

# 城市道桥与防洪

主管：中华人民共和国住房和城乡建设部  
主办：上海市市政工程设计研究总院(集团)有限公司

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### ● 本期看点

- 智慧道路交通城市级云平台构建
- 城市道路体检评价指标体系构建
- 节段间“金属接触+高强螺栓”联合受力钢塔柱的线形控制技术
- 超大直径盾构空推过站方案及重难点

2023年第3期(总第287期)

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## 封面工程

本期封面工程为深圳坪盐通道工程,设计单位为深圳市市政设计研究院有限公司,建设单位为深圳市交通公用设施建设中心。

坪盐通道是深圳市规划“八横十三纵”干线路网的重要组成部分,也是坪山区南向重要的对外通道,主要承担坪山区与市中心区、盐田区之间的快速联系交通,以及盐田港东港区的疏港交通等重要功能。坪盐通道建成后极大地缩短了坪山城市副中心与市中心之间的时空距离,对构建深圳东部综合交通新体系、加快推进实施“东进战略”具有重要意义。

坪盐通道北起坪山区的坪山大道,南至盐田区的盐坝高速,路线全长 11.252 km。道路等级为城市快速路,设计速度 80 km/h,双向 6 车道。全线共设 2 座大型互通立交、1 座特长隧道和 18 座大、中桥。其中,关键工程——马峦山隧道为分离式独立双洞隧道,右线长 7.904 km,左线长 7.899 km,属城市道路特长隧道,也是目前广东省内建成的最长市政道路隧道。马峦山隧道建设条件复杂,工程技术难度大,设计理念先进,集多项科研成果及创新亮点于一体,为深圳市相关工程建设积累了丰富的技术成果和经验。

坪盐通道工程于 2013 年 4 月开始设计,2021 年 12 月完成建设。

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# Urban Roads, Bridges & Flood Control (Monthly)

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**Abstract:** The existing problems and demands for the construction of the domestic smart roads are analyzed. It is proposed that the construction of city-level cloud platform for smart road traffic is the key to construct the smart road. On this basis, the overall scheme architecture, software function modules and operation management mode for the city-level cloud platform of smart road traffic are put forward. Through the application of advanced digital technologies of digital twin, CIM (city information model), big data, cloud computing, internet of things, and artificial intelligence, the city-level data center is constructed, the integration of software and hardware is implemented, the city-level cloud platform is developed and deployed, the all-factor digital twin is carried out for the urban road network and roadside facilities, and the digitization empowerment of infrastructure management and maintenance, traffic control and emergency decision business application is realized. Finally, the smart road traffic system is built for the future.

**Keywords:** smart road traffic; city-level; cloud platform; infrastructure management and maintenance; traffic control; emergency decision; construction operation

Construction of Evaluation Index System for Urban Road Physical Examination ..... SAI Wanyin ( 5 )

**Abstract:** Urban roads are the important urban infrastructure. However, there is no relatively complete physical examination standard for urban roads. Therefore, it is necessary to build an evaluation index system for urban road physical examination. On the principles of combining the quantitative method with the qualitative method and combining the bottom-line indicators with guiding indicators, and on the basis of referring the relevant documents and specifications, the evaluation index system for urban road physical examination composed of 6 quality improvement goals and 29 physical examination indicators is built completely to cover each component module and construction process of urban road. Finally, the evaluation methods, evaluation influencing factors and evaluation steps are introduced and analyzed. And the three-point research conclusion is summarized and formed.

**Keywords:** road engineering; urban road; urban physical examination; quality improvement; indicator system; evaluation method

### ROADS & COMMUNICATION

Research on Design Concept of Complete Street for Jinan Airport Project ..... HU Xiaoxiao, JIN Wei ( 11 )

**Abstract:** From the perspective of policy orientation, concept and classification, the complete street design concept is discussed, the guideline is summed for six regions of Beijing, Shenzhen, Nanjing, Shanghai,

Chengdu and Wuhan, and the all-factor design content is sorted out. Taking Jinan Airport Project as an engineering example, the complete street design concept will be applied in it. The full-element refining design of the street is carried out from four aspects of traffic space, public activity space, greening space and ancillary facilities along the street in order to achieve the desired effect.

**Keywords:** complete street; street classification; all-factor; functional composition

Research on Design Method of Urban Road Quality Improvement Based on Street Concept .....  
..... KANG Lianguo, MA Guogang, TONG Jingsheng, LIU Shungui ( 16 )

**Abstract:** Over the years, the main purpose of urban road design is still to improve the function, which is not separated from the engineering attribute category of municipal roads, and cannot substantially improve the urban quality. Referring the street concepts at home and abroad, four typical design methods for improving the quality of urban roads have been formed, that is, the idea target design method, the type design method, the user group demand design method and the space composition all factor design method. These methods carry out the integrated collaborative design for the multiple functional activities in the range of three-dimensional space interface formed by road red line and building retreat, which open up the new thinking and direction for the design of urban road quality improvement.

**Keywords:** road engineering; street concept; urban road; quality improvement; design method

Research on Interchange Station and Interchange Mode of Subway in Recent Construction .....  
..... ZHANG Jianhong ( 20 )

**Abstract:** In view of the increasingly dense rail transit network in major cities, the transfer station as a button connecting the different lines plays a vital role, and its core is the transfer mode. The reasonable transfer mode can not only improve the daily travel efficiency of the people, but also reduce land, construction scale and engineering cost to a certain extent. With the needs of the city, in order to speed up the development progress of city, the multiple lines are reported to the leadership, approved and constructed together within the confines of policy. As a result, the scheme phase has to consider how to design the interchange station in advance in recent construction. Based on many years of design experience, combined with various interchange modes and the actual engineering cases in operation, the interchange stations in recent construction are further studied and summarized.

**Keywords:** rail transit; short term; interchange station; interchange mode

Study on Key Points of General Design of River Crossing Tunnel of Urban Trunk Road in Jiaxing .....  
..... DONG Zhanyu ( 24 )

**Abstract:** The general design, analysis, comparison and selection process of Qingfeng Road Tunnel – the first river crossing tunnel of the trunk road in Jiaxing are introduced in detail. Taking Jiaxing City Qingfeng Road Tunnel Construction Project as an example, and based on the general design requirements in the *Code for Design of Urban Road Line* (CJJ 193–2012), the key points of the general design of river crossing tunnel of urban trunk road are further summarized.

**Keywords:** urban road; trunk road; tunnel; river crossing; general design; non-motorized vehicle lane

Thinking and Analysis on Optimal Design of Rotary Intersection ..... YOU Qiangsheng ( 31 )

**Abstract:** Intersection is an important part of urban roads, the throat of urban road network system and the key node of urban traffic arteries. Therefore, the type selection of intersection is crucial. Due



to the backward concept of early urban planning, the uneven urban development, the gradual increase in household car ownership and the unreasonable selection of intersections in China, the traffic congestion has become an increasingly prominent livelihood problem in various cities. Taking the rotary intersection optimization scheme of Longguang Avenue People's Hospital in Fengcheng City as an example, many schemes are compared by the problem-oriented, and finally a reasonable reconstruction mode of intersection is selected to solve the traffic safety and traffic congestion in the city.

**Keywords:** rotary intersections; ring road; traffic volume; twice crossing of safe island

Study on Reconstruction Scheme of Huangmugang Interchange ..... ZHANG Wang( 35 )

**Abstract:** Through the study on the reconstruction scheme of Huangmugang Interchange in Shenzhen, the problems of the existing urban interchange to the construction of city development and rail transit are analyzed. The main factors required to be considered in the design of the node reconstruction of urban hub interchange are discussed. The study, comparison and selection processes of the schemes are discussed. A set of interchange reconstruction design and comparison methods is provided. The referring functions are used for the reconstruction of the similar hub interchanges for the future.

**Keywords:** traffic engineering; rail transit; hub interchange; node reconstruction

Study on Countermeasures to Alleviate Traffic Congestion in Main Urban Area of Changzhi .....  
..... CHEN Yanmei ( 40 )

**Abstract:** With the development of urban economy and the acceleration of the urbanization process, the urban area of Changzhi continues to expand and the motor vehicle ownership continues to increase. As a result, the urban traffic congestion is becoming more and more serious and the travel cost of the people is becoming higher and higher. It is extremely urgent to discuss the alleviation countermeasures for the traffic congestion in Changzhi. According to the overall planning of Changzhi and the overall planning of Changzhi High-tech Zone, the urban positioning, planning structure and planned road network of Changzhi are analyzed and understood. In view of the existing traffic problems in the current central district of Changzhi, the countermeasures are put forward to alleviate the traffic congestion in the central urban area, especially in the main urban area from four aspects of constructing the expressway system, building the "well"-shaped backbone traffic corridor, perfecting the arterial road network and speeding up the construction of secondary branches.

