

Rail Transit

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西安城市轨道交通网络分析

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摘要: 西安城市轨道交通正处于高速发展阶段, 根据近期规划, 城市轨道交通线路将从2018年底4条线路增至2023年14条线路, 逐渐地形成网络规模。利用复杂网络的理论研究城市轨道交通网络规模的可靠性、抗摧毁性对提升线网的可达性以及提高网络的运营效率、抗摧毁能力具有很强的现实意义。在L空间中, 对西安城市轨道交通网络建立拓扑结构, 通过计算度、平均度、平均路径长度、网络效率、聚类系数等指标, 对整个网络进行可靠性分析, 分析结果认为近期规划的西安城市轨道交通网络属于无标度网络。为进一步对可靠性进行研究, 模拟了网络出现随机故障及遭受故意攻击时的表现, 通过网络效率的变化衡量网络的抗摧毁能力。结果表明西安城市轨道交通网络正处于发展扩张阶段, 节点度分布尚不均衡, 对于随机攻击表现出强鲁棒性, 而对故意攻击则表现出一定的脆弱性。

关键词: 西安城市轨道交通网络; 复杂网络; 无标度网络; 抗摧毁能力

Xi'an Urban Rail Transit Network Analysis

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Abstract:

Xi'an urban rail transit is rapidly developing. According to the recent plan, urban rail transit will increase from 4 lines at the end of 2018 to 14 lines in 2023, gradually forming a network scale. Base on the theory of complex network, calculating the reliability and scalability of urban rail transit network scale is of great practical significance to improve the reachability of the network and to improve the operational efficiency and anti-destruction ability of the network. In L space, the topological structure of Xi'an urban rail transit network is established, and the reliability of the whole network is analyzed by means of the indexes such as degree of calculation, average degree, average path length, compactness, clustering coefficient and so on. It is considered that Xi'an urban rail Traffic network is scale-free network. By studying the anti-destructive ability of the network, the reliability of the network is further studied, and the random network failures are simulated and the performance of the network under deliberate attacks is simulated. The network's anti-destruction capability is measured by the change of network efficiency. The results show that the urban rail transit network in Xi'an is in the process of expansion and expansion. The distribution of node degree is not balanced. It shows robustness to random attacks and obvious vulnerability to intentional attacks.

keywords: Xi'an urban rail transit network; complex network; scale-free network; anti-destruction

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总线型拓扑高速铁路通过能力计算

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摘要: 基于开行方案, 针对列车在总线型拓扑结构高速铁路线上跨线、混速运行, 利用“图解法”精确计算线路通过能力。构建以开行列车数最大为目标, 运行线间隔时间、动车运用所存车能力、停站时间、股道数为约束的最大化运行线开行模型。算法原理为先确定瓶颈区段; 再按瓶颈区段顺序铺画运行线, 将运行线耦合度作为启发式信息, 利用改进蚁群算法确定时间窗占用最小的运行线铺画; 每次铺画完后再添加一条满足开行方案的运行线直到无法铺画; 统计运行图上开行的运行线数即为总线型拓扑线路在该开行方案下的通过能力。以京沪高铁为干线、九条城际(客专)为支线, 计算在给定开行方案下的京沪高铁线路通过能力。

关键词: 高速铁路; 通过能力计算

The Calculation of Bus Topological Structure High Speed Railway Lines' Capacity

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Abstract:

Based on the line plan, aimed at operating trains on high speed railway lines of bus topological structure with different speeds, we utilize Graph-Solution Method to calculate the capacity of the main line of the high-speed railway. The objective function of the Capacity Calculation Model is to maximize the number of trains. Constraints concludes the headway, the capacity of the station of restoring EMU, the stopping time, and the number of station tracks. Then the Graph-Solve Method is proposed to solve the model. Firstly, difficult sections should be determined. Secondly, we arrange trains' operation by difficult sections' order. The degree of coherence can be used as heuristic information for ant algorithm to complete the timetable with minimum time window. Thirdly, we will insert another train line until we can't do that anymore. At last, the number of trains is the capacity of bus topological structure high speed railway lines under this particular operation scheme. In the case that Beijing-Shanghai High Speed Railway acts as main line, and 9 inter-city lines act as branch lines, we calculate the capacity of Beijing-Shanghai High Speed Railway under the given line plan.

