maintenance of bridge health monitoring system.
key words: structure health monitoring; sensor fault; generalized likelihood ratio test; threshold

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基于自动补水的连通管式桥梁挠度监测系统

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摘 要: 连通管式桥梁挠度监测系统在使用过程中因液位蒸发导致连通管内的液体逐渐减小，会引起系统失去功能或存在液位过低导致的测量误差。为了解决该类问题，提出了一种基于自动补水装置的连通管式桥梁挠度监测系统，开发了以半导体制冷原理为基础的自动补水的挠度监测装置，并进行了实验室自动补水实验测试，最后在云南某桥进行了应用示范，证明该种自动补水挠度监测系统工作良好，具有可实用性。

关键词: 自动补水; 连通管; 挠度监测

中图分类号: U446.2

Bridge Deflection Monitoring System Based on Connected Pipe and Automatic Water Supply

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Abstract: In the working process of the connected pipe type bridge deflection monitoring system, the liquid level in the pipe is gradually reduced due to the evaporation. System failure or measurement error caused by the low liquid level will arise. In order to solve the problem, a kind of bridge deflection monitoring system based on connected pipe type and automatic water supply was put forward. Based on the principle of semiconductor refrigeration, the automatic water supply deflection monitoring device was developed. In addition, the experiment of automatic water supply in laboratory was carried out. Finally, this system had been applied to a bridge in Yunnan. It showed that this kind of automatic water supply deflection monitoring system worked well.

key words: automatic water supply; connected pipe; deflection monitoring

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远程桥梁健康监测的数据预处理与传输技术研究

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摘 要：为了使桥梁健康监测中得到的测量数据更加真实有效，根据基于数据流的数值滤波方法，对“异常”数据进行滤除。再通过对高频率采集数据进行聚集化处理，将处理后的特征数据通过远程传输的方式传输至数据中心，从而减少数据中心的数据存储量，并满足特殊情况下的数据分析，也为后续的桥梁安全评估和养护措施的制定提供可靠的数据支持。

关键字：桥梁健康监测; 数据预处理; 远程传输; 限幅滤波; 数据聚集化

The Research on the Data Preprocessing and Transmission Technology in the Remote Bridge Health Monitoring

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Abstract: In order to make the measurement data to be more real and effective in the bridge health monitoring, according to the numerical filtering method based on data flow, the "abnormal data" was filtered out. After the data aggregation processing of the high frequency gathered data, the characteristic data were transmitted to the data center by means of remote transmission. It reduced the data storage in the data center, and met the special circumstances of data analysis. It also can provide reliable data support for the subsequent safety assessment and the establishment of maintenance measures of the bridge.

key words: the bridge health monitoring; pretreatment of the data; remote transmission; limiting filtering; the data aggregation

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交叉口指路交通标志直行信息布局研究
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摘 要: 针对现有国家标准中存在指路标志直行信息布局不合理的问题, 本研究利用E-prime软件测定60位驾驶员对24块指路标志的视认反应时间及操作正确率等数据, 结合调查问卷, 通过独立样本t检验分析对比学习标志对驾驶人视认情况的影响, 用Means过程分析个体因素的差异, 提出符合视认规律的指路标志直行信息最优布局。采用单因素方差分析法多项对比分析, 对32块地点距离标志与指路标志进行了组合验证。结果表明, 指路标志直行信息布局应按照信息由近到远的顺序由下至上排列, 驾驶人预先学习阅读相关标准可大幅提高视认交叉口指路标志的正确率。本文的成果为国标的修订提供了技术储备, 对于设计更符合视认特征的交叉口指路标志有重要价值。

关键词: 交叉口指路标志; 信息布局; 视认模拟实验

Research of Straight Information Layout in the Intersections Destination Signs
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Abstract: In order to solve the problem of unreasonable layout of destination signs in existing national standards, this study uses E-prime software and questionnaires to determine the reaction time and accuracy of operation of 24 destination signs by 60 drivers. Independent-sample T-test analysis is used to compare the different affection on drivers' visibility in learning signs. Means process is used to analyze the differences of individual factors and the optimal layout of guide signs alignment information was proposed. Compositional verification is used for the 32 directional signs and destination signs, the results indicate that the straight information layout in directional sign should be in accordance with the information order from close to far with the bottom arrangement, drivers learn to read in advance the relevant standards can significantly improve the accuracy of the visibility of the
intersection guide signs. This paper provides a technical reserve for the revision of Chinese national
standard to design guide signs in intersections, which is important for designing the proper layout with
better visual characteristics.

**key words:** Intersection destination sign; information layout; visual recognition simulation experiment

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基于混沌猴群算法的结构有限元模型修正研究
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摘 要: 有限元模型修正可转化为优化问题，基于此，将全局寻优算法—混沌猴群算法引入到有限元模型的修正中。利用响应面法，实现结构响应与待修正参数间非线性隐性关系的显式表达，基于最小残差原理，建立优化目标函数；利用混沌猴群算法求解该函数，得到修正后的结构有限元模型。以一个数值算例验证了该方法在结构有限元修正中的应用的可行性。本文研究拓宽混沌猴群算法的应用范围，为有限元模型修正提供了一种新的思路。

关键词: 桥梁工程；有限元模型修正; 混沌猴群算法; 响应面法; 均匀设计

中图分类号: U448.27

Research on Finite Element Model Updating Based on Chaotic Monkey Algorithm

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Abstract: Based on the fact that the mathematical essence of the finite element model updating is an optimization problem, the global optimization algorithm, chaotic monkey algorithm was introduced into the finite element model updating. In this method, the nonlinear implicit relationship between structural response and parameters to be modified was expressed explicitly. Based on the response surface method, optimization objective function considering the principle of least residual error was established; after solving the function by using chaotic monkey algorithm, the updated structural finite element model was obtained. A numerical example has been used to verify the feasibility of the proposed method. This paper not only expands the application fields of monkey algorithm, but also provides a new thinking for finite element model updating.

keywords: bridge engineering; finite element model updating; chaotic monkey algorithm; response surface; method; uniform design

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基于脉冲涡流的钢筋缺陷检测试验研究

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摘 要: 为探究脉冲无损检测效果, 本文基于电磁脉冲涡流原理设计并搭建一套钢筋缺陷检测系统, 完成了对不同缺陷程度的钢筋试件脉冲涡流检测试验研究及有限元仿真分析, 提取并分析不同程度缺陷钢筋试件的电压幅值信号变化规律, 试验研究表示, 本检测系统可以有效检测在15mm提离高度以内的钢筋缺陷位置及评估缺陷程度。本试验为今后脉冲涡流检测钢筋混凝土试件积累可靠资料。

关键词: 钢筋缺陷; 脉冲涡流; 幅值; 仿真

中图分类号: TU528

Experimental Study on the Non-destructive Testing of Steel Bars with Pulsed Eddy Current

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Abstract: In this paper, based on the principle of electromagnetic pulse eddy current (PEC), a set of defect detection system was established. Then the experimental study based on PEC and the finite element simulation analysis were completed for different steel bars. Furthermore, the variation of the voltage amplitude signal for the steel bars with different degrees of defects was extracted and analyzed. The results show that the detection system could effectively detect the position and the degree of defects in the steel bar within the lift-off height of the 15mm. The experiment could accumulate reliable data for the future pulse eddy current testing of reinforced concrete specimens.

key words: pulsed eddy current; hall voltage; amplitude; nondestructive testing

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基于车桥耦合振动和分布式测试的主梁结构健康监测方法

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摘 要: 桥梁健康监测可在桥梁运营状态发现损伤, 并及时提供管理养护建议。本文基于车桥耦合振动和分布式测试数据发展一种针对城市桥梁主梁结构的损伤定位与量化方法, 提出了主梁结构损伤的两步识别算法。在第一步中, 利用某一节点的实测加速度频谱和转换概念估计单元应变频谱, 并与实测的单元应变频谱对比以损伤定位; 第二步中, 利用第一步中判别的未损伤单元的应变频谱和转换概念估计损伤单元的应变频谱, 通过估计与实测的应变频谱峰值进行损伤定量。以某装配式简支T型主梁为例进行数值验证。结果表明算法具有如下特点: 仅需梁结构当前（损伤）状态监测数据以及容许较大建模误差的结构（简化）先验模型, 无需模型的优化迭代且具有较强的抗噪性, 本文提出的方法可为城市桥梁结构提供一种运营状态下易于实行的结构健康监测方案。

关键词: 桥梁结构健康监测; 车桥耦合振动; 分布式测试; 转换概念

中图分类号: U446

Research on the Risk Assessment and Counter Measures of Nanjing No.4 Yangtze River Bridge in Operation Period

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Abstract: Bridge structural health monitoring can be used to detect damage in bridge operation state and make full use of comprehensive information to optimize maintenance timely. This paper presents a type of damage localization and quantification method for bridge structures based on the distributed measurements from vehicle-bridge interaction vibration. A two-step damage identification algorithm is proposed. In the first step, elemental strain spectrums of all elements are estimated by using the transmissibility matrix from the measured acceleration spectrum of only one node; and damages are located comparing both estimated and measured strain spectrum. In the second step, strain spectrums of damage elements are estimated again by the transmissibility matrix from the measured strain spectrums.
of undamaged elements; and damages are quantified at this time comparing the peak values of both estimated and measured strain spectrum. A T-shape main beam of a prefabricated simply-supported bridge is studied numerically. Results show that the algorithm has the following characteristics: damage detection using only data of damaged structure and a priori model with a certain amount of modeling errors, without using the iteration process and having a strong anti-noise ability.

**key words:** bridge structural health monitoring; vehicle-bridge interaction vibration; distributed measurements, transmissibility concept

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Research of Lateral Vibration Reduction Reinforcement Technology of Double-column Light Piers under Heavy Haul Condition

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ABSTRACT
Accompanying with the increasing railway speed and the rapid development of heavy haul transportation, light bridge piers are subjected to increasingly serious lateral vibration, which has already significantly influenced the safe operation of trains. To solve this problem, this research analyzed the causes of large lateral vibration of light double-column bridge piers by studying the Wentanghe Bridge section of Shuohuang Railway in China. Besides, the schemes for reinforcing piers were designed, compared and selected, together with the contrast tests for the operative performance of the bridge before and after reinforcement. Results showed that low lateral stiffness is the direct reason for the large lateral vibration of light piers, which is especially serious under the effect of heavy-haul trains. To reinforce this kind of piers, it is fundamental to improve the lateral stiffness and natural vibration frequency of bridge piers. For light double-column bridge piers, pouring reinforced concrete between double columns is a practical and effective way to connect and reinforce piers as it can remarkably increase the lateral stiffness of piers. By using the critical parameter method and based
on the feasibility, adaptability, reliability and economy principles of reinforcement, we can accurately select the thickness and height values of the reinforced concrete to be poured. Being convenient in construction, this method does not influence the normal operation of trains and does no damage to pier shafts. Moreover, both the lateral stiffness and natural vibration frequency of bridge piers can be improved by more than 100%, showing a significant reinforcement effect.

**KEYWORDS:** heavy load; double-column bridge piers; lateral reinforcement; critical parameter; performance test
锈蚀预应力混凝土梁受荷裂缝研究

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摘 要：通过对8片不同锈蚀程度的预应力钢筋混凝土梁进行静载实验，分析不同锈蚀率对预应力混凝土梁受荷裂缝的分布、间距、宽度影响，基于裂缝宽度的综合理论，建立了锈蚀预应力混凝土梁的裂缝平均间距和宽度计算方法，并通过现有文献试验数据对公式进行了验证。结果表明：锈蚀率较低时，PC梁的受荷裂缝间距和宽度变化不明显；锈蚀率超过19.47%时，由于预应力筋截面积减少和粘结性能的退化较大，裂缝间距和裂缝宽度变化显著。因此在计算锈蚀PC梁的裂缝宽度和间距时，应当考虑锈蚀的影响。

关键词：预应力混凝土；预应力钢筋；锈蚀；裂缝宽度；裂缝间距

Study on Load Crack of Corroded Prestressed Concrete Beams

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Abstract: Through the static load test of 8 prestressed RC beams with different corrosion degrees, the influence of different corrosion rate on the distribution, spacing and width of the crack of the prestressed concrete beam is analyzed. Based on the Comprehensive Theory of Crack Width, the calculation method of average spacing and width of cracks in prestressed concrete beams was established, and the formulas are validated by the existing literature test data. The results show, when the corrosion rate is low, the variation of spacing and width of crack in PC beam is not obvious. when Corrosion rate is more than 19.47%, The decrease of the cross-sectional area of the prestressed tendon and the degradation of the bond performance have a great influence on the crack spacing and crack width. Therefore, the influence of corrosion should be considered when calculating the crack width and spacing of Corrosion pc beam.

key words: post-tensionedconcretebeam; Prestressed reinforcement; Corrosion; crack width; Crack spacing

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不同缺口类型钢筋力学性能试验研究
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摘 要：为模拟局部锈蚀对钢筋静力及疲劳性能的影响，设计并制作了4种缺口形状、6种缺口深度及7种缺口长度的钢筋样本，对96根缺口钢筋和4根完好钢筋进行了轴向静力拉伸和疲劳试验，对比了不同缺口尺寸下的应力集中系数，研究了缺口类型和缺口尺寸对钢筋疲劳寿命的影响，经统计回归，得到了钢筋疲劳寿命与缺口深度的函数关系，建立了钢筋应力范围-疲劳寿命-缺口深度的疲劳曲线方程。试验结果表明：缺口深度相同时，三角形缺口应力集中系数最大，依次为变长度三角形、圆形和椭圆形，缺口处应力集中的程度随应力水平的增大而增大，以往采用圆形或椭圆形状来模拟局部锈蚀偏不保守；不同缺口钢筋的实际应力范围和疲劳寿命在对数坐标下呈线性关系。可为日后建立疲劳预测模型和有限元分析提供试验依据。
关键词：疲劳试验；静力拉伸试验；应力集中；缺口；疲劳寿命；钢筋

Experimental Study on Mechanical Behavior of Different Notched Steel Bars
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Abstract: An experimental study was proposed in this paper to simulate the effect of pitting corrosion on the static and fatigue properties of steel bars. Artificial pits including four types of pit shapes, six types of pit depths and seven types of pit lengths were designed and manufactured. Tensile static and fatigue tests were conducted on ninety-six steel bars with artificial pits and four uncorroded steel bars. Stress concentration factor under different notches were compared. The effect of notch shape and notch size on the fatigue life of steel bars was studied. An empirical relationship between fatigue life and notch depth was proposed by statistical regression method, and a regression model considering the stress range, fatigue life and notch depths was established. The experimental results show that triangular-shaped notch has the maximum stress concentration factor under the same notch depth,
followed by triangular-shaped notch with variable length, round-shaped notch and ellipse-shaped notch. The magnitude of stress concentration at the artificial notch increases with the increase of stress level. It is nonconservative using round-shaped or ellipse-shaped to simulate the pitting corrosion. A linear relationship is observed for the stress range and fatigue life of the notched steel bars in logarithmic scale. The current may provide an experimental basis for establishing fatigue prediction model and finite element analysis in future studies.

**key words:** fatigue test; tensilestatic test; stress concentration; notch; fatigue life; reinforcement

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Research on Transverse Distribution Coefficient of External Prestressing and Carbon Fiber Reinforced Beam

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ABSTRACT

In order to analyze the integral forced performance of external prestressing and carbon fiber reinforced beam, the analytical solution of the carbon fiber-concrete composite beams under the vertical concentrated load and external prestressing based was derived on the classical theory of elasticity and contact in this article. The deflection curve equation and the transverse distributing influence lines of simply supported beam after the joint reinforcement were obtained base on eccentric compression method and the results of simply supported beams with or without joint reinforcement were compared. The results show that the integral forced performance of external prestressing and
carbon fiber reinforced beam was effectively improved and the new calculation method of transverse distribution factors has practical value.

**KEYWORDS:** Bridge Engineering; Simply Supported Beam; External Prestressing and Carbon Fiber Reinforced Beam; Transverse Distribution Coefficient; shear slip
相变混凝土箱梁的梯度温差效应研究
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摘 要：以控制混凝土箱梁日照温度梯度所产生的主拉应力为目的，采用稻壳灰封装石蜡作为相变材料制备具有“结构+功能”一体化功效的相变混凝土，通过实验探究了稻壳灰-石蜡相变混凝土的热稳定性及其热工、力学参数，并以京杭运河大桥为工程背景讨论了相变混凝土设置位置和厚度对温度梯度效应的影响。通过研究发现：稻壳灰-石蜡相变混凝土具有良好的相变稳定性，多次相变循环后石蜡不会出现大量渗漏现象，但掺入稻壳灰后相变混凝土强度将有所降低；混凝土箱梁日照温度梯度所产生的主拉应力随顶板上表面相变混凝土厚度的增加呈现先增大后减小再增大的现象，但随箱梁顶板下表面、腹板外表面上相变混凝土厚度的变化不敏感；在混凝土箱梁顶板上表面设置一定厚度的稻壳灰-石蜡相变混凝土后，箱梁顶板附近区域温度有明显降低，且日照梯度温度产生的最大拉应力有近40%的降低。

关键词：桥梁工程；相变混凝土；箱梁；梯度温差；温度应力

中图分类号: U441.3

Study on Temperature Gradient Effect of Phase-change Concrete Box-girder
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Abstract: In order to decrease the principal tensile stress induced by temperature gradient in concrete box girder, a phase-change concrete with both structural and temperature control functions was developed by introducing paraffin encapsulated by rice husk ash as additives, and a series of experiments were conducted to obtain its thermal and mechanical parameters and check up its thermal stability. Taking Beijing-Hangzhou Canal Bring as an example, the influence of phase-change concrete laying position and thickness to thermal stress was investigated. It is found that Rice-Husk-Ash-Paraffin phase-change concrete has a good performance of thermal stability, and a serious leakage will not occur after numerous phase change cycles. It is also discovered that thermal stress in box girder
increases first, then decreases and subsequently increases with the thickness of phase change concrete laying at the top surface of roof plate increasing, but is neither sensitive to the thickness of phase change concrete laying at web plate nor the bottom surface of roof slab. The concrete temperature nearby roof plate of box girder will decreasing obviously by casting a layer phase change concrete with a certain thickness, and the maximum tensile stress induced by gradient temperature will correspondingly decreased nearly 40%.

**key words:** bridge engineering; phase change concrete; box girder; temperature gradient; thermal stress

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预应力钢丝绳在预应力板梁抗弯加固中的应用研究

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摘 要: 本文提出了对预应力板梁采用预应力高强钢丝绳进行抗弯加固的新方法，并详细介绍了这种加固方法的施工工艺，对预应力钢丝绳抗弯加固预应力板梁进行了重点试验研究。试验结果表明，预应力钢丝绳抗弯加固能显著提高混凝土梁的开裂荷载、截面刚度、屈服荷载、最大承载力，能有效限制预应力板梁裂缝宽度，钢丝绳能达到极限拉伸应变，使得加固材料利用率充分发挥。该加固技术可以较好的解决现有加固方法中的诸多不足，是一种高效主动的加固技术。

关键词: 预应力钢丝绳；预应力板梁；抗弯加固；应用研究

Application Research on Flexural Reinforcement of Prestressed Slab Beams with Prestressed Steel Wire Ropes

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Abstract: In this paper, a new method of prestressed high-strength steel wire rope for prestressed plate girder is proposed, and the construction technology of this reinforcement method is introduced in detail. The prestressed steel wire rope reinforced prestressed plate girder is experimentally studied. The results showed that this reinforcement method could significantly improve the cracking load, stiffness, yield load and maximum flexural capacity of prestressed slab beams. The width of flexural cracks in concrete beams is effectively controlled. This method can also exploit the strain capacity of the wire rope to its maximum. The reinforcement technology can solve the shortcomings of the existing reinforcement method, and it is an efficient and effective reinforcement technology.

key words: prestressed steel wire rope; prestressed slab beams; flexural reinforcement; application research

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海河大桥正交异性钢桥面板加固新技术
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摘 要：正交异性钢桥面板钢箱梁的疲劳开裂是既有钢桥的常见病害，其维修加固难度较大，分析了海河大桥正交异性钢桥面板及桥面铺装病害产生的原因，根据该桥病害特点及交通荷载情况，提出正交异性钢箱梁桥面板采用刚性加固的方案，测试了超高性能混凝土的原材性能，分析采用超高性能混凝土刚性加固后正交异性钢箱梁桥面板局部刚度和受力性能的改善状况，有效改善了桥面铺装层的受力性能，有效降低钢结构局部应力，提高了钢结构及桥面铺装层的疲劳耐久性；利用实桥加载测试，验证了正交异性钢箱梁桥面板刚性加固对局部受力性能的改善状况。

关键词：正交异性桥面板；疲劳开裂；超高性能混凝土；局部加载试验

New Reinforced Technology of Orthotropic Steel Bridge Deck of Haihe River Bridge

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Abstract: The fatigue crack of the orthotropic steel bridge deck of steel box girder is a common disease of existing steel bridges. It is more difficult to repair the disease of existing steel bridges. In this paper, combined with the Haihe River Bridge diseases, analyze the causes of steel plate and weld cracking disease, and analyze the reason of the orthotropic steel deck pavement. According to the disease characteristics and traffic load, reinforced the orthotropic steel box girder bridge deck with rigid reinforcement scheme. The experiment was carried out on the UHPC. The UHPC can effectively improve the local stiffness of bridge decks. The UHPC can improve the mechanical properties of bridge deck pavement, and reduce the local stress of steel structure, and improve the fatigue durability of steel structure and Bridge Deck Pavement. Through the local loading test, after the strengthening of high toughness concrete, the local stress of steel box girder orthotropic plate is greatly reduced, effectively improve the orthotropic plate local fatigue cracking resistance.

key words: Orthotropic bridge deck; Fatigue crack; Ultra high performance concrete; Local loading
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Research of Ultra-thin Topping Overlay Using Cold-mix Modified Resin Material for Epoxy Asphalt Steel Bridge Deck Pavement

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ABSTRACT

Epoxy asphalt concrete is widely used for steel bridge deck pavement in China. Little research has been conducted on the preventive maintenance technology of epoxy asphalt deck surfacing in comparison to that of asphalt pavement. Conventional thermoplastic asphalt overlay materials on thermosetting epoxy asphalt pavements tend to delaminate because of low bonding strength. This paper studies the fiber-reinforced ultra-thin polymer overlay, which is thinner than 5 mm and consists of an epoxy resin polymer binder and aggregates. The performances of epoxy resin including elongation at break, curing time, bonding strength and deformation characteristics are evaluated. Test methods such as pull-out test, bending test and so on are employed for rating the overlay materials. Different sorts of fibers are compared, and basalt and carbon fiber is find out to be the best solution for the reinforcement of the epoxy resin. Field application shows that the texture depth can be promoted to be above 0.9 mm
and the overlay performs well after 2 years using.

