

# 城市道桥与防洪



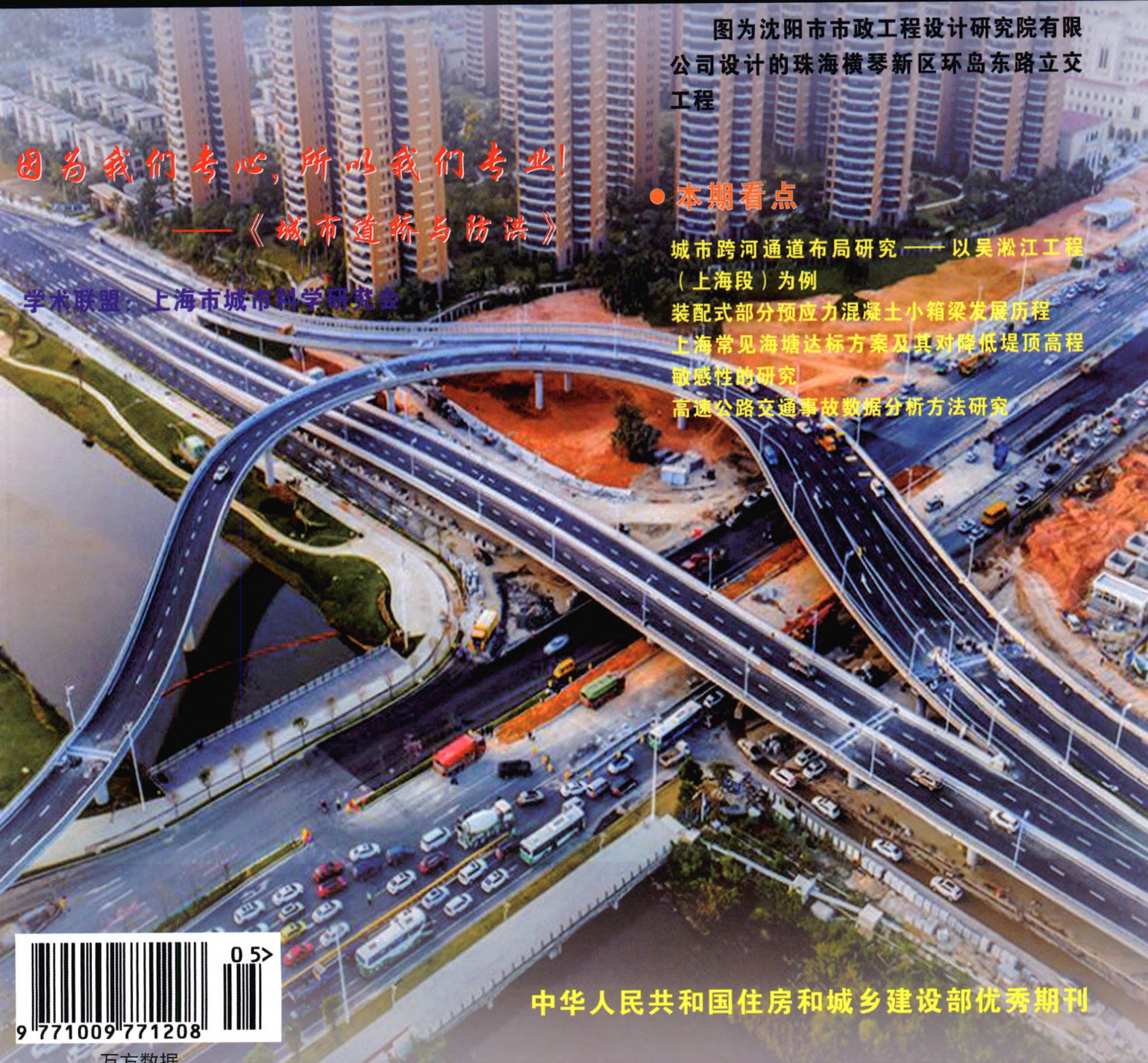
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因为我们专心，所以我们专业！  
——《城市道桥与防洪》

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### ● 本期看点

- 城市跨河通道布局研究——以吴淞江工程(上海段)为例
- 装配式部分预应力混凝土小箱梁发展历程
- 上海常见海塘达标方案及其对降低堤顶高程敏感性的研究
- 高速公路交通事故数据分析方法研究



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- 广4 青岛润邦防水建材有限公司(封4)
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## 封面工程

本期封面工程为珠海横琴新区环岛东路立交工程,由沈阳市市政工程设计研究院有限公司设计。

环岛东路立交工程位于横琴新区口岸服务区,项目包含:环岛东路-港澳大道立交工程、环岛东路-濠江路立交工程、DX-16 路道路工程(环岛东路至琴海东路段)。

项目为迎接澳门回归 20 周年献礼工程及区重点项目,是优化新区发展空间的强力引擎。该区域的交通顺畅性是口岸功能实现和辐射能力增强的重要保障。建成后的立交工程,对途经莲花大桥的各类出入境客、货流进行分流,对市区方向、长隆方向和横琴二桥方向的车流进行集散,提升横琴口岸的旅客集散能力,加快了建设横琴新区综合交通枢纽城市的步伐,为推进粤港澳大湾区城市间的快速接驳、保证口岸进出顺畅发挥着积极作用。

港澳大道立交桥梁长 1 223.36 m,包含主线桥及 3 座匝道桥。濠江路立交桥梁全长 2 178.35 m,包含主线桥及 9 座匝道桥。高架桥上部结构采用连续钢混组合梁和连续钢箱梁两种结构型式。桥梁横断面为鱼腹式流线形断面。立交桥墩采用现浇钢筋混凝土曲线花瓶墩。

环岛东路立交项目设计于 2017 年 11 月启动,2018 年 5 月完成。2019 年 12 月项目建设完工。

# Urban Roads, Bridges & Flood Control

(Monthly)

Number 5, 2020 (Total Number 253)

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Study on Layout of Urban Cross-river Channel ..... FU Yajun (1)

**Abstract:** In order to study how to plan the cross-river channels as a whole after the reconstruction of urban inland rivers in the urbanization process, starting with the mode of cross-river channel, the typical layout schemes of cross-river channels at home and abroad are qualitatively analyzed. The reasonable spacing of cross-river channels is basically obtained. Taking Wusong River Project (Shanghai Section) as an example, the layout scheme of cross-river channel is analyzed. Finally, the reasonable layout scheme is determined. The traffic adaptability of bridge layout after completed is analyzed. The spacing rationality is quantitatively verified.

**Keywords:** layout of cross-river channel, traffic adaptability, traffic demand, Wusong River Project

Passenger Flow Analysis and Functional Orientation of Baogong Avenue in Hefei .....

..... WANG Yong, LIU Xiaoqian (5)

**Abstract:** In the new round of overall urban planning in Hefei City, Baogong Avenue located in the northeastern region of Hefei City is positioned as a rapid urban ray, which connects the central city and Feidong County in the east - west direction, and is both passenger transport and freight transport corridors. Therefore, relying on passenger flow forecast, the function of Baogong Avenue in the urban road network structure is analyzed. On the basis of study on the main road network of the whole city, the functional orientation of Baogong Avenue is sorted out. The passenger flows of its main road section, auxiliary road section and node ramp are analyzed. The study conclusion is achieved from two aspects of functional analysis and passenger flow analysis.

**Keywords:** urban traffic, main road network, functional analysis, passenger flow forecast

Overall Design of Hunnan Avenue - Shengli Avenue Interchange in Shenyang ..... YU Haibin (10)

**Abstract:** Hunnan Avenue - Shengli Avenue Interchange is a hub-type interchange at the expressway junction of Hunnan Avenue and Shengli Avenue in Shenyang, and is a transportation hub connecting the south and the west of the city. The project background and functional orientation of Hunnan Avenue - Shengli Avenue Interchange are introduced. The traffic flow of the project is predicated by the regression analysis method and the double constraint method. The overall design, vertical and horizontal section design,

and structural design of the interchange are specially expounded and analyzed.

**Keywords:** interchange, prediction of traffic flow, overall design, bridge structural design

Design of Huolin River Avenue (Xingong Road I – Outer Ring) Project ..... LI Jinbao ( 14 )

**Abstract:** Huolin River Avenue (Xingong Road I – Outer Ring) is an important component of the eastern functional area of Tongliao City. Aiming at its reconstruction engineering, the functional orientation, necessity and scheme design of road are introduced in detail. The reconstruction project of old road is affected by the surrounding factors of road. Therefore, the factors of road alignment and economy are compared. Finally, the reasonable plane, vertical section and cross section designs of road are determined. Some important intersections along the line are analyzed and demonstrated. The reasonable and feasible technical scheme is determined. It is realized to meet the requirements of road traffic capacity. The operation the project is good after completion acceptance. The urban road network structure of Tongliao City has been perfected. Good economic benefit and social benefit have been achieved.

**Keywords:** expressway, traffic flow forecast, plane design, node scheme

General Design of Datong City Kaiyuan Street Expressway Reconstruction Project ..... LI Shanwei ( 18 )

**Abstract:** With the expansion of the city scale and the adjustment of traffic distribution in Datong, the inter-group travel is growing rapidly, which requires the support of the expressway network. On the basis of the "two-horizontal two-vertical" expressway system planning of Datong City, the scheme of Kaiyuan Street Expressway Reconstruction Project is studied from the system, network and function of the traffic. The technical standards and scale of the project are determined. The laying and layout forms of the street are proposed. The relationship of the reconstruction project with the urban road network, rail transit and land development along the line are handled well in order to make the project guarantee the smooth conversion of node traffic, have the due traffic capacity and service level, and fully play the function and role of expressway.

**Keywords:** urban expressway, general design, grade separation

Study and Discussion on Design of Zibo City Huafu Avenue Reconstruction Project .....