**Keywords:** main urban area; traffic congestion; alleviation countermeasures; express system

Research on Design Scheme of High-filled Roadbed in Collapsible Loess Gullies ..... FANG Zengyao ( 44 )

**Abstract:** The treatment of collapsible loess should be paid more attention when the high grade roads and high-filled embankments are constructed in loess gully area. Relying on the high-filled embankment project of the north extension of East Huancheng Road in Jinzhong, the design method of "strong foundation, steady embankment, solid slope and drainage" is proposed. The lime soil compacted pile is used to treat II-class self-weight collapsible gully site and control the bearing capacity of the foundation not less than 250 kPa. The layered dynamic compaction method is used to fill the roadbed, and the deformation of the roadbed is dynamically monitored. The measures of grading slope and setting slope foot are taken to enhance the stability of the slope. And double rows of circular culvert are set at the bottom of the trench to solve the problem of rainwater crossing. The roadbed is in good condition two years after construction, which can be referred for the design of the similar projects.

**Keywords:** collapsible loess; high-filled roadbed; lime-soil compaction pile; dynamic compaction

Study on Composite Foundation Reinforcement of Geogrid and Cement Mixing Pile Based on ABAQUS

..... ZENG Shuai ( 48 )

**Abstract:** In the process of urban road construction, various geological conditions are usually encountered. The soft soil foundation is one of the common geological problems. The subgrade of urban road is the foundation of pavement and should meet the requirements of strength, deformation and stability. Because the soft soil has the characteristics of large natural water content, high compressibility, low bearing capacity and low shear strength, when the soft soil is used as subgrade foundation, various foundation reinforcement measures should be taken to treat the soft soil foundation to make the urban road meet the design requirements. Taking Dangxiao Road (Dongliu Road – Fuxiang Road) in Changsha Economic Development Zone as an example, the corresponding numerical model is established with ABAQUS to simulate the working conditions of not using the reinforcement measures and using the reinforcement measures of geogrid combined with cement mixing pile aiming at the working condition of using geogrid and cement mixing pile to reinforce the soft soil to form a composite foundation. According to three indexes of vertical settlement, horizontal displacement and vertical stress, the law of reinforcement performance of composite foundation is analyzed. The research conclusion plays a good guiding role in soft soil foundation treatment of urban road.

**Keywords:** ABAQUS; geogrid; cement mixing pile; composite foundation reinforcement

Application of Green Wisdom Concept in Municipal Design of University Campus ..... SUN Wei ( 54 )

**Abstract:** With the continuous improvement of the requirements of university construction in the new era, the planning and design of university campus be based on safety and practicality, but also needs to take into account green, wisdom and other factors. The scientific optimization and collaborative design are carried out especially for the road, drainage, heat, water supply, electric power and other municipal majors in Zibo campus of Shandong Agricultural Engineering College. The design strives to be harmonious, forward-looking and flexible so as to meet the diversity and sustainability requirements of the future development of newly-built colleges and universities in the new era, which can be used as a reference for the design of the similar projects.

**Keywords:** university campus; municipal design; scientific optimization; collaborative design; green; advanced; wisdom; quality

## BRIDGES & STRUCTURES

Alignment Control Technology of Steel Pylon by United Stress of "Metal Contact + High-strength Bolt" between Segments ..... LI Junping ( 57 )

**Abstract:** The common connection methods between the segments of steel pylon are two methods of "metal contact + high-strength bolt" connection and welding connection. It is very important to ensure the steel pylon alignment of the completed bridge in spite of the connection mode between the pylon segments. Taking the steel pylon by united stress of "metal contact + high-strength bolt" between pylon segments as an example, the difficulties to construct this kind of steel pylon and the technical measures to ensure the pylon alignment are introduced in detail, which can be referred for the similar projects.

**Keywords:** bridge pylon; segment; interface matching; alignment control; pre-assembly



Key Technology and Innovation of Ba River Bridge in Xian Ring III Road System Project .....

..... ZHANG Lei, ZENG Peng ( 61 )

**Abstract:** The total length of Ba River Bridge in Xian Ring III Road System Project is 1.061 km, including the main road bridge of Ba River Bridge, the auxiliary road bridge of Ba River Bridge and the auxiliary road bridge of Guangyun Lake. The total area of the bridge is 43 881 m<sup>2</sup>. The total estimate is RMB 219.7 million yuan. It is the largest municipal cross-river bridge project in Shaanxi Province. The bridge is located over Guangyun Lake, a large-scale tourism development project in Xian, and spans Ba River within "the first water city in the west" - Xian Chanba Ecological Park with the high landscape requirements. The characteristics of Ring III Road to set up the main and auxiliary roads are used in the overall design, and the design idea of the "same span and different elevation of main road bridge and auxiliary road bridge" is put forward innovatively. The composite system of (2 × 50 + 80 + 2 × 50) m through concrete filled steel tubular arch beam is adopted for the main bridge of the main road bridge, and the (25 + 2 × 50 + 80 + 2 × 50 + 25) m continuous box beams are used for the main bridge of the auxiliary road bridge, which are the ingenious conceptions. The good landscape effect is achieved while satisfying the traffic functional requirements of the main and auxiliary roads, which can be referred for the similar projects.

**Keywords:** Ba River Bridge; main road bridge; auxiliary road bridge; through concrete-filled steel tubular arch beam combination; continuous box girder

Design of Main Bridge of Guangzhou Bridge in Meizhou City .....

WANG Peng ( 65 )

**Abstract:** As a kind of (139+106) m single-pylon single-plane asymmetric cable-stayed bridge, the pylon-pier-beam consolidation system is used for the main bridge of Guangzhou Bridge. The main beam is an integral prestressed concrete box girder with wide and large cantilever and approximate triangular inclined web. The bridge pylon is a rectangular section "I"-shaped prestressed concrete structure with elliptical ends. The main pier is a concrete double thin-wall pier. Midas/civil finite element analysis software is selected for the static calculation of the whole bridge. The results show that the strength and stiffness of the bridge meet the specification requirements.

**Keywords:** single pylon; single cable plane; cable-stayed bridge; prestressed concrete box beam; finite element analysis

Experimental Study on Hydrodynamic Effect of Pier Arrangement of Maanshan Yangtze River Highway-Railway Bridge .....

ZHAO Weiyang, HU Yong, ZHU Yude, ZHANG Hu ( 68 )

**Abstract:** The bridge construction will change the hydrodynamic condition of the local reach of the project in a certain range, and will bring certain influence to the navigation condition. Taking a Yangtze River highway-railway bridge in Maanshan as an example, the characteristics of flow movement in the engineering reach are studied by using the established physical model. The variations of flow velocity, flow direction and branching ratio of the bridge reach are specially analyzed. The influence of the bridge after completion on the hydrodynamic conditions is simulated. The results show that after the implementation of the recommended span layout scheme, under the condition of different flows, the upstream water level of the bridge axis in the bridge site reach is banked up, the flow velocity is slightly reduced, and the downstream flow velocity is slightly increased, and the inshore flow velocity of the downstream bridge site is slightly increased. But the range is not large. The influence range of bifurcation ratio of branch in this

reach is within 0.3%. The flow velocity of Zhengpu Port on the downstream of the left bank side is basically unchanged. The bridge construction will not greatly change the flow condition in the bridge site reach, and has little influence on the navigable flow condition.

**Keywords:** bridge pier; hydrodynamic force; navigation condition; model test; influence

#### Design of Protection System for Main Cable System of the Overlong-span Self-anchored Suspension Bridge

..... MENG Xiangyong, LI Chunyan, ZHANG Huzhi ( 72 )

**Abstract:** Based on the background of the main bridge of Yunlongwan Bridge, the design of the protection system for the main cable system of the double-pylon self-anchored suspension bridge with the (30+80+205+80+30) m span layout are systematically introduced. There are two main cables in parallel vertical planes designed to this bridge. Each cable consists of 27 strands, and each strand contains 91 wires of high-strength galvanized aluminum alloy parallel steel wire. By the investigation and analysis of the application of the main cable protection system of suspension bridges in China, the desiccant system of the main cable is added to protect the main cable on the basis of traditional wire wrapping and coating protection system, which blows the dry air into the main cable continuously and circularly to ensure the durability of the main cable of the bridge in operation stage. At the same time, the anti-corrosion measures are designed for the corresponding accessories of the main cable, and for the convenience of maintenance, the path for inspecting and repairing is set on the top of the main cable. The design of the protection system and maintenance measures guarantees the permanent durability of the main cable, which can provide some references for the design of the similar suspension bridges.