**KEYWORDS:** Ultra-thin Polymer Overlay; Epoxy Resin; Fiber-reinforced; preventive maintenance
通过荷载试验检验箱梁体内预应力加固效果

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摘 要：本文对桥梁加固的技术特点进行了叙述，以某公路桥的大跨径预应力混凝土箱梁体内预应力加固工程为实例，通过加固前后的桥梁荷载试验来检验加固实际效果，为桥梁加固方法的推广及效果验证提供良好的工程借鉴。

关键词：荷载试验；大跨径预应力混凝土箱梁；体内预应力加固

Through the Load Test Inspection the Prestressed Reinforcement Effect in the Body of Box Girder

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Abstract: In this article, the author describes the technical features of the bridge reinforcement, take the project of prestressed reinforcement in the body as an example. This object is a long-span prestressed concrete box girder of highway bridges, through the bridge load test of before and after the reinforcement inspection the reinforcement effect, it provides a good reference for the popularization of bridge reinforcement method and its effect verification.

key words: load test; long-span prestressed concrete box girder; prestressed reinforcement in the body

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摘要：系杆拱桥以其结构受力合理、外形美观、施工方便等一些优点得到了广泛应用。但早期修建的这类桥梁，由于吊杆在防腐设计方面考虑不足，引起钢丝锈蚀，降低了吊杆的安全性，更有甚者还发生了恶性事故。本文通过阐述某大桥吊杆更换实例，结合精细建模计算，对吊杆更换施工动态模拟分析，阐述更换吊杆的关键技术，实现对系杆拱桥的快速可靠加固，为其他类似工程提供参考和借鉴。

关键词：系杆拱；钢丝锈蚀；更换吊杆；加固

Analysis and Replacement Method of Typical Tied Arch Bridge Diseases

Abstract: Bowstring arch bridge with its reasonable structure, beautiful shape and convenient construction has been widely applied. But early to build this kind of bridge, because of there is little thought for suspenders in anticorrosion cause steel corrosion, reduce the security of the derrick, moreover malignant accident happened. This article expatiates in combination with fine modeling calculation, dynamic simulation analysis of derrick replacement construction, this paper to replace the key technology of derrick, realize the rapid and reliable for arc bridge reinforcement, providing a reference for other similar projects.

key words: bowstring arch bridge; corrosion of steel; wire suspender replaced; reinforce

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荆岳长江大桥环氧沥青钢桥面铺装小修保养研究
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摘 要: 为研究荆岳长江大桥环氧沥青混凝土铺装的服役性能和小修保养对策, 对其进行了现场调研与分析, 包括铺装经受的交通量特征及铺装病害类型和程度等。调研观测发现纵向裂缝是最主要的破坏形式, 主要位于U肋肋顶、轮迹带附近。注重对裂缝和坑槽两类典型病害的小修保养, 可以有效延缓环氧铺设层的病害发展, 研究结果可为钢桥面养护管理工作提供参考。

关键词: 桥梁工程; 环氧沥青钢桥面; 小修保养

中图分类号: U238

Research on the Routine Maintenance of Epoxy Asphalt Concrete Pavement on Steel Bridge Deck of Jingyue Yangtze River Bridge
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Abstract: To obtain the service performance and minor maintenance measures of the epoxy asphalt pavement condition on the JingYue Yangtze River Bridge, an on-site survey is conducted to collect information regarding traffic composition and extents of pavement distresses. The survey shows that longitudinal fractures are the most important form of damage, mainly located in the U-ribbed ribs, near the wheel path. It is possible to effectively delay the development of the pavement of the epoxy pavement, and the results can provide a reference for the steel bridge deck maintenance and management work.

key words: bridge engineering; epoxy asphalt mixture for steel bridge deck pavement; routine maintenance

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公路改扩建项目中桥梁拼宽技术的探索与分析
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摘 要: 桥梁拼宽技术主要指以横向拼接加宽的方式对既有结构物进行改扩建，包括既有结构物的利用，新结构物的设计，以及新结构物与既有结构物的连接方式等内容。本文主要结合工作中遇到的既有公路改扩建项目对拼宽桥的连接形式进行探索分析，以期为其他类似工程提供参考和借鉴。

关键词: 桥梁拼宽; 结构形式; 刚接; 理论计算

Exploration and Analysis of Bridge Widening Technology in Highway Reconstruction Project

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Abstract: The bridge widening technology mainly refers to the way of transverse joint widening the existing structure expansion, including the use of existing structures, the design of new structures, new content and structure and existing structure connection. In this paper, combined with the existing highway reconstruction project to explore the connection of the bridge, in order to provide reference for other similar projects.

key words: Bridge widening; structural style; Just pick; Theoretical calculation

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Transverse Distribution Coefficient of Slab Beams Strengthened by External Prestress and Carbon Fiber Sheet

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ABSTRACT
In order to analyze transverse distribution coefficient of slab bridge reinforced by CFRP and external prestress, considering the effect of CFRP shear slip and interface of the bottom plate, based on the basic idea of the hinge plate method, transverse distribution coefficients analytical expression of the simply supported slab bridge reinforced by CFRP and external prestress was deduced. Transverse distribution coefficients before and after reinforcement were analyzed by specific examples. The results show that transverse distribution coefficient was calculated using the original structure size is
not reasonable for the design of conventional reinforcement. The contribution of CFRP and prestressed reinforcement should be considered, especially, the impact of external prestressed steel for transverse distribution coefficient should not be ignored. A reliable calculation method for the design and strengthening staff was provided and had a practical value.

**KEYWORDS:** Bridge Engineering; Simply Supported Slab Bridge; Coefficient of Transverse Distribution; Carbon Fiber Reinforced; External Prestressing
横向体外预应力加固预应力板梁桥试验研究

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摘 要：预应力空心板梁桥以其低建筑高度、预制方便、用料经济等优点在国内得到广泛的应用推广，但铰缝易开裂破损，不易维修，维修后病害复发等问题困扰着桥梁养护单位。本文针对某铰缝开裂的预应力板梁桥实际工程，采用桥梁有限元计算模型结合现场试验的方法，对横向体外预应力作用机理及施加原则进行研究，定性得出施加横向预应力后桥梁整体性得到加强，横向分布系数更加均匀，且加固效果与横向张拉力的大小及数量正向相关的结论；通过对现场试验结果的分析，定量得到本桥在施加横向预应力后最大受力梁体的横向分布系数降低幅度为5.5%~8.5%的结论。

关键词：横向体外预应力；板梁；横向分布系数；铰缝

中图分类号：U446.1

Experimental Research on Transverse External Prestressed Reinforcement of Pre-stressed Concrete Board Bridge

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Abstract: For such advantages as low construction height, being easily prefabricated and economical material using, pre-stressed concrete hollow board bridge is applied widely in domestic, however, the disadvantages of joint between boards, such as easily broken, not easy to repair, disease repeated, are troubling the maintenance corporation of bridge. Through a practical pre-stressed concrete hollow board bridge with cracking of joint between board, The thesis adopts method of bridge finite element model combined with field test, studys the mechanism and principles of transverse external prestress, qualitatively makes the conclusion of that bridge integrity is strengthened and transverse distribution coefficient is more uniform after applying the transverse external prestress, and the reinforcement effect is positive correlation with the magnitude and amount of transverse external prestress; quantitatively makes the conclusion of that after applying the transverse external prestress, the reduction range of
transverse distribution coefficient of the most unfavorable beam is from 5.5% to 8.5%.

**key words:** Transverse external prestress; board bridge; transverse distribution coefficient; joint between boards

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先简支后连续桥梁空心板梁底板斜裂缝加固研究
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摘 要: 为研究简支后连续桥梁空心板梁底板斜裂缝加固对策, 对其进行了现场调研与有限元分析。研究发现底板斜裂缝主要是空心板梁现浇连续段施工质量较差, 尤其为支座位置处混凝土空洞、浇筑不密实等, 致使底板实际应力状态约为设计理想状态10倍, 采用粘贴钢板加固可以有效控制空心板梁底板斜裂缝发展, 为类似桥梁加固提供了参考。

关键词: 空心板梁桥; 底板斜裂缝; 病害机理; 加固处治

Study on reinforcement processing of simply supported-continuous beam bridge with inclined cracks of bottom slab
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Abstract: To obtain the reinforcement processing of simply supported-continuous beam bridge with inclined cracks of bottom slab, the field investigation and finite element analysis were carried out. It is found that the main reason for the slanting of the bottom slab is that the quality of the concrete in the connecting part of the continuous section and the lower part of the hollow slab is unqualified, so that the actual state of the bottom plate is about 10 times of the ideal state of the bottom plate. The use of the bonded steel plate reinforcement can effectively control the hollow slab The development of the slanting slab at the bottom provides a reference for similar bridge reinforcement.

key words: hollow core slab beam bridge; diagonal crack disease mechanism; reinforcement processing

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摘要：本文以某高速公路上一座连续刚构特大桥为分析对象，做了简要的力学计算，对桥梁产生病害的主要原因进行了分析，希望能对此类结构形式的桥梁检测提供参考。

关键词：连续箱梁桥；上部结构；承载力验算；病害原因；分析

The Calculation and Analysis of Continuous Box-girder Bridge

Abstract: The paper is based on the analytic target of a continuous rigid-frame bridge on expressway. We did a brief mechanical calculation and made a detailed analysis of the main reasons which caused the diseases. We hope to provide reference for the same kind of bridge detection.

key words: continuous box-girder bridge; superstructure; load-carrying capacity; the causes of diseases; analysis
湿热环境下CFRP加固混凝土结构粘结界面力学性能研究

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摘要：碳纤维增强复合材料（CFRP）具有轻质、高比强度、耐腐蚀、抗疲劳等优点，因而广泛应用于土木工程加固领域。为了研究湿热环境对CFRP-混凝土粘结界面力学性能影响，本文以25oC/95%RH、25oC/85%RH、60oC/95%RH、60oC/85%RH四种工况下5d、10d、15d三个不同劣化时间共52组CFRP-混凝土试件进行正交双面剪切试验。分析了在不同湿热环境下对CFRP-混凝土粘结界面力学性能影响。

关键词：CFRP-混凝土界面；双剪试验；湿热环境

中图分类号：U238

Study on the Mechanical Properties of CFRP-Concrete Bonding Interface on Hygrothermal Environment

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Abstract: With many features, such as light weight, high specific strength, corrosion resistance, fatigue resistance and so on, Carbon fiber reinforced polymer (CFRP) is widely used in the field of civil engineering reinforcement has. In order to study the effect of hygrothermal environment on the mechanical properties of CFRP-Concrete bonding interface, a total of 52 CFRP-concrete specimens were subjected to orthogonal double-sided shear test with three different degradation times, 5 d, 10 d, 15 d and four conditions 25oC/95%RH, 25oC/85%RH, 60oC/95%RH, 60oC/85%RH. In this paper, the effects of different hygrothermal environments on the mechanical properties of CFRP-Concrete Bonding Interface were analyzed.

key words: CFRP-Concrete interface; double shear tests; hygrothermal environment

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基于足尺试验的混凝土梁桥加固技术研究

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摘 要：应用足尺试验的方法研究混凝土梁桥的加固技术，进行钢板-混凝土组合加固足尺预应力钢筋混凝土小箱梁抗弯、抗剪性能试验研究，进行钢板-混凝土组合加固及钢板-预应力混凝土组合加固足尺预应力钢筋混凝土空心板梁抗弯性能试验研究，进行钢板-混凝土组合加固及钢板-UHPFRC组合加固足尺预应力混凝土T梁抗弯、抗剪性能试验研究。试验结果表明：组合加固足尺混凝土梁与未加固的对比梁相比，正常使用阶段的承载性能和极限状态下的承载性能显著提高；开裂后的抗弯刚度明显提高；组合加固梁的延性未发生明显降低。足尺试验研究及分析表明，组合加固技术可显著改善混凝土梁桥的受力性能。

关键词：桥梁工程；混凝土梁；组合加固；足尺试验

中图分类号: U446

Research on Strengthening Technology of Concrete Beam Bridges Based on Full Scale Test

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Abstract: The technology of strengthening concrete beam bridge was studied by full scale test. The full-scale tests were carried out to study the flexural and shear behavior of prestressed reinforced concrete box girders by using steel plate-concrete composite strengthening technology. The full-scale tests were carried out to study the flexural behavior of prestressed reinforced concrete hollow slab girders by using steel plate-concrete composite strengthening technology and steel plate -prestressed concrete composite strengthening technology. The full-scale tests were carried out to study the flexural and shear behavior of reinforced concrete T-girders by using steel plate-concrete composite strengthening technology and steel plate-UHPFRC composite strengthening technology. The full-scale tests results show that composite strengthening methods, compared with girders without strengthening,
the bearing capacity of the normal using stage and the ultimate stage increased significantly. Flexural rigidity after cracking were improved obviously, and the ductility did not significantly reduce. Full scale experiments and analysis show that the composite strengthening technology can significantly improve the performance of concrete beam bridges.

**key words:** bridge engineering; concrete beam; composite strengthening; full-scale test

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摘 要: 结合密涿高速Q1标K11+085.848泃河特大桥40m箱梁的安装，简要介绍高速公路施工中双导梁架桥机安装40m预应力箱梁的施工工艺，总结大箱梁的安装经验。

关键词: 特大桥; 箱梁; 安装工艺

Ju River Bridge on 40m Prestressed Box Girder Installation Process

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Abstract: Combined with dense zhu high-speed Q1 standard K11 + 40 m 085.848 Ju river extra-large bridge box girder installation, and a brief introduction to the highway construction of double guide beam settled installed 40 m prestressed box girder construction technology, summarizes the big box girder installation experience.

key words: Extra large bridge; the box girder; the installation process

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Research on Optimization Design of Rise-span Ratio of Suspension Bridge for Sunda Strait

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ABSTRACT

The proper design of a super-long span suspension bridge crossing over a strait may be a serious challenge for bridge engineers. Super-long span suspension bridge is not only the extrapolation of the conventional concept, but also needs the corresponding parameters. Suspension bridge combined highway and railway is a preferred choice for super-long span strait bridge. However, design and construction of super-long span suspension bridge are not included in the current design codes, and further studies are needed on some key technologies. Rise-span ratio of main cable is an important
parameter which needs to be determined firstly during the design process of a suspension bridge, and has a significant influence on the structural force of the bridge. In order to study the influences of different rise-span ratios on the structural force of the suspension bridge, the finite element model of Sunda Strait Bridge was established by using MIDAS CIVIL software. Differences of deflection-span ratio, end-rotation of girder, tower-top displacement, steel quantity needed and fundamental frequency ratio of torsion to bend of suspension bridges with various rise-span ratios (1/8.5, 1/9.0, 1/9.5, 1/10.0, 1/10.5, 1/11.0) were compared respectively. Some conclusions are given, which can provide references for the optimal design of Sunda Strait Bridge.

**KEYWORDS:** rise-span ratio; finite element analysis; Sunda Strait; suspension bridge; design research
我国钢-超高性能混凝土轻型组合桥面结构研究与应用

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摘要: 轻型组合桥面结构是指由正交异性钢桥面板和薄层超高性能混凝土(UHPC)组成的新型桥面形式。与传统的钢桥面+沥青铺装体系相比, 钢-UHPC轻型组合桥面结构具有优异的抗疲劳性能和显著降低的全寿命维护成本。在过去6年里，湖南大学对这一新型桥面结构进行了系统研究，以揭示其基本受力特性。通过大量理论和试验研究，项目组编制了广东、湖南两省的地方标准，以方便钢-UHPC轻型组合桥面结构的设计、施工以及检验验收。到目前, 钢-UHPC轻型组合桥面结构已应用于我国13座实桥, 涵盖了梁桥、拱桥、斜拉桥、悬索桥等四种基本桥型。工程实践表明, 钢-UHPC轻型组合桥面结构为解决正交异性钢桥面板疲劳开裂、钢桥面沥青铺装层易损等难题提供了一种全新的思路，应用前景十分广阔。

关键词: 超高性能混凝土(UHPC); 轻型组合桥面结构(LWCD); 力学性能; 技术规范; 实桥应用。

Research and Application of the Novel Steel-UHPC Lightweight Composite Deck in China

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Abstract: The lightweight composite deck (LWCD) is a novel bridge deck system composed of an orthotropic steel deck (OSD) and a thin ultra-high performance concrete (UHPC) layer. Compared to conventional OSD+asphalt overlay systems, the LWCD can basically eliminate the fatigue cracking risk in the OSD and can significantly reduce the life-long maintenance cost of the bridge deck. During the past six years, the research group at Hunan University has made great effort to reveal the basic performance of the new bridge deck system. Based on extensive theoretical and experimental studies, two provincial technical guidelines have been proposed to facilitate the design, construction, and quality inspection of the LWCD. To date, the LWCD has been applied to thirteen real bridges in China.
The application covers the four basic bridge types, i.e., girder bridge, arch bridge, cable-stayed bridge, and suspension Bridge. Practice has indicated that the LWCD provides a new solution for alleviating the premature damage issues with OSDs and asphalt overlays.

**key words:** Ultra-high performance concrete (UHPC); lightweight composite deck (LWCD); Mechanical performance; Technical guideline; Application.

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大跨度混凝土箱梁桥竖向预应力钢绞线张拉工艺对比试验研究

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摘 要: 预应力钢绞线的有效预应力度与其采用的张拉工艺密切相关。本文以3座大跨度连续刚构箱梁桥为工程背景，通过室内试验及施工现场试验对比采用低回缩锚具张拉工艺与传统张拉工艺对竖向预应力钢绞线有效预应力度的影响。试验结果表明，低回缩整体二次张拉工艺可有效减小锚具回缩量，提高钢束的有效预应力值。

关键词: 箱梁; 竖向预应力; 低回缩锚具; 有效预应力

Contrast Test for Vertical Prestressing Stand Tensioning Technology on Large-scaled Concrete Box Girder Bridges

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Abstract: The effective prestressing of the prestressed steel strand is closely related to the tensioning technology. Taking three large-span continuous rigid-frame box girder bridges as the engineering background, through the indoor test and the construction site test, compare the effective prestressing under tensioning technology with the low retracting anchorage and the traditional tensioning technology. The test results show that integral secondary tension technology with low retracting anchorage can effectively reduce the retraction of anchorage and improve the effective prestressing value.

key words: box girder; vertical prestressing; low retracting anchorage; effective prestressing

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Research on Properties and Micro-structure for Creep of Concrete Filled Steel Tubes

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ABSTRACT
To study the different lateral restraints, the different constituents of expansion agents, the influence of the different steel ratios and concrete creep properties, this paper carried out a lateral
restraint and a non-lateral restraint with the contents of expansion agents as 4%, 8% and 12% and the creep test with different steel ratios divided into 3.8%, 4.1%, 6.6%, 9.2% and 10.8%. Performances of raw material used in the test were measured precisely. The test results show that: under the same conditions of similar diameters of concrete tubes, the lateral restraint improves the strength of concrete tubes and reduces the creep of concrete. Under the same external loading conditions, the increases of steel ratio increases the lateral restraint, reducing the stress which leads to a further reduction of creep. Experiments with lateral confinement of the concrete filled steel tube creep rate is about 0.09 ~0.30 times of steel pipe concrete creep degree without lateral constraints, the degree of creep for the concrete filled steel tubes increases, while the steel ratio decreases. Study on creep test with different content of expansion agent indicates that: creep degree of concrete structure increases as expansion agent of decreases. To study the internal mechanism of creep steel concrete filled tubes in different lateral restraint and different contents of expansion agents, the microscopic pore structure of steel core concrete test was conducted through the RapidAir457 pore structure tester. Microscopic studies show that: the number of air content and bubble chord of the lateral restraint core concrete less than the non-lateral restraint core concrete. The number of air content and bubble chord of core concrete with the content of expansion agent being 4% is the largest, whereas the content of expansion agent being 8% is in the middle, and the content of expansion agent being 12% is the smallest. Thus, selecting the appropriate lateral restraint and the addition of optimum quantities of expansion agents in concrete structure can effectively reduce the creep of concrete.