..... WANG Hui, CHENG Anhui, CAO Zhichao ( 21 )

**Abstract:** Huafu Avenue is an urban major road in the south of the central area of Zibo City. With the construction of the south urban area, a large number of residential areas and shops along street are newly constructed in this area. At present, the type of road section of highway has been unable to meet the demands of urban development. It is urgently to carry out the urbanization reconstruction and to perfect the municipal facilities and traffic facilities along street so as to better serve the development and construction at both sides of road. At the same time, the reconstruction of this road can be together with Shiji Road and Xiwu Road to compose the important urban entrances and exits at the south of the central urban area and to relief the present traffic pressure of the present Liuquan Road. The reconstruction design of Huafu Avenue is further discussed and summarized from the selection of cross section type, selection of road line, channelization of intersection, retaining and protection of roadbed, and design of structural layer.

**Keywords:** Huafu Avenue, reconstruction engineering, cross section type, line, intersection channelization, roadbed retaining and protection

Design of Road Reconstruction Scheme for Lishuang Bridge Reconstruction Project ..... WANG Guangling( 24 )

**Abstract:** Reasonable cross-section form, horizontal and vertical linear index, subgrade and pavement design are the key to urban road reconstruction. Combined with Suzhou Old Urban Road Reconstruction Project, and aiming at the current construction conditions and traffic volume prediction results, the three-plate cross-section layout is recommended. By removing the original side zoning and compressing the form of non-motorized lane, the current two-way four lanes can be realized two-way six lanes. Meanwhile, the new side zoning is built and four-row greening is retained. The road greening landscape needs of the old urban area are fully considered. The 20-cm C20 concrete is used in the general subgrade design of the new widening section. Two schemes are recommended in the pavement design according to the current deflection value, which provides experience and reference for the urban road reconstruction projects.

**Keywords:** cross-section form, subgrade and pavement design, traffic volume prediction, two-way six lanes, deflection value

Design Practice of Green Concept in Mountain Highway Reconstruction and Expansion Project ..... YU Muyang, ZHANG Shuo ( 27 )

**Abstract:** Aiming at the problems of complicated terrain and geology, and the difficult land acquisition and demolition, the mountain highway reconstruction and expansion projects will greatly impact the ecological environment. In order to make the design concept of green highway throughout all aspects and the whole process of the project design, the green development concept of highway engineering is systematically studied firstly. Then on the basis of summarizing the characteristics of mountain highway reconstruction and expansion project, the design essentials and principles especially for the mountain highway reconstruction and expansion projects based on the green highway concept are put forward. Finally taking a provincial highway of S478 Mountain Highway Reconstruction and Expansion project as an example, the design practice is carried out from the aspects of line optimization, index selection, section layout, landscape planning, etc., which minimize the impact on the mountain natural ecological environment and provide the reference for the design practice of the green highway concept in the mountain highway reconstruction and expansion projects.

**Keywords:** green concept, mountain highway, reconstruction and expansion project, design, practice

Study on Informatization Technique in Initial Planning of Municipal Road ..... LI Wuping ( 31 )

**Abstract:** Municipal Road is an important component of urban road traffic. Its construction planning needs to combine the target of urban economic development, traffic demand and short-term construction. It is one of projects with the highest approval level, the most departments and the most levels. It is the beginning of municipal road construction and the basic guiding principle to be followed. How to carry out the reasonable planning and construction of municipal road has become an important component of the current urban development. Especially, it is necessary to solve the problems of municipal road planning under the

background of rapid urban development. The informatization means adopted in the initial planning of municipal road is explored and studied. The technologies of BIM, GIS and UAV oblique photography are used to provide a set coordinated management and informationalized solution for the initial planning stage of municipal road and provide the data basis for the analysis of urban municipal engineering data.

**Keywords:** informatization, initial planning, BIM, GIS, oblique photography

Optimizing Design of On-ramp and Off-ramp of Urban Elevated Expressway ..... BIAN Guojian ( 35 )

**Abstract:** In order to optimize the design of on-ramp and off-ramp of urban expressways, the traffic characteristics of intersection at the on-ramp and off-ramp of elevated expressway are analyzed. The spatial layout strategies of rationalizing the design of interleaving area, three-dimensionally separating the direct traffic of the transverse road, balancing the road network traffic flow and sharing the dispersal function are studied. The applicable conditions of various optimizing schemes are put forward.

**Keywords:** elevated expressway, on-ramp, off-ramp, optimizing design, intersection, traffic organization

Study on Traffic Safety Improvement Measures of Crosswalk ..... BAI Yufang, CHEN Yi ( 39 )

**Abstract:** In recent years, the governments at all levels pay great attention to the crossing safety of pedestrian in China. The innovation to improve the safety of crosswalk is carried out in many places with a certain achievement. But the scientificity and effectiveness of some measures are questionable. Therefore, the relevant laws, regulations and norms of crosswalk are firstly sorted out, and are also the main basis of setting up the crosswalks at present. Then the innovation measures of some crosswalks are listed including adjusting the crosswalk style, intellectualizing the application of zebra crossing and promoting the comity zebra crossing. Finally, based on the basic principle of traffic engineering, several aspects paid attention to improve the safety of crosswalk are analyzed. Three major factors of crosswalk control mode, visual distance and visual area, and lighting and reflect light should be handled properly. Five detailed measures are proposed to improve the safety, in which some measures are innovated for the current norms, and provide the reference for scientifically setting up the crosswalks.

**Keywords:** crosswalk, traffic safety, visual distance and visual area, low-cost safety engineering

Discussion on Road Alignment Design and Safety Evaluation Method Based on BIM .....

..... YU Meng, MA Xiangnan ( 43 )

**Abstract:** The traditional road alignment design method is difficult to realize the dynamic correlation between the horizontal alignment and the vertical alignment, and ignores the influence of the combination of horizontal and vertical alignments so that it cannot comprehensively evaluate the road alignment safety. In view of this, the application advantages of BIM Technology in road alignment design are analyzed, and the Civil 3D is determined as the BIM modeling platform. Relying on an expressway project, the realization methods of 3D curved surface modeling, road plane alignment and vertical section alignment design are discussed. Based on BIM technology, a safety evaluation method and standard for vehicle running speed and 3D line-of-sight in position space are proposed.



**Keywords:** BIM technology, plane alignment, vertical section alignment, safety evaluation

Research on Design Scheme of Open-type Service Area of Jiangxi Expressway ..... CAO Fengjie ( 46 )

**Abstract:** Aiming at the need for the integration of the expressway service area and local economic development, and combined with the design example of Xinzhou Service Area in Shangrao - Pucheng Expressway in Jiangxi Province, the design concept of open-type service area is proposed, and the design scheme and parameter values of the open-type service area are analyzed and discussed. At the same time, according to the factors of the geological conditions, the engineering scale and the promotion of local economic development of the service area, and on the basis of controlling the engineering investment of service area, the optimal design scheme of open-type service area is determined.

**Keywords:** expressway, open-type, service area, design scheme, engineering investment

Discussion on Overlaying Design of Old Asphalt Pavement of Urban Road ..... PANG Zanlong ( 50 )

**Abstract:** The overlaying design of old asphalt pavement is carried out. The existing pavement conditions should be surveyed and evaluated. The pavements if with the diseases should be treated according to the causes, types and severities of the diseases. The traffic characteristics, service objects and construction conditions of urban road within city are different from a highway. The urban road should be designed of overlaying reinforcement according to its own characteristics. The suitable overlaying thickness, overlaying type, structural composition and material are determined.

**Keywords:** urban road, old asphalt pavement, overlaying reinforcement design

Roadbed Disease and Control Method for Reconstruction and Expansion of Highway ..... SUN Ke ( 54 )

**Abstract:** With the rapid development of the economy in China, some highways have been difficult to meet the needs of traffic development and are urgently to reconstruct. According to the diseases caused in the old and new roadbeds in the highway reconstruction expansion process, the disease causes and forming mechanism are analyzed. The relevant construction treatment method is proposed. The relative experience can be referred by the relevant professionals.

**Keywords:** widening roadbed of highway, differential settlement, longitudinal crack

Study on Prevention Technique of Reflection Crack for Cement plus Asphalt Pavement of Municipal Road .....

..... WANG Liyong, FENG Pei ( 56 )

**Abstract:** Aiming at the problems of reflection crack disease easily caused in the reconstruction of cement plus asphalt pavement, the reflection crack of overlaying asphalt layer is classified, its causes are analyzed, and the main development mode of reflection crack is summarized. The design thinking of preventing and retarding the reflection cracks is proposed.

**Keywords:** cement plus asphalt pavement reconstruction technique, old cement concrete pavement, overlaying asphalt layer, reflection crack, stress absorbing layer, rubblization

## BRIDGES & STRUCTURES

Development History of Fabricated Partial Pre-stressed Concrete Small-box Beam ..... PENG Zhimiao ( 59 )

**Abstract:** After more than 20 years of promotion, development, application and perfection, the fabricated partial pre-stressed concrete small-box beam has played the great role in the highway construction of China, and will be widely used as the pre-stressed structure on the highway and municipal bridge in the future. The development history of small-box beam is briefly introduced, and several revisions of small-box beam are compared and known. The relative experience can be referred by the relevant professionals.

**Keywords:** composite short-box beam, pre-stressed small-box beam, fabricated, partial pre-stressed concrete

Analysis on Pylon Stress of Single-pylon Cable-stayed Bridge ..... DAI Shihong ( 63 )

**Abstract:** The main span of a cable-stayed bridge is arranged by 90 m+128 m. It is a single-pylon double-plane double-layer street truss bridge cable-stayed bridge, and is a semi-floating system. The finite element solid model of complete pylon is established by ABAQUS universal finite element program to analyze the stresses of pylon anchorage zone, bottom crossbeam and steel anchorage beam, which can be referred for the application of ABAQUS in the analysis of bridge structure.

**Keywords:** cable-stayed bridge, pylon, steel anchorage beam

Design of Special-shaped Steel Single-pylon Cable-stayed Bridge ..... ZHANG Peng ( 66 )

**Abstract:** The Pingxi River Bridge in Dongkou County is a special-shaped steel single-pylon cable-stayed bridge with the main span 100 m across Pingxi River in Dongkou County. The bridge is a double-plane bridge with a pylon-beam-pier consolidation system. Its main beam is a single-box single-chamber P-K prestressed concrete box girder on both sides. The total width of the bridge is 34.6 m. The stayed cable is a parallel steel wire stayed cable with cold-cast anchor. The main pylon is a special-shaped steel box structure, and the cable is anchored to the main pylon through a steel anchor box. The main span spans the Pingxi River and is constructed by the cast-in-cantilever method. The anchor span is located on the shore and is constructed by cast-in-place support.