**Keywords:** double-pylon self-anchored suspension bridge; main cable; protection system; desiccant system; path for inspecting and repairing

#### Study on Design of Seismic Mitigation and Absorption for Continuous Beam Bridge in Liquefaction Site in High-intensity Area

..... NI Wenlong, ZHOU Jianhua, CHEN Hongxing ( 76 )

**Abstract:** Based on the  $3 \times 18.6$  m continuous box girder of a viaduct project in Haikou Port, and relying on the study basis of *Specifications for Seismic Design of Highway Bridges* (JTG/T 2231-01-2020), the finite element software is used for the seismic design and analysis. The study shows that the design of seismic mitigation and absorption is suitable for the continuous beam bridges in liquefaction site in high-intensity area. The design of seismic mitigation and absorption is adopted, the basic period of the structure is long, the nonlinear characteristics are strong, and the time-history method is more suitable for analysis. After eliminating the liquefaction soil between piles, the stress of the bridge substructure, especially the pile foundation under earthquake action is improved.

**Keywords:** seismic mitigation and absorption; liquefaction site; high-intensity area; continuous beam bridge; time-history analysis; friction pendulum bearing

#### Analysis on Seismic Response of High-pier Curved Bridge Considering Friction Slip of Bearing

..... ZHANG Yunzhou, CHAI Shangyun ( 80 )

**Abstract:** In order to study the characteristics and laws of seismic response of high-pier curved bridge considering the friction slip of bearing, the finite element model of two-connected continuous curved bridge is established by using Midas civil software. Based on the double broken line restoring force model of laminated rubber bearing, the influence rule of bearing shear stiffness on seismic response is studied. The results show that the maximum displacement at the top of the pier decreases by 5.5%, the maximum



bending moment at the bottom of the pier decreases by 4.7%, and the maximum shear force at the bottom of the pier increases by 27.1% after considering the friction slip effect of bearing. With the increase of the shear stiffness of the bearing, the bending moment at the pier bottom and the maximum longitudinal displacement at the pier top first increase and then decrease, and the shear force at the pier bottom and the maximum longitudinal displacement of the beam body gradually decrease.

**Keywords:** high pier; curved bridge; friction slip; laminated rubber bearing; double broken line

Research on Impact of Footbridge on Seismic Performance of Long-span Bowstring Arch Bridge .....

..... ZHOU Hao ( 85 )

**Abstract:** The structure of footbridge set on long-span arch bridge is novel. It is greatly significant to verify the impact of footbridge on the seismic performance of through bowstring arch bridge. Taking a bowstring arch bridge in Shenzhen as the research object, the impact of setting the footbridge on the seismic performance of the whole bridge in the stage of bridge completion is analyzed by dynamic time history method. The research shows that the setting of footbridge can reduce the stresses of bridge arch rib and boom under the longitudinal and vertical seismic actions, and increase the stresses of bridge arch rib and boom under the transverse and vertical seismic actions, which have little effect on pile foundation.

**Keywords:** through bowstring arch bridge; simulation model; dynamic time-history; seismic analysis

Design of Long-span Steel-concrete Combined Continuous Beam Bridge .....

..... SHEN Jiongwei ( 88 )

**Abstract:** Based on Jinling Bridge of 324 National Highway in Nanning, the key technologies of design and construction of long-span steel-concrete combined continuous beam bridge are studied. The main bridge of Jinling Bridge is a continuous beam bridge with the span layout of (75+180+75) m, which is the largest-span steel-concrete combined continuous beam bridge in China. Combined with the characteristics of the bridge, the key technologies of bridge design and construction are studied, which can be referred for the similar projects.

**Keywords:** steel-concrete combined beam; box girder; steel-concrete combined section; design

Analysis on Temperature Sensitivity of Multi-arch Rib Special-shaped Bowstring Steel Arch Bridge .....

..... LIU Yafeng, WANG Lijun, DENG Xinghui, QI Wenyang ( 94 )

**Abstract:** In order to study the influence of different forms of temperature changes on the completion state of special-shaped bridges, taking a multi-arch rib special-shaped bowstring steel arch bridge as the engineering background, the Midas Civil space finite element calculation model is established, and four parameters of overall temperature, beam-arch temperature difference, longitudinal bridge cable plane temperature difference and transverse bridge cable plane temperature difference are elected to analyze the temperature sensitivity and to obtain the effect degrees of various parameters on the deformation, stress and cable force of bridge structure. The results show that the beam-arch temperature difference has a great influence on the deformation, stress and cable force of bridge structure, which is the common sensitive parameter of all three. The overall temperature effect has a great influence on deformation, and has a little effect on stress and cable force. The temperature differences of the longitudinal and transverse cable planes have the greater influence on the cable force, and a little influence on the deformation and stress.

**Keywords:** multi-arch rib special-shaped bowstring steel arch bridge; static characteristics; parameter analysis; analysis of temperature sensitivity

Analysis on Characteristics of Railway Bridges in Interchange Reconstruction of Caobao Road Project .....

..... WANG Xiaojing ( 98 )

**Abstract:** The new project of Caobao Road Expressway in Shanghai involves the reconstruction of the current Jiamin Interchange. The reconstruction scheme of Jiamin Interchange is mainly introduced. The control factors, design characteristics, key and difficult points of the main bridge project across the railway corridor are specially introduced. The railway bridges in the engineering range are the special-shaped continuous steel box girder T-shaped rigid-frame bridges by the rotation construction method to span 7 lines of high-speed railway and ordinary railway. The main bridge across the railway has the very wide width, large changes in plane size, special-shaped section layout, and the longitudinal slope of the bridge reaches 6%. The special-shaped structural layout brings the problem of vertical and horizontal extremely unbalanced rotation. The difficulty of extremely unbalanced rotation of long-span bridges can be solved through the accurate counterweight, the temporary stay cable auxiliary structure and other measures, which can provide reference for the similar projects.

**Keywords:** interchange; reconstruction; special-shaped; steel box girder bridge; rotation; imbalance; auxiliary structure

Overall Calculation and Analysis on Key Components of Yumin Bridge in Jieshou City .....

..... LIU Shengguang ( 102 )

**Abstract:** The main bridge of Yumin Bridge in Jieshou City is a self-anchored suspension bridge with a main span of 142 m. The design steps the bridge mainly include the determination of the overall layout, the establishment of static finite element model, the analysis of overall stability, the determination of cable alignment, the analysis of internal force during operation and the checking calculation of component strength. In addition, it is necessary to establish a dynamic model to understand the natural vibration mode of the bridge, analyze the response of the structure under the action of earthquake, and then check the seismic performance of the bridge. The summarized contents can provide the valuable reference for the design of the similar bridges.

**Keywords:** Yumin Bridge; self-anchored suspension bridge; suspension bridge modeling; cable system; effective length of main pylon

Analysis on Influence of Concrete Shrinkage and Creep Effect on Steel-concrete Composite Continuous Beam Bridges after Completion .....

..... LIU Xiaoluan, LU Chuanan, ZHANG Yu ( 106 )

**Abstract:** The steel beam and concrete deck of steel-concrete composite continuous beam bridge are connected by shearing force nails, the shrinkage and creep deformation of concrete deck will be restrained by steel beam, which will cause the stress redistribution of concrete deck and steel beam. Taking a steel-concrete composite continuous beam bridge of an urban expressway loop project as the analysis object, the results show that the shrinkage and creep of concrete has some negative effect on the alignment and stress of the composite continuous beam bridge after completion. The environmental average annual relative humidity change has little effect on the alignment and steel beam stress of composite continuous beam bridge. The increase of relative humidity is beneficial to the stress of bridge deck.

**Keywords:** steel-concrete composite continuous beam bridge; shrinkage; creep; stress redistribution; environmental annual average relative humidity

Numerical Analysis on Transverse Force of Asymmetric Cable-stayed Bridge with High and Low Pylons .....

..... TONG Hanyuan, WANG Xiaoliang, CHEN Jindong, LIAO Zhaoqian ( 110 )

**Abstract:** The transverse force of asymmetric cable-stayed bridge with high and low pylons is one of the keys to analyze its structure, which is of great significance to the safety and durability of the bridge structure. Relying on an asymmetric cable-stayed bridge with high and low pylons, the bar system model and solid model are established respectively to numerically analyze its transverse force. The force law of the structure under multiple working conditions is studied. Comparing the calculation results of the two models, the analysis shows that the stress difference between the two models under live load is 0.5 ~ 2 MPa, and is basically the same under the crowd load. The bar system model is more conservative than the solid model.