**KEYWORDS:** Concrete filled steel tubes(CFT); Lateral restraint; Creep; Microstructure; Mechanism.
铁路钢桥面浇注式沥青保护层材料特性分析

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摘 要：针对铁路系统运营特征对钢桥面保护层材料使用寿命等性能提出的特殊要求，结合正交异性钢桥面板及浇注式沥青混凝土的特性，通过对铁路铺装保护层使用特点分析，开展浇注式沥青混凝土与常用的聚合物水泥混凝土性能对比分析。试验结果表明，浇注式沥青混凝土保护层材料疲劳耐久性、密水性及协调变形能力具有明显优势；与聚合物水泥混凝土相比，疲劳寿命极大提高，密水性提高50%。研究成果对指导我国大跨径铁路钢桥面保护层材料设计具有重要作用。

关键词：铁路; 钢桥面铺装; 保护层; 浇注式沥青混凝土; 耐久性

中图分类号: U24

Pavement Comparison and Analysis of Railway Steel Bridge and Highway Steel Bridge

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Abstract: Because of the difference of using function, conditions and load, there is a wide difference between the paving material requirements of railway bridge and highway bridge. In this paper, the pavement structure using conditions and technical performance of railway bridge and highway bridge was analyzed. Based on these analysis, the typical pavement material such as Gussasphalt mixture and epoxy asphalt are discussed about the applicability on the railway steel bridge deck pavement. And the recommended pavement structure, which has important guiding significance to railway steel bridge pavement design and construction was proposed in this paper.

Key words: Railway; Steel bridge pavement; protective layer; Gussasphalt; Using condition
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高强钢筋混凝土预制装配桥墩拟静力试验数值分析

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摘  要: 为研究配置高强钢筋的预制拼装桥墩抗震性能，分别开展配置普通钢筋和高强钢筋预制桥墩拟静力循环加载试验，并基于Opensees平台对试验结果进行模拟分析。试验及仿真分析表明，配置高强钢筋的预制拼装桥墩极限承载力高，抗力峰值后刚度衰减较慢，残余位移小，具有良好的自复位性能，抗震性能较好。Opensees纤维单元能够较好地模拟两类桥墩的滞回特性，但对于配置高强钢筋墩柱的滞回环捏缩效应，试验和模拟结果存在一定差异。

关键词: 高强钢筋；滞回性能；预制桥墩；数值模拟

Seismic Behavior of Segmental Precast Piers with High-strength Bars by Experiment and Simulation

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Abstract: In order to investigate seismic behavior of segmental precast piers with high-strength bars, two specimens with respectively HRB400 and HRB600E bars were designed and tested under cyclic quasi-static loading. Finite element models were established for simulation. The results showed that specimens with high-strength bars exhibited higher lateral strength, less post-peak stiffness degradation and lower residual drift, implicating better self-centering capability. Hysteretic behavior simulations of fiber models based on Opensees corresponded well with test results. However, there were still errors when the models were simulating pinching effects of hysteretic loops of piers with high-strength bars.

key words: high-strength bar; hysteretic behavior; segmental precast piers; numerical simulation

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The Effect of the Distance of Transverse Position Symmetry Bias of Axis Forces on the Shear Lag of a Main Girder with Double-rib Cross Section

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Abstract: The effect of axial load on the shear lag effect of double main ribs is studied in this paper, considering the axial load has a certain symmetry deviation in the transverse direction of the bridge. The solution of differential equations and the corresponding boundary conditions are derived for the static equilibrium control Based on energy method. The formula for calculating the normal stress and the shear lag coefficient of the panel is established considering the effect of shear lag. The calculation results of the shear lag effect of the simply supported beam and the cantilever beam show that the panel will experience the negative shear lag - no shear lag effect and the positive shear lag effect when $\xi=0$ to $\xi=b$. 

摘 要：针对斜拉桥双主肋主梁等工程实际，研究轴向荷载作用位置相对截面形心在横桥向对称偏移时的双主肋主梁剪力滞效用，推导了桥面板上任一点正应力和剪力滞系数的计算公式。结果表明，当轴向荷载横桥向作用位置从 $\xi=0$ 向 $\xi=b$ 对称移动时，桥面板将经历负剪力滞效应 - 无剪力滞效应 - 正剪力滞效应的变化过程，结论与有机玻璃模型ANSYS解符合良好。轴向荷载横桥向对称偏移引起的双主肋主梁剪力滞效益明显，建议在结构设计时应予以考虑。
key words: Shear Lag Effect; Wide-flange Beam; transverse position symmetry bias; Energy-Variation Principle

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基于局部密度方差理论的高性能混凝土骨料细观均匀度定量评价

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摘 要: 为了探明高性能混凝土（HPC）材料材性与骨料均匀度之间的关系，定量地评价骨料均匀度是重要的前提。基于局部密度的方差理论，建立均匀度指标评价体系；以数字图像处理技术为手段，进行骨料的外形特征提取，进一步对HPC切面骨料分布细观均匀度进行数值定量计算。研究结果表明：采用高清相机对骨料形态提取简单有效，针对骨料均匀度定量评价所提出的两种局部密度计算指标——由标准局部边长l_0得出的U_1、U_2和对二者取平均值得出的U_3，可对骨料均匀度进行定量分析。对于选取的两个HPC切面测区，旋转0°、5°、10°、15°模拟不同拍摄角度后，利用本文提出的U_1、U_2、U_3三个不同指标来综合评价混凝土骨料均匀性，评价数值波动性小，方差分别在0.6%、0.5%以内；对于单一测区，在4组评价样本中，分别进行综合均匀度评价指标U的计算，其方差为0.098098和0.081729，方差波动性小；后续工程实践中可以用混凝土试块实测值作为修正参数，也可采用多次拍摄计算平均值、赋予U_1、U_2、U_3不同的权重因子或结合其他均匀度评价方法同时验证，可实现特定HPC骨料均匀程度科学评价的目标。

关键词: 桥梁工程; 均匀度定量评价; 局部密度方差; HPC ; 细观

中图分类号: U444 文献标志码: A

Quantitative Evaluation on Aggregate Microscopic Uniformity of High Performance Concrete Based on Local Density Variance Theory

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Abstract: Aiming at probing into the relationship between HPC properties and aggregate uniformity, it was a prerequisite to quantificationally evaluate aggregate uniformity. Based on the local density
variance theory, evaluation indicators system for the aggregate uniformity was established. By means of digital image processing techniques, aggregate shape features were extracted. The aggregate microscopic uniformity of section was further quantificationally calculated. The results show that it is simple and effective to use high-definition cameras to extract aggregate morphology. The local density calculation indexes for aggregate uniformity quantitative evaluation, including calculated by local side and the average , can quantificationally analyze aggregate uniformity. The aggregate microscopic uniformity of two selected HPC section testing zone, after rotating 0°, 5°, 10°, 15° to simulate different shooting angle is comprehensively assessed by the three different indicators, and proposed in this paper. The variances are and with low volatility. For each testing area, comprehensive evaluation index for uniformity evaluation is calculated and the variances are 0.098098 and 0.081729 with low volatility. The concrete test block measured values can be used in follow-up engineering practice as parameter calibration. Multiple shots to calculate the average, changing different weighting factor for, and, or combining with other uniformity evaluation method can be adopted to verify the results at the same time, and it can achieve the goal that scientific evaluation for a specific aggregate.

**key words:** bridge engineering; uniformity quantitative evaluation; local density variance; microscopic

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桥梁箱体结构自调温固液相变材料机理研究

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摘 要：本文在已有的相变材料及相变理论研究分析的基础上, 提出了一种适用于桥梁箱体结构“自调温”的石蜡—稻壳灰相变储能混凝土（PCM-RHAC）新型材料, 通过研究相变储能稻壳灰（PCM-HAC）材料对混凝土温升过程中的影响规律, 建立了相变储能稻壳灰控温混凝土的吸热温升模型, 提出了相变储能稻壳灰混凝土吸热温升估算公式。进一步地, 通过对普通混凝土与相变储能混凝土箱体结构温度场数值模拟及对比, 分析了其在混凝土箱体结构中的“自调温”效用。该研究对后续的PCM-RHAC相关试验及应用具有指导性意义。

关键词：箱体结构; 自调温; 固液相变材料; 温差应力

中图分类号: TU528

Study on Mechanism of Self-adjusting Solid-liquid Phase Change Material of Bridge Box Structure

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Abstract: Based on the analysis of existing phase change materials and phase transition theory, a new kind of paraffin waxy ash-phase change energy storage concrete(PCM-RHAC) that suitable for self-adjusting temperature of bridge box structure was presented in this paper. By studying the influence of phase change energy storage rice husk ash on the temperature rise process of the concrete, the model of heat absorption and temperature rise of the phase change energy storage of the rice husk ash temperature control was established, and the phase change energy storage of the rice husk ash concrete thermal temperature rise estimation formula was presented. Furthermore, through the numerical simulation and comparison of the temperature field of ordinary concrete and phase change energy storage concrete box structure, the self-adjusting temperature effect in the concrete box structure is
analyzed. This study is instructive for the subsequent PCM-RHAC related tests and applications.

**key words:** box girder structure; temperature auto-adjusting; solid-liquid phase change material; thermal stress

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基于液气相变材料的混凝土箱梁结构自调温试验研究

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摘要: 混凝土箱梁结构广泛应用于土木工程领域，由于混凝土材料导热性能差，在强烈日照情况下箱梁内外会产生过大温差，从而导致结构开裂。为了从根本上防止箱梁开裂，本文提出了运用相变储能技术控制箱梁结构内外温差不超过开裂温差限值的新思路，选取三氯三氟乙烷 (R113) 液气相变材料，通过试验验证该方法能够有效控制箱梁结构内外温差，起到自调温的作用。

关键词: 混凝土箱梁, 温差, 液气相变材料, 自调温

Experimental Study of Automatic Temperature Regulation of Concrete Box Girder Based on Gas-liquid Phase Change Material

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Abstract: Concrete box girder structure is widely used in civil engineering field. Because of the poor thermal conductivity of concrete material, the large temperature difference between inside and outside of the box girder will happen in the condition of strong sunlight, which can lead to structural crack. In order to avoid cracking of box girder, this paper presents the use of phase change energy storage technology aiming to control temperature difference, which should below the limit value. Select three chloro three fluoroethane (R113) gas-liquid phase change material. Through experiments this method can effectively control the box girder temperature difference between inside and outside, thus make the function of automatic temperature adjust.

key words: concrete box girder; temperature difference; gas-liquid phase change material; automatic
temperature adjust

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Research and Application of Steel Box Girder Manufacturing Automation Technology in Hong Kong-Zhuhai-Macao Bridge Project

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ABSTRACT

In the background of the Hong Kong-Zhuhai-Macao Bridge engineering, the technical and managerial challenges of steel box girder fabrication are described in this paper. Based on the creative concept and practice of automatic production line of steel box girder ,the automation technology and equipment used in the steel manufacturing process which have reached the international advanced level are introduced in this paper. The main points are U-shaped ribs processing, automatic assembly and welding technology, fillet weld of U-shaped ribs phased array detection technology, and welding data management system. The results of the study led to the birth of the world's first automatic production line of steel box girder .This achievement is of great significance to promote the construction of steel bridge, the transformation and upgrading of bridge-building and “one belt and road initiative” and improve the quality of bridge construction.

KEYWORDS: Hong Kong-Zhuhai-Macao Bridge; Steel Box Girder; Automated Manufacture; Innovation
The Technical Challenges of Cross-sea Bridges in China

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ABSTRACT

Different from bridges over rivers, cross-sea bridges face more severe natural conditions, e.g., strong wind, saline water, complicated hydrodynamic environments caused by the wave-current interaction in the estuaries or coastal sea areas. The difficult construction situations of three famous cross-sea bridge projects in China, i.e., Donghai Bridge, Hangzhou Bay Bridge and Zhoushan Island-Mainland Connection Project and the corresponding precious experiences of technical challenge are described. The major factors, such as typhoon/strong wind, ship collision and pile scour, for the technical challenges of cross-sea bridges are inferred from a case study of Zhoushan Island-Mainland Connection Project. Considerable experiences have been accumulated through the design
and construction of cross-sea bridges in China in the last two decades. However, continuous attentions, health monitoring and technical challenges are still necessary for the risk of strong wind, ship collision and pile scour, because the increasing tendency of building cross-sea bridges farther from the coastline may lead to higher possibility of stronger wind and more severe pile scour, and the gradually growing ship number of water transportation may raise the probability of ship collision to cross-sea bridges.

**KEYWORDS:** cross-sea bridge; strong wind; pile scour; ship collision
Punching Shear Behavior of Light-type Steel-UHPC Composite Slab: An Experimental Study

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ABSTRACT
This paper focuses on the punching shear behavior of steel-UHPC composite slabs. A series of specimens was tested under concentrated load. The failure modes observed from experiments were punching shear failure of UHPC layer, studs failure and yielding of steel plate. 3D finite element models were conducted, and the results show good agreement between analytical and experimental values.

KEYWORDS: punching shear; UHPC; composite slab
Experimental Research on Mechanical Properties of Super Resin Concrete

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ABSTRACT
In this paper, research on super resin concrete used in bridge reinforcement engineering had been carried out: the basic mechanical properties, including the compressive strength, tensile strength under the best super resin concrete mixture ratio had been obtained. The relationships between the basic mechanical properties and the curing time and curing temperature were concluded also. At last, the bonding strength between the super resin concrete and the concrete materials was determined through the test. Results indicated that the best super resin concrete mixture ratio of the super resin concrete is 1:1:3.8, whose compressive strength, tensile strength is much better than that of the ordinary concrete. The strength becomes large in a much faster speed within 24h. After 48h, the strength could reach 95% of the level of the 7d strength. The elastic modulus of the super resin concrete trends to be stable under the temperature from 10°C to 50°C, thus it could be used for rapid reinforcement and restoration works. Also the test indicates that the super resin concrete could be used as a kind of ideal reinforcement material due to its good bonding strength cohering with the concrete materials, which means that the super resin concrete has a good application prospect in the field of bridge rapid reinforcement.

KEYWORDS: resin concrete; reinforcement material; best mix; compressive and tensile test; bonding properties
悬索桥主缆“缠包带+除湿系统”新型防护体系应用研究

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摘 要: 本文介绍了云南龙江特大桥主缆采用一种有别于传统防护体系的新型主缆防护方法，该防护体系采用缠包带外包主缆进行防护，具有良好的密封性和防腐性，同时加装主缆除湿系统降低主缆内部湿度，从而对主缆进行防护。

关键词: 悬索桥；主缆防护；缠包带；除湿系统

Study on the Application of New Protective System of "Cable - wrapped + Dehumidification System" in Main Cable of Suspension Bridge

Abstract: This paper introduces a new type of main cable protection method, which is different from the traditional protection system in the main cable used in Longjiang Yunnan Bridge. The protection system is wrapped by wrapping tape to protect the main cable, with good sealing and corrosion resistance.Meanwhile, install dehumidification system in the main cable to reduce internal humidity to protect it.

key words: suspension bridge; main cable protection; wrapped belt; dehumidification system

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Effect of Side Retainers on Transverse Seismic Response of a Nonstandard Continuous Bridge

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ABSTRACT

Reinforced concrete side retainers are widely used to restrain the lateral displacement of elastomeric bearings in girder bridges in China. The extensive damage observed on side retainers in the aftermath of the 2008 Wenchuan earthquake attracted a great research interest in the improvement of the seismic performance of side retainers. In this circumstance, experimental work was conducted to examine the seismic behavior of side retainers designed in compliance with current engineering practice as well as to search for a new type of side retainer with the objective of damage control. Based on the experimental results, a simplified analytical model is proposed to simulate the constitutive relationship of the regular side retainers. In the background of a typical nonstandard continuous girder bridge, nonlinear time history analysis is performed to investigate the influence of side retainers on the distribution of seismic force in the transverse direction. The results show that by the use of “too strong” side retainers, the seismic force tends to concentrate on some particular piers with smaller heights, which adds difficulties to the seismic design of the piers. As the retainers on each pier function in different performance states during earthquakes, the rigidity center of the bridge deviates, which not only alters the distribution of the seismic force among piers but also causes some retainers to break down resulting in shear failure of the elastomeric bearing pads. Hence, the strength of the side retainer necessitates specific design to protect the elastomeric bearing pads from damage in earthquakes, and not to exert an unfavorable influence on the distribution of the seismic force.

KEYWORDS: continuous bridge; side retainer; seismic response; simplified analytical model; shear force; bearing deformation
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泸定大渡河特大桥抗震设计创新

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摘 要：针对雅康高速公路泸定大渡河特大桥桥址区地震动参数高的特点，开展结构抗震创新研究。基于延性设计理念，引入防屈曲钢支撑作为中央扣杆件，得到的铰结式耗能型中央扣能显著改善大桥的抗震性能，成为高地震烈度区大跨悬索桥理想的中央扣形式；采用波形钢腹板钢混组合结构作为桥塔横梁，试验研究表明这一组合横梁是高烈度地震区大跨径悬索桥塔理想的横向联结方式。以上设计创新，确保了大桥的抗震安全。

关键词：桥梁工程; 抗震设计理念; 铰结式耗能型中央扣; 波形钢腹板钢混组合横梁

中图分类号: U442

Innovation of Seismic Design of Luding Dadu River Bridge

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Abstract:Given the characteristic of high ground motion parameter of the bridge site region of Luding Dadu River Bridge along Ya’an-Kangding Expressway, this project initiated a structure seismic innovative research. Based on the philosophy of ductility design, the buckling-restrained brace was introduced to serve as the central buckle pole, and the articulated energy-consuming central buckle obtained can significantly improve the anti-seismic property of the bridge, so it became the ideal mode of the central buckle of long-span suspension bridges in the high earthquake-intensity areas. Besides, the corrugated steel web steel-concrete composite structure was adopted as the bridge tower crossbeam, and was proved to be an ideal transverse combination mode of the bridge towers of the long-span suspension bridges in the high earthquake-intensity areas through experimental study. The above design innovation ensures anti-seismic safety of the bridge.
key words: bridge engineering; seismic design idea; articulated energy-consuming central buckle; corrugated steel web steel-concrete composite crossbeam

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Study on Constitutive Theory of Confined Concrete in Bridge Piers

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ABSTRACT

It is necessary to simulate the elastic-plastic state of piers when we use the finite element software to proceed the seismic analysis of bridges. The material mechanics theory shows that stiffness of cross-sections is equal to the ratio of bending moment and the curvature so we can calculate elastic stiffness and plastic stiffness by the moment-curvature curve. The moment-curvature curve of piers is determined by the mechanical properties of outer protective layer of concrete, core confined concrete, vertical reinforcement and axial force of the bridge pier. Among them, mechanical properties of unconstrained concrete and reinforcement can be get by referring to the civil industry standards [7]. The mechanical properties of core confined concrete is more complicated because it’s determined by many factors including the thickness of the outer protective layer, the strength of concrete, steel bar intensity, reinforcement ratio and stirrup ratio etc. Some scholars have established different theoretical models about the constitutive relation of core confined concrete. Among them, mander constitutive relation is frequently applied to engineering practice. Mander constitutive model is mainly aimed to calculate the peak compressive stress and its corresponding strain. This model consists of many semi-empirical and semi-theoretical formulas. This paper will introduce the model of mander constitutive relation through 2 calculation examples and verify the correctness by comparing the manual calculation results with the results of Midas/Civil.
**KEYWORDS:** stiffness of cross-sections, moment-curvature curve, core confined concrete, Mander constitutive model, bridge piers.
Experimental Research on Seismic Performance of Crossbeam with Corrugated Steel Web in Cable Bent Tower of Dadu River Bridge

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Abstract: A quasi-static model test was conducted on seismic performance of crossbeam with corrugated steel web in cable bent tower of extra-large span suspension bridge, in order to support the design of the Luding Dadu river bridge on the highway from Yaan to Kangding. Based on the analysis of force-displacement hysteretic curve, skeleton curve, energy dissipation and ductility performance, carried out an evaluation of the seismic performance of the tower-crossbeam system and a preliminary exploration on the length of plastic hinge. The experiment result indicates that the crossbeam with corrugated steel web can satisfy the seismic design requirement, the connection system between tower and crossbeam can realize the design concept of “Strong-column and weak-beam □ Strong-shear and...
weak-bending Strong-joint and weak- component”, the suggested connection system provides a new idea for the seismic design of large-span suspension bridge in high intensity region.