**Keywords:** cable-stayed bridge, special-shaped steel pylon, parallel steel wire, steel anchor box

Design of Cable-stayed Bridge in Foshan City Haiwu Road West Extension Project ..... GU Chao ( 69 )

**Abstract:** The main bridge of the Foshan City Haiwu Road West Extension Project crosses the waterway of Foshan. It is a span 135 m + 135 m single-pylon double-plane cable-stayed bridge. The main beam is a combined beam system composed of prestressed concrete beam and steel-concrete composite beam. The length 64.1 m of this bridge is situated on the transition curve. Its structure construction and its structure stress are complex. It can be referred for the design of the curved beam cable-stayed bridges and for reference of relevant professionals.

**Keywords:** cable stayed bridge, combined beam, composite beam, curved beam

Design of Two-span Continuous Steel-box Seamless Bridge ..... HU Mei ( 73 )

**Abstract:** Jinchang River Bridge is located in Shanghai Putuo District. This bridge is a two-span (19.5 m+33.5 m) continuous steel-box seamless bridge. The scheme meets the landscape requirements, also reduces the maintenance and repair cost of bridge and improves the bridge durability. The engineering situation, structural design essentials, structural analysis, main calculation conclusion, design calculation difficulties and taken measures of this bridge are introduced.

**Keywords:** consolidation of bridge abutment and main girder, seamless bridge, integrated abutment, temperature effect, soil pressure, simplified calculation

Design of Non-welding Heavy-load Traffic Steel Truss Bridge ..... HU Xiaobin, ZHAO Zilong ( 76 )

**Abstract:** Aiming at the design of heavy-load traffic bridge under the conditions of limited construction technology and tight project schedule, the seamless steel truss bridge scheme is proposed. The whole bridge is bolted to eliminate the disadvantage of reducing the bearing capacity of traditional truss structure by welding the secondary internal force. The internal force distribution of structure is made to balance by the adjustment of member bar section layout, which can be referred for the design of the similar structures.

**Keywords:** heavy-load traffic, steel truss bridge, seamless

Design of Main Cable Anchorage Zones for Several Self-anchored Suspension Bridges .....

..... ZHANG Hongjin, CHANG Fu Ping WEI Mingguang ( 79 )

**Abstract:** The main cable anchorage zone is a key force transfer zone of self-anchored suspension bridge. The reasonable selection and design of the structural form of the main cable anchorage zone are one of the most critical technologies for the self-anchored suspension bridge. Taking the design of the main cable anchorage zones for several self-anchored suspension bridges as the engineering example, the structural designs and calculations of the common anchoring methods of concrete structural anchorage, steel structural anchorage and steel-concrete composite structural anchorage for three main cable anchorage zones are compared and analyzed. The advantages and disadvantages of three anchorage methods are obtained, and the conditions of structural forms for the main cable anchorage zone are reasonably selected.

**Keywords:** self-anchored suspension bridge, main cable anchorage zone, design

Overall Scheme of Yangzhou Wanfu Expressway and Beijing-Hangzhou Grand Canal Bridge .....

..... ZHENG Qiang ( 84 )

**Abstract:** Yangzhou Wanfu Expressway adopts the construction mode of elevated main road and ground auxiliary road. The background, technical standards, road overall scheme and elevated bridge scheme of this project are introduced including the construction form, lane scale, expressway entrance and exit scheme, long-term scheme reserved for Shawan Road Interchange, span layout of elevated bridge and structural scheme of elevated bridge. The overall scheme of Beijing-Hangzhou Grand Canal Bridge is also introduced.

The relevant design scheme can be referred for the similar projects.

**Keywords:** urban expressway, elevated bridge, through steel truss arch bridge

Design and Analysis of 230-m Mesh Suspender Composite Girder Arch Bridge ..... ZHOU Hao ( 87 )

**Abstract:** Shenshan Bridge is a mesh suspender steel-concrete composite girder arch bridge with the main span 230 m. The main girder adopts the steel-concrete composite spine girder section. Its total width is 56 m and its long cantilever arm is 18 m. The main arch adopts the secondary parabola arch with the hexagon section. Its arch height is 41.273 m and its rise span ratio is 1/5.5. The mesh suspender of bridge is the first attempt to use in the municipal super-wide deck bridge. The parameters of arch axis, rise span ratio, arch section form, arch height, arch dip angle, wind bracing setting, suspender spacing and main girder form are compared and analyzed. The relevant research and design results can provide reference for the design of the similar bridges in the future.

**Keywords:** mesh suspender arch bridge, steel-concrete composite girder, super-wide deck, spine girder, parameter analysis

Brief Analysis on Design of Xingguo County Fenghuang Bridge ..... HU Haiyan, XU Fulin ( 91 )

**Abstract:** The main bridge of Xingguo County Fenghuang Bridge is a 30 m+50 m+30 m variable cross-section pre-stressed concrete girder arch composite structure. Its main pier is 6.5 m high. The pier body adopts the solid thin-wall rectangular pier. The arch foot support is set up at both sides to connect the main girder. According to the stress calculation and analysis of the main girder at the combined section of the girder and arch of this bridge, the unreasonable causes of the structural stress of this bridge are analyzed, and the optimization scheme of steel cable configuration at the bottom edge of arch top girder section is proposed in order to provide the reference for the design of the similar projects in future.

**Keywords:** pre-stressed concrete girder arch composite bridge, optimization of steel cable, structural stress characteristics

Analysis and Optimization on Key Stress Performance of Concrete Transverse Connection between Main and Auxiliary Gate-type Pylons ..... ZHANG Huan ( 94 )

**Abstract:** The crossgirder connecting the main and auxiliary pylons of the archway-type pylon of suspension bridge is usually not designed as a main stressed member. But the differential construction methods will cause the relative displacement between the main and auxiliary pylons because of the vertical force difference. And with creep and temperature under long-term load, the connecting crossgirder will crack. This problem is often neglected in the design. By comprehensively analyzing the stress performance of upper and lower connecting crossgirders and combined with the different construction schemes, the influences of connection time on its stress performance and on lateral stability of pylon are evaluated. The finite element model of spatial member system and the 3D solid model as the main analysis means are used to analyze the influences of different loads on the stress performance of connecting crossgirder including the crossgirder stress, crack and stability during construction. The structural dimensions of connecting crossgirder are

optimized and analyzed, which can be referred for the similar designs.

**Keywords:** relative vertical displacement, crack, creep, girder height

Structural Design of Double-layer Intersection Bridge ..... HUANG Tao ( 98 )

**Abstract:** The future city is developing in the direction of three-dimensional space. The three-dimensional transportation will be seen everywhere double-layer intersection. Moreover, the deck at intersection is often affected by many factors of ground road clearance, bridge piers and etc. Therefore, the structural design of double-layer intersection is very important. Based on an example of double-layer intersection in the three-dimensional transportation of Jianzhou New Town, three different structural design methods are proposed, and analyzed and compared by the finite element model. Some qualitative and quantitative engineering conclusions are obtained to provide the reference for the similar projects.

**Keywords:** three-dimensional city, double-layer intersection, steel structure, structural design

Design of Footbridge on U-shaped Structure of Qianhu Expressway in Nanchang ..... HUANG Xiaoqi ( 102 )

**Abstract:** Four footbridges were constructed on the U-shaped structure of Qianhu Expressway in Nanchang. By comprehensively considering the surrounding constraints, the open steel truss beam footbridge is used. The Midas Civil 2015 finite element software is adopted to carry out the modeling calculation and analysis, and the amount of steel for the open steel truss beam bridge is compared and analyzed, which can be referred for the design of the similar urban open steel truss beam footbridges.

**Keywords:** open steel truss beam, footbridge, U-shaped, slender proportion, natural vibration frequency

Analysis on Seismic Response of Small-box Girder Bridge in High Seismic Area with Nonlinear Boundary .....

..... YANG Zhixiong ( 105 )

**Abstract:** On the basis of considering the boundary nonlinearity and material nonlinearity, the time-history method is used to analyze the influence of four types of horizontal force dispersive bearing, high damping bearing, lead-core rubber bearing and friction pendulum bearing on the structure of small-box girder under the different pier heights. The results show that the lead-core rubber and friction pendulum vibration isolation bearings can effectively reduce the vertical and horizontal responses of the structure under earthquake action. The conclusions can provide references for the design of bridges in similar high earthquake areas.

**Keywords:** high seismic area, small-box girder, lead-core rubber bearing, friction pendulum bearing

Study on Selection of Medium-span and Small-span Steel and Composite Structure Bridges .....

..... ZHOU Qing, FU Chenxi, HAN Dazhang ( 108 )

**Abstract:** By comprehensively considering the actual engineering construction needs for several typical reconstruction and expansion application examples of an approach bridge removed and rebuilt, a assembled wide bridge with limited headroom, and an overpass of interconnecting branch line, the schemes of potential application bridge types are compared from the aspects of bridge applicability, economy and durability so as

to determine the reasonable bridge types in the different application scenarios, which carry out the beneficial exploration for the construction and application of small-span and medium-span steel and composite structure bridges, provide the rich reference cases for the application of the similar projects, and play certain role in the development and promotion of small-span and medium-span steel and composite structure bridges.

**Keywords:** small span and medium span, steel and composite structure, bridge selection, highway reconstruction and expansion

Application of Spatial Curved-surface Steel Truss Bridge in Urban Landscape Design .....

JIA Zhiqiang, GUO Hongmin ( 111 )

**Abstract:** With the continuous improvement of living environment, the design concept of urban landscape bridge is also constantly updated, and various structural forms of bridge are widely used in urban landscape design. By fully exploiting the characteristics of surrounding architectural environment, the design direction of urban landscape bridge is organically to integrate the historical culture and regional characteristics into the design of landscape bridge. Taking Suzhou Xinye Bridge as an example, the urban landscape bridge is discussed not only to meet the basic traffic function, but also to meet the demand of urban landscape. At the same time, the spatial finite element model is established to analyze the mechanical behavior of spatial curved-surface steel truss bridge.