**Keywords:** cable-stayed bridge; deck slab; lateral analysis; finite element analysis

Application and Analysis of UHPC in Channel-section Steel-concrete Composite Beam ..... LIU Yu ( 113 )

**Abstract:** Based on the background of a long-span continuous steel-concrete composite beam, the overall and local comparative analysis of steel-UHPC composite beam and steel-concrete C50 composite beam is carried out. The results show that the stiffness of the steel-UHPC composite beam is slightly smaller than that of the steel-concrete C50 composite beam in the overall calculation. The stress of the steel beam in steel-UHPC composite beam is about 27% lower than that of the steel-concrete C50 composite beam in fundamental combination. In the local finite element analysis, the bridge deck of steel-concrete C50 composite beam has cracked under frequent combination, the maximum tension stress of steel-UHPC composite beam bridge deck is less than that of steel-concrete C50 composite beam, which only appears at the lower limb of longitudinal ribs, and the maximum tension stress is less than the cracking stress of UHPC material. The steel-UHPC composite beams can greatly reduce the dead weight of structure and further reduce the section of the steel beam, which is expected to solve the problem of bridge deck cracking in the long-span continuous composite beam.

**Keywords:** steel-UHPC composite beam; long-span continuous composite beam; finite element analysis; bridge deck stress

Application of External Prestressing Technology in Continuous Steel Box Girder Bridge .....

..... MENG Fanliang ( 117 )

**Abstract:** Relying on a continuous steel box girder bridge in Shanghai, the effect of the external prestressing technology in the continuous steel box girder bridges is analyzed. In order to ensure the strength and stability of anchoring and force transferring components, the applied steel anchor box and transverter structures are introduced. At the same time, the finite element model is established by using Midas Civil to analyze the effect of external prestressing technology on reducing the stress on the upper edge of steel box girder at the negative bending moment zone of fulcrum. The achieved conclusion can provide the reference for the design of the long-span steel bridges.

**Keywords:** external prestressing; steel structure; long-span bridge; finite element analysis; continuous steel box girder

## FLOOD CONTROL & DRAINAGE

Thinking on Construction Scheme of Full-underground Wastewater Treatment Plant in Land Limitation .....

..... XU Jing ( 120 )

**Abstract:** The rapid growth of population and economy in Wuxi has kept the operation of a wastewater

treatment plant (WWTP) at the full capacity in recent years. In order to solve the hidden danger, the Phase III extension project is implemented for the WWTP. The sewage treatment scale will increase from the current 150 000 m<sup>3</sup>/d to 250 000 m<sup>3</sup>/d in the short term after completion, which will meet the requirements of the 2025 plan. In order to build a modern WWTP with the distinctive characteristics of the times, the technological process of "pretreatment + AAOA+MBR + air flotation + disinfection" is adopted for Phase III WWTP supplemented by a number of low-carbon environmental protection design concepts. Combined with the long-term situation, the basic situation, operating conditions and Phase III extension engineering planning of the current WWTP are introduced, and the utilization of reserved space in the future is reasonably looked forward.

**Keywords:** full-underground WWTP; extension engineering; upgrading and reconstruction

Preparation and Adsorption Characteristics of Activated Carbon from Biochemical Sludge of Wastewater Treatment Plant ..... WANG Youhao, ZHU Wuxing ( 125 )

**Abstract:** The activated carbon of sludge is prepared at 500 °C with biochemical sludge as raw material and zinc chloride as modifier. The effects of different initial pH on the adsorption of methylene blue by activated sludge carbon are investigated. The isothermal curves and kinetic models are fitted. The results of SEM images show that the surface of the prepared activated sludge carbon is rough and the hollow structure is developed. The carbon loss in the preparation process is large. The experimental results show that the adsorption value of activated sludge carbon to methylene blue increases with the increase of pH in the research range, but its effect is limited in the range of 3 ~ 9. Langmuir adsorption isotherm and pseudo-second-order kinetic model fit the adsorption process of methylene blue by activated sludge carbon better.

**Keywords:** sludge; activated carbon; adsorption; modification

Discussion and Design of Sludge Advanced Dewatering Process for a Wastewater Treatment Plant ..... YANG Shengxin, HE Jiahui ( 129 )

**Abstract:** Take the selection and design of sludge advanced dewatering process for a wastewater treatment plant (WWTP) in Dongguan as an example, by comparing three different sludge treatment processes in the floor space, total investment, operating cost and the other economic and technical indexes, the application of three different sludge treatment combinations is obtained. At the same time, according to the shortage of land and fund of this project, the "sludge storage tank + mechanical thickening + pharmaceutical conditioning + ultrahigh pressure plate frame press filtration dewatering" process is determined as the sludge treatment process of this project. And the design of sludge advanced dewatering process is further carried out so as to reduce the water content of the sludge below 60%, which can provide a reference for the design of the similar projects.

**Keywords:** advanced dewatering of sludge; economic and technical indexes; comparison; technological design

Start and Commissioning of CASS Process with Low Influent Load ..... YU Jing ( 133 )

**Abstract:** Abstract: In order to solve the common problems of the newly built wastewater treatment plant (WWTP) in the New District, such as long commissioning period and unstable effluent quality caused by low influent flow and water quality in the initial start-up period, starting from the characteristics of the CASS process, and combined with the typical WWTP cases, the key parameters of operation mode,



operating cycle, sludge load and mixed liquid return ratio in the original design are specially adjusted and optimized, and the CASS tank can overcome the low influent load. In a short period of time to start up and in the commissioning stage, each effluent indicator can reach the design standards stably, which can provide a reference for the start-up and commissioning of low water flow load faced by the similar WWTPs.

**Keywords:** low load; CASS process; start-up; commissioning optimization

Study on Optimization of Sponge Reconstruction Scheme in Residential Area Based on SWMM Simulation Results  
..... WANG Bin, TAO Yanbin ( 137 )

**Abstract:** Under the condition of meeting the planning indexes such as runoff control rate, many kinds of LID technical schemes can be adopted in the sponge reconstruction of residential area. Designers often have a lot of discretion about how to choose between these schemes. It is proposed that the field observation is carried out for a residential area before design, the parameters of SWMM model to be adopted are calibrated, and then the results are simulated in combination with the different rainstorm recurrence periods of SWMM. By considering the factors of the hydrological characteristics improvement, engineering cost and environmental benefits of the planned land, the comprehensive benefits of LID combination scheme are evaluated by using the fuzzy synthetic evaluation method. Finally, the best LID engineering combination scheme is found out. This method can provide the reference for the application of low-impact development technology.

**Keywords:** low-impact development; SWMM; integrated benefits; fuzzy synthetic evaluation

Key Measures for Dike Reinforcement at Estuary of Desheng River ..... ZHU Xiaolei ( 141 )

**Abstract:** Desheng River is one of Taihu Basin Huxi Diversion and Drainage Projects, and has the functions of water diversion, drainage waterlogging and navigation. As an important backbone river channel in Changzhou City, its estuary is often affected by the river regime, the ships and the other dangers. By fully understanding the dangerous situations, the targeted dike reinforcement scheme is proposed. The dike reinforcement is carried out from the stabilization, seepage resistance, drainage, ecologicalization and other aspects in order to satisfy the compound functional requirements of the dike, which provides the experience and reference for the similar projects.

**Keywords:** estuary; dangerous situation; dike reinforcement; ecologicalization

Analysis on Improvement of Flood Control Capacity of Lubu Reservoir in Yuyao .....  
..... CHEN Qiang, LIU Lisheng ( 144 )

**Abstract:** With the development of economy and society, the situation of the flood control system of watershed is becoming more and more serious. It is great significance to improve the flood control capacity of built reservoirs. By analyzing the current flood control capacity of Lubu Reservoir in Yuyao City, the relevant engineering measures to improve the flood control capacity of the reservoir are put forward, which has certain reference value for alleviating the flood control pressure of downstream towns and improving the flood control capacity of similar reservoirs.