**key words:** Extra-large span suspension bridge; cable bent tower; crossbeam with corrugated steel web; model experiment; seismic performance; design concept

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Large Tonnage 6-DOF Coordinated Testing System Based on Stewart Platform

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Abstract: Based on the present situation of the multi-degree-of-freedom synchronous loading system at home and abroad the performance and technical advantages of “large tonnage 6-DOF Coordinated testing system” are introduced. The system innovatively uses the force posture and position posture control technology of 6-dof Stewart platform, with the multi-degree-of-freedom synchronous loading performance such as tensile, compression, shear, bending and torsion, which can simulate the complex stress and boundary conditions of bridge key components and joints. The system can be widely used in research of seismic Isolation equipment and seismic design of bridge and structure.

key words: 6-DOF; Large tonnage; Stewart platform; Boundary conditions; Testing system
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泸定大渡河特大桥抗风技术研究

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摘 要: 本文通过风洞试验对泸定大渡河特大桥的颤振性能进行了优化研究, 确保了桥梁结构的颤振稳定性。首先, 采用ANSYS软件分析了桥梁结构的动力特性, 并测试了不同风攻角下桥梁的颤振临界风速。然后, 通过数值模拟研究了风攻角对流场的影响, 在此基础上提出了使桥梁颤振稳定性满足要求的优化方案。研究结果表明: 该悬索桥桥面设计高度处的风攻角以负攻角为主, 而负攻角下桥梁的颤振稳定性较差。若封闭桥面系中央开槽, 并在其上、下侧同时设置竖向中央稳定板, 可以使该悬索桥的颤振临界风速很好地满足颤振检验风速的要求。

关键词: 钢桁梁悬索桥; 颤振性能; 气动优化; 大风攻角; 风洞试验

中图分类号: U446.1; O355

Technology Research on Wind Resistance of Luding Dadu River Grand Bridge

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Abstract: For Luding Dadu river grand bridge, the flutter performance was studied by wind tunnel test to ensure the structural flutter stability. At first, the dynamic characteristics of the bridge were calculated by the ANSYS software, and the flutter critical wind speeds at different angles of attack were measured. Subsequently, the effects of angle of attack on the flow field were studied by numerical simulation, and aerodynamic optimization methods were further presented to ensure the flutter stability of bridge. The results show that the mean angle of attack of inflow at the height of bridge deck is negative at which the flutter performance of the suspension bridge is weakened. The critical flutter
wind speeds at different angles of attack can well meet the requirement of flutter checking wind speed by closing the central slot of bridge deck, setting upper and lower central vertical stabilizers.

**key words:** suspension bridge with steel truss girder; flutter performance; aerodynamic optimization; large angles of attack; wind tunnel test

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Lessons Learned from Bridge Collapses in Service

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ABSTRACT

Thorough investigations of bridge collapses, both during construction and in service, can provide many lessons to improve engineering practice. This paper focuses on the lessons learned from the landmark Point Pleasant, Mianus, and Schoharie Creek bridge disasters in the United States. All of these bridges failed, with loss of life, after years of service. The failure of the Point Pleasant or Silver Bridge over the Ohio River illustrates how a critical flaw leading to fracture can destroy a non-redundant structure. The Mianus River Bridge case shows the impact of corrosion on hanger pins. The Schoharie Creek Bridge collapse illustrates the need to install and maintain scour protection. The careful investigation of these failures has led to improved maintenance procedures. These cases also show the need for inspectors to understand structural behavior of bridges. There are lessons for bridge designers in these case studies. Critical elements of the bridge must be accessible for inspection and maintenance. Redundant designs are preferred, because collapses will then be localized rather than general. The lessons for bridge maintenance and management are equally important. It is vital for inspectors to understand the fundamental structural behavior of bridges, including load paths, in order to properly identify the most critical elements for inspection.

KEYWORDS: bridges, collapse, maintenance, fatigue, scour
The Anti-collision Equipment and Engineering Application of Luzhou Yangzi River Bridge

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Abstract: With the increasing of cross river bridges and promotion of channel, more and more bridges face the risk of ship collision. The appropriate anti-collision equipment can increase the impact resistance of bridges, and reduce losses of both bridges and vessels. This paper introduces a type of anti-collision equipment for Luzhou Yangzi River Bridge from two aspects including scheme comparison and effect verification. The paper also shows an engineering application to prove the practicability of the equipment.

key words: ship collision; composite material; anti-collision equipment; energy consuming

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Influence of Straining Beams on the Seismic Fragility of Double-column Bridge Piers

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ABSTRACT

The piers of girder bridges are relatively vulnerable when subjected to ground motions. The seismic fragility of different types of piers is evaluated in this paper to investigate the influence of the straining beams on the safety of double-column (DC) piers under earthquakes. The seismic capacity of eight DC piers with straining beams varying in number and height was firstly studied by pushover analyses. Empirical formulas were derived for the calculation of the seismic capacity of general DC piers using pushover data, and the damage indexes of selected piers were determined for five damage states correspondingly. Finite element models of typical girder bridges with the different piers were
then developed using OpenSees and nonlinear time history analyses were carried out to obtain the seismic demand of these piers. Fragility curves were generated for the piers by comparing their seismic demand and damage indexes at the damage states. Results indicate that (1) DC piers are more vulnerable when subjected to longitudinal ground motions compared with the case of transverse inputs; (2) the damage probability of the piers decreases with the increase of the relative height of straining beams for transverse seismic inputs; and (3) the DC piers with two straining beams perform better in transverse direction, than those with a single straining beam.

**KEYWORDS:** girder bridge; double-column pier; straining beam; seismic fragility; damage index
基于速度反馈和时滞效应的人行桥横向振动研究

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摘要：以伦敦千禧桥为背景，考虑行人横向作用力的时滞效应，研究柔性人行桥的横向参数振动问题。运用多尺度法对行人基于该桥横向速度反馈调整模式时的动力方程进行求解，探讨了速度反馈时的临界时滞，及时滞、反馈调整系数对千禧桥临界人数、响应幅值的影响。结果表明：在考虑行人基于千禧桥横向速度反馈调整模式进行调整时，作用力时滞、反馈调整对千禧桥参数振动响应的影响不可忽视。

关键词：人行桥；时滞；反馈；动力响应；稳定性

Based on the Speed of Feedback and Time Lag Effect of the Pedestrian Bridge Transverse Vibration Research

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Abstract: With regard to the Flexible footbridge transverse parameters vibration problems, on the consideration of the time-lag effect by pedestrians on the Millennium Bridge, lateral speed of pedestrians on footbridge are studied by applying multi-scale method. Some adjustments are made on speed feedback adjusting model. The critical time-lag under are analyzed respectively. Time-lag, feedback adjustment coefficient of the Millennium Bridge on critical numbers and the influence of the response amplitude are studied as well. The results show that the influence of acting force time-lag and feedback adjustment on the Millennium Bridge vibration response cannot be ignored, considering the adjustment on the adjusting models namely the transverse speed based on pedestrian footbridge.

key words: footbridge; time-lag; feedback; dynamic response; stability
Mechanical Deformation Mechanism and Verification of Sections at Junction of Light and Dark Tunnel in Mountain Area

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ABSTRACT

The project of light and dark tunnel junction in mountainous area is a complex engineering which combines tunnel structure, slope rock-soil mass and protection project. Among them, junction of light and dark tunnel suffers from a complex and changeable load. The stress and deformation of the junction is very different under a variety of conditions. So it presents a lot of inconvenience to the construction and monitoring operations. According to the load condition which acts on the junction of light and dark tunnel, we divided the junction hole into: thrust type, compression type and combined thrust-compression type. Three kinds of structures were simulated by numerical analysis. And we have explored the structural deformation and stress of these types which under different condition. So whether in any construction process, we could come to its mechanical deformation mechanism and the weak point in structure. And then based on the weak parts, we install some monitoring points and choose four fields for monitoring. The monitoring results show that the actual deformation, stress and structural failure location are basically consistent with the numerical simulation results. The deformation mechanism of light and dark tunnel junction we obtained in this paper can provide the basis for selecting the treatment measures and controlling the structural deformation. What’s more, the results can also be used as reference for similar engineering design, construction and site monitoring.

KEYWORDS: mountain area; junction of light and dark tunnel; hole; Mechanical deformation mechanism; Site monitoring and verification
盾构穿越不同土层的地表沉降规律及预测方法研究

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摘 要: 以南京地铁3号线为工程背景, 通过对全线盾构施工的大量现场实测资料进行分析, 选取了软塑~流塑状态粘性土地层, 可塑~硬塑状态粘性土地层和粉砂土地层等3种盾构通过的典型地层进行分析, 确定了南京地区地层损失取值: 软塑~流塑状态粘性土地层为2.2%~6.8%; 可塑~硬塑状态粘性土地层为0.9%~5%; 粉砂土地层为0.5%~3.7%。并拟合出了三种典型地层的沉降槽宽度系数计算公式。分析了盾构穿越引起的地表沉降规律, 并根据所得的沉降规律提出相应的预防控制措施。对盾构穿越南京地区特定地层的隧道施工、设计有一定的工程指导意义。

关键词: 南京地铁; 盾构施工; 沉降槽宽度系数; 地层损失

Research of Rules and Prediction of Ground Settlement in Different Stratum by Shields Tunneling

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Abstract: Based on the measured data of the line 3 of Nanjing Metro by shield tunneling, three kinds of typical formation that shield passing through are picked for analysis and the three kinds are respectively as follows: soft flowing plastic clay plastic-hard plastic clay and silt soil stratum. The rate of ground loss of soft flowing plastic clay is 2.2%~6.8%, the plastic-hard plastic clay is 0.9%~5%, while the silt soil stratum is 0.5%~3.7%. Besides, the calculation formula of the width coefficient of
settlement is obtained from the fitting curves. The law of ground settlement caused by shield passing through the formation above are been discussed. The study of the paper has certain guiding significance not only to the design and construction of shield passing through typical formation but also to the prevention and reinforcement of ground settlement.

**key words:** Nanjing Metro; Shield tunneling; Width coefficient of settlement; Ground loss

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山岭隧道衬砌开裂成因分析

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摘 要: 采用有限元模拟的方法, 对隧道衬砌开裂的原因, 从是否设置仰拱、水荷载、围岩劣化等方面分析衬砌的受力和变形。在同岩条件下, 有仰拱隧道边墙、墙脚处的水平位移小于无仰拱隧道, 但有仰拱隧道的内力大于无仰拱隧道。但当隧道排水系统失效, 需要承受额外水荷载时, 有仰拱隧道能够有效调整结构受力, 使结构整体受力更加合理。同时, 有仰拱隧道能够有效控制衬砌变形和围岩塑性区的发展。

关键词: 隧道; 衬砌开裂; 仰拱; 水荷载; 围岩劣化

Analysis of the Causes of Tunnel Lining Crack

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Abstract: Finite element method is used to analyze the reasons of the lining cracking of the tunnel, and the stress and deformation of the lining are analyzed from the aspects of whether the arch, the water load and the surrounding rock are deteriorated. In the same rock condition, the horizontal displacement of the tunnel wall in tunnel with invert is less than that in tunnel without invert, but the force of the tunnel wall in tunnel with invert is larger than that in tunnel without invert. However, when the tunnel drainage system fails, and the tunnel is subjected to additional water load, the tunnel with invert can effectively adjust the structural stress, so that the whole structure is more reasonable. At the same time, the tunnel with invert can effectively control the deformation of the lining and the development of the plastic zone of the surrounding rock.

Keywords: tunnel; lining crack; invert; water load; surrounding rock deterioration

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宝兰客专徐家川黄土隧道受力特性试验研究

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摘 要: 文章针以采用三台阶七步流水法施工的宝兰客专徐家川黄土隧道为工程背景, 通过现场监控量测, 研究了围岩压力、钢拱架应力、初衬与二衬接触压力、二衬钢筋轴力和混凝土应变等随时间变化规律及分布特征, 并对实际工程的安全状态进行评估; 通过监控量测, 了解隧道工程施工的一般规律和特点, 为今后类似黄土隧道工程的设计施工提供参考。

关键词: 黄土隧道; 监控量测; 围岩; 接触压力

Test Study on the Mechanical Characteristics of Xujiachuan Loess Tunnel on Baoji-Lanzhou PDL

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Abstract: Based on the engineering background of Xujiachuan loess tunnel on the Baoji-Lanzhou Passenger Dedicated Lines (PDL) which is constructed with Three-Stairs and Seven-Steps-Paralled-Line-Production, comprehensive in situ monitoring were carried out such as surrounding rock pressure, stress in steel arch, stress between the first lining and the second lining, steel axis force in the secondary lining, concrete strain, etc. The development and distribution characteristics of the above stresses within ground and structures were discussed and tunnel construction safety was evaluated. Meanwhile, through the above monitoring and analysis, some construction rules and characteristics of tunnel construction were obtained, which can be the reference for similar loess tunnels that are designed and constructed in the future.

Keywords: loess tunnel; monitoring measurement; surrounding rock; contact pressure

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高地应力下爆破能量分布及破岩特性研究

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摘要: 为研究高地应力下爆破荷载和动态卸载效应对破岩效果和损伤破坏范围的影响，在理论上分析了在爆破荷载和动态卸载作用下裂隙区和弹性区岩石应力分布和破裂特征。基于断裂力学和可释放应变能的岩石损伤破坏破坏准则计算了岩石破碎块度d和岩石损伤破坏破坏范围Rd。计算结果表明，当初始地应力达到50 MPa以上，由于动态卸载释放的原岩中已积聚的弹性应变能可以达到裂隙区破碎能的16%以上。高地应力卸载后在爆腔腔壁将产生一个径向拉应力，在裂隙区边缘拉应力为2MPa，拉伸位移为0.1mm~0.3mm，在弹性区由于卸载波径向拉伸应力的作用促使其聚积的应变能沿径向释放，使弹性区形成新的损伤破坏，损伤破坏区厚度为0.03m。随着爆腔半径和裂隙区半径的增大，动态卸载释放的能量和损伤破坏区的厚度也将随之增大。

关键词: 高应力; 爆炸能量; 动态卸载; 断裂; 应变能释放; 损伤破坏

Study on Hard Rock Blasting Energy Distribution and Fragmentation Characteristic under High Situ Stress

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Abstract: In order to study the influence of dynamic unloading effect and blasting load under high geostress on rock breaking efficiency and damage zone, the fracture zone and elastic zone’s characteristics of rock deformation and fragmentation under blasting load and dynamic unloading wave are theoretically analyzed. It calculates rock fragment size and damage zone Rd, which are based
on the energy release principle of fracture mechanics and the criteria damage failure of rocks. The result show that, the blasting cavity wall will produce a dynamic unloading wave with a fairly large radial tensile stress that leads to generate circumferential crack on account of dynamic loading effect in fracture zone. When the initial geostress value is up to 50MPa, the energy released by the dynamic unloading can reach more than 16% of rock breaking energy in the fracture zone. The radial tensile stress reached to 2MPa in the edge of crack zone. In the elastic zone, elastic energy radially release under the action of radial tensile stress caused by dynamic unloading. New damage zone was formed in elastic zone. The thickness was 0.03m. With the increase of the blasting cavity radius and crack zone radius, a range of damage areas will generate in the elastic zone.

**key words:** high geostress; explosion energy; dynamic unloading; fracture; strain energy dissipation; damage

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沟槽式高填黄土明洞洞顶土压力统一计算方法研究

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摘  要: 针对现有理论模型没有考虑滑裂面对明洞洞顶垂直土压力影响的问题，综合考虑大、小边坡坡角的情况，推导出沟槽式高填黄土明洞洞顶垂直土压力统一计算式。随后，采用荷载等效方法，将数值计算的明洞顶土压力“抛物线”荷载转化为均布荷载，与统一公式计算结果进行对比，验证了统一理论方法的正确性。最后，进一步探讨了小坡角沟槽情况下填料性质、明洞与沟槽宽度比等参数的敏感性对土压力集中系数的影响。结果表明：小坡角沟槽情况下，填土内摩擦角、黏聚力以及沟槽与明洞宽度比对明洞洞顶土压力集中系数基本无影响；填土模量增大可以减小土体压缩相对变形量，减轻明洞洞顶应力集中现象。因此，实际小坡角沟槽明洞工程中，尽量提高土体压实度，减小明洞结构受力。

关键词: 沟槽式; 高填明洞; 土压力; 滑裂面; 计算方法

中图分类号: TU43

Research on Earth Pressure Unified Calculation Method for Open Cut Tunnel in High Fill Loess Trench

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Abstract: According to the existing theoretical model without considering the slip surface effect of vertical earth pressure on the top of open cut tunnel, deriving the unified formula of vertical earth pressure on the top of trench open cut tunnel taking into account the large and small slope angle. Then,
using the equivalent load method makes "parabola" load of the numerical calculation earth pressure on the top of open cut tunnel into uniform load, and comparing with the results of the unified formula, which verifies the correctness of the unified theory. Finally, the sensitivity analysis effecting to the earth pressure concentration coefficient are performed to further study the main factors such as the filling properties and the trench-width ratio as the case of the small angle trench. The results show that as the case of the small angel trench, internal friction angle, cohesion and trench-width ratio have no influence to the earth pressure concentration coefficient on the top of open cut tunnel. Enlarge the filling modulus can reduce the relative deformation of the soil and the stress concentration phenomenon on the top of high fill open cut tunnel. Therefore, try to improve the soil compaction to reduce structure stress for the small angel trench open cut tunnel in the actual project.

**key words:** trench; high fill open cut tunnel; earth pressure; slip surface; calculation method

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跨越地铁超深大空间地下结构基础抗拔研究

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摘要：对于地下水位较浅的超深大空间地下工程，当跨越地铁线路时，若基础抗浮设计不合理会对地铁的安全运营造成不可估量的破坏。本文以实际工程为例，通过数值计算的方法对基础抗拔设计方案进行分析，结果表明，在基坑开挖范围内，沿着两条地铁隧道两侧及中间密集布置大直径钻孔灌注桩，可使隧道因地基回弹造成的位移限制在4~5mm之间，因浮力造成的竖向位移在11.0~15.4mm之间波动，隆起坡度最大仅0.019‰; 在远离地铁的开挖区域采用合理的抗浮锚杆设计，可保证整个混凝土底板受到的弯矩处于较低水平，不会出现裂缝。本工程在不同分区采用抗拔桩和抗浮锚杆的组合设计方案即能满足基础抗浮及地铁安全运营的要求，又能降低建造成本，可以为相似工程设计及施工提供有益参考。

关键词：跨越地铁；基础抗浮；抗拔桩；抗浮锚杆

中图分类号: U238

Research on the Anti-floating Foundation Design of Oversized Ultra Deep Underground Structure Crossing the Metro

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Abstract: For the oversized ultra deep underground engineering crossing subway lines with shallow water level, unreasonable anti-floating design of foundation may cause immeasurable damages to the safe operation of subway. A numerical analysis method is employed to the anti-floating design scheme of the foundation for an actual project, where existing two adjacent parallel subway tunnels under the underground structure. In the excavated foundation pit, three rows of large diameter bored
piles are densely distributed along the tunnel sides and centerline of the two tunnels to restrict. The simulation results show that the displacement of the tunnels caused by foundation rebounding can be limited to 4~5 mm, the fluctuation of vertical displacement caused by floating ranges from 11.0 to 15.4 mm, and the maximum value of the uplift gradient is only 0.019‰. The reasonable design of anti-floating anchors in the area of excavation far from the subway can be effective to lower the moment in the integral concrete floor and thereby avoid the appearance of cracks. The scheme of the combining design of uplift piles with anti-floating anchors in different regions can not only meet the requirements of anti-floating performance of the foundation and the safe operation of the subway, but also reduce the construction cost, which can provide useful references for the design and construction of similar projects.