**Keywords:** urban landscape design, cross-channel bridge, design of landscape bridge, spatial curved-surface steel truss bridge, stress analysis

Comparison, Selection and Analysis of Steel Plate Composite Girder Appropriate for Three-lane Expressway .....

PENG Boyang, LI Xiaolong ( 115 )

**Abstract:** The steel plate composite girder is widely used with many structural systems. On the premise of three-lane bridge with 16.25-m width and 40-m span, the scheme design is carried out respectively according to the main girder spacing and structural systems commonly used in France, Japan and America. The similarities and differences among the systems are found after the cross-sectional comparison. More girders and few girders are separately calculated and analyzed. The factors affecting the mechanical characteristic of structure are analyzed. The influences of girder height on the stress and displacement of the main girder are listed. It is found that the longitudinal stress and the vertical displacement of the main steel girder decrease linearly with the increase of girder height. The relative experience can guide the engineering practices and provide the reference for the similar projects.

**Keywords:** steel plate composite girder, system, affecting factor

Analysis on Factors Influencing Shrinkage and Creep of Concrete Deck of Simply-supported Steel-Concrete Composite Box Girder .....

LIU Guoguang ( 119 )

**Abstract:** Combined with the relevant provisions of the *Code for Design of Highway Reinforced Concrete and Prestressed Concrete Bridges and Culverts* (JGT 3362-2018), various factors affecting the shrinkage and creep of concrete are listed. The parameters closely related to the design of composite girders are selected.

The effects on the shrinkage strain, creep coefficient, structural deformation and the respective stress of steel and concrete are analyzed in detail.

**Keywords:** simply-supported steel-concrete composite girder, bridge deck, shrinkage, creep

Computational Analysis on Effect of Internal Force at Pier Bottom with Isolation Bearings on Ramps in Lianggang Highway (S32-Airport South Entry Rd Viaduct) ..... JIANG Xiaolu ( 124 )

**Abstract:** In combination with the project example of S32-Airport South Entry Rd Viaduct, by using Midas finite element analysis software and the high-pile base slab calculation software, the different column heights of viaduct models are established. The differences of the internal forces at pier bottoms of plate-type rubber bearing and isolation bearing are analyzed under the action of E1 and E2 seismic forces. By sorting out and judging the internal force data, the ability of isolation bearing to reduce the seismic force is analyzed, the influence of the height of the stand column on its reducing ability, and finally the causes of this phenomena is preliminarily analyzed in order to obtain the conclusion beneficial to the design and construction of the similar projects.

**Keywords:** internal force at pier bottom, seismic force, insolation bearing, Midas

Analysis on Influence of Temperature Gradient on Edge Web of Box Girder ..... YANG Xingang ( 128 )

**Abstract:** The temperature stress of the bridge box girder structure will be generated under temperature load. The study of this stress is usually focused on the overall temperature rise and drop, and the temperature stress of the bridge deck roof. The temperature stress of the edge web is still to be further studied. Combined with an engineering example, the stress of the box girder caused by the temperature gradient of the edge web is analyzed and compared with the dead weight and the stress caused by the temperature gradient of the bridge deck roof. It is concluded that the prestressed structure can response more effectively to the temperature gradient in terms of ensuring structural safety.

**Keywords:** box girder, edge web, gradient temperature

Brief Discussion on Selection of Beam Bottom Elevation of Small and Medium-sized River-crossing Bridge in Shanghai ..... ZHAO Xudong ( 131 )

**Abstract:** Shanghai area is densely covered with rivers. The layout of district roads are closely related with the layout of river network, in which the selection of bridge beam bottom elevation has a great influence on the road connection and the contradictions are also more prominent. The selection of beam bottom elevation of the bridges crossing small and medium-sized rivers and not undertaking the fairway tasks is discussed. The relative experience can be referred by the relative professionals.

**Keywords:** reconstruction of road bridge, small and medium-sized river-crossing bridge, beam bottom elevation

Application of Trough Beam in Capacity Expansion and Reconstruction of Bridge across Channel ..... GUO Hongmin, JIA Zhiqiang ( 134 )

**Abstract:** Along with the development of the economy and the expansion of urban areas, the early construction of bridges across canals often becomes the traffic bottlenecks. The traffic contradictions are increasingly prominent and it is urgently to need the capacity expansion and reconstruction. Taking Suzhou Shishan Bridge Widening Project as an example, the application of trough beam bridge is introduced to overcome the difficulties of intersection restriction on both sides, improvement of channel standards, heavy channel traffic, old and new bridges integrated with the environment. The comfort of long-span footbridge and the application of TMD damper are compared and studied.

**Keywords:** bridge widening, trough beam, bridge across channel, comfort of footbridge, TMD damper

Analysis on Seismic Reinforcement of Railway Double-column Piers with Cable-stayed Rebar .....

HAO Yong ( 138 )

**Abstract:** Taking a railway double-column pier as an example, it is proposed that the internal force and displacement responses of bridge pier under seismic action are reduced by setting the cable-stayed rebar in order to ensure the safety of double-column pier under seismic action and to achieve the goal of preventive seismic strengthening. The Pushover analysis of double-column pier is carried out to calculate the yield curvature and ultimate curvature of the bridge pier, and the corresponding bending moment and displacement. The calculation results are adopted as the reinforcement evaluation indexes to evaluate the reinforcement effect of the cable-stayed rebar on double-column pier under the frequent earthquake and rare earthquake. The ANSYS finite element analysis software is used to carry out the nonlinear time-history response analysis. The internal force responses and displacement responses of the double-column pier before and after reinforced are compared. The necessity and rationality of the reinforcement are studied. The results show that the bridge pier is in the elastic stage and the internal forced at pier bottom is decreased under the frequent earthquake after the original double-column pier is set with cable-stayed rebar. The bridge pier is changed from the destructive state to yield state under the action of the rare earthquake, which meets the idea of ductile seismic reinforcement.

**Keywords:** bridge engineering, cable-stayed rebar, seismic reinforcement, double-column pier

Brief Discussion on Design of Post Fire Repair of Urban Bridges ..... WANG Yuanqing ( 143 )

**Abstract:** Rational use of space under urban bridge is of great practical significance for making full use of road space resources and saving urban land resources, which also attracts more and more attention of the people. In recent years, the fire caused by the illegal occupation of the space under bridge is more and more frequent in various regions. Combined with a practical project, how to repair the damaged structure quickly after a fire of the urban bridges without interruption of traffic is briefly discussed.

**Keywords:** urban bridge, fire, detection, repair, reinforcement, design

## FLOOD CONTROL & DRAINAGE

Study on Common Seawall Target Scheme and Its Sensitivity to Lowering Levee Top Elevation in Shanghai .....



..... SHI Zhenyu ( 145 )

**Abstract:** Shanghai lies at the front of the Yangtze River Delta. The seawall is divided at the Changjiang Estuary and the north bank of Hangzhou Bay. With the economic, social and industrial development of coastal areas along the river, as well as global climate change, sea-level rise and other major changes in the situation of water and work in the front of the seawall, the original design standards cannot meet the requirements of the planning. Therefore, the Shanghai Municipal Water Affairs Bureau launches a new round of seawall target construction. Taking a seawall target project in Pudong as an example, the basic ideas of seawall target is sorted out. Three basic measures of heightening the elevation of the high wall top, protecting the beach to promote siltation and to weaken the incoming sea wave, and roughing the slope surface are summarized. Its sensitivity to lowering the elevation of the levee top is analyzed. The results can be referred for the design of seawall target.

**Keywords:** seawall, target scheme, sensitivity

Discussion on Application of "Sponge City" in Northwest Region ..... WANG Kenan ( 149 )

**Abstract:** With the rapid development of urbanization, the great achievements have been made in the construction of urban drainage system at this stage in China. However, many problems of hard pavement brought by the excessive development and construction lead to the excessive hardening of underlying surface, which not only change and destroy the natural ecological background of a city, but also bring the flood disasters. In the result, the drainage capacity of the traditional urban drainage system is challenged. Therefore, the health and perfected urban drainage system is very important. Under the control of urbanization construction space, the idea of "sponge city" can be integrated into the mode of urban drainage system in order to upgrade the current single urban drainage system. The construction of low-impact development facilities in the drainage system can promote the recycling of water resources, effectively response to the environmental change and the different types of rainfall flood events, and at the same time, realize the free migration of rainwater in city. Based on an example of the sponge city experimental area in Xining City of Qinghai Province, the application of the "sponge city" rainfall flood management idea in the northwest region is discussed.

**Keywords:** sponge city, low-impact development, municipal drainage, storm water management model (SWMM)

Study and Discussion on Beam Bottom Elevation of Cross-river Bridge in Non-navigable Channel of Shanghai ...

..... FAN Qunjie ( 153 )

**Abstract:** Shanghai is located in the lower reaches of the Taihu Lake Basin, where the river network is dense, low-lying and there are many bridges across the river. Due to the low lying of Shanghai, there is a big contradiction between the beam bottom elevation control and the bridge connection slope in the bridge engineering. By comprehensively analyzing the flood safety of non-navigable channel, the planned levee crown elevation and the operating vessel traffic in the area, and based on the river grade, the suggestion of optimizing value for bridge beam bottom elevation is proposed. Taking Changning District as an example, the reasonable valuing range of bridge beam bottom elevation in this district is analyzed, which provides a certain

reference for the control of bridge beam bottom elevation in an area.

**Keywords:** river in area, non-navigable channel, clearance, beam bottom elevation, Shanghai

Study on Countermeasures for Repair and Replacement of Sewage Pipelines in a Pipeline Network Project .....

..... ZHANG Qing ( 156 )

**Abstract:** The sewage pipe repair technology is widely used in the reconstruction of a large number of old drainage pipes now. Taking the repair and replacement of sewage pipelines in a pipeline network project as an example, four schemes of the trenchless ultraviolet ray in-situ curing repair, support excavation pipe replacement + trenchless local pipe repair, current reinforced concrete pipe lining steel pipe reinforcement repair and pipe perimeter grouting reinforcement + pipe internal crack repair are proposed. And these four schemes are compared and selected. Finally, the trenchless lining steel pipe reinforcement repair scheme is recommended. The relative experience can be referred for the similar projects.