**Keywords:** Lubu Reservoir; flood control capacity of reservoir; engineering measures

## MANAGEMENT & CONSTRUCTION

Temporary Structure Layout for Integral Incremental Launching Construction of Steel Beam Arch Bridge with

Variable-width Section ..... LUO Gansheng, ZHANG Shuya, CHEN Yousheng, DING Weihong ( 146 )

**Abstract:** The incremental launching construction method is often used for bridges with single straight line and constant bridge width, while the incremental launching process of steel beam arch bridge with variable-width section is complex and difficult. Taking the main bridge of Xindian Bridge as the engineering background, the structural characteristics of the bridge are analyzed in detail. The temporary structural layout type suitable for the integral incremental launching construction of the bridge is proposed. The stress calculation and analysis are carried out for this structure. And the safe and reasonable structural construction is obtained. At the same time, based on the detailed process of incremental launching construction of the bridge, the reasonable connection method of temporary structure and main structure is proposed. The engineering practice shows the temporary structure layout for the integral incremental launching construction of steel beam arch bridge with variable-width section is rational and feasible.

**Keywords:** bridge engineering; steel arch bridge; integral incremental launching construction; variable-width girder

Study on Optimization and Improvement of Incremental Launching technology of Railway Steel Truss Bridge ..... WU Yindong ( 150 )

**Abstract:** In the existing railway reconstruction project of Kunshan – Lujiabang section of Beijing–Shanghai Railway, the through steel truss beam with the span of 80 m across the channel of Qingyang Port is constructed by incremental launching method. The key contents of bridge construction and the main system composition of incremental launching are introduced, and the improvement of incremental launching device system is studied. The steel truss assembly support is combined with the bridge substructure to form the incremental launching construction platform. According to the working principle of the long-distance jack, the integrated self-anchored incremental launching device is combined with the slideway to form the self-anchored dynamical system. The incremental launching device integrates the jack and the reaction frame into a whole to realize the synchronous advance of jack and reaction frame. The incremental launching system is easily installed after improved, and the incremental launching efficiency is high, which greatly reduce the number of operators.

**Keywords:** railway; steel truss; incremental launching; improvement; self-anchored; integration

Comparison and Selection of Form Traveler Scheme for Cast-in-place Box Girder of a Highway Cable-stayed Bridge ..... YANG Guang, TAN Ziyang ( 154 )

**Abstract:** As one of the key links of cable-stayed bridge construction, the form traveler construction of main girder has a significant impact on the quality safety, construction period and engineering cost of the bridge. Taking the bent cap of viaduct in the main urban line of a project as an example, the construction schemes of the cable form traveler and the combined diamond form traveler are analyzed from the technology, safety and economy to demonstrate the feasibility of the rear fulcrum diamond form traveler in the construction of the main girder of wide cable-stayed bridge, which can be referred for the similar projects.

**Keywords:** cable-stayed bridge; cable form traveler; combined diamond form traveler

Scheme, Key and Difficult Points of Oversized Diameter Shield Empty-push Passing Station ..... WANG Xin, FAN Yuming ( 157 )

**Abstract:** By analyzing the drum or roller method, trolley haulage method, sliding traction method and other passing methods, a new idea and method of empty push passing of large-diameter shield are put forward. The large shield is moved forward on the reinforced concrete base through the back force provided by the bottom assembled segments, which is technically feasible and economically more reasonable. By sorting out the passing-station process, the main key and difficult points of crossing-station construction are analyzed in the aspects of the compatibility of the base structure with the internal structure of the working well, the friction reduction and auxiliary measures for passing-station construction, and the safeguard measures for vertical transportation. There is little experience in large-diameter shield passing station in China. The method of empty-push passing station proposed in this project has a good reference for similar projects.

**Keywords:** shield tunnel; passing-station scheme; empty-push passing station; passing-station base

Study on Control Measures for Shield Undercrossing Water Conveying Pipeline at Short Range .....

..... KANG Jing ( 161 )

**Abstract:** With the rapid development of urban rail construction, the undercrossing engineering in subway construction is becoming more and more complicated, especially undercrossing the large-diameter water conveying pipeline and drainage pipeline at short range. It is necessary to ensure not only the safety of subway interval and pipeline during construction, but also the safety of both after subway operation. Therefore, it is very important to analyze the impact of shield tunneling on the existing pipelines. Combined with an in-out line project of subway in Shenyang, the finite element software MIDAS GTS is used to simulate the influence of subway shield tunneling on the large-diameter water conveying pipeline. The calculation result is verified by the field monitoring result. After comparison and analysis, it is verified that all taken measures are reasonable and reliable, which provides a beneficial reference for undercrossing the water conveying pipelines during shield tunneling in the future.

**Keywords:** shield method; water conveying pipeline; underpinning system; undercrossing at short range

Key Construction Technology of Underground Diaphragm Wall under Superhard Stratum .....

..... CUI Wei ( 164 )

**Abstract:** Superhard stratum is one of the common complex working conditions in foundation pit supporting construction. Relying on the project of Evergrande Center, the key construction technologies of the underground diaphragm wall in the superhard stratum area are analyzed and studied. The quality control technology of the underground diaphragm wall construction in the superhard stratum is discussed. The lead-in method of five lead-in holes in a single slot is determined. The slotting construction technology cooperated with three machines of rotary drilling, slotting machine and groove milling machine is confirmed. And some construction suggestions for the similar projects are given. The results show that the proposed method of single-slot five-lead holes and the construction technology of rotating-grabbing-milling have the good feasibility.

**Keywords:** superhard stratum; lead-in method; rotating-grabbing-milling construction technology; quality control

Analysis and Research on Improving Installation Qualification Rate of Disk-type Microporous Aerator .....

..... HUO Teng ( 167 )

**Abstract:** The disk-type microporous aerator has the characteristics of small aeration bubble diameter, small gas-liquid interface diameter, large area, uniform bubble diffusion and strong corrosion resistance,

which will not cause the mesh blockage and is especially suitable for the new construction and expansion of urban wastewater treatment plant (WWTP) and large WWTP, and the reconstruction of old aeration tank. Although the process treatment capacity of the disk-type microporous aerator is remarkable, its aeration uniformity directly depends on the installation accuracy of the disk-type microporous aerator in the construction process. Through the engineering examples, how to improve the installation accuracy of disk-type microporous aerator by using QC quality management means is analyzed and discussed to solve the common quality problems in the installation process of disk-type microporous aerator, to improve the qualification rate of one-time installation and to shorten the construction period caused by rework. Thereby, the rate of sewage treatment to the standard is improved.

**Keywords:** disk-type; microporous aerator; installation qualification rate; quality team

Damage Control Technology of Shield Cutter for Tunneling in Water-rich Composite Stratum ..... WANG Haifeng ( 171 )

**Abstract:** When the earth pressure balance shield machine is tunneling in the water-rich composite stratum, the abnormal damage of shield cutters often occurs because of the inhomogeneity through the stratum plus the developed stratum karst caves, thereby reducing the shield tunneling efficacy, increasing the shield construction cost and also increasing the safety risk of cutter changing. Therefore, it is of great significance to carry out the research on the damage control technology of the shield cutter tunneling in the water-rich composite stratum. Taking the Zhouqi Interval Tunnel of Xuzhou Urban Metro Line 2 as the engineering case, the problems of damage control of shield cutter tunneling in water-rich composite stratum are solved by the research, which provides the references for the follow-up similar projects.

**Keywords:** water-rich composite stratum; shield cutter; damage control

Study on Performance Evaluation of Municipal Roads Before and After Hot In-place Regeneration Construction ..... LIN Peng ( 175 )

**Abstract:** In order to compare and analyze the impact of the hot in-place regeneration technology on the pavement performance and functionality of road, the performances of asphalt cement and asphalt mixture before and after the hot in-place regeneration are tested, and the functionalities of the original pavement and regenerated pavement are evaluated. The results show that the heating process of hot in-place regeneration will not significantly age the asphalt cement and not affect the gradation. Due to the addition of regenerant, the rutting factor and stiffness modulus of asphalt cement decrease, the asphalt becomes soft, and the low-temperature performance and water stability of asphalt mixture are significantly improved. The skid resistance and flatness of the pavement after the hot in-place regeneration are significantly better than those before regeneration.

**Keywords:** hot in-place regeneration; dynamic shear rheological test; low-temperature bending beam test; pavement performance; functional evaluation

Application of Trenchless Rehabilitation Technology in Improving Quality and Efficiency of Wastewater Treatment ..... LI Jiali, LIU Jianwei ( 179 )

**Abstract:** Taking the sewage treatment quality and efficiency improvement project of an old city in Nanjing as an example, according to the results of pipeline inspection and evaluation, the health status of the pipelines is analyzed. Combined with the pipeline defects, constructing environment, trenchless rehabilitation technological characteristics, applicable conditions and economic benefits, the



rehabilitation scheme is designed. The application of four trenchless rehabilitation technologies, such as ultraviolet light in-situ curing, spot in-situ curing, stainless steel quick seal and manhole centrifugal spraying in the sewage treatment quality and efficiency improvement project is introduced, and the trenchless rehabilitation effects are evaluated, which can be referred for the similar projects.