**key words:** Crossing the metro, Uplift-resistant Design, Anti-floating anchor, Uplift pile

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Experimental Study about Traffic Load Mechanical Effect on Transition Section of Bridge Tunnel under an Operating Highway’s Fractured Surrounding Rock

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ABSTRACT

In order to study the later operation vehicle-pavement mechanics behavior, action effect and impact dynamic response of bridge-tunnel transition section under a fractured surrounding rock, the indoor model test of the system is carried out based on the physical engineering project. Combined with the different characteristics of bridge tunnel transition section physical engineering, the similarity of physical and mechanical indexes between the bridge-tunnel structure and the tunnel surrounding rock are deduced based on the similarity theory. And the model test process, operation steps and methods are
systematically analyzed and expounded. According to the results of model test, when the bridge-tunnel transition section under the condition of fractured surrounding rock, later operation vehicle-pavement mechanics behavior, action effect and impact dynamic response will lead bridge tunnel transition section lining structure key position adverse force state. This would cause excessive displacement or settlement of the bridge mid-span, overlapping end and tunnel bottom, which will lead to a crack. And the safety and stability of surrounding rock which located in transition section tunnel entrance would be reduced. So the key parts of lining structure which located in bridge-tunnel transitional Section with a fractured surrounding rock need to take some measure (Strengthen regular inspection and preventive maintenance treatment). Then we should enhance the safety factor, which could avoid a damage due to lining structure or a disease caused by security risks. The results of this paper can effectively guide the conservation of lining structure (located in bridge-tunnel transitional Section with a fractured surrounding rock) key parts and monitoring method of deformation internal force. The results can be used as reference for similar engineering design, construction and site monitoring.

**KEYWORDS:** Fractured surrounding rock; Bridge-tunnel transition section; Laboratory test; Lining structure; Vehicle load; Mechanical behavior
榆林市公路隧道建设关键技术

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摘 要：本文在充分调研榆林市公路隧道发展历史、现状的基础上，对本市公路隧道建设取得的成绩和存在的问题给予深刻剖析，并对未来的发展方向提出期望和建议。

关键词：榆林；隧道；建设；关键；技术

Key Technologies of Highway Tunnel Construction in Yulin

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Abstract：Based on the history and status quo of Yulin highway tunnel full investigation on the development, give profound analysis to obtain the city highway tunnel construction achievements and existing problems, and puts forward some suggestions and expectations on the future direction of development.

key words: Yulin; tunnel; construction; key technology

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层状岩体对公路隧道围岩稳定性的影响分析

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摘 要: 针对公路隧道层状岩体围岩变形破坏的复杂性，以拟建康定至新都桥高速公路隧道群为工程背景，通过数值模拟研究层状岩体对公路隧道围岩稳定性的影响。研究结果表明: 节理面的存在弱化了围岩的参数，使围岩表现出了各向异性，围岩的稳定性由节理控制，对于隧道的变形、围岩的塑性区面积及围岩松弛区都有较大的影响。具体表现为隧道变形在沿节理面的垂直方向上变形最大，围岩塑性区及围岩松弛区主要沿节理面的垂直方向上分布，其结果可为指导拟建隧道群的设计和施工提供有效依据。

关键词: 公路隧道; 层状岩体; 数值模拟; 围岩稳定性;

中图分类号: U457

Analysis of Impact of Layered Rock Mass on Stability of Road Tunnel

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Abstract: Aiming at the complication of the deformation and the failure of the highway tunnel surrounding rock made of layered rock mass, with the engineering background on proposed Kangding-Xinduqiao highway tunnel group, the paper studies the influence of layered rock mass on stability of surrounding rock of highway tunnel by numerical simulation. The results shows that the existence of joint surface weakens the parameter of the surrounding rock, and makes the anisotropy of surrounding rock occured. The stability of the surrounding rock is controlled by the joint surface, which has strong influence to the deformation of the tunnel, the area of surrounding rock’s plastic zone, and the relaxation zone of the surrounding rock. It is shown that the deformation of the tunnel is the largest in the vertical direction along the joint surface, and the plastic zone of the surrounding rock and the
relaxation zone of the surrounding rock are mainly distributed along the vertical direction of the joint surface. The results can provide an effective basis for the design and construction of the proposed tunnel group.

**key words**: highway tunnel; layered rock mass; numerical simulation; the stability of the surrounding rock

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强岩溶隧道开挖溶洞影响安全分析

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摘 要：随着“一带一路”国家战略的进一步深入，交通路网的建设也正大规模的跟进，在复杂地质地区路网的建设也正越来越多，特别是在卡斯特地貌地区地下工程的修建，地下工程遇溶洞时带来的施工风险也越来越面临着严峻的挑战。为保证施工安全，较为准确的分析隧道遇溶洞开挖时的安全影响，利用曙光三维有限元软件对隧道开挖过程中围岩在遇溶洞地质条件下的地表沉降和衬砌内力进行分析，对施工中的风险提供建议，检验开挖进尺的合理性。以保证地下工程在强岩溶区遇溶洞开挖时的施工安全。有效控制地下岩溶的危害，为工程界遇相类似工程提供一定的参考。

关键词：强岩溶区；遇岩溶隧道工程；开挖时地表沉降；衬砌内力分析

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Analysis on the Safety Influence of Tunnel Excavation in Karst Area

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Abstract: With the further The Belt and Road national strategy, the traffic network construction is also a large scale up, the construction of the road network in complex geological area is also more and more, especially in the Custer areas for the construction of the underground project, bring underground engineering in cave construction risk is increasingly faced with severe challenges. In order to ensure the safety of construction, a more accurate analysis of the tunnel excavation of the cave in safety, on the surface of surrounding rock during tunnel excavation in the case of karst geological conditions of the settlement and internal force of lining are analyzed by the dawn of the three-dimensional finite element software, to provide suggestions for the risk of construction, reasonable test footage to protect. The construction safety of underground engineering in karst area in karst area is proved, which can effectively control the harm of underground karst, and provide a reference for similar projects in the
engineering field.

**key words:** strong karst area; karst tunnel; surface subsidence; lining internal force analysis

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公路隧道仰拱质量问题的病害特征及机理初探

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摘要: 本文总结了公路隧道仰拱质量问题在定期检查中表现出的病害特征，又通过辅助专项检查手段分析了这些病害特征产生的主要原因，查明仰拱质量问题与表观病害特征是相关的。通过有限元分析软件对病害产生的机理进行了探讨，表明隧道仰拱质量问题会使仰拱端头和边墙处弯矩剪力增大，直接成为诱导隧道结构变形开裂的主要因素。

关键词: 公路隧道; 仰拱质量; 病害特征; 机理

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Study on Disease Characteristics and Mechanism of Inverted Arch in Highway Tunnel

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Abstract: This paper summarizes the disease characteristics of road tunnel invert during the regular inspection, and analyzes the main causes of these diseases by means of auxiliary special inspection methods. It is found that the problem of invert quality is related to the apparent disease characteristics. Through the finite element analysis software, the mechanism of the disease is discussed, which indicates that the quality of the tunnel arch invert will increase the bending moment at the end and side walls of the arch, and become the main factor to induce the deformation and cracking of the tunnel structure.

Key words: highway tunnel; invert quality; disease characteristics; mechanism

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757845524@qq.com，主要从事运营公路隧道病害检查处治设计，在建公路隧道监控量测、超前地质预报、质量检测等方面的工作。陈鹏，硕士，西南交通大学。陶双江，硕士研究生，高级工程师，四川省交通运输厅公路规划勘察设计研究院。邓刚，博士，高级工程师，四川省交通运输厅公路规划勘察设计研究院。刘会钢，硕士研究生，工程师，四川省交通运输厅公路规划勘察设计研究院。
Experimental Study of Tube Segment Uplift on the Foundation Treatment of Immersed Tunnels by Sand-flow Method

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ABSTRACT
The whole process of immersed tunnel segment uplifting in the sand-flow foundation treatment was imitated by a full-scale model experiment of sand-flow method. A series of suitable reaction parameters were obtained through the real-time monitoring of sand deposit and the observation of sand
deposit digging. The analysis showed that the increase of trench gap water pressure and the changes of sand particle deposition mode were the direct causes of tube uplifting. The process of tube uplifting could be divided into three stages of pulsatile up stage, rapid up stage and smooth up stage. It was also found that the tube uplifting process which had no effect on the pressure of sand pump outlet and the uniformity of sand deposit extension would influence the expanding rate of sand deposit radius significantly, the peak value of water pressure and the time point of tube uplift start were determined by the weight of tube, the compactness of sand deposit was between loose and medium dense, the uplifting process of model board could compact the sand deposit. These results gained through this study can be applied as references for the design and construction of the immersed tunnel foundation treatment.

**KEYWORDS:** Immersed tunnel, Foundation treatment, Sand-flow method, Full scale model test, Tube segment uplifting
Deep Loess Tunnel Foundation Grouting Reinforcement Effect Analysis

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ABSTRACT
For lining crack problems in loess tunnel construction, combining with the topography characteristics, this paper studied the tunnel surrounding rock deformation characteristics and grouting reinforcement effect with the method of numerical simulation combined with field observations. The results showed that as surrounding rock stress redistribution after tunnel excavation, with the increase of buried depth, increasing plastic zone led to uneven subsidence of foundation, which was the main cause of lining crack. Grouting technique could improve the stress state of foundation and the inverted arch, which controlled plastic zone development and deformation of loess tunnel foundation effectively. Monitoring 3 typical section of the road center accumulative deformation, grouting reinforcement could control the deformation obviously, which satisfied the requirement of tunnel stability for a long time.

KEYWORDS: loess tunnel foundation; buried depth; lining crack; grouting; plastic zone
国道213线映汶段灾后恢复重建复杂隧道工程应用

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摘 要: 国道 213 线映秀至汶川段恢复重建工程位于“5.12 汶川地震”极重灾区中心区域，由于路线沿位于高山峡谷地形区域内的岷江布设，震后原生、次生地质灾害严重，特别是雨季泥石流、水毁问题严重。因此在总体设计时为了提高与既有映汶高速共同形成的生命通道的综合抗灾能力，采用了新建隧道上跨既有高速公路隧道、在既有国道 213 隧道基础上进行分岔改建、新建隧道与既有高速公路的联络通道及新建泥石流明洞工程等多种复杂隧道结构。本文在介绍项目隧道工程结构的基础上，重点分析了几种特殊隧道结构的设置、设计和施工情况，为今后国内类似改建工程中隧道结构的应用提供了一些思路，同时也对隧道小净距上跨既有隧道和既有隧道分岔改建等复杂隧道结构的设计和施工有较强的借鉴作用。

关键词: 复杂隧道结构；小净距上跨；隧道分叉改建；大断面交叉

Application of Complex Tunnel Engineering in Post-disaster Recovery and Reconstruction of Ying-Wen Section of National Highway 213

Abstract: National highway no.213 Yingxiu to wenchuan restoration and reconstruction project located in the heart of the disaster areas hit by the significant earthquake of the "5.12 wenchuan earthquake". Due to the route arranged along the minjiang river that is located in alpine and gorge region, Primary and secondary geological disaster is serious after earthquake, Especially debris flow and waterlogging problems in the rainy season. Therefore, in the overall design in order to improve comprehensive anti disaster ability of the life channel together formed by the existing yingxiu to wenchuan highway and national highway no.213 Yingxiu to wenchuan, Buiting the new tunnel to cross over the existing highway tunnel, Bifurcating On the basis of the existing national highway no.213 tunnel, Building contact channels between the new tunnel and the existing highway tunnel, Building Open-cut Tunnel under the debris flow and so on the many kinds of complex tunnel structure. This paper analyze several kinds
of special setting. Design and construction situation of tunnel structure on the basis of tunnel engineering. The paper provides some ideas for the future similar domestic application of tunnel structure. At the same time, it also has a good reference for the design and construction of the complex tunnel structure, which has a small distance crossing over the existing tunnel and bifurcating on the basis of the existing tunnel.

**key words:** Complex tunnel structure; Small distance over cross; Tunnel Bifurcation; Large span cross

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The Analysis of Hard Rock Blasting Unloading Effect in High Situ Stress

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ABSTRACT

Blasting in high situ stress field is different from earth surface because of its dynamic unloading effect. In order to study the coupling of dynamic loading and unloading in blasting process, the explicit finite element method and explicit-implicit finite element method were respectively employed to investigate the influence of high stress in blasting effect. The explicit-implicit algorithm simulation results showed that the change rules of stress and strain are obviously different from explicit finite
algorithm simulation results. The stress and strain change rate caused by dynamic unloading are obviously greater. The radius of blasting cavity calculated by explicit-implicit finite element method increased 0.015m than the result calculated by explicit finite element method. Based on the results of explicit finite element method, a theoretical model was also established which help clarify the effects of high situ stress unloading when blasting in high situ stress field. It shows that the maximum tensile radial strain in the edge of blasting caving is 0.12mm, the dynamic unloading radial tensile effect can lead to the failure of the rock. According to those finding, some blasting engineering design suggestions were put forward.

**KEYWORDS:** high situ stress; Coupled static and dynamic; Dynamic unloading; explicit-implicit algorithm
新建公路桥梁跨越现有铁路隧道设计方案评估

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摘 要: 新建公路桥梁如果跨越既有铁路隧道修建时, 势必会对既有隧道造成安全影响, 因此要对设计方案进行安全评估。本文通过有限元软件MIDAS/GTS, 以定南高速公路联络线龙形高架一桥新建桥梁为工程实例, 对新建公路桥梁跨越现有铁路隧道时对隧道造成的影响进行了详细的分析, 并依据计算结果提出了相应的安全防护措施。结果显示: 路堑开挖引起的轨道隆起值在临时补修的控制范围之内; 桩基施工本身对隧道影响极其微小, 桩基开挖不会引起隧道结构的变形; 路基段车辆荷载对隧道基本没有影响。

关键词: 桥梁工程; 隧道工程; MIDAS/GTS; 安全评估

The New Highway Bridges Across the Existing Railway Tunnel Design Scheme Evaluation

Abstract: If new highway Bridges across both the railway tunnel construction, is bound to affect caused by the tunnel safety, so to design scheme for safety assessment. In this paper, the finite element software MIDAS/GTS, to settle the south link dragon elevated highway bridge new bridge as the engineering example, the newly built highway Bridges across the effects on the tunnel when the existing railway tunnel are analyzed in detail, and according to the results of calculation, corresponding safety protection measures are put forward. The result shows: the cutting excavation of track uplift value in temporary repair of control; Itself very little impact on the tunnel, the pile foundation construction of pile foundation excavation will not cause deformation of the tunnel structure; Subgrade section of vehicle load has no effect on tunnel basic.

key words: bridge project; tunnel engineering; MIDAS/GTS; the safety assessment
基于线位选择的隧道运营风险评估方法研究

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摘 要：以某跨江隧道为背景，针对工程可研阶段遴选出的线位方案，按照线位选择与施工工法进行隧道运营安全风险源辨识。采用风险判断矩阵和专家调查法对各方案的风险进行评估，再结合层次分析法，从设计、施工、维护角度对隧道通风、线型、地质、水文、建设及安全措施等分项进行计算评估。根据各线位及开挖工法的运营安全评估结果，得到A2线位盾构工法为风险等级最低的方案。同时，针对给出的风险源类型，提出了对应的风险管理办法，实现了在可研阶段科学高效的选线及工法选择的目的，也为项目决策提供了多方位的参考。

关键词：跨江(海)隧道；运营风险评估；线位选择；风险分析

Research on the Risk Assessment of Tunnel Operation Based on Line Position Selection

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Abstract:A cross river tunnel as the background, according to the engineering scheme of bit line selection of the research stage, the tunnel operation safety risk identification in accordance with the line selection and construction method. The risk judgment matrix and expert investigation method to assess the risk of each scheme, combined with analytic hierarchy process, from design, construction and maintenance of tunnel ventilation, linear, geological, hydrology, construction and safety measures separately assess. According to the operation safety evaluation results of each line and the excavation method, get the A2 line for the lowest risk level of shield construction scheme. At the same time, the corresponding risk management methods are proposed according to the types of risk sources. The research of line selection stage of scientific and efficient and objective method of selection, but also provides multiple references for project decision.
**key words:** Cross River (Sea) Tunnel; Operational risk assessment; Line selection; Risk analysis

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A Time-delay Calculation Method of Tunnel Blasting and Engineering Applications of Digital Electronic Detonators

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ABSTRACT

The time-delay calculation method is significant for decreasing blasting vibration effect induced by tunnel blasting. According to the calculation theory of optimal millisecond delay blasting, considering the physical and mechanical parameters of rock and tunnel blasting construction parameters, a time-delay calculation method of each holes interval detonation using digital electronic detonators in tunnel is proposed. The effects of dose and time-delay using digital electronic detonators on the velocity and principal frequency of a blasting seismic wave were discussed. Then the time-delay calculation method using digital electronic detonators was applied to several projects. A reasonable time-delay of tunnel blasting should be addition of three time-delays. The first time-delay is the time that the stress wave travels from the charges centre to the free surface and then reflects to the charges centre. The second time-delay is the time that the crack propagates along the borehole to the tunnel face. The third time-delay is the time that the throw reaches from the new airport surface to the corresponding width. The results show that a reasonable time delay of an electronic detonator for single holes interval initiation could effectively decreases the peak particle velocity and increases the principal frequency of a blasting seismic wave for zone near shallow tunnel blasting source. Besides, this time-delay calculation method has been successfully applied in actual tunnel blasting projects. It is proved that this method is shown to be a good guideline to decrease tunnel blasting vibration.

KEYWORDS: tunnel blasting; digital electronic detonators; a time-delay calculation method; engineering applications
下沉式泵房在水下隧道中的应用与数值模拟研究

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摘  要：厦门第二西通道工程跨海域段为采用钻爆法施工的水下隧道，该隧道在海域最低点的废水泵房有效容积要求达6519m³，采用常规的利用联络通道或主洞下部扩挖的泵房方案均不能满足蓄水需求。在对影响泵房方案因素分析的基础上，提出了纵向式、横向式、纵横混合式和下沉式四种大容积泵房布置方案。通过对四种泵房方案的定性分析，得出了纵向式与下沉式泵房方案在施工出渣便捷性、运营经济性、养护便利性等方面较其他两种方案有较好的优势。对这两种方案进行有限元数值模拟，得出了下沉式泵房方案在结构安全性优于纵向式泵房，为大容积水下隧道泵房形式设计提供了借鉴。

关键词：水下隧道；泵房；下沉式；有限元；钻爆法；纵向式

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Application and Numerical Simulation of Subsided Pumping Station in Underwater Tunnel

Abstract: One-level water pumping and drainage scheme is adopted in the Second Western Passage of Xiamen constructed by drilling and blasting method, in which effective volume of 6015 m³ is needed for the waste water pumping house in the lowest point of the sea area. However, common design schemes that connecting passage or downward expansion of the main tunnel can not meet the requirements. Therefore, several available design schemes of the pumping house for large-scale pumping house, including longitudinal pumping house, transverse pumping house, longitudinal-transverse mixed pumping house and submerged pumping house, are proposed based on the analysis of the influence factors. A qualitatively comprehensive analysis is carried out and its result suggests that the longitudinally and submerged arrangements of the pumping house are better than the other two pumping houses in convenience of muck discharge, operation economy and convenience of maintenance. After numerical simulation of these two appropriate schemes, submerged arrangement
of the pumping house proved to be the best scheme taken in structural safety in consideration. The new submerged pumping house structure can provide good reference for future design of waste water pumping stations in underwater tunnel with drilling and blasting method.