**Keywords:** hollow slab girder, disease type, degradation law, prediction model

Application of a New Micro-sand Sedimentation Treatment Technology in River Water Treatment .....

..... CHEN Hanlong ( 158 )

**Abstract:** An efficient micro-sand sedimentation treatment technology is applied in the water treatment of a river in Shanghai. This set of micro-sand sedimentation treatment device adopts the integrated treatment process mainly including four parts of coagulation zone, flocculation curing zone, sedimentation zone, and micro-sand circulation and separation system. In the project, two sets of micro-sand sedimentation treatment devices are used with a total treatment capacity of 20 000 m<sup>3</sup>/d. The results show that the effect of this new type of micro-sand sedimentation treatment is obvious. In the experimental observation period, the removal efficiencies of COD, ammonia nitrogen and TP reached 27.5%, 58.8% and 42.5% respectively. However, the removal of ammonia nitrogen is likely to be accompanied by the production of nitrate nitrogen, and the removal gain of total nitrogen is small.

**Keywords:** micro-sand sedimentation, chemical oxygen demand (COD), ammonia nitrogen, total phosphorus (TP)

## MANAGEMENT & CONSTRUCTION

Overall Design Scheme of Rapid Prefabrication Process for an Underground Channel .....

..... QIAN Wenfei ( 161 )

**Abstract:** With the continuous development of the national urbanization process, the traditional cast-in-place process has a series of problems, such as relatively poor construction quality, great impact on the surrounding environment and rising labor cost, etc., which are different from the high quality development goal proposed by the state. Therefore, the prefabrication technology is started to implement in China from the policy aspect. Taking the prefabrication process of an underground channel as an example, the key links of block structure, joint form, waterproof material and hoisting point layout are systematically studied and discussed. A set of design scheme is proposed. The relevant experience can provide the technical support for

the construction of projects, and also can be referred for the similar projects.

**Keywords:** underground channel, rapid construction, prefabrication, joint, waterproof, anti-misalignment measures

Current Situation and Exploration of Prefabricated Pier Joint Type ..... ZHOU Xinglin ( 165 )

**Abstract:** In recent years, the prefabrication of bridge pier is booming. In the municipal bridges, the prefabricated pier joints are mostly grouting sleeves. But there are no reliable field detection methods for the grouting density. In terms of detectability, there are the safety risks. On the basis of absorbing the advantages of the common pier joint types for cross-sea bridges and municipal elevated bridges, the wet joint type of locking steel joint with straight threaded sleeve or taper sleeve + small amount of cast-in-situ concrete is proposed. This kind of joint type is safe, reliable, economical and fast, which can be referred for the design and construction of the similar projects.

**Keywords:** prefabricated pier, joint type, grouting sleeve, straight threaded sleeve, locking steel joint with taper sleeve, cast-in-situ joint

Comparative Analysis on Splicing Methods of Prefabricated Bent Cap for Municipal Elevated Bridges ..... WANG Lei ( 170 )

**Abstract:** With the continuous construction of urban elevated bridges, the prefabrication and assembly technology has been applied more and more in the municipal bridges. The hoisting stitching of bent cap is of great significance as a key link in the construction of prefabricated bridges. Based on several engineering examples, three methods of few-support method, preset corbel method and hooping method for splicing the bent cap of municipal elevated bridge are summarized. The advantages and disadvantages of these three methods are analyzed and compared. The relevant suggestions for practical application are given.

**Keywords:** urban elevated bridge, bent cap, hoisting, support

Overview on Construction Method of Urban Composite Girder Bridge ..... WANG Jian ( 172 )

**Abstract:** The composite girder bridge is more and more widely used in the construction of urban bridges. The current construction methods often used for the urban composite structural girder bridges are summarized. The step-by-step construction method of steel girder and deck of the composite girder bridge and the construction characteristics of the whole construction method are summarized. Various joint construction technologies of prefabricated deck are introduced. Some construction technical measures for improving the structural stress condition are expounded.

**Keywords:** composite girder bridge, incremental launching method, hoisting method, prefabricated deck, bridge construction

Simulation Analysis on Construction of Bailey-beam Steel Pipe Support of a Portal Pier ..... GAO Zhonghu, ZHAO Wenyu, WU Zhongtie, WANG Xiaoqin ( 177 )

**Abstract:** Based on the engineering background of a portal pier cast-in-place construction of a bridge, a

Bailey-beam steel pipe support is adopted. The existing line is below. The vertical and horizontal brace beams, Bailey beam and steel pipe support are analyzed and calculated by the large finite element analysis software Midas Civil. The aim is to provide some reference for the analysis, design and construction of the portal pier support.

**Keywords:** Bailey beam, steel pipe support, construction design, portal pier

Construction Technology of Cast-in-place Box Girder Support Foundation in Silt Sand Soft Soil Subgrade of Cable-stayed Bridge ..... LIU Fumin ( 180 )

**Abstract:** The main span of Shenzhou Friendship Bridge is a cast-in-place concrete box girder, and is constructed by floor cast-in-place support. Because of the support foundation in the 4-6m silt subgrade, the bearing capacity of subgrade is low and the deformation is large. The construction technology of concrete filled steel tube (CFST) to expand the foundation is used to improve the bearing capacity of subgrade. The upper load-bearing capacity of the support is arranged according to the equal-span continuous steel girders. The top of the steel pipe pile is arranged with double-shaped I40b I-steel crossbeam. The crossbeam is welded with the steel plate of pile top. The longitudinal beam is arranged on the crossbeam. The crossbeam and the longitudinal beam are welded at the contact point. The longitudinal beam is supported by the bowl-shaped full-frame bracket. The square wood crossbeam with horizontal line is installed on the bracket. The large steel formwork is laid on it as the bottom board of box beam in order to ensure the quality of the box beam construction and the safety of the bracket structure, which provides a reference for the bracket construction of the cast-in-place box beam on the similar soft soil foundations.

**Keywords:** silt subgrade, cast-in-place box beam, bracket foundation, construction technology

Design of Inspection Vehicle for Main Pylon of Yangpu Bridge ..... LUO Dongwei ( 183 )

**Abstract:** To safely and efficiently inspect the main pylon of Yangpu Bridge, a new inspection vehicle scheme suitable for the main pylon of the diamond-shaped cable-stayed bridge is put forward in accordance with the structural characteristics and the technical and performance requirements of the main pylon of this bridge. In the scheme, the main pylon is maintained by subareas. Aiming at the different maintenance areas, the different hanging points are set up to carry out the different combinations of form traveler and avoid the interference of stayed cables in order to realize the full coverage maintenance of the main pylon.

**Keywords:** Yangpu Bridge, inspection vehicle for main pylon, form traveler

Application of PLC Synchronous Jacking Technique for Multi-span Simply-supported T-beam of Large Railway Bridge ..... GE Ming ( 187 )

**Abstract:** In the past engineering practices, there are many cases of applying PLC synchronous jacking technique in the reconstruction of highway and urban bridges. However, there are still relatively few projects of overall synchronous jacking of railway bridges with large height. Based on a slope adjusting project of large single-line railway bridge, the application scheme and construction process of PLC synchronous jacking technique in the integral jacking of multi-span simply-supported T-beam are studied, and the construction

control essentials of the stability control of support system, reliability inspection of jacking system and construction monitoring of jacking process are put forward. The maximum jacking height of this bridge beam is 0.754 m. The safety of the whole process can be controlled, and the construction period and cost are saved. The practice shows that PLC synchronous jacking technique has a good application prospect in railway bridge slope adjustment, support replacement, headroom increase and other projects.

**Keywords:** railway engineering, bridge jack-up, PLC, construction control

Study on Method of Compiling Overhaul Plan for Road Network of District Based on Simple Health Detection Data

..... YU Lijia ( 191 )

**Abstract:** The existing road maintenance norms mainly aim at the overhaul design projects in a single road, and are hard to adapt the demand of compiling the overhaul plan for road network of district. Therefore, the overall thinking of compiling the overhaul plan for road network of district is proposed. The overall thinking can be divided into four processes of collecting data and determining simple health detection road, synthesizing many factors to revise health detection and to sort out plan, carrying out detailed detection and design scheme of single road based on plan, and revising and adjusting plan. The method is proposed to revise the simple health detection data according to many factors of road built year limit, road maintenance situation, site expert survey and grading, district position and surrounding engineering environment. Finally, based on Shanghai Free Trade Zone Lingang New Area Road Overhaul 3-year Action Plan, the overhaul plan is compiled.

**Keywords:** urban road, overhaul, road maintenance, valuation

Study on Selection of Preventive Maintenance Timing of Hollow Slab Girder Bridge Structure .....

..... LI Yuanbing ( 194 )

**Abstract:** Based on the statistical curve of time varying progress of each main disease of pre-stressed concrete and ordinary reinforced concrete hollow slab girder bridges, and also considering the factors of bridge differentiation on the heavy / light vehicle road section, heavy / light traffic road section and high grade / low grade road section, the overall technical condition of hollow slab girder bridge structure in preventive maintenance should be controlled no less than Class 3 (Class C), and the initial time of preventive maintenance of structure should be controlled at the bridge condition index (BCI) of 80 minutes when the structure is still in Class 2 (Class B) bridge, is about to degrade into Class 3 (Class C).

**Keywords:** hollow slab girder, preventive maintenance, preventive maintenance target, preventive maintenance timing

Study on Preventive Maintenance Method of Hollow Slab Girder Bridge .....

ZHANG Liang ( 198 )

**Abstract:** Taking the small-sized and middle-sized bridges in Shanghai as the background, combined with the current relevant standards and the bridge full-life maintenance idea of China, the detection contents and methods of hollow slab girder bridge in preventive maintenance stage are proposed, and the detailed technical measures to maintain and treat the structures are put forward.

**Keywords:** hollow slab girder, preventive maintenance, structure disease, preventive measure, detection measure

Study on Influence and Plan of Maintenance and Replacement of Composite Beam Concrete Bridge Deck .....