**Keywords:** drainage pipe; quality and efficiency improvement; trenchless rehabilitation

Pressure Filtration, Curing and Reuse Treatment Technology of Waste Mud .....

..... YAN Jun, LI Xinghua, SHENG Yanan ( 183 )

**Abstract:** The bridge bored-in-place pile made by the positive and negative circulation rotary drilling technology will produce a large amount of waste mud during construction. The traditional treatment methods, such as direct discharge, on-site landfill and centralized outward transportation will have a great impact on the environment. The pressure filtration, curing and reuse treatment technology of waste mud is selected. By comparing the equipment types, and analyzing the pressure filtration curing process and reuse, it is considered that this technology can avoid the pollution to the environment and the occupation of land resources caused by the traditional treatment methods of waste mud, reduce the engineering cost, improve the construction progress, realize the reuse of waste mud from the pile foundation construction, and conform to the concept of high-quality green construction.

**Keywords:** waste mud; pressure filtration curing; reuse; green construction

Analysis on Crack Cause at Tensile End of Prestressed Bent Cap and Study on Technological Countermeasures

..... CHENG Xudong, YE Tao, SHAO Binlei, QIN Chao, LI Mianhong ( 186 )

**Abstract:** It is common for prestressed bent cap structure to crack at its tensile end during the prestressing tensile construction. By analyzing the causes of cracks at the end of prestressed bent cap, it is proposed that the preventive measures and design for the cracks should be optimized. The achieved conclusion and suggestions have the referring significance for the design of the similar structures.

**Keywords:** prestressed concrete; bent cap; cracking; cause analysis; treatment suggestions

Mechanical Spiral Winding Repair Project for Main Sewage Pipe of a Road in Wuxi .....

..... QI Leiting, CHEN Qiuping, ZHOU Bingyu ( 190 )

**Abstract:** Aiming at the structural defects such as rupture and disconnection occurred at DN600 pipe body and pipe joint of a road to varying degrees, the mechanical spiral winding pipe technology is determined for repair through the repeated demonstration. The technical principle, design focus, construction process and quality control essentials of this technology are analyzed. It is summarized that this technology has the advantages of operation with water, no impact on overflow, simple and rapid construction. The repaired projects have achieved the good results.

**Keywords:** sewage pipe; structural defects; mechanical spiral winding

## STUDY ON SCIENCE & TECHNOLOGY

Study on Quantitative Analysis Method of Underground Ring Road in Urban CBD Construction .....

..... CHI Lei ( 193 )

**Abstract:** With the continuous improvement of the urban development and construction in China, many

cities have planned central business district CBD as the engine of urban social and economic development. Due to the high development intensity and strong traffic demand in CBD, the traffic congestion in the morning and evening have also been highlighted. Therefore, many cities have planned the underground ring roads to make up the deficiency of ground road network. Through the research on the characteristics of CBD road network and the analysis on the cases at home and abroad, combined with the road network capacity theory, the calculation model of whether to build the underground ring road is put forward, which provides the theoretical support and technical means for the quantitative analysis on the planning and construction of underground ring road.

**Keywords:** underground ring road; urban CBD; road network capacity; quantitative analysis

Analysis and Design on Integrated Management Indicators of Expressway ..... YIN Feng ( 196 )

**Abstract:** The definition of management and maintenance cost and benefit of expressway is the complicated pending problem. Aiming the problem and based on the reality and simple principle, by analyzing the concept and establishing the expression of management and maintenance costs, the important parameters such as the importance coefficient of certainty management and the randomness routing maintenance coefficient are obtained, and the dynamic cost-effect optimization managing mode is put forward, which is a process tending to "light" maintenance grade through project-decision indicators, maintenance engineering and the supervision of effect indicators. Based on the cost analysis, the corresponding relation between cost and effect is set up to obtain the benefit indicators of certainty, half-certainty and randomness routing maintenance.

**Keywords:** cost; benefit; randomness routing maintenance; objective indicator; importance coefficient; maintenance coefficient

Experimental Study on Anchorage and Connection Performance of Embedded Grout Corrugated Steel Pipe on Edge ..... LU Yongcheng, YUAN Huiyu, WANG Zhiqiang ( 199 )

**Abstract:** Under the advocacy of the concept of green and low-carbon development, the application of bridge prefabrication and assembly technology is more and more extensive in urban bridge construction. Relying on the practical project of prefabrication assembly bridge of Shanghai Lianggang Avenue, the precast column rebar is anchored and connected with the grout corrugated steel pipe. In order to verify that the anchorage and connection of embedded grout corrugated steel pipe on edge can provide the reliable bonding and anchoring ability, by considering the different reinforcement anchorage lengths, pouring, grouting and other technical factors, the pullout test research on the bonding and slipping mechanical behavior of grout corrugated steel pipe and rebar is carried out to study and summarize the mechanical behaviors such as damage development process, failure mode, force and displacement curve, which provide the technical support for the application of practical projects.

**Keywords:** on edge; grout; corrugated steel pipe; anchoring; connection; performance

Study on Pavement Performance of RAP Recycled Asphalt Mixture with BRA ..... WANG Ning, LIU Xiaopeng ( 205 )

**Abstract:** In order to reduce the permanent deformation of asphalt pavement and improve the pavement performance of asphalt mixture, the characteristics of BRA materials are summarized. The raw materials of RAP recycled asphalt mixture with BRA content and the design of mix proportion of recycled mixture are summarized. The pavement performance of RAP recycled asphalt mixture with BRA content is analyzed

from the aspects of high-temperature stability, low-temperature crack resistance and water stability. The results show that when the dosage of BRA is 2%~3%, the comprehensive pavement performance of RAP recycled asphalt mixture with BRA content is better, and it is suitable for the pavement construction in high temperature and rainy areas. The mixture is worth popularizing and applying in similar projects.

**Keywords:** Budun rock asphalt; waste asphalt; high-temperature stability, low-temperature crack resistance; water stability

Grading Optimization of AC-13 Based on Crack Resistance .....

..... HUANG Xuefeng, WU Chenyue, TAN Yunpeng ( 209 )

**Abstract:** In order to improve the crack resistance of the asphalt surface, a group of gradations is initially drawn up according to the characteristics of the crack-resistant gradation. The crack resistance is used as the basis for screening the gradation, and then the high-temperature performance, low-temperature performance and water temperature performance are further optimized. The results show that the fracture energy of the crack-resistant gradation under the SCB test is better than that in AC-13, and the equivalent fatigue life of the crack-resistant gradation under the different failure probabilities can be increased by at least 22%. The high-temperature performance of crack-resistant gradation shows the same trend. The dynamic stability is lower than that in AC-13, but the shear strength is better than that in AC-13. With the increase of crack-resistant gradation fine material content and oil-stone ratio, the low-temperature performance and water stability performance are better than that in AC-13. Through the optimization of crack resistance and pavement performance, the range of crack resistance surface layer gradation is determined.

**Keywords:** AC-13; cracking resistance; gradation; pavement performance

Effect of Flame Retardant on Performance of Asphalt Mixture ..... Liu Huaixing, WANG Hua ( 213 )

**Abstract:** With the rapid development of highway construction in China, the scale and number of highway tunnel construction are increasing year by year. The traditional pavement in the tunnel shows some disadvantages. The tunnel space is relatively closed, and the asphalt concrete also has the potential risks. The different flame retardants are used to prepare the flame retardant asphalt. Through the oxygen index test, direct combustion test, rutting test, low temperature bending test, immersion Marshall test, freeze-thaw splitting test and other methods, the effects of different mixed flame retardants on the flame retardant performance and pavement performance of asphalt mixture are analyzed. The study results show that the home-made flame retardant has the good flame retardant effect, and the optimal mixing amount is 6%. The added flame retardant can improve the high temperature performance of asphalt mixture, improve the low temperature performance, reduce the water stability and reduce the combustion time. The residual dynamic stability after combustion is improved to a certain extent. That is, adding the flame retardant can greatly improve the flame retardant property of asphalt mixture.

**Keywords:** flame retardant; asphalt mixture; flame retardant property; tunnel engineering

Study of Early-strength Semi-flexible Grouting Material .....