**key words**: underwater tunnel, pumping house; submerged pumping house; numerical simulation; drilling and blasting method; longitudinal-transverse pumping house

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城市地下工程隧道矿山法施工爆破临界模拟分析

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摘 要: 现代城市地铁及地下管廊建设过程中，下穿重要建筑、河流等复杂地质地段较多，地铁矿山法施工过程不论是采用光面爆破，还是采用预裂爆破或水压爆破等方式，对地下工程修建穿越区域必定产生一定的影响。这是采用爆破施工所带来的必然缺陷，为了保证建造过程周边环境的安全，提前给施工决策提供重要参考，确保地下工程开挖过程中的自身结构及周边建筑物的安全。利用二维数值模拟软件针对钻爆法施工过程中的围岩爆破扰动后地层应力从分布及周边环境干扰进行模拟，为施工中的风险控制提供决策。本文所提到的模拟分析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: 城区间隧道; 矿山法施工; 临界模拟计算; 爆破荷载

中图分类号: U455.6 文献标志码: A

Urban Tunnel Blasting in Mine Construction and the Critical Simulation Analysis

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Abstract: Modern urban subway and underground utility tunnel construction process, the wear important complex geological section is more, such as buildings, rivers, no matter the construction process of underground mining method adopt smooth blasting, and adopts the pre-splitting blasting and hydraulic blasting method, to underground engineering construction across the region will produce certain effect. This is the blasting construction brought about by the inevitable defects, in order to ensure the safety of construction surrounding environment decision to provide important reference to construction in advance, to ensure its structure in the process of underground engineering excavation and the safety of the surrounding buildings. Using two-dimensional numerical simulation software for drilling and blasting method in the process of the construction of rock blasting disturbance after
formation, to simulate the stress from the distribution and the surrounding environment for the construction of risk control to provide

**key words**: The city tunnel; Mine construction; Critical simulation; The blasting load

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贵阳地铁悬臂掘进机隧道开挖施工地层变形控制分析

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摘要：在城市地下工程施工过程中，常用的地下隧道开挖方法有盾构TBM法、矿山法爆破施工等工法，在贵阳由于受地下强岩溶的影响，为了规避不必要的地质风险带来的工程灾难，首次在地铁隧道开挖中大规模采用岩石悬臂掘进机施工，确保了施工安全，为了保证地铁掘进施工下穿建筑和开挖时的安全，保证地面及周边环境的安全，采用曙光三维软件对其开挖过程中地层进行模拟分析，其分析结果用于指导施工，在岩石悬臂掘进机施工过程中顺利地通过复杂地质段落，保证了过程安全，保护了当地地面及周边环境安全，本文就利用悬臂掘进机隧道开挖施工地层变形控制分析结果，为工程界今后遇相类似工程提供一定的参考。

关键词：岩石悬臂掘进机；地下工程掘进；地层变形；控制分析

中图分类号: U452.1+2 文献标志码:A

Guiyang Subway Cantilever Machine Tunnel Excavation Construction of Deformation Control Analysis

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Abstract: In the process of urban underground engineering construction, the underground tunnel excavation methods have a shield TBM method, mining method, the blasting technique, such as in guiyang due to the influence of the underground karst, in order to avoid unnecessary risk of geological engineering disaster, for the first time in the subway tunnel excavation rock cantilever machine is used for the large-scale construction, ensure the construction safety, in order to ensure the subway tunneling construction under the safety in construction and excavation, ensure the safety of the ground and the surrounding environment using shuguang formation in the process of the excavation of 3 d software simulation analysis, the analysis result is used to guide the construction, the rock in the process of cantilever construction of the machine smoothly through complex geological section, to ensure the
process safety, protect the local ground and the surrounding environment, in this paper

**key words:** Cantilever rock boring machine; Underground engineering excavation; Strata deformation; Control analysis

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爆破动载下水平产状砂质板岩洞室稳定性研究

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摘 要：钻爆法是隧道开挖采用最为广泛的施工技术，施工过程中，爆破振动对围岩的扰动较大，尤其是层状岩层。层状岩层采用爆破施工容易在拱顶出现离层、断裂和弯折等问题。研究依托同马山隧道工程，建立了离散元数值模型，着重分析了层厚、层间结合程度及岩石坚硬程度对钻爆法施工中层状围岩稳定性的影响。研究得出随着岩层厚度减小，拱顶塌落范围增大，边墙、拱顶等位置破碎程度增加；层间结合程度越差、岩石坚硬程度越低，洞室成形愈加困难；洞室失稳破坏是围岩压力与爆破动载共同作用结果，拱顶与边墙处最易发生破坏。

关键词：层状岩；钻爆法；爆破动载；围岩稳定性

中图分类号：U25

The Stability of Caverns in Horizontal Sandy Slate under Blast Dynamitic Load

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Abstract: New Austrian method currently adopted by most tunnels in China can make a disturbance to layered rock during construction phase and fractions, gaps and bending in the crown tend to happen. In order to analyze the stability of caverns in horizontal sandy slate under blast dynamitic load, a discrete element model is proposed based on Tongmashan tunnel with thickness of layer, combination level between adjacent layers and rock strength varying. The results reveal that as the thickness of rock layer deceases, the collapse range in crown increases and so does tattered parts in sidewall and crown; when combination level between adjacent layers and rock strength is low, the cavern cannot hold its stability; both of the pressure and blast dynamitic load account for instability of the underground tunnel and the
most fragile parts are the crown and sidewall.

**key words**: layered rock; drill and blast method; blast dynamitic load

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场地动力特性对衬砌隧道地震反应的影响: 平面SV波入射

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摘要: 采用间接边界元法, 研究了SV波入射下场地动力特性对隧道地震反应的影响。方法充分利用半空间
格林函数和全空间格林函数在构造开口半无限空间域和闭合域内散射波场方面的优势, 将含有衬砌隧道的层
状半空间分解为开口层状半无限空间域和一个环形衬砌闭合域。文中验证了方法的正确性, 并以基岩上单一
土层和基岩上三层土为例, 计算分析了弹性层状半空间中隧道衬砌内表面动应力集中系数。结果表明随着基
岩土层刚度比的增大, 动应力集中系数峰值减小; 随着土层厚度增大, 动应力集中系数峰值总体上呈减小趋
势; 对于不同土层层序, 动应力集中系数峰值明显不同。

关键词: 衬砌隧道; 动应力集中系数; 土层层序; 平面SV波

Effects of Site Resonant Characteristics on the Seismic Response of Lined Tunnel: Incident Plane SV Waves

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Abstract: The effects of site resonant characteristics on the seismic response of lined tunnel under plane SV waves are studied by adopting indirect boundary element method. Retained the advantages of both full-space IBEM and half-space IBEM, the model of lined tunnel buried in layered elastic half-space is decomposed into the closed region and the opened layered elastic half-space region. The method is verified and the coefficient of dynamic stress concentration around a lined cavity in layered elastic half-space is investigated with the model of single and three layers over bedrock. Result shows that the coefficient amplitudes increase with the increasing of bedrock-to-soil layer stiffness ratio, while decrease with the thickening of layer on the whole, and they have very different amplitude for arrangement of different layers.
key words: lined tunnel; coefficient of dynamic stress concentration; arrangement of different layers; plane SV waves

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Dynamic Response of Tunnel Portal in Mountainous Areas with High Seismic Activities

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ABSTRACT

Many portal structures of tunnels in mountainous area have been severely damaged during strong earthquakes in recent years, especially in the Wenchuan earthquake. This paper analyzes the dynamic responses of tunnel portal structures using three dimensional (3D) Finite Difference
Method (FDM) for a real highway tunnel in Wenchuan area. The deformation characteristics and stress behaviour of the tunnel portal structure is numerically simulated through a 15-second seismic wave period. It is found that the tunnel structures at diagonal directions are subjected to tensile and compressive deformations during the seismic motion, corresponding to the seismic damages at tunnel upper-structures and bottom sidewalls. Even though the principal stresses at various monitoring points generally reach their peaks at different times, the points at tunnel diagonal directions tend to approach reach the maximum tensile and compressive stresses simultaneously. It is also identified that the damages of tunnel upper-structure is generally caused by excessive relative displacement of lining, while the damage of bottom sidewalls are normally caused by structural principal stress. In addition, a large-scale shaking table laboratory test is performed to validate the damage locations and crack distributions of lining under strong seismic motion. The laboratory results regarding the crack characteristics of lining match well with the relative displacement and principal stress of the tunnel from the simulation analysis.

**KEYWORDS:** Tunnel seismic damage; Dynamic response; Strong earthquake; Finite Difference Method (FDM); Shaking table laboratory test
盾构隧道斜螺栓接头受力性能及火灾下温度分布规律研究

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摘 要：目前盾构法已成为隧道修建的一种常用方式，本文以国内应用较多的盾构隧道环向斜螺栓接头为研究对象，利用大型有限元计算软件ABAQUS建立环向复合管片及环向斜螺栓接头的三维实体模型，对环向斜螺栓接头在常温下的力学特性进行计算分析。在此基础上，对接头模型进行传热分析，研究环向斜螺栓接头在火灾下的温度分布规律。分析结果表明：采用高强螺栓能够有效的减少接头张开量，增大接头刚度；在采用高强螺栓的情况下，斜螺栓最大轴应力易在初始阶段达到屈服，屈服后接头弯矩和轴力的增大对斜螺栓的应力影响并不大，对接头和斜螺栓变形影响较大；在常温下，接缝附近斜螺栓的应力分布呈现反对称分布；火灾情况下手孔处温度极高，80min后可达到1000℃，并且接缝处混凝土和螺栓温度也较其他部位高。

关键词：盾构隧道；复合管片；斜螺栓接头；力学性能；火灾；温度分布

Research of Mechanical Properties of Shield Tunnel with Oblique Bolt Joint and Temperature Distribution under Fire

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Abstract: At present, the shield method has become a common way of tunneling construction. In this paper, take the widely used shield tunnel with circumferential oblique bolted joint as the research object, using ABAQUS to establish the three-dimensional finite element solid model of the circumferential composite lining with circumferential oblique bolted joint, then calculate and analyze the mechanical properties of the circumferential oblique bolted joint under normal temperature. On this basis, the heat transfer analysis of the joint model was carried out to study the temperature distribution of the circumferential oblique bolted joint under fire. The results show that the high-strength bolt can
effectively reduce the opening of joint and increase the joint stiffness. In the case of high-strength bolts, the maximum axial stress of oblique bolt is easy to yield at the initial stage, then the increase of bending moment and axial force of the joint has little influence on the stress of the bolt, but have more influence on the deformation of the joint and the bolt. Under normal temperature, the stress distribution of the oblique bolt near the seam will show a special antisymmetric distribution. In the case of fire, the temperature at the hand hole is very high, after 80 min can reach 1000 °C and the temperature of the concrete and the bolt at the seam is higher than the other parts.

key words: shield tunnel; composite segment; oblique bolt joints; mechanical properties; fire; temperature distribution

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沉管隧道管节接头耐火试验

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摘 要：管节接头的防火性能受制于耐温极限仅为100℃的Ω橡胶止水带；管节接头的防火效果取决于防火隔断的设计。因此，本文主要通过自行研制的1:1全比例尺的大型构件试验进行，研究在RABT升温曲线下，测试采用不同耐火保护方案时，沉管接头复合构造处OMEGA止水条温度变化情况。模拟管节接头部位的高温受热状况，比较各种不同防火措施条件下的隔热效果。试验结果表明：管节接头的耐火保护部分，采用防火隔断（龙骨+3cm玻镁防火板+2cm硅酸铝耐火棉+1cm玻镁防火板）+底层防火板（2cm玻镁防火板）的耐火保护方案可以满足RABT升温曲线下，外部火灾温度1200℃，而接头处止水带温度保持在70~100℃的正常工作温度，并建议沉管隧道防火隔断处务必做好锚固连接，推荐采用龙骨加固方案。

关键词：沉管隧道；管节接头；防火试验；双层防护；橡胶止水带

Immersed Tube Tunnel Fire Test Socket Joint Were Reviewed

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Abstract: Socket joint fire performance subject to heat resistance limit is 100℃ only Ω rubber water-stop; Socket joint fire effect depends on the design of fire partition. Therefore, this article mainly through the self-developed 1:1 full scale test of large components, research under RABT temperature curve, the test using different fire protection scheme, immersed tube joint compound structure of OMEGA water-stop temperature changes. Simulate the socket connector parts of high temperature heat condition, compare different under the condition of fire prevention measures of heat insulation effect. Fireproof protect part of the test results show that the socket joint, using fire partition (keel + 3 cm bo magnesium fire board + 2 cm aluminum silicate refractory cotton + 1 cm glass magnesium fire prevention board) + fire prevention board (2 cm glass magnesium fire board) at the bottom of the fire protection scheme can satisfy RABT under temperature curve, external fire temperature 1200℃, and water-stop temperature
joint in the normal work temperature of 70 ~ 100 ℃, and suggests that immersed tube tunnel fire partition area for the anchor connection, keel is recommended for the reinforcement scheme.

**key words:** immersed tube tunnel; Socket joint; Fire prevention trials; Double protection; Rubber water-stop
断层破碎富水隧道岩溶水处治探讨

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摘 要：在大规模的交通建设过程中，地下隧道的施工的比重越来越大，在岩溶区施工隧道，穿越岩溶区断层带、富水破碎带在所难免，为了克服岩溶水在施工过程中带来的工程灾难和施工突发事故的发生，采取必要的预处理措施避免工程灾难和风险的发生很有必要，在必要的地质探测手段已经摸清的复杂地质地段，提前对特殊地质地段进行预加固处理，保证了隧道后期掘进过程的环境及施工安全[1]，往往能起到提前防范风险的目的，确保了在建工程的顺利进展。

关键词：断层破碎带隧道; 岩溶水处治; 探讨

To Explore the Rich Water Tunnel Karst Water Treatment Fault

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Abstract: In the process of large-scale transportation construction, increasing the proportion of the underground tunnel construction in karst area is bigger, the tunnel construction in karst area, across the fault zone, water rich zone can hardly be avoided, in order to overcome the karst water in the construction process of the engineering construction and bring disaster emergency accidents, take the necessary measures to avoid a pretreatment it is necessary to engineering disaster and risk, in the complex geological areas necessary geological exploration means has to find out the advance of the special geological location of pre reinforcement, ensure the environment and construction safety of the tunnel excavation process of late, often can play in advance to prevent risks, to ensure the smooth progress of the construction project.

key words: The fault fracture zone of tunnel; Karst water treatment;Discuss

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Study on Settlement Characteristics of the Ground Movement Caused by Metro Tunnelling and the Application of the Safety Assessment

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ABSTRACT

There are a lot of researches on the stratum deformation characteristics and the surface safety analysis of the subway construction, but the study of the subway building under the high-speed railway has not been further studied and there is no practical engineering application to ensure the safely construction of the tunnel and the normal operation of the train. Therefore, this paper presents the settlement characteristics form different crossing angles by the numerical simulation of FLAC3D, including the ground settlement trough, the stratum slip line and the irregularity characteristics of the ballastless track. Through the comparison of the specification, the numerical simulation and site
conditions, an effective safety assessment is proposed about the shield engineering under crossing the high-speed railway, which includes the control standard of the surface, the quality evaluation of the track and the stress standard of the surface, so some safety measures are put forward to guide the construction according to different security level. A case of the shield section crossing the Wuhan-Guangzhou High-speed Passenger-only Railway between the Guang-Zhou North Railway Station and the Hua-cheng Road Station, the first subway project under crossing the high-speed railway in China, are presented, through the analysis of the deformation characteristics and the application of the safety assessment, a series of measures is taken to make sure the safely pass of the shield tunnel and the normal operation of the high-speed railway. Therefore, this research can provide technical support for the safety evaluation of subway under construction.

KEYWORDS: Subway construction; High-speed railway; Deformation characteristics; Safety assessment; Numerical simulation; Case application

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特长大隧道岩溶地质洞段隧道支护衬砌设计优化研究

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摘 要：为了加强各设计单位对规范的理解和把握的一致性，依托礼让隧道工程按荷载结构法和有限元强度折减法对各工况进行数值模拟计算，通过减少初支厚度、降低初支混凝土等级、调整初支加劲措施和减少仰拱厚度等对原支护衬砌设计方案进行了优化，并再次运用数值模拟法验证了其合理性。

关键词：特长大隧道，岩溶，二次衬砌，数值模拟

Study on Optimizing Tunnel Lining Design of Super Long Tunnel in Karst Geologic Section

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Abstract: In order to strengthen the understanding of various design organizations about the consistency of specification, relying on Lirang Tunnel project, we do numerical simulation computation on every project situation according to load structural method and finite element shear strength reduction method, and optimize the original design of tunnel lining by reducing initial thickness, reducing initial concrete grade, adjusting initial reinforcement measures, reducing the thickness of the inverted arch and so on, and use numerical simulation method to prove its rationality again.

Key words: super long tunnel, karst, secondary lining, numerical simulation
Research on Distribution Model of Slurry Pressure of Shield Tunnel

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ABSTACT

This paper focuses on the distribution model of the slurry pressure in the shield tunnel when grouting simultaneously. The theoretical derivation of the slurry pressure distribution model according with Newton flow pattern and Bingham flow pattern is carried out respectively. The theoretical calculation formula of the slurry pressure in the cross section of the shield tail is established. The relationship between slurry viscosity coefficient and the time and the relationship between the slurry pressure and slurry viscosity coefficient is analyzed. On this basis, the law that the slurry pressure dissipation changes with time, and the distribution of the slurry pressure along the longitudinal direction of the tunnel is summarized. Furthermore, monitoring on the spot proved the rationality of the above theoretical derivation. The results of this paper have great reference and guidance significance for the simultaneous grouting of shield tunnel.

KEYWORDS: shield tunnel; slurry pressure; distribution; dissipation; slurry viscosity coefficient
城市核心区隧道近接建筑桩基保护技术研究

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摘 要: 重庆渝中连接隧道穿越市核心区解放碑, 其周边高楼林立, 其中右洞明挖段基坑壁与高层建筑桩基紧靠, 基坑施工风险和桩基保护难度大。由于社会影响方面原因, 传统桩基托换方案无法实施, 针对此情况与工程实际条件, 从技术、经济、社会影响等方面, 在对桩基托换、地圈梁+扩大基础加固、异形钢板+预应力锚索加固保护等方案综合分析比较基础上, 提出异形钢板+预应力锚索的桩基加固保护方案。通过三维数值模拟和工程现场实测, 分析了施工过程岩土体位移、桩基变形、桩基应力、钢板与锚索应力等发生和发展规律。结果表明, 该保护方案可以有效控制桩基变形和应力, 能够确保施工过程建筑物的安全。

关键词: 城市核心区; 隧道基坑; 近接; 桩基; 保护

中图分类号: U452.2+5

Research on the Protection Technology of the Tunnel Close to the Building Pile Foundation in the Core Area of the City

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Abstract: The Yu-zhong city tunnel in Chong-qing, through the city's core area of JieFangBei and is surrounded by high-rise buildings, of which the right side of the excavation wall and the pile foundation of high rise building are close, so foundation pit construction risk and pile foundation protection is difficult. Due to the social impact of reasons, the traditional pile foundation underpinning scheme cannot be implemented, in view of this situation and the actual conditions of the project, from
the aspects of technology, economy and society, etc., on the pile underpinning scheme, ring beams and expansion of the foundation reinforcement, special shaped steel and prestressed anchor cable pile reinforcement protection scheme conducted a comprehensive analysis and comparison, put forward the special shaped steel and prestressed anchor cable pile reinforcement protection plan. Based on three dimensional numerical simulation and field measurement, the occurrence and development of rock and soil displacement, pile foundation deformation, pile stress, stress of steel plate and anchor cable are analyzed. The results show that the protection scheme can effectively control the deformation and stress of the pile foundation, and can ensure the safety of the building during the construction process.

key words: urban core area; tunnel foundation; close to; pile foundation; protection

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城市复杂地段地铁深基坑开挖三维数值模拟分析

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摘 要: 现代城市地铁建设过程中，地铁车站紧邻高大建筑物、重要管线、河流等情况较多，车站深基坑开挖时，必须确保深基坑周边建筑的安全，因此在深基坑开挖之前对施工开挖方案的制定尤为关键。利用三维数值模拟软件对车站深基坑开挖过程中围护结构及周边建筑物的受力影响进行模拟，为施工前和施工过程中的风险控制提供正确决策，确保在建深基坑工程的安全。本文所提到的三维数值模拟分析方法对今后深基坑类似工程的设计施工提供一定的借鉴。

关键词: 地铁深基坑; 开挖过程三维数值模拟; 分析

中图分类号:U231.4 文献标志码:A

Deep Foundation Pit Excavation of a Metro in the City's Complex Area of Three-dimensional Numerical Simulation Analysis

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Abstract: In the process of modern urban subway construction, the subway station close to tall buildings, pipelines, rivers, and so on and so forth is more important, the deep foundation pit excavation, must ensure the safety of deep foundation pit surrounding buildings, so before deep foundation pit excavation of construction excavation scheme formulated particularly critical. Using three-dimensional numerical simulation software in the process of the deep foundation pit excavation retaining structure and surrounding buildings, to simulate the stress influence for before construction and construction process of risk control to provide the right decisions, to ensure the construction safety of deep foundation pit engineering [1]. Mentioned in this paper, a three-dimensional numerical simulation analysis method for deep foundation pit design and construction of similar projects in future provide certain reference.