..... WANG Junsheng ( 202 )

**Abstract:** From the full-life economic design viewpoint of bridge, the replaceable scheme of composite beam concrete deck is proposed. Based on this scheme, the stress of bridge structure during the replacement process of deck and the influence of the different replacement sequences on the steel structure are studied. The optimal strategy of deck replacement is proposed from the viewpoints of simple construction operation and good structural safety so as to ensure the structural safety of bridge during the maintenance, especially the replacement of deck, and also guarantee the centenary service life requirement of the bridge.

**Keywords:** composite structure, bridge deck, full life, maintenance and replacement

Study on Setup Scheme of Bridge Manhole Considering Full-life Management and Maintenance .....

..... WANG Peixiao ( 206 )

**Abstract:** For a prestressed concrete box girder bridge in service, various faults will often occur because of the severe environment and vehicle overload. Due to no permanent manholes generally set up for the conventional prestressed concrete box girder, the faults within this kind of box girder cannot be found and treated in time, which will bring the trouble for the maintenance and repair of bridge. By setting up the permanent manholes for the existing concrete box girder bridges, and the finite element analysis on local stress state of the girders after set up, a reasonable strengthening scheme is proposed to solve the needs of internal maintenance and repair of box girder, and to provide the safety guarantee for the full-life cycle operation of bridge.

**Keywords:** manhole, concrete box girder, carbon fiber sheet, finite element calculation

Calculation and Analysis of Underground Deep Buried Sewage Pipe in Metro Shield Interval .....

..... CHEN Aiying ( 209 )

**Abstract:** During the underground deep burying of sewage pipeline in metro shield interval, a certain degree of pipeline subsidence and deformation will be caused because of soil loss, which will affect the safety of pipeline operation, and then affect the implementation and operation safety of metro tunnel. By calculation and analysis, the influence of shield on pipeline is quantized so as to determine the control indicators to be adopted for the metro construction and the relocation range necessary for sewage pipeline. For the large-diameter sewage pipelines, the strict calculation and special design as a risk source must be carried out in the preliminary design of metro in order to minimize the interaction between metro and pipeline.

**Keywords:** metro, shield interval, sewage pipe, calculation and analysis

Study of Double-row Steel Sheet Pile Cofferdam Structure in Longhu Tunnel Project .....

..... YU Wen ( 213 )

**Abstract:** Because of the good engineering performance, simple construction, reusability and strong

applicability, the steel sheet pile cofferdams are used in more and more projects. In Longhu Tunnel Project, two kinds of steel sheet pile cofferdams are designed by considering the factors of structural stability, anti-seepage performance, and difficulty level of sinking and pulling pile. The PLAXIS and slide finite element analysis software are used to calculate the structural deformation and seepage of the two schemes respectively. The advantages, disadvantages and applicable conditions of the two schemes are analyzed by comprehensively considering the construction conditions.

**Keywords:** steel sheet pile cofferdam, finite element, Longhu Tunnel

Analysis on Influence of Tunnel Construction on Reservoir Safety ..... PAN Chunhui ( 216 )

**Abstract:** Based on the actual case of a mountain tunnel passing through Meilin Reservoir in Shenzhen, the finite element method is used to simulate the safety and stability of the tunnel, and the influence of excavation on the reservoir during the tunneling construction. According to the construction conditions of complete drainage and water blocking drainage restriction respectively, the deformation of primary lining in the tunneling stage, the safety of secondary lining in the operation stage and the deformations of reservoir under different construction conditions are analyzed and studied. The deformation trend of the reservoir under different drainage construction conditions is different. The deformation is larger under the condition of complete drainage, and smaller under the condition of grouting and drainage restriction. Therefore, it is recommended to adopt the construction method of "water blocking and drainage restriction". During excavation, the grouting shall be carried out on the tunnel face and the soil layer within a certain range of the tunnel circle.

**Keywords:** mountain tunnel, reservoir, drainage, grouting, finite element calculation

Analysis on Pipe Jacking Method for Underground Excavation of Pipe Curtain in Soft Soil Area .....

..... ZHANG Xiaohong ( 219 )

**Abstract:** The underground excavation method as an effective technology to reduce the environmental influence has been applied in the rock and composite stratum of some cities in China. The research projects are carried out in soil clay area in order to implement the underground excavation of pipe curtain in soft soil area. Taking a pipe curtain structural section civil engineering project as an example, the jacking construction method of steel pipe is analyzed. The steel pipe jacking construction method is the first step of the underground excavation of the pipe curtain. A closed curtain is formed by connecting the steel pipes with locks to isolate the internal and external water and soil bodies. Then, the underground excavation is carried out under the enclosure of pipe curtain. Finally, a large section of underground space is formed, which provides the conditions for the follow-up excavation and structural construction.

**Keywords:** steel pipe jacking, construction supervision, process flow

Application of Big-sandbag Cofferdam in Land Reclamation Engineering ..... HE Haiqun ( 222 )

**Abstract:** With the economic and social development, land reclamation has been becoming a requirement for many countries around the world. The big-sandbag cofferdam has been successfully applied in many land

reclamation projects because of its good integrity and flexibility, and good adaptation to the deformation of embankment foundation. However, there are also cases of cofferdam instability in the big-sandbag cofferdam construction. Taking a land reclamation project as an example, the design and construction of big-sandbag cofferdam are introduced. Based on the limit equilibrium method, the reasons of collapse in its construction process are analyzed. Some corresponding experience and suggestions are provided for the later engineering site construction.

**Keywords:** land reclamation, soft foundation, big sandbag, cofferdam, stability analysis

## STUDY ON SCIENCE & TECHNOLOGY

Study on Data Analysis Method of Expressway Traffic Accidents .....

..... PENG Xiang, SONG Cancan, WANG Weili, KANG Kexin ( 225 )

**Abstract:** The expressway traffic accident data is of great significance for the management department to improve the road traffic safety. In order to study the historical traffic accident data distribution and accident development trend of two expressways in Guizhou Province, the proximity and correlation analysis method is used to perfect the accident data firstly, then the influence of road feature on the traffic safety is analyzed, the unit range of continuous downhill road section and tunnel road section is divided, and finally the unit of road section is further divided into the blocks to establish the prediction model of accident probability and block position in the range of different blocks, in which the second half section of continuous downhill road section conforms to the linear relation, and the tunnel entrance / exit section conforms to quadratic function relation. Based on the accident distribution features, the improvement scheme is proposed so that the managers are assisted to master the road section range of traffic accidents possibly to happen in the different features of road sections and to grasp the improvement priority.

**Keywords:** traffic accident, continuous downhill, tunnel, prediction model

Study on Differential Settlement Characteristics of Roadbed for Road Widening Project in Soft Soil Area .....

..... HOU Zhifeng, JIN Canzhang ( 230 )

**Abstract:** Due to the special engineering characteristics of soft soil, it is more difficult to carry out urban road reconstruction and expansion projects on soft soil foundation than in general areas. It is the key to solve the problem of differential settlement between the old and new subgrade. The possible disease forms and mechanism of urban road widening in soft soil area are firstly analyzed. Then, based on a municipal road project, the finite element software ANSYS15.0 is used to study the differential settlement rules of the new and old roadbeds under the conditions of different widening widths, different roadbed heights and different subgrade soil modulus. And finally, the technical measures to reduce the differential settlement between the old and new roadbeds in the urban road reconstruction and expansion project in the soft soil area are proposed, and its impact effect is introduced in order to provide some theoretical guidance for the construction of the similar road reconstruction and expansion projects.

**Keywords:** soft soil, urban road, roadbed widening, differential settlement



Study on Micro-surfacing Technology in Pavement Maintenance of High-grade Highways ..... LI Yanbin ( 233 )

**Abstract:** In order to compare the effect difference between SBS modified emulsified asphalt and rubber powder modified asphalt in the micro-surfacing technology of pavement maintenance, the indexes of two modified materials after mixed with the asphalt are obtained by the screening and control of two modified material contents. The range of dosage with better index result is selected, in which the content of SBS modifier is about 3%~7%, and the best content of rubber powder is about 10%~15%. The pavement performances of two mixtures are evaluated through the experiments. The results show that SBS modified asphalt material as pavement material has the better rutting performance in the micro-surfacing technology, and the rubber powder asphalt material as pavement material has the better anti-slide performance in the micro-surfacing technology.

**Keywords:** pavement maintenance, SBS modified emulsified asphalt, rubber powder modified asphalt, experiment, pavement performance

Analysis and Study on Influence Factors of Finite Element Simulation of Concrete Filled Steel Tube Arch Rib .....

..... WANG Jixiang ( 236 )

**Abstract:** Two simulation methods of arch ribs of a 500-meter-class concrete filled steel tube (CFST) arch bridge are studied in detail. The joint cross section and the two-unit method are used to establish the full-bridge spatial finite element model by means of Midas/Civil software. The similarities and differences among the steel pipe stress, the core concrete stress and the displacement of the key sections in the main construction stages by two methods are compared and analyzed. And the influence factors of arch rib simulation are analyzed, which can provide a reference for the relevant long-span concrete arch bridges.

**Keywords:** concrete filled steel tube arch rib, joint cross section, double-unit, influence factors

Study on Characteristics of Salt Swelling and Subsidence of Saline Soil in Alataw Pass of Xinjiang .....

..... GUO Xiaowen, LI Wei ( 239 )

**Abstract:** Based on the Alataw Pass City - Wenquan County - G30 Highway Construction Project, the influence of the freezing-thaw cycle times, salt content, moisture content and load on the deformation of saline soil during salt swelling and melting is studied by the control variable method. The test result shows that the salt swelling property will gradually increase with the increase of the moisture content of saline soil during the salt swelling test. With the increase of salt content, the salt swelling property of saline soil is also more obvious, and with the decrease of temperature, the salt swelling amount of saline soil also gradually increases. But when the salt content and moisture content reach a certain degree, the salt swelling amount does not increase as the decrease of temperature. During the subsidence test, the settlement of soils in each group increases with the increase of moisture content under the condition of not considering the salt content. The greater the salt content, the greater the settlement under the same load. With the increase of pressure, the saline soil will still settle considerably.

**Keywords:** saline soil, subsidence, salt swelling, submerging test, settlement rate

Analysis of Flood Response to Timber Arch Lounge Bridge Based on Numerical Simulation .....