..... CHEN Songqiang, YANG Guobao, XU Li, WANG Jinchang ( 217 )

**Abstract:** Due to the advantages of asphalt and cement pavement, the semi-flexible composite concrete is used in the intersections, long longitudinal slopes and other road sections. However, because it takes a long time for the semi flexible grouting material to harden to the required strength, it is necessary to

develop the early-strength semi-flexible grouting material. 42.5 ordinary Portland cement (hereinafter referred to as ordinary cement), fine sand, mineral powder, expansion agent and admixture are selected, and the proportion of semi-flexible grouting material meeting the requirements is determined by the orthogonal test. Then, the quick hardening cement is used to replace the ordinary cement. When the replacement ratio are 0.15~0.2 by research, the performance of semi-flexible grouting material after 4 h can meet the requirements.

**Keywords:** semi-flexible grouting material; orthogonal test; reasonable ratio; early strength

Study on Ultimate Bearing Capacity of Pile Foundation of Highway Bridge in Karst Steep Slope Area .....

..... LIU Xuefeng, YANG Hexian ( 222 )

**Abstract:** Karst and steep slopes are the key factors affecting the ultimate bearing capacity of pile foundations. In order to study the influencing factors and prevention measures of the ultimate bearing capacity of the pile foundation under the poor geological conditions, the pile foundation model is established by using the finite element software and its effectiveness is verified according to the relevant specifications. Aiming at five different slopes and four karst roof thicknesses, the orthogonal simulation test is carried out to analyze the change of the bearing capacity of the pile foundation and the bearing form of the pile under the different working conditions. The results show that the karst cave will cause the greater settlement, the foundation settlement is inversely proportional to the thickness of the karst roof, and 3 times pile diameter is the largest influence range of the karst geology on the pile foundation. The steep slope greater than 45° will cause the greater foundation settlement and then reduce the ultimate bearing capacity of pile foundation. The steep slope with a gradient more than 45° should be avoided in the practical engineering. Its influence on the bearing capacity of pile foundation should be specially considered if inevitable. The mode of the karst caves and steep slopes to reduce the ultimate bearing capacity of piles mainly reduces the lateral friction effect of piles, and the bearing form of piles is changed from friction piles to end-bearing piles.

**Keywords:** karst; steep slope; pile foundation; ultimate bearing capacity

Research and Analysis of Bearing Capacity of High-Filled Road Foundation .....

..... GUO Hongyang, MEI Zhao, LIANG Qingxue, DU Fei ( 226 )

**Abstract:** Combined with the practical engineering cases, based on the theories of the bearing capacity of Prandtl L and Terzaghi K, the bearing capacity of the filled road subgrade and its design check calculation method are analyzed so as to provide a reference for the design of the similar projects in the future.

**Keywords:** high-filled road; bearing capacity of foundation; Prandtl L theory; Terzaghi K theory

Study on Reasonable Scale of Urban Rail Transit Network Based on BP Neural Network .....

..... ZHANG Yijing, ZHANG Yi, WANG Tao, XIE Lelong ( 230 )

**Abstract:** At present, the urban rail transit is in the critical period of vigorous development in China. However, the rational scale calculation model and theory of urban rail transit network have not been formed yet in China. Therefore, it is necessary to further explore the calculation method of the rational scale of urban rail transit network. Firstly, the influence factors of urban rail transit network scale are expounded from the aspects of the national policy and transportation strategy, the urban economic and social development level, the urban scale and form, and the transportation demand and supply. The town population, urban built-up area, gross domestic product (GDP), average daily passenger volume of the



whole network, share ratio of urban rail transit in public transport and network load intensity are extracted as six quantitative indicators. Then, employing the impact indicator data of urban rail transit network scale in 21 cities of China over the years, a rational scale calculation model of urban rail transit network based on BP neural network is established. Finally, taking Shanghai, Shenzhen, Chongqing, Changsha and Nanning as examples, the model is used to predict the rational scale of urban rail transit network in 2035 in order to provide the scientific evidence for urban rail transit network planning and to promote the sustainable development of urban transportation in China.

**Keywords:** urban rail transit; network scale; impact indicators; back propagation (BP) neural network model

#### Research on Protection Performance of Class A Standard Wave-shaped Beam Guardrail for Passenger Cars

..... CHEN Dazhang, GONG Shuai, KANG Hanjing, LIU Siyuan, MA Qing, HU Xuecheng ( 236 )

**Abstract:** In order to understand the protection performances of Class A standard wave-shaped beam guardrail for the passenger cars as the mainstream vehicle model of expressway, the full-scale impact test with real vehicle is used to verify whether the protection performances of Class A standard wave-shaped beam guardrail for passenger cars to satisfy the requirements of *Standard for Safety Performance Evaluation of Highway Guardrail (New Standard for short)*. Through the investigation, study and analysis on the accidents, the protection capacity of Class A standard wave-shaped beam guardrail is verified under the condition of the real roads. The study result shows that the protection performances of Class A standard wave-shaped beam guardrail for passenger cars satisfy the requirements of *New Standard*, and the performance is good in the practical application. The study achievement affirms the safety protection performance of Class A standard wave-shaped guardrail for passenger cars, which provides a basis for the rational application of Class A standard wave-shaped beam guardrail.

**Keywords:** wave-shaped beam guardrail; protection performances; passenger cars; full-scale impact test with real vehicle

#### Key Designs and PAM Enhancement of Electrocoagulation Removal of Non-point Source Pollution in Orchard Planting

..... LI Ting, SUN Hui, KONG Qinggang, ZUO Xiaojun, WANG Tao, LI Yang ( 240 )

**Abstract:** Aiming at the unclear problem of electrocoagulation removal of non-point source pollution in orchard planting, taking the conventional non-point source pollutants in orchard planting as the research object, the key designs of electrocoagulation are investigated, the effects of pH and conductivity are analyzed, and the enhancement conditions of polyacrylamide (PAM) are discussed. The results show that the performance of electrocoagulation treatment is optimal when the voltage is 10 V (2.5 mA/cm<sup>2</sup>) and the electrode spacing is 1 cm. The removal rates of total suspended solids (TSS), nitrate nitrogen (NO<sub>3</sub><sup>-</sup>-N), ammonia nitrogen (NH<sub>3</sub>-N), total nitrogen (TN) and total phosphorus (TP) are 70.6%, 30.4%, 78.4%, 23.7% and 92.1% respectively. Acidity (pH=5) and alkaline (pH=9) conditions are not conducive to the removal of these pollutants. The increase of conductivity is beneficial to remove NH<sub>3</sub>-N, but not to remove the other pollutants. When the dosage of PAM is 0.5 mg/L and the settling time is 5 min, the enhancement effect is the best for the removal of TSS, NH<sub>3</sub>-N and TP, and the increasing range of removal is 39.1%, 10.3% and 7.5% respectively. However, it will inhibit the removal of NO<sub>3</sub><sup>-</sup>-N and TN to some extent. The research results can provide the theoretical and data reference for the electrocoagulation pretreatment of non-point source pollution in orchard planting.

**Keywords:** orchard planting non-point source; total suspended solids; nitrogen and phosphorus; electro-

coagulation; polyacrylamide

## APPLICATION OF ACHIEVEMENTS

Application of Slope Adjustment and Jacking Technology in Reconstruction of Viaduct in Vertical Curve Section  
..... ZHOU Jianhua, GAO Xin ( 245 )

**Abstract:** With the rapid development of economy in China and the expansion of the periphery of urban areas, the early urban viaducts can no longer meet the needs of urban development and renewal in some sections. The adoption of advanced technology of slope adjustment and jacking for the reconstruction of viaducts is a development trend, which has a broader application scenario. Through the analysis of an example of a viaduct reconstruction project, the overall design idea of the viaduct slope adjustment and jacking, and the key technical problems of the bridge upper and lower structure jacking are introduced, and the relevant solutions are proposed, which have the reference significance for similar projects in the future.

**Keywords:** urban viaduct; vertical curve; slope adjustment and jacking; jack

Development and Design of Jacket Steel Pipe Connecting Device for Suspender of Bowstring Arch Bridge .....  
..... FU Yonggao, WANG Lei ( 249 )

**Abstract:** A kind of jacket steel pipe connecting device composed of trapezoidal thread, flange plate and synchronous jack is designed. The device can realize the windowing inspection and internal force adjustment of seamless steel pipe so as able to solve the difficulties of hard to maintain and not convenient for the follow-up installation when the suspenders for the jacket steel pipe of bowstring arch bridge are maintained. At the same time, the checking computation of strength and fatigue is carried out for the weak positions of weld seams and screw threads of the device. The practical performances and functional realizability of the device are verified through the laboratory load test. Finally, the device is successfully applied to the real bridges with the good results.