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key words: The subway deep foundation pit; Three-dimensional numerical simulation of excavation process; Analysis of the

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考虑应力路径变化的应力应变函数及验证

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摘 要: 为研究基坑开挖中应力路径对土体变形的影响，本文首先分析了基坑开挖过程中应力路径的特征。在经典非线性弹性模型的基础上提出了考虑应力路径的应力应变函数，并同时推导出了三轴应力空间弹塑性刚度矩阵。随后通过不同应力路径的室内试验对该的应力应变函数进行了验证。验证结果显示: 计算曲线与试验曲线拟合效果良好，说明所提出的应力应变函数能在一定程度上反映出应力路径对土体应力应变关系的影响。

关键词: 应力应变函数; 刚度矩阵; 应力路径; 应力增量比;

中图分类号: TU

Verification of the Stress and Strain Function Considering Stress Path Variation

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Abstract: In the process of excavation, the stress path of the soil deformation is the problem. Firstly, this paper analyzes the stress path characteristics in the process of excavation. Then, a stress-strain function that is considering stress paths established on the basis of the nonlinear elastic model. And the elastic-plastic stiffness matrix of the three axis stress space is deduced. And then, the stress-strain function is verified by laboratory tests of different stress paths. The validation results show: The calculated and experimental curves fit well, and The influence of the stress path is reflected by the stress-strain function.

key words: the stress-strain function; Stiffness matrix; stress paths; Stress increment ratio;

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复合式衬砌隧道减震机理及其应用研究

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摘 要：基于波函数展开法，研究了剪切波入射下隧道“围岩-一次衬砌-减震层-二次衬砌”复合式减震结构的减震机理，结合跨断层隧道复合式减震结构大型振动台模型试验，通过分析跨断层及其复合式减震结构衬砌动力响应特性和破坏形态，得到以下有益结论：在地震力作用下，由于在一次衬砌和二次衬砌间设置剪切模量较低的减震层，一次衬砌通过剪切变形承担了主要的地震力作用，而减震层进一步减缓作用在二次衬砌上的作用力，从而形成具有变形受力梯度的组合受力结构，降低了二次衬砌衬砌动应力集中系数，但一次衬砌动应力集中系数增大；跨断层隧道复合式衬砌结构可以明显降低二次衬砌加速度峰值及其功率谱幅值和动应变幅值，减少二次衬砌裂缝数量和宽度，但一次衬砌裂缝数量增多，裂缝分布形态也更复杂，进一步说明复合式衬砌减震结构中一次衬砌承担主要地震力作用。研究结论可以穿越断层破碎带隧道抗震设防提供参考。

关键词：减震机理；跨断层隧道；复合式减震结构；振动台试验

Study on the Mechanism and Application of the Damping Composite-lined Tunnel

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Abstract: Based on the Fourier-Bessel expansion method, the damping mechanism of the ‘rock-primary support-buffer layer-second lining’ composite-lined tunnel subjected to incident plane SV waves was studied in this paper, and then a large-scale shaking table model test on the fault-crossing tunnel with damping composite linings was conducted, and some significant conclusions were generated by analyzing the dynamic stress characteristic and fracture patterns of the tunnel. The max dynamic stress of the second lining decreases and that of the initial lining increases with buffer layer set between the first and second lining, and the first lining bears most of the force from the surrounding...
rock with the improved shear deformation capacity by the low shear modulus of the damping layer. The acceleration amplitude and the power spectrum amplitude of the secondary lining decreased, the dynamic strain amplitude reduced, and the cracks number and width decreased in fault-crossing tunnel with damping composite linings comparing to the fault-crossing tunnel without damping measure, however the cracks number of the first ling was larger than the second lining, and the fracture distribution was more complex, which shows that the initial lining bear most of the seismic force in the damping combined-lining structure. The research conclusions can provide references on the shock and sorption design of fault-crossing tunnels.

key words: the damping mechanism; fault-crossing tunnel; damping composite-lined structure; shaking table test
Underground Water Control and Stability Analysis for an Excavation in Guangzhou Metro Construction, China

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ABSTRACT

Underground water will bring difficulties and threats to the construction of subway if no proper methods are used to control it. The topography and geological conditions of Yantang station on the No. 3 subway line of Guangzhou metro is complex, which results in a complex seepage in the construction
site. In order to verify if additional curtain grouting should be used to control the underground water, a numerical program GEO-H is developed based on a double-fractures seepage model, which combines the seepage constitutive equations of trunk fractures and fractured rock masses. Permeability coefficients of the stratums according to the in-situ tests and the water head distribution monitored in the boreholes in the site are taken as input information of GEO-H. The results of numerical simulation show that additional curtain grouting can reduce the hydraulic gradient, pore water pressure and the amount of water inflow in the stratums below the foundation pit bottom. It also proves that the double-fractures seepage model is suitable for seepage analysis in complex geological condition containing weathered rock masses.

**KEYWORDS:** underground water; subway construction; seepage; double-fractures seepage model
Exploration and Discussion on the Setting of Rescue Cross Channel Between New and Old Tunnels of Highway Reconstruction and Extension Project

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Abstract: The adits set between two single tunnels for people or vehicle passing were cross channels for passenger escaping, rescuing people and vehicle passing in and out tunnel. Code for design of road tunnel(JTG D702004) regulated that separated tunnel should set cross channel between it’s two single tunnels: the distance of adit for people passing could be 250m (and ≤500m), for vehicle passing could be 750m (and ≤1000m). With the development of the economy and society, some tunnels should be reconstructed and extended, and it was a common form to adding a new tunnel to original old one; Meanwhile, the new problem that how to set rescue cross channel between new and old tunnels appeared. Taking the project of Xiao-Mo reconstructed and extended of Kun-Mo expressway as the background, this paper analysed and discussed on the setting of rescue cross channel of tunnels.

key words: Road tunnel; Cross channel; Reconstruction and extension; Disaster prevention and rescue
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Deformation and Safety Control of Buried Pipelines Crossed by Very Large Diameter Slurry Shield Tunneling

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ABSTRACT

The buried pipelines in urban cities nowadays have a dense distribution and easily get disturbed by tunnelling around. Therefore, ensuring the safety of pipelines during the tunnel construction is important. According to the correlation between ground subsidence and pipeline stress when the pipeline is perpendicular to the tunnel drive, a maximum value of ground subsidence based on the deformation capacity of the pipeline was proposed. A case study of Shanghai South Hong-mei Road Tunnel was carried out, where the deformation of buried pipelines crossed by very large diameter slurry shield tunnelling and its safety control were discussed in order to provide a reference for the prevention of pipeline accidents during construction in practical engineering.

KEYWORDS: ground subsidence; tunnel construction; buried pipelines; safety control
The Application of Spectral Energy Analysis Method for GPR Signal on Four-dimensional Dynamic Monitoring for Water Leakage in Operating Tunnel

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ABSTRACT
There is leakage problem in most operating tunnels, and it will affect the operation of tunnel and the safety of structure, also it will destruct the lining structure, especially in karst areas. In this article, the ground penetrating radar (GPR) were used, the frequency response parameter of target medium was calibrated in spectrum analysis diagram by the spectral energy analysis method, the frequency response characteristic of water medium was exerted from GPR reflection waves, the spectral energy strength of water medium was calculated in the space particle, the hydrogeology changes of groundwater were analysed and interpreted in the surrounding rock of tunnel, and all of these will improve the detection and recognition ability, and avoid the multiplicity to a certain extent. With the regular detection in a new tunnel, the dynamic change trend of groundwater in the surrounding rock was not only known and four-dimensional real-time monitoring was implemented, but also the focus monitoring location of water leakage was delineated. It had achieved the purpose of early warning for the water leakage and provided technical support for the safety operation of tunnel.
KEYWORDS: ground penetrating radar (GPR), spectral energy analysis method, operating tunnel, early warning for water leakage, dynamic monitoring, four dimensions
带裂工作的隧道衬砌结构安全性分析

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摘 要: 二次衬砌开裂是公路隧道最常见的病害之一，分析研究带裂工作的隧道衬砌结构安全性，具有极强现实意义和理论价值。本文基于断裂力学裂缝模型，采用数值分析，讨论了带裂工作的隧道衬砌结构安全性的评价计算方法；通过模型实验，分析比较了无损衬砌和带裂工作衬砌的承载性能。结果表明：（1）断裂力学有限元方法，可对带裂工作衬砌结构进行安全性评价。（2）裂缝出现于不同部位所需荷载的大小为，拱脚<拱顶<拱腰<仰拱。（3）当裂缝位于拱顶、拱脚处时，对衬砌结构安全性影响最为显著。（4）裂缝会导致衬砌结构承载能力下降，当仰拱底存在纵向裂缝时，衬砌承载能力将下降37.5%。

关键词: 隧道; 开裂衬砌; 安全性; 裂缝模型; 模型试验

中图分类号: U45

Safety Analysis of the Secondary Lining Structure of Existing Tunnel with Cracks

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Abstract: Because cracking of the secondary lining is one of the most common diseases in road tunnel, it is of great practical significance and theoretical value to analysis and research on the safety of lining structure of existing tunnel with cracks. Based on crack models of fracture mechanics, the calculation method of safety evaluation for the secondary lining structure of existing tunnel with cracks was discussed through numerical analysis. The bearing capacity of non-destructive lining and cracked lining was analyzed and compared by model tests. Results showed: (1) the finite element method of fracture mechanics could be used to evaluate the safety of the secondary lining structure of existing
tunnel with cracks. (2) The size order of the required load when the cracks occurred in the different parts, the arch foot the vault the hance the inverted arch. (3) When the crack was located at the vault and arch foot, it had the most significant influence on the safety of lining structure. (4) the bearing capacity of the lining structure declined because of cracks, and it decreased by 37.5% when there was longitudinal crack at the bottom of the inverted arch of tunnel.

**key words:** tunnel; lining with cracks; safety; crack model; model test

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Boundary Definition and Calculation Method of Carbon Emission in Tunnel Ventilation System

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ABSTRACT

This paper evaluates the potential of energy saving and emission reduction for tunnel ventilation systems, and uses the calculation method of whole life-cycle carbon emission model. According to the characteristics of tunnel engineering itself and the analysis of the tunnel ventilation system of carbon emission factor and path, the paper determines the carbon emission boundary of tunnel ventilation...
system and puts forward the calculation of carbon emissions from materials, calculation of carbon emissions from transportation of materials, calculation of carbon emissions of power consumption from machinery. The study provides the basis for the research of tunnel life-cycle carbon emissions.

**KEYWORDS:** Tunnel; Ventilation system; Full life-cycle; Carbon emission factor; method
Seismic Risk Evaluation for Planning Mountain Tunnels Using ET and ET based Improved AHP

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ABSTRACT

Seismic risk evaluation (SRE) in the early stages (e.g., project planning, preliminary design) for a mountain tunnel located in seismic areas has the same significant importance as that in the final stages (e.g., performance-based design, structural analysis and optimization). SRE for the planning mountain tunnels serves to bridge the gap between the planning on the macro level and the design/analysis on the micro level in terms of risk management of infrastructural systems. A transition from subjective or qualitative description to objective or quantitative quantification of seismic risk is aimed to improve the seismic behaviour of mountain tunnels and thus reduce the associated seismic risk. A new method to perform systematic SRE for the planning mountain tunnels is proposed in this paper, using extension theory (ET) and ET-based improved analytical hierarchy process (AHP). A new risk classification criterion is also suggested herein to classify and quantify seismic risk for the planning mountain tunnels. This proposed SRE method is applied to a real mountain tunnel in southwest China (Huangcaoping Tunnel #2), using the extension model for SRE based on matter element theory and dependent function operation. The reasonability of the proposed method and the flexibility to be applied to other planning mountain tunnels are finally illustrated in this paper.

KEYWORDS: Seismic risk evaluation; mountain tunnels; extension theory; analytical hierarchy process; classification criterion

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基于地质条件与力学特性的越江盾构隧道结构健康监测技术研究

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摘 要：运营期隧道结构健康监测的案例相对较少，监测技术、评价方法尚不成熟，健康监测方案针对性不强，缺乏系统的健康监测管控技术体系。针对苏通GIL管廊越江盾构电力隧道，通过地质条件分析、结构受力特性研究，探究重点监测项目、监测部位，制定合理的监测方案，通过比选提出满足要求的仪器选型方案，制定健康监测数据管理方案。通过研究，选取了13个典型监测断面及重点监测部位，以水土压力、钢筋应力、螺栓轴力、接缝张开和隧道沉降为重点监测指标，采用振弦式、压差式及电阻应变式传感器，形成远程自动化采集传输系统；借助三维地质模型搭建了隧道结构全寿命周期的数字化管控平台，实现前期勘察、设计、施工信息及长期健康监测数据的可视化管理。研究结果已在依托工程中得到应用，可有效指导越江电力盾构隧道的长期健康监测实施及数据分析管理，动态监控结构安全状态，延长隧道使用寿命。

关键词：越江盾构隧道；结构受力特性；健康监测；数据管理；管控平台

中图分类号：U455.43

Research of Cross-river Shield Tunnel Structure Health Monitoring Technology Based on Geological Conditions and Mechanical Properties

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Abstract: Under operation period, There is only little case on tunnel structure monitoring. The method of monitoring and evaluation are not perfect and the control platform of tunnel structure
health monitoring is very not systematic. Through analysis on geological conditions and mechanical properties, the monitoring scheme of cross-river shield power tunnel is studied and define reasonable monitoring items, itoring position and monitoring facility. First, by researching mechanical properties of typical sections, the monitoring items are water and soil pressure, steel stress, bolt axial force, joint open and tunnel settlement. the important positon is monitored by vibrating wire sensor, different-pressure sensor and resistance strain sensor to building automation transmission system. Then, the control platform of tunnel structure health monitoring is constructed to complete visual management of reconnaissance, design, tunnel construction and health monitoring data. The result of the research show the control platform can evaluate tunnel health and ensure the safety of the tunnel.

**key words:** Cross-river Sheild Tunnel; Structure Mechanical Properties; Health Monitoring; Date Management; Control Platform

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不中断交通进行隧道二衬拆换处治的探讨及实例分析

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摘要：复合式衬砌是由初期支护和二次衬砌及中间夹防水层组合而成的衬砌形式，在我国隧道工程中得到了广泛的应用，随着隧道数量的不断增多，施工技术参差不齐，以及前期修建的隧道使用年限不断增加，隧道病害开始显现，衬砌缺陷是其中的主要病害之一。为确保隧道工程的安全、畅通运营，及时检查、发现病害，分析病害成因，采用合理的整治和维护方法，是隧道运营养护阶段的重要环节。本文结合项目实例对复合式衬砌隧道二衬病害整治进行阐述，为其他类似工程提供参考和借鉴。

关键词：衬砌病害; 加固设计; 二衬套拱; 二衬拆换

Composite Lining of Tunnel Lining for the Treatment Analysis and Examples with Keeping the Traffic

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Abstract: Composite lining is a new type of lining, which is composed of the initial support, the two lining and the waterproof layer. With the increase of the number of tunnels, the construction technology is uneven, and the use of the tunnel construction is increasing, the tunnel disease began to appear, the lining defect is one of the main diseases. In order to ensure the safety and smooth operation of the tunnel project, check and find the disease in time, analyze the cause of the disease, and adopt the reasonable regulation and maintenance method, it is an important link in the operation and maintenance phase of the tunnel. In this paper, combined with the project example of composite lining tunnel two lining disease remediation, for other similar projects to provide reference and reference.

key words: Lining disease; Strengthening design; Tunnel repair
A Study of the Relationship Between the Stress and Failure Mode of Compressible Concrete Specimens

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ABSTRACT
An investigation of compressible concrete specimen’s strength and its changing mechanism based on numerical simulation of the failure process of axis-stressed concrete specimens with different aspect ratios was described. The state of internal stress and growth of crack of axis-stressed concrete specimens were investigated, as well as the changing mechanism of specimen strength under different ambient pressure values. The results revealed that specimen strength and failure surface decreased as the aspect ratio is increased. The specimen strength is dependent on the state of internal stress and decreased with decreasing ambient pressure. Additionally, the failure mode shifted from shear failure to tensile failure gradually.

KEYWORDS: Concrete, failure mode, state of stress, concrete strength
高折射率高亮反光材料在公路隧道照明中应用研究

The Research of Applying the Material Which Has High Index of Refraction and Highlight Reflection to Highway Tunnel Lighting

摘要：随着我国隧道里程的不断增加，为确保隧道交通安全产生的照明能耗也不断增加，反光材料的使用在一定程度上能够提高隧道的照明效果，提升隧道行车安全，但是反光材料的适用性以及在隧道中的布置方案，在很大程度上会影响隧道的照明效果。本文结合隧道的交通环境和照明条件，提出一种高折射率高亮反光材料在隧道照明中的布置方案，在减少隧道照明能耗的同时，提升隧道交通的行驶安全。

关键词：隧道照明；高折射率高亮反光材料；布置方案；施工要求
单轴压缩下软岩破裂及裂隙扩展试验研究

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摘 要：将单轴压缩试验与DIC技术相结合，对不同倾角预制裂隙试样进行测试，研究了裂隙软岩破裂形式、裂隙扩展模式、扩展方向和角度、裂隙对岩体力学性质的影响、变形场分析以及软岩破裂的时间效应。试验结果表明：试样破裂形式分为劈裂张开和剪切滑移两种类型，所对应的主生裂隙分别为翼裂隙和次生裂隙；翼裂隙扩展角随着预制裂隙倾角的增长呈先减小后增大的趋势，在裂隙倾角为30°时最小；裂隙会降低试样的峰值应力，在裂隙倾角为45°时最小，为完整试样的89%；裂隙倾角较大时，预制裂隙较容易扩展，反之则比较困难；试样的位移主要分布在预制裂隙和翼裂隙组成的滑移面左侧，而向向应变主要分布在滑移面周围；试样先达到峰值应力，然后出现裂隙，两者间隔时间很短，且间隔时间与试样的峰值应力有着良好的线性关系，其随着峰值应力的增强而延长。可以采用DIC技术对采矿等工程中岩体变形破裂进行监测预警。

关键词：软岩破裂；裂隙扩展；DIC技术；时间效应

中图分类号：U238

Experimental Study on Soft Rock Rupture and Crack Propagation under Uniaxial Compression

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Abstract: In this paper, the uniaxial compression test and DIC are combined to test soft rock samples with different inclination prefabricated cracks. The rupture form of fractured soft rock, propagation mode, propagation direction and angle of fractured, analysis of deformation field, the effect of fracture on mechanical properties of rock, and the time effect of soft rock rupture were studied. The results show that the rupture modes of the specimens are divided into two types: split and shear slip, and the corresponding main fractures are the wing crack and the secondary crack respectively. With the
increase of the inclination angle of the prefabricated cracks, the wing crack propagation angle first
decreases and then increases, which is the smallest when the inclination angle is 30 °. Fracture will
reduce the peak stress of specimen, which is the smallest when the inclination angle is 45°, which
is 89% of the whole sample. The prefabricated fracture is easier to expand when the fissure angle is
larger, otherwise it is more difficult. The displacement of the specimen is mainly distributed on the left
side of the slip surface composed of prefabricated cracks and wing cracks, while the lateral strain is
mainly distributed around the slip surface. The initial crack is generated after the sample reaches the
peak stress, the interval time of them is very short, the interval time and the peak stress of the sample
has a good linear relationship, the interval time increases with the increase of the peak stress of the
sample. DIC technology can be used to monitor and early warning of the deformation and failure of
rock mass in mining and other projects.

**key words:** soft rock rupture; crack propagation; DIC technique; time effect

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Study on Crossing Construction Mechanical Effect of Subway Station under Building

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Abstract: For the influence of the building’s stiffness and load, the construction mechanical effect of subway station under building has big difference with general underground subway station. By taking a subway station which is under a three-layer frame structural building in Beijing as an engineering background, the whole dynamic construction process of the station constructed by middle hole construction method is studied through large scale model test and numerical simulation. Based upon the results of model test and numerical simulation, the distribution and development rules of displacement and stress of the surrounding rock and building during the whole construction process are analyzed. And so it gives a reference on understanding the environmental effect of construction and its corresponding engineering measures.

key words: subway station; building; cross construction; middle hole construction method; model test; numerical simulation

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不同断面型式下水中悬浮隧道波动响应特性的实验分析

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摘 要：悬浮隧道的断面型式是其重要控制性指标，波浪荷载则是其主要控制荷载之一，因此有必要研究不同断面型式的隧道波动响应特性。本文采用模型实验方法，针对圆形、八边形和椭圆形等三种断面型式的悬浮隧道，进行了三种波高、三种波浪周期、三类断面的多组工况实验，并测试了关键位置的压强值。实验结果表明：（1）由于波浪作用，使得悬浮隧道同一位置不同时刻的压强在不断变化，同一时刻不同位置的压强差也明显存在，从而造成了其波动特性。（2）随着波高增加、波浪周期减小，三种断面的隧道表面压强幅值和压强差值均相应增加。（3）压强分布均匀性排序为，圆形>椭圆形≈八边形；压强幅值绝对值排序为，圆形>八边形>椭圆形；迎、背浪表面压强差排序为，椭圆形>八边形>圆形。（4）对于波浪作用下的悬浮隧道，椭圆形断面的受力相对最小，但波动稳定性最差；圆形断面的受力相对最大，但波动稳定性最好；八边形断面居中。

关键词：悬浮隧道；断面型式；模型实验；波浪；波动特性

中图分类号：U45

Experimental Analysis on the Wave Response Characteristics of Underwater Submerged Floating Tunnel with Different Cross Sections

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Abstract: The cross section of submerged floating tunnel is an important control index and the wave load is one of the main control loads, therefore, it is necessary to study the wave response
characteristics of submerged floating tunnel with different types of cross sections. According to these submerged floating tunnels with circular shape, octagonal shape and elliptic shape, many tests were made with three wave heights, three wave periods and three cross sections by model test, and pressure values of some critical position of these models were measured. These tests results showed:

(1) Because of the wave action, the pressure of the same position at the same time in the tunnel was changing constantly, and the pressure difference at different positions at the same time was obvious, which resulted in the wave response characteristics. (2) With the increase of wave height and the decrease of wave period, surface pressure amplitude and pressure difference of tunnels with three cross sections increased accordingly. (3) The order for pressure distribution uniformity of tunnels with three cross sections: circular shape > elliptic shape ≈ octagonal shape; the order for absolute value of pressure amplitude of tunnels with three cross sections: circular shape > octagonal shape > elliptic shape; the order for pressure difference between front and rear surfaces of tunnels with three cross sections: elliptic shape > octagonal shape > circular shape. (4) According to these submerged floating tunnels under the action of waves, the force of the elliptic shape cross section was relatively smallest, but the stability was the worst; the force of the circular shape cross section was relatively largest, but the stability was the best; the octagonal shape was in the middle.