..... ZHANG Xuan, WANG Baisheng ( 243 )

**Abstract:** In recent years, the research on flood control and disaster prevention of timber arch lounge bridge is mainly based on the experience summary of water destruction cases to propose the macroscopic maintenance strategy. There is a lack of quantitative analysis of the flood load and the stress of lounge bridge structure. Therefore, based on the computational fluid dynamics (CFD) and finite element method, the analysis method of the flood resistance safety of lounge bridge is proposed. The load distribution law under different flood frequencies is studied, and the flood response and structure safety of bridge arch frame are quantitatively evaluated, which provide reference for flood prevention and safety monitoring of the timber arch lounge bridge. The results show that under the action of flood load, the horizontal force on member bars presents the linear distribution along the water depth, and the vertical force is evenly distributed. The main arch structure is deformed. Its upstream face is extruded towards the river and its backwater face is stretched towards both banks. The superstructure slopes towards the direction of water flow. The end plantlet of backwater face on the main arch is pulled and is easy to break away from the node, which lead to the collapse of bridge deck. The friction coefficient of the foundation and the shear resistance of the soil determine the stability of bearing, which is a key factor affecting the flood safety performance of the whole structure of lounge bridge.

**Keywords:** timber arch lounge bridge, flood control and disaster prevention, numerical simulation, flood response, computational fluid dynamics (CFD), finite element structure analysis

Numerical Model Analysis of Influence of Anti-h Anti-slide Pile on Settlement of Steep Slope Subgrade .....

..... FAN Zuoyin, ZHANG Yubao ( 249 )

**Abstract:** Based on the construction project of Alashankou City Wenquan County G30 Highway, the typical numerical model of steep slope subgrade is established by means of numerical simulation. Under the condition of seasonal frozen soil, the influence factors of anti-h pile on the slide resistance of steep slope subgrade are studied, and the influence of pile spacing, freeze-thaw cycle times and section side length on settlement of steep slope subgrade is emphatically analyzed. The results show that the anti-h pile spacing has a great influence on the settlement. When the anti-h pile spacing is between 6 m and 7 m, the settlement of the steep slope subgrade is relatively stable. The influence of freezing-thaw cycle times on the settlement is first increased and then decreased. The section side length is not large the better. In a certain range, the settlement can be significantly reduced by increasing the side length of the section. But the settlement effect is not obvious if increasing this parameter continuously.

**Keywords:** numerical modeling, steep slope subgrade, freezing-thaw cycle, subgrade settlement

Study on Mechanical Properties of Horizontal Load Pile Foundation in Soft Soil Foundation .....

..... ZHANG Kai, LIU Xukai, ZHOU Yan ( 253 )

**Abstract:** Through the comparative study of different domestic norms and literatures and the analysis of

engineering cases, it is suggested that the horizontal displacement of pile foundation up to 6-mm horizontal load should be regarded as the allowable lateral axial bearing capacity of pile foundation, or the horizontal bearing capacity of pile foundation can be estimated by the formula of building pile foundation standard. Considering the nonlinear characteristics of pile-soil interaction in soft soil foundation, the NL method is introduced to analyze the internal force and deformation of horizontally loaded pile and an accurate analysis method of pile foundation in the soft soil foundation under the horizontal load effect is established. Under the same horizontal load effect, the deformation value and internal force value of the horizontally loaded pile calculated by the NL method are about 150% and 15% higher than the m method. The m-method is conservative in the design of horizontally loaded pile.

**Keywords:** pile foundation, horizontal load, nonlinear ground reaction coefficient, NL method, lateral axial bearing capacity, m method.

Brief Analysis on Calculation Method of Cement Concrete Pavement Structure with Non-standard Vehicle Type Distribution ..... GAO Hui, GE Xuzhen ( 257 )

**Abstract:** According to the engineering examples, the vehicle types in the domestic steel plant areas are mainly non-standard vehicle types, and in the traditional road structure calculation software, only the current situation of vehicle type selection is calibrated. It is suggested that the non-standard vehicle types should be converted into the standard types before the calculation of pavement structure, which can be referred by the same types of engineering designers.

**Keywords:** steel plant, non-standard, vehicle type, pavement structure

Realization of Wind-induced Vibration of Cable-stayed Bridge in Ansys ..... GAO Nengxiang ( 260 )

**Abstract:** The finite element model of a long-span cable-stayed bridge is established by Ansys, and the natural frequency and mode shape of the bridge are obtained by the dynamic feature analysis of the cable-stayed bridge. The harmonic synthesis method is used to program Matlab in order to synthesize the three-dimensional spatial fluctuating wind field of the cable-stayed bridge and obtain the fluctuating wind speed time history at each discrete point of the main girder and pylon of the bridge. The wind speed time history at each discrete point is converted into the time history of buffeting force at each node in the finite element model. The buffeting time domain analysis of the bridge is carried out, and the dynamic response result of the bridge under the wind load is obtained.

**Keywords:** wind-induced vibration, Ansys, fluctuating wind field, time domain analysis, buffeting vibration

Seismic Analysis of Highway-Railway Integrated Elevated Station ..... DU Xinghua ( 266 )

**Abstract:** Based on an expressway - municipal railway integration project in Ningbo, the seismic performance is analyzed for the structural characteristics of the highway railway integrated elevated station. The relative design requirements of the different industry standards are compared. According to the dynamic parameters of the site, the response spectrum analysis of the station structure under the action of frequent earthquake and fortification earthquake is carried out. Under the rare earthquake, the nonlinear time history

analysis is carried out, and the ductility of the pier column is checked by the uniaxial hinge. And the static elastic-plastic analysis method is used for the supplementary analysis. The analysis result shows that all indexes of the structure meet the requirements.

**Keywords:** integrating bridge and architecture, rail transit, elevated station, seismic analysis, super-long structure

Review of Research on Bridge Piers Subjected to Vehicle Collision .....

..... HAN Yan, WANG Longlong, LIU Zhihao ( 271 )

**Abstract:** In order to promote the development of anti-collision design for bridge pier, the research status of vehicle colliding bridge pier is expounded from the aspects of research method, impact force value, pier anti-collision design and damage evaluation. The problems in the current research and the direction of further research are pointed out. The results show that the experimental method, theoretical analysis and finite element numerical simulation have own advantages. The combination and the mutual verification of three methods will be the development trend of the vehicle-bridge collision research. The calculation formula for vehicle impact on bridge piers convenient for engineering applications needs to be established. It is to further explore how to quickly and reasonably evaluate the damage degree of bridge structure after an accident of vehicle collision on bridge pier. And it is to further research the anti-vehicle collision design method of urban bridge piers able to reduce the bridge pier and vehicle collision damages with less land occupation and good anti-collision effect.

**Keywords:** vehicle colliding bridge pier, review, impact force, anti-collision design, damage evaluation

Evaluation of Nonlinear Static Analysis Method Based on Bridge Coefficient .....

ZHANG Xiaoxuan ( 276 )

**Abstract:** Taking the bridge coefficients as the reference standards, the real seismic wave response spectrum and the design response spectrum are used as the seismic demand respectively to analyze the calculation accuracies of reinforced concrete continuous girder bridge by four nonlinear static methods (bearing capacity response spectrum method, N2 method, modified modal Pushover analysis method and self-adaption bearing capacity response spectrum method). The study result shows that the calculation results obtained by four nonlinear static analysis methods are gradually close to the calculation results of nonlinear dynamic analysis with the increase of seismic intensity. N2 method gives the results of the closest dynamic analysis in the case of the real seismic waves. And the difference between the results of four nonlinear static analysis methods is very small in the case of the design response spectrum.

**Keywords:** nonlinear static analysis method, nonlinear dynamic analysis method, bridge coefficient, Pushover

Non-directional Force Effect of Suspender Force of Bowstring Arch Bridge under Wind Pressure .....

..... JIN Chengdi, FAN Lingyu, LINGHU Yunyun ( 280 )

**Abstract:** The lateral deflection of bowstring arch bridge under the common effect of wind pressure and arch axis pressure is studied, and the non-directional force joint action of suspender force is also considered. The

above effect is relatively calculated by two examples of a single-truss box arch rib and composite beam used as straining beam, and a frame-type bracing of double-truss bowstring arch bridge. The optimal design of local stiffening of thin elastic plate of box arch rib is carried out in order to improve its stability.

**Keywords:** bowstring arch bridge, suspender force, non-directional force effect, local stability of thin plate

Analysis and Study on Structural Seismic Concept of Underground Tank ..... WANG Gang ( 286 )

**Abstract:** Underground tanks usually exist in large underground wastewater treatment plants, urban rainwater and wastewater pumping stations, storage tanks, etc. There are a series of difficulties about the seismic analysis in underground tanks, such as the selection of design theory, the analysis of fluid force, the design of structure measures, the impact of setting joint form, etc. The common seismic design theory of underground structure is introduced. The existing problems and seismic design characteristics of underground tank structure are analyzed and summarized. Based on a series of cases, the attentions are proposed for the design, which can be referred for the similar projects.

**Keywords:** underground tank, anti-seismic, structural design

Study on Resistance of Plant Fiber Reinforced Cement Pipe to Strong Acid and Alkali Corrosion .....

..... SHEN Xudong, CAO Cong, JIANG Donghai, ZHENG Yongwei ( 290 )

**Abstract:** The municipal drainage pipe is commonly used as the cement pipe or reinforced concrete pipe as the main pipe material. The municipal sewage may corrode the pipes. The corrosion situation of the plant fiber reinforced cement pipe soaked in a solution with the pH value of 1, 2, 3, and 14 for one month is studied. By the apparent observation, quality and compressive strength measurement, two indexes of anti-corrosion coefficient and mass loss rate are used to determine the corrosion situation of plant fiber reinforced cement pipe under the test condition. The results show that the quality and compressive strength of plant fiber reinforced cement pipe soaked in a solution with strong acid and alkali for one month have no significant loss, and its durability has a certain guarantee. This kind of pipe can be used in the construction of municipal drainage pipeline.

**Keywords:** plant fiber, cement, strong acid and alkali, compressive strength, quality loss

Experimental Research on Physical and Mechanical Properties of Plant Mix Heat-recycled Asphalt Mixture .....