**Keywords:** bowstring arch bridge; bridge maintenance; suspender; jacket steel pipe

Analysis Method and Application Research of Intelligent Patrol Inspection System in Traffic Tunnel .....  
..... YU Jianqing ( 253 )

**Abstract:** In order to efficiently solve the problems of slow response speed, delayed messages, untimely emergency scheduling and so on in the patrol inspection and maintenance of traffic tunnel, by analyzing various accidents and disasters in the practical operation and maintenance of traffic tunnel, the accident and disaster early warning model of traffic tunnel is established. Hereby, the intelligent patrol inspection scheme is proposed. This scheme can realize the smart operation and maintenance patrol inspection functions such as fire monitoring, traffic early warning and dangerous chemical leakage disposal of the tunnel, and can improve the efficiency of maintenance and the refinement of management level of the traffic tunnels.

**Keywords:** traffic tunnel; robot; smart tunnel; operation and maintenance platform; intelligent patrol inspection system

Research on Construction of Green Road Based on Reclamation Application of River and Lake Sediment .....  
..... QIN Kongyuan ( 259 )

**Abstract:** Based on the systematic research on the hydrothermal solidification production process of river and lake sediments, combined with the application experience of river and lake sediment recycling products in the G15 Jiading–Liuhe Section Widening Reconstruction Project, the application technology of river and lake sediments in green road construction is proposed including the design indicators and construction techniques of sediment products such as the pavement bricks, kerbs, drainage structures and revetment building blocks. The LCA evaluation is carried out for a standard brick of river and lake sediment. Compared with the traditional clay solid standard brick and concrete standard brick, it has the advantages of 6 environmental impact type indicators, and the corresponding research and production suggestions are given according to the life cycle 3E impact assessment results. The green road products of river and lake sediment reclamation have achieved the good economic, social and environmental benefits in engineering applications, which have the reference significance for the ecological construction of urban road.

**Keywords:** river and lake sediment; reclamation; hydrothermal solidification; road construction; life cycle assessment

Application of Surcharge Preloading of Plastic Drainage Plate in Soft Foundation Treatment of Guangzhou Coastal Engineering ..... CHAI Xiandun ( 266 )

**Abstract:** Taking Guangzhou Nansha New Area Henglidao Jian Project as an example, the surcharge preloading of plastic drainage plate with good applicability is used as the recommended scheme for the treatment of large–scale soft foundations, and its optimization design is carried out. The consolidation checking calculation is carried out by surcharge preloading of plastic drainage plate with Lizheng geotechnical method and the overall stability of the deep anti–skid dike after the treatment of soft foundation is calculated. The calculation results show that during the surcharge preloading, the settlement is relatively large and the maximum is 1.87 m. After the surcharge preloading, the stability checking of deep anti–skid dike meets the standard requirements. Therefore, the surcharge preloading effect of plastic drainage plate is good and reaches the design intent.

**Keywords:** beach soft foundation; plastic drainage plate; surcharge preloading; drainage consolidation; Lizheng geotechnical; deep anti–skid

Application of Smart Water Affairs in Improving Efficiency of Municipal Drainage System ..... WANG Liang, LI Wentao, ZHANG Haifei, ZOU Donghao ( 269 )

**Abstract:** Taking the drainage system of Xintang Town as an example, combined with the strategic goal of building a national new smart city in Guangzhou and the needs of realizing the intelligent construction of municipal drainage system in Xintang Town, the application of smart water affairs in the "squeezing external water and increasing concentration" of sewage pipe network system and the flood control and drainage prediction of rainwater system is introduced. The online real–time monitoring is carried out for the water level, water quality, flow and external water intrusion of the sewage pipe network system, which is of great benefit to improve the operation efficiency of the WWTP. The real–time monitoring and early warning of the waterlogging prone points of the rainwater system and the water level of the external river are carried out, and the urban waterlogging risk early–warning system is constructed to avoid the disasters. Thereby, the intelligent, professional and refining operation and management of the drainage pipe network system are realized.

**Keywords:** smart water affairs; improving quality and efficiency; drainage system; intelligent early warning

## THE RELATIVE SPECIALITIES

Brief Discussion on Structural design of Large Complex Underground Space ..... ZHANG Lei ( 273 )

**Abstract:** With the rapid development of economy in China, the utilization rate of underground space in the developed cities is very high. Large underground space integrating the utility tunnel, commerce, ring road, ramp, expressway and subway section is a very complex system. Taking the underground space of a new area in Nanjing as an example, the structural design methods of large underground space are briefly analyzed. The robot software and yjk software are used to carry out the structural design. The calculation results of temperature stress are analyzed and the calculation results of two-dimensional robot are verified by three-dimensional calculation.

**Keywords:** large complex underground space; robot software; yjk software; structural design; seismic condition

Discussion on Treatment Method of Deep Silt Soft Soil Foundation in Pearl River Delta .....  
..... LIN Guoqiang, XU Jianjun ( 278 )

**Abstract:** The region of Pearl River Delta is located along the southeast coastline in China and belongs to the Delta littoral facies ~ marine continental deposit unit with the developed deep silt soft soil. How to correctly understand and solve the problem of such soft silt foundation is the key point of engineering construction. Combined with the construction experience of road engineering in the south coastal area of the Pearl River Delta, the foundation treatment modes and methods on the deep soft silt foundation of the Delta littoral facies ~ marine continental deposit are analyzed and discussed in order to analyze the conclusion to deepen the understanding of the designer to the characteristics of the deep soft soil and the method of the foundation treatment in the region of the Pearl River Delta, which can be referred for the similar projects.

**Keywords:** deep silt; drainage consolidation; constant (over)-load preloading; deformation settlement

Research on Settlement Stability of Underwater Shield Tunnel during Operation ..... WANG Anfei ( 282 )

**Abstract:** Based on the monitoring data of the structure settlement of Yingtian Avenue Yangtze River Tunnel in Nanjing and the riverbed of the tunnel site for more than 10 years, the settlement change law of the underwater shield tunnel during the operation period is analyzed. The results show that the overall settlement of shield tunnel mainly occurs outside the river bottom, including open-cut section and large embankment section, and more than 80% of the settlement occurs within 6 years after the operation. The local scour (within 5 m) of the riverbed above the shield tunnel and the change of water level can cause the tunnel settlement response, but it is not enough to have a big impact, and the stable state can be restored with the return of the riverbed silt.

**Keywords:** underwater shield tunnel; settlement monitoring; riverbed monitoring; settlement law

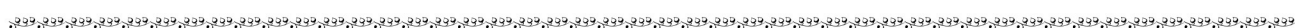
Design of Smart Street Lamp under Background of Smart City ..... WEI Xiaofei, GE Haijian ( 285 )

**Abstract:** Smart and new energy street light is a lighting device equipped with the intelligent light energy of the Internet of Things, and the smart lamp pole is the best entry and service port of smart city and smart park, which can realize all kinds of information collection, information transmission and information issue,



and is a rare ideal carrier to develop the smart cities at all levels function. The inputs of smart lamp pole can realize the multi-pole integration of road improvement, and save the investment and maintenance cost. The all-around real-time monitoring of the modern municipal lighting is implemented. The smart street lamp and the intelligent lighting of light energy of the Internet of Things should become the future direction of development.

**Keywords:** smart lighting; data communication; control mode; smart lamp pole; Internet of Things



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青岛润邦防水建材有限公司是一家集科研、生产、施工、服务于一体的复合型发展的民营科技企业。拥有国家防水防腐保温工程专业承包一级资质，致力于建筑防水防腐材料、路面养护材料的研究开发和应用。公司以优质的防水材料为基础，积累了二十几年的防水施工经验，培养了大批防水施工专家。现可承接各种大型建筑防水防腐工程，以及公路、铁路桥梁防水防腐、路面养护等工程。

### »» 主营产品

#### 路桥防水养护材料：

- ◎ JBS环保型桥梁防水涂料
- ◎ JBS-C沥青路面养护涂料
- ◎ JBS-1500高渗透结晶型硅烷防水剂
- ◎ FYT-1改进型沥青防水涂料
- ◎ RBS速熔快通路面灌缝胶
- ◎ 牢巴路瓶装尖嘴式冷灌缝胶

#### 硅烷防水防腐系列产品：

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- ◎ GW-302膏体硅烷
- ◎ 硅烷防腐防水涂料
- ◎ 环氧基硅烷改进型浸渍液
- ◎ SHJS高渗透改性环氧聚碳硅烷系列产品

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