**key words:** submerged floating tunnel; cross section type; model test; wave; wave response characteristics

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公路隧道深大竖井安全快速建设技术研究

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摘 要：目前公路竖井仍采用煤矿传统的复合式衬砌及单行作业掘砌，而煤矿部门建井技术已由此种落后的
方式发展到了单层模筑混凝土衬砌配合短段混合作业掘砌；另外，送风井与排风井双井布置还是通过设置中
隔板单井布置仍然存在争议，本文根据竖井复合式衬砌和单层模筑衬砌不同的结构及相配合的掘砌方式，送
风井与排风井分设与合设不同的布置方式，对米仓山隧道通风竖井进行多方案研究，表明单层模筑混凝土衬
砌与短段混合作业掘砌方式优于复合式衬砌及单行作业掘砌方式；推荐采用单层模筑混凝土衬砌双井布置；
在井口场地条件有限的情况下，建议采用单层模筑混凝土衬砌单井布置。

关键词：公路隧道；深大竖井；掘砌方式；单行作业；混合作业

Construction Technique of Deep and Large Shaft for Highway Tunnel
Based on Safety and Celerity

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Abstract: Highway vertical shaft is still using composite lining and single operation which is traditional technique in mining industry, while the shaft construction technology in mining industry has been developed from this backward way to single-layer lining with mixed operation by short section excavation and lining; in addition, the arrangement of air supply well and air exhaust well is in dispute. According to the different structure and operation method of composite lining and single-layer lining, the different arrangement of air supply well and air exhaust well, various schemes of ventilation vertical shaft of Micangshan Tunnel is discussed in this paper. The results show that the single-layer lining with mixed operation by short section excavation and lining is better than composite lining with...
single operation. Separate arrangement of air supply well and air exhaust well is recommended except for when the condition of the wellhead site is limited.

**key words:** Highway tunnel; Deep and Large vertical shaft; way of excavation and lining; single operation; combined operation

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沉管隧道管节结构耐火保护技术

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摘 要：本文通过对现有隧道结构防火技术进行了技术经济比较，依托构件与实体隧道火灾试验平台，开展了沉管隧道管节构建耐火保护试验，提出了港珠澳沉管隧道管节结构耐火保护技术建议方案。

关键词：沉管隧道；管节结构构件；火灾；耐火保护

中图分类号：U451

Fire Protection Technology of Pipe Section Structure of Immersed Tunnel

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Abstract: Through the technical and economic comparison of the existing tunnel structure fire prevention technology, we carried out the immersed tunnel pipe section fire protection test based on component and entity tunnel fire test platform protection of technical recommendations. According to the result of the test, the suggestion scheme of fire protection are proposed for pipe section of Hong kong-zhuhai-macao bridge.

key words: immersed tunnel; pipe section structural member; fire protection
The Mechanism and Technique Application Analysis of Static Pressure Twice Compaction Backfilling Cement Pile

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ABSTRACT

Cement-soil compaction pile is a more effective method for treating collapsible loess foundation, there are two key technologies of hole-forming and backfilling compaction of the cement-soil. High-Speed railway requires not only the less settlement after construction and the shorter construction period, but also the lower pollution and noise. Cement-soil compaction pile technologies are successfully used in High-Speed railway located in area of collapsible loess in China. According to improving the hole-forming device, the static pressing piling machine is used to form the pile-hole conveniently. The construction method of static pressure compaction backfilling cement-soil pile is studied in this paper, the definition of the static-pressure-twice-compaction-backfilling-cement-soil-pile is also proposed.

KEYWORDS: Twice compaction, Cement-soil pile, Collapsible loess
东湖通道暨东湖绿道全过程绿色施工创建管理探索

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摘 要：绿色施工是绿色建筑全寿命周期中的重要阶段，本文以地处5A级景区内的东湖通道和东湖绿道工程为例，从组织管理、过程管理、技术运用方面阐述了大型市政工程绿色施工创建的全过程，对此类项目绿色施工的管理和实施具有开拓性和借鉴性。中建三局作为BT业主方承担绿色施工组织者角色，从过程施工减少对东湖景区干扰和工程完工后提升景区品质全盘统筹考虑，策划东湖通道和东湖绿道系列工程，并对施工阶段进行重点把关，将施工策划、施工准备、施工运行和竣工后场地恢复及评价与总结等进行阶段性控制。施工过程中通过引入环评监理、水系连通、鱼群放生、生态围挡、湖底淤泥再利用、定型设施应用、温拌沥青、水生态补偿、信息化办公等多项绿色施工创新措施，将施工过程对原有生态环境的影响降至最低，在追求低耗、高效、环保的同时，兼顾实现经济、社会、生态综合效益的最大化。

关键词：东湖通道; 东湖绿道; 绿色施工; 过程管理

Abstract: Green Construction (GC) is an important stage in the whole life cycle of green building. Based on East Lake Passage project and East Lake Greenway project, GC is expounded from the aspects of organization management, process management and technology application, which has guidance for other projects. As the role of GC Organizer, the BT, namely China Construction Third Engineering Bureau Co. Ltd, plans East Lake Passage and East Lake Greenway project from the process of reducing the interference and improving the quality of the East Lake scenic spot, and provides the basis condition according to the key point of this project, such as decision-making and design. It also focus on construction stages, such as planning, preparation, construction, and restoration,
evaluation and summary after completion. During the construction process, BT introduces a series of green construction measures, such as the EIA supervision, the water system connectivity, the reuse of sludge, water ecological compensation, fish release, mobile steel pontoon, silt reuse, stereotypes facilities, warm mix of asphalt, ecological enclosures, water eco-system compensation and information office, to minimize the impact of construction on the ecological environment. In a word, these measures would achieve maximize benefits of the economic, social and ecological.

**key words:** East Lake Passage project; East Lake Greenway project; Green construction; Process management
Hygrothermal Environment Evaluation in Extra-long Tunnel: A Case Study of A Water Tunnel in Jilin Province

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ABSTRACT
In order to solve the hygrothermal problems of extra-long tunnels in the building stage, the paper introduced the problems of hygrothermal environment in extra-long tunnels and made clear the origins and characters of hygrothermal environment. A calculation method for humidity load and heat load for an extra-long tunnel was provided. A calculation case on the hygrothermal load of the water
tunnel in Jilin Province was carried out. Relative control strategies were offered to solve the tunnel hygrothermal problems which showed a reference for the governance of hygrothermal environment in extra-long tunnels.

**KEYWORDS**: Extra-long tunnel; humidity load; heat load; control strategy
嵌岩抗拔桩倒锥体临界长度和抗拔极限承载力的确定方法

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摘 要: 采用幂函数模拟倒锥体破坏时的破裂面形状，通过极限平衡方法推导嵌岩抗拔桩的抗拔极限承载力计算公式，得到了嵌岩抗拔桩发生倒锥体破坏时的临界长度表达式，并且给出了嵌岩抗拔桩发生倒锥体破坏时的极限承载力及临界长度的简易使用方法，指出嵌岩抗拔桩直径D为0.5~1.5米时，抗拔桩的倒锥体临界桩长约为抗拔桩直径D的4~2倍; 同时讨论了临界桩长与抗拔桩及基岩参数的关系，指出了临界桩长与抗拔桩直径D以及基岩的黏聚力c呈正相关关系，与抗拔桩基岩的内摩擦角φ呈负相关关系，临界桩长与直径比值与抗拔桩直径D呈负相关关系; 并且临界桩长增加的幅度随着直径D增大而减少，基岩的黏聚力c对临界桩长的影响较大，基岩的内摩擦角φ对临界桩长的影响较小。通过实例试验及相应预测函数验证了本文提出嵌岩抗拔桩的极限承载力计算方法。

关键词: 基岩; 抗拔桩; 倒锥体; 临界长度; 抗拔极限承载力

中图分类号: TU43

Determination Method of Critical Length and Ultimate Capacity of the Uplift Pile with the Inverted Cone in Basement Rock

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Abstract: Based on limit equilibrium method, a procedure for computing uplift capacity of uplift pile in basement rock is deduced according to power function failure mode of inverted cone, and the expression of inverted cone critical length is obtained, and a simple method for uplift capacity of uplift pile and inverted cone critical length is presented. It is pointed that for rock uplift pile, critical length of uplift pile is about 4 ~ 2 times of uplift pile diameter D when uplift pile diameter D is 0.5~1.5 meter. The relationship between the critical length and parameters for pile and rock is also discussed.
in this paper and it shows that the critical length $L_c$ is positively related to the uplift pile diameter $D$ and the rock cohesion $c$, and negatively correlated with the rock internal friction angle $\phi$; and the ratio of critical length $L_c$ and uplift pile diameter $D$ is also negatively correlated with the diameter $D$; meanwhile the rate of critical length $L_c$ increase amplitude decreases with the increase of diameter $D$, the rock cohesion $c$ has a great influence on the critical length $L_c$, but rock internal friction angle $\phi$ is the opposite. Compared with the experimental result and the predictive function result, the ultimate capacity computing method of the uplift pile is confirmed effectively.

**key words:** basement rock; uplift pile; inverted cone; critical length; ultimate capacity

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摘要：地铁隧道空间的密闭性，地铁隧道发生火灾时人员疏散困难，可能引发重大事故。笔者通过建立地铁隧道火灾人员疏散模型，运用 Pathfinder 软件对不同的地铁隧道火灾疏散场景进行针对性分析，确定完成疏散所需要的时间。根据仿真分析结果，提出优化联络通道的宽度和间距，并利用仿真分析验证其有效性。为地铁隧道本质化安全设计提供参考和依据，对减少地铁火灾事故中人员伤亡，降低地铁隧道火灾事故风险等具有重要的参考意义。

关键词：安全科学与工程; 火灾疏散; 地铁隧道

Abstract: Due to the closed nature of the subway tunnel space, the subway tunnel fire evacuation difficulties, may lead to a major accident. In this paper, based on the establishment of the subway tunnel fire evacuation model, using Pathfinder software to analyze the different subway tunnel fire evacuation scenarios, determine the time required to complete the evacuation. According to the simulation results, the optimization of the width and spacing of the contact channel is proposed, and the simulation results are used to verify the effectiveness of the proposed communication channel. To provide reference and basis for the nature of the subway tunnel safety design, to reduce casualties in the subway fire accident, reduce the risk of subway tunnel fire has important reference significance.

key words: Safety science and Engineering; fire evacuation; subway tunnel
公路隧道病害探究与全寿命周期防治对策

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摘要：目前公路隧道面临病害现象较普遍，病害处治费用高、反复处治频率高和处治后耐久性较差的难题。本文结合近期处治的42座隧道病害统计分析隧道病害类型主要为渗漏水、衬砌结构病害和底板类病害三大类，病害特征体现为病害隧道质量缺陷明显、隧道建成较短时间内就出现病害、二次衬砌拱顶掉块、隧道路面隆起开裂、病害处治费用高且反复处治等方面；深层次分析隧道病害原因，从设计、施工、建设管理和运营管理等角度提出基于全寿命周期的病害防治对策，探讨病害处治的目标与原则、处治措施与可实施性和质量检验方式，为公路隧道建设和运营管理提供参考。

关键词：公路隧道；病害类型；病害预防与处治；全寿命周期；隧道养护

Disease Exploration and Prevention Measure for Highway Tunnel Based on Full Lifetime

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Abstract: So far troubles arisen in highway tunnel, such as spread of disease, high cost of treatment, high frequency of ceaseless disposal and less durability after disposal. Based on statistic analysis of treatment about 42 tunnels, this paper classified tunnel diseases into 3 type, namely leakage and seepage, lining structure disease, floor disease. These features consisted of some aspects of distinct quality defect; disease appeared shortly after construction, disfigurement of second lining vault, bulging crack of tunnel surface and high cost with frequent occurrence. After analyzed the causes deeply, the paper put forward treatment measures from design, construction, management and operation maintenance, and discussed the treatment goals and principal, measures and practical inspection
method, in order to provide reference to highway tunnel construction and operational management.

**key words:** Disease treatment; disease type; disease prevention and maintenance; full lifetime; maintenance for tunnel

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Experimental Study on Distribution Characteristics of Freezing Front for Model Tunnel in Cold Regions under Ventilation

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ABSTRACT

In order to study the distribution characteristics of freezing front for ventilation tunnel in cold regions, relying on the Da Ban Mountain Tunnel in Qinghai, the model experiment system with similarity ratio of 1:37 was established. The influence of different wind speeds (0, 1.8, 2.6 and 3.6m/s) on radial and longitudinal temperature distribution of tunnel model under the air temperature of -10.6°C was studied. The radial four regional governing equation and longitudinal parabolic governing equation of freezing front are established. The correctness of governing equation of freezing front for model data is verified in comparison with field data, and the correction parameters of freezing front are obtained. The modified calculation model of freezing front can be used to the approximate estimation for frozen depth of tunnel in cold regions and the checking of correctness of numerical solution and
computer program.

**KEYWORDS:** Tunnel in cold regions; ventilation; freezing front; model experiment
不同断面形式悬浮隧道在爆炸冲击作用下动力响应研究

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摘 要: 以矩形、圆形和椭圆形三种典型的悬浮隧道断面形式为研究对象，利用 LS-DYNA 有限元软件分析在管段中部水平距离 5m 处 100KG 当量 TNT 炸药爆炸冲击波作用下的悬浮隧道响应，对比研究三种断面形式管段位移、速度、加速和冲击压力及结构应力，得出以下结论: 1) 三种断面形式悬浮隧道管段水平位移峰值纵向呈“W”分布，且最大位移小于 0.3m，竖向位移远小于水平位移; 2) 速度峰值沿隧道纵向分布呈倒“V”形分布，且椭圆形断面速度峰值小于矩形和圆形，最小值均超过《爆破安全规程》（GB6722-2014）限值; 3) 水平方向加速峰值远大于竖向，加速度峰值椭圆形最小，矩形最大，且圆形和矩形加速度峰值均超过了人体所能承受的极限; 4) 三种断面形式所受冲击压力和结构应力峰值均小于 10MPa，不足以使结构发生脆性破坏，但均超过了类似水工结构允许冲击压力峰值。

关键词: 悬浮隧道; 不同断面形式; 爆炸冲击; LS-DYNA 有限元软件

Study on the Dynamic Response of the Tunnel with Different Cross Section under Explosive Impact

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Abstract: The rectangular, circular and elliptical three typical floating tunnel section form as the research object, analysis on pipe middle horizontal distance 5m 100KG TNT equivalent explosion shock wave response of the floating tunnel by the finite element software LS-DYNA, the speed of a comparative study of three sections of pipe displacement, acceleration and impact pressure and structure stress, draw the following conclusions: 1) three sections of floating tunnel longitudinal horizontal displacement peak showed a "W" distribution, and the maximum displacement is less than
0.3m, the vertical displacement is much smaller than the horizontal displacement; 2) peak velocity
along the tunnel longitudinal distribution of inverted "V" shape, and The elliptical section is less
than the peak velocity of rectangular and circular, the minimum value was more than "blasting safety
regulations > (GB6722-2014) limits; 3) horizontal peak acceleration is greater than the vertical
acceleration, maximum and minimum oval, rectangular, circular and rectangular peak acceleration
exceeds the limit of human body can bear; 4) three sections the impact stress and the structural stress
peak was less than 10MPa, not enough to make the structure brittle failure, but more than a similar
hydraulic structure allows the pressure peak.

key words: submerged floating tunnel; different cross section; explosive impact; LS-DYNA finite
element software

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地铁隧道施工对邻近刚性接口管线的影响研究

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摘 要：地铁隧道施工对周围管线的影响已成为地铁工程中的重点和难点问题之一。研究地铁隧道盾构施工对周围管线的变形影响规律，并据此对管线进行合理加固与保护成为地铁等隧道建设中面临的重要研究课题。本文基于Winkler弹性地基梁理论模型，分别推导出与隧道轴线平行和垂直情况下的刚性接口地下管线由于盾构开挖引起的弯矩、应力、应变、转角和变形计算公式，分析了隧道直径、管隧距离、沉降槽宽度系数、管径、管壁厚、特征系数、岩土体弹性模量、管材弹性模量、地层损失率及泊松比等参数对管线沉降的影响特征，为隧道施工中对地下管线的安全保护提供理论基础。以西安地铁三号线通-胡区间施工工程为背景，制定了管线变形监测方案，工程实践表明，理论预测公式计算结果与实际相符。

关键词：盾构施工；管线变形；刚性接口；沉降计算

中国分类号：U458.1

Study on the Influence of Adjacent Rigid Connection Pipeline Affected by Shield Construction of Metro Tunnel

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Abstract：The influence of surrounding pipelines due to subway tunnel construction has become one of the key and difficult problems. Studying on the deformation law of the surrounding pipelines due to shield construction of metro tunnel and reasonable protection of pipeline is the common task faced in the construction of metro tunnel. Basing on Winkler elastic foundation beam theory model, when the pipelines parallel and perpendicular to the tunnel, the calculation formula such as moment, stress, strain, rotation and deformation of the rigid connection pipelines affected by shield tunnel excavation was derived based on Peck formula in this paper. The impact parameters on the pipeline settlement,
such as tunnel diameter, distance from pipeline to tunnel, settling tank width coefficient, pipe diameter, pipe wall thickness, pipe material elasticity modulus, underlying rock soil elasticity modulus, characteristic coefficient, Poisson's ratio, stratum loss were analyzed to provide the theoretical basis for safety protection of underground pipeline in tunnel construction. Taking the Tong-Hu interval tunnel of Xi'an metro Line 3 as the background, pipeline deformation monitoring scheme was drew up. The engineering practice shows that the calculation results of theoretical prediction formula are consistent with the actual.

**key words:** shield construction; the deformation of pipelines; rigid connection; Settlement calculation

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Prediction Method for Oxygen Concentration of Super-long Tunnel in High Altitude Areas

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ABSTRACT

When tunnels are built in high altitude areas, the most difficult problem is the lack of oxygen. Studies show that when the altitude is over 3,000 meters, the oxygen concentration will evidently drop which will slow down the tunnel construction and harm the tunnel workers' health. Although ventilation can alleviate the bad conditions caused by drilling and blasting method, the distribution of oxygen concentration is still a big question. In this paper, field measurements and numerical simulations are adopted and the results show that oxygen is affected by the two main factors. One is the tunnel length excavated, the other is the mechanical power used in the tunnel. This paper presents a method to predict the oxygen concentration along the tunnel length excavated over 3,000 meters high under construction. Then the numerical simulation is adapted to give various kinds of work scenarios. Thus a more detailed prediction method is given. By comparison of tested results acquired from the highest highway tunnel in China and the results from prediction method, they are in good agreement.
with each other.

**KEYWORDS:** high altitude, super-long tunnel, oxygen, prediction method, field measurement
Optimization of Construction Ventilation Scheme and Application of Dry Dust Removal Technology in Long Tunnel

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ABSTRACT

To find out the distribution of dust and harmful gases and check the effect of ventilation and dust prevention after blasting in tunnel construction with the drilling and blasting method, the wind velocity, dust concentration and the concentration of harmful gas in You-zhu-shan tunnel of Gui-Guang high-speed railway were studied by CFD simulation and field test. The ventilation scheme optimization was carried out and the optimum scheme of main tunnel as air intake while parallel
heading as air outlet is put forward. With dust removal technology and effect of dry dusting machine being explored, the analysis of its dust removal mechanism. The dry dusting machine being installed in the dust concentration site which is around 30m away from the Tunnel face is effective to the centralized dedusting on the procedures of blasting and sprayed concrete. The results showed that Additional ventilation system can discharge the harmful gas like CO. Meanwhile, the duster, after 2-min operation, resulted in the reduction of dust concentration from 75mg/m3 to 3mg/m3. Therefore, the combination of dry duster and jet fan ventilation can succeed in solving the excessive concentration of dust under tunnel construction.

**KEYWORDS**: tunnel engineering; construction ventilation; dry dust-removal; numerical simulation; field test