..... MA Lizhi ( 294 )

**Abstract:** Four kinds of milling planing materials with the different durable years and a kind of milling planing material with the different mixing rates are used to systematically carry out the design of mix proportion and the experiment of physical and mechanical properties of the plant mix heat-recycled asphalt mixture. The results show that for the milling planing materials with the different aging degrees and at the mixing rate of the same milling plan material, the more serious the aging of asphalt recycled in milling planing material, the greater the 600C stability of heat-recycled asphalt mixture, and the worse the bulk density, the void content and the water stability. But the range of variation is not large. For the same milling planing material, the bulk density and the residual stability of mixture decrease with the increase of mixing

rate of milling planing material. The void content of mixture increases with the increase of mixing rate of milling planing material, while the dynamic stability of mixture shows a trend of increase at first and then decrease.

**Keywords:** plant mix heat-recycled, asphalt mixture, physical and mechanical properties, milling planing material

Research on Foaming Conditions and Performances of Foamed Warm Mix Asphalt .....  
..... DONG Pingyang, YIN Teng, WANG Linsong, XU Guangji ( 297 )

**Abstract:** The optimal foaming conditions of warm mix asphalt are tested and studied, and the properties of asphalt before and after foaming under the optimal foaming conditions are compared in order to verify the reliability of asphalt properties after foaming. The implementation of the warm mixing technique of asphalt mixture can effectively reduce the interference with the surrounding environment, and has the obvious environmental protection benefit and social benefit.

**Keywords:** warm mix asphalt, water consumption, intensity of pressure, foaming temperature, property

Quality Evaluation Method of Lightweight Live 3D Model ..... CHEN Jiao ( 301 )

**Abstract:** Guided by BIM design based on the live 3D model, according to the different demands of each stage of civil engineering design, and also considering the geometric accuracy and texture quality of the model, the data quality evaluation method of lightweight live 3D model is proposed to solve the difficulties of the data quality control of live 3D model after lightweight. The solid foundation is laid in order to make it widely applied in BIM design. The traditional delivery form of surveying and mapping data results is changed. The designers are promoted to use BIM technology from the surveying and mapping links so as to speed up the popularization and application of BIM technology. The depth and breadth of BIM technology application are strengthened. Finally, the popularization and application of BIM technology are realized in the full-life circle process of construction industry.

**Keywords:** lightweight, BIM, live 3D model, quality evaluation

## APPLICATION OF ACHIEVEMENTS

Brief Analysis on Application of New Graphene Material in Asphalt Concrete Pavement ..... CAO Xining ( 304 )

**Abstract:** Since discovered in 2004, the graphene honored as a miracle material has been a research and development hotspot for the scientists and industrial circles in various countries because of its multiple excellent performances. This material has been tried in many fields of aerospace, electronic engineering, shipping, new energy, environmental cleaning, asphalt pavement and concrete. The study is focused on the application test of new grapheme material in the asphalt concrete pavement.

**Keywords:** grapheme, asphalt concrete, application test

Application of BIM Technology Based on Bentley Platform in River Design ..... Yue Zhe ( 306 )

**Abstract:** With the rapid development of computer and three-dimensional technology, the design of water conservancy project is not only limited to solve the two-dimensional and single field technical problems, but also gradually developed into a three-dimensional and multi professional integrated design mode. Based on the platform of Bentley series software, a set of 3D design methods suitable for river regulation engineering is proposed through the technical means of creating model, collision detection, engineering quantity calculation and real effect.

**Keywords:** BIM technology, Bentley software, river design, 3D collaboration

## THE RELATIVE SPECIALITIES

Study on Scheme of Interchange Station in Central Urban Area by Undermining Method .....

..... WANG Chunkai, WU Pengqi, LI Yunying ( 309 )

**Abstract:** Based on Beijing Road Station of Guiyang Metro Line 3, the scheme of interchange station in the central urban area by the undermining method is studied. According to the study, the cross interchange mode is adopted under the certain conditions. According to the passenger flow forecast, the platform width is 15.5 m. Combined with the requirements of equipment clearance, pipeline laying, construction error, etc., the clear width of station is 22.8 m, which is a long-span station. When the deformation control requirements of the station construction in the central urban area are high and the section span of the undermined station is long, the center drift method can be used for construction. Through the numerical simulation, the stress analysis of the primary support and secondary lining of the undermined structure is carried out. And through the calculation, it can be found that when certain primary support measures are taken, the center drift method can play a certain role in deformation control. The waterproof quality of the undermined station can be ensured by the optimization of the undermining section, and the whole package waterproof and joint waterproof reinforcement. The structure type of the undermined station by the center drift method can meet the seismic requirements.

**Keywords:** interchange station, undermining method, waterproof, center drift method, seismic resistance

Analysis on Influence of Large Deep Foundation Pit Construction in River Channel on Adjacent Bridge and Countermeasures .....

SUN Fan, CHEN Bing ( 314 )

**Abstract:** At present, the construction of large deep foundation pit close to and parallel to the bridges is rare in urban area. The deep and thick permeable sand layer in river channel has the characteristics of difficult grooving, high underground water level and infinite supply, which will great increase the engineering difficulties and the bridge safety risk. Combined with an engineering case of Beijing and according to the protection of existing bridges, the risk sources affecting the safety of foundation pit and existing bridges are analyze in detail. Based on the numerical simulation and calculation, the relevant engineering measures are especially formulated for the construction of deep foundation pit in the river channel close to bridge. The monitoring data show that the safety of bridges during construction is ensured. The relative engineering experience can be referred for the similar projects.

**Keywords:** deep foundation pit in river channel, close to construction, risk control, finite element analysis

Discussion on Tunnel Design Scheme under Complex Conditions ..... LANG Jun ( 317 )

**Abstract:** Through the discussion of the tunnel scheme formulation process for the exit section of Zhuyougang Tunnel and the long shallow buried bias section of highly weathered phyllite stratum, it can be seen that the determination of tunnel scheme under special conditions should be carried out by the selection of many schemes. On the premise of ensuring safety, practicality, reliable quality, economy, rationality and advanced technology, the environmental protection should be achieved as far as possible and the selected scheme should be necessarily analyzed and calculated.

**Keywords:** tunnel, shallow buried bias, design scheme, numerical analysis

Numerical Simulation and Analysis of Construction Process of Qinghuai East River Tunnel .....  
..... CHENG Dapeng, ZHANG Yin, YU Daiguang, LI Jin ( 321 )

**Abstract:** In order to ensure the smooth implementation of the Xicun Tunnel in Qinghuai East River Project, the finite element method is used to carry out the numerical simulation and analysis on the natural stress field of the project area. A three-tunnel parallel calculation model is established. The stress and strain analysis is carried out in three processes of newly excavating river, newly building tunnel and upper covering backfilling. The value of single layer depth of layered excavation and backfilling is proposed to monitor the change of the displacement and stress on the top of tunnel during layered excavation and backfilling. The study shows that there is a hidden danger of slope stability when the upper covering at the entrance of tunnel is excavated to a depth of about a quarter. In the process of covering backfilling, the bottom of the tunnel presents the upward slightly arch deformation because of greater vertical stress. The study result can be directly applied to the design calculation and construction quality control of the diversion tunnel project, and can be popularized and applied in the similar projects.

**Keywords:** finite element calculation, tunnel design, excavation backfill, safety coefficient, plastic failure

Experimental Study on Recharge of Confined Aquifer in Shanghai Area ..... DING Guohong ( 325 )

**Abstract:** There are more and more large deep foundation pits in Shanghai, and the confined aquifer is thick. It is difficult for the waterproof curtain to completely cut off the confined aquifer. It is bound to have a great impact on the surrounding environment if suspended waterproof curtain is often used. At present, more and more attention has been paid to the concept of using the recharge measures to control pumping induced settlement, but the theory is still lack of research, and the feasibility and key technology of recharge also need to be studied. Based on the first city railway project in Shanghai, a series of tests of single well recharge, pumping recharge integration and group well recharge are carried out. The test results show that it is feasible to carry out recharge in the silt layer, and the effect is related to such factors as the spacing of recharge wells, the length of filter pipe, the pressure or not and the magnitude of applied pressure.

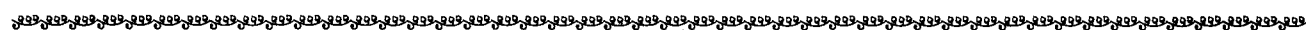
**Keywords:** pumping of foundation pit, recharge test, recharge pressure, confined aquifer



Comparison and Analysis of New and Old *Highway Engineering Budget Quota* ... GAO Xuelei, DING Yi ( 328 )

**Abstract:** By comparison and analysis, the changes in *Highway Engineering Budget Quota* issued in 2018 are expounded. Combined with the engineering cases in Shandong Province, taking the manual consumption, material consumption and mechanical shift consumption as the key point of measurement, the influence of new quota on the construction installation engineering cost is analyzed.

**Keywords:** highway engineering, compiling method, budget, quota, cost



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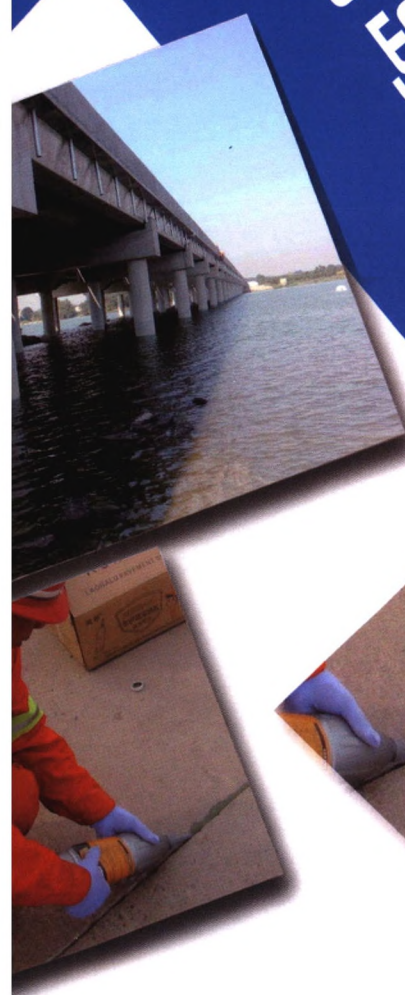
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