keywords: high-speed railway; Calculation of Capacity

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Analysis of the Characteristics and Robustness of Metro Network Based on User Demand

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Abstract: Urban rail transit (URT) is an important support for the urban passenger transport system, it has gradually become the preferred means of transportation for residents, and plays a vital role in solving the problem of urban traffic congestion. More the emergencies tend to paralyze certain rail transit stations, thus affecting the overall efficiency of the rail transit network (RTN). So the analysis of the topological characteristics and robustness of urban traffic track networks is of great significance for optimizing the road network structure and ensuring stable operation. Based on the description of complex network theory, this paper uses Space L method to empirically analyze the indicators and distribution laws of urban rail transit networks (URTN) such as node degree, average path length and clustering coefficient in Shanghai, Chongqing and Xi' an, then the user demand factor is integrated into the robustness of each site to deliberate attacks to measure the node contributes to users with different transmission requirements. The results show that the URT network scale has a great impact on the urban network structure function. From the perspective of different users, the key nodes of the network may be completely different for the same metro network. And the research can provide a theoretical reference for the routine maintenance, safe operation and reasonable planning and design of the rail transit network.

Key words: urban rail transit network; complex network; user demand; robustness

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Identification of Important Nodes on Urban Based on CRITIC Method

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Abstract: Urban rail transit stations play an important role in passenger distribution and connectivity intervals in the network. If a node fails, it will lead to the embarrassment of large-area orbital networks. How to effectively evaluate its influence in the passenger flow network is the focus of research on network structure optimization and reducing operational risks. Based on the complex network theory, the station is taken as the research object. By establishing the network passenger flow distribution model and combining the rail transit smart card data, the CRITIC method is used to determine the objective comprehensive weight and determine the important nodes of the urban rail transit network. The research method was applied to the Xi' an subway network, and the key stations of Xi' an subway were identified and the current situation of Xi' an subway early peak passenger flow was systematically analyzed, and opinions on subway network operation were put forward.

Key words: CRITIC method; Urban rail transit; important node evaluation; AFC data

基于多年卡数据的轨道交通网服务功能的空间演变

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摘要: 掌握居民的出行行为变化, 以及由居民出行行为变化所揭示城市功能区演变, 能够为城市规划管理部门制定及评估相关城市政策提供指导。作为城市居民重要的出行方式, 城市轨道交通积累了大量的 AFC (Auto Fare Collection, AFC) 刷卡数据, 包含了数以百万计乘客的出行时空信息, 这为相关研究提供了新视角。本文利用北京市 2014 年至 2017 年轨道交通刷卡数据, 基于贝叶斯定理及 GMM (Gaussian Mixture Model) 模型, 对 4 年来轨道交通车站层面所服务乘客的出行行为及其所揭示的城市功能区演变进行了研究, 结果显示: (1) 大部分车站的客流量及客流组成保持稳定, 而部分车站客流量增长迅速, 规律出行乘客占比增加; (2) 北京市仍然具有明显的圈层结构, 轨道交通沟通城市内外部的功能未发生变化, 同时线网的外延也使得部分居民的居住地外延; (3) 城市内部各功能区在发生缓慢演变, 其中望京区域集中了越来越多的工作岗位, 而对工作及居住混合类车站所在区域进行职住调节, 将有效缓解城市内部的交通压力。

关键词: 轨道交通网; 乘客出行行为; 城市功能区; 演变

Rail Transit Network Service Spatial Dynamics: Insights from Multiyear AFC Data

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Abstract:

As an important public transport in Beijing, the passenger flow and service functions change of Metro at station level reflects city spatial dynamic. Based on Bayesian theory and GMM (Gaussian Mixture Model), this paper studies the evolution passenger flow and service function of metro at station level in the past five years from 2014 to 2017 by AFC (Auto Fare Collection) data. The passenger flow patterns of most stations remain stable, while a few stations change significantly, indicating that the urban functions of such stations have changed. The analysis of service function dynamic at station level shows that the city's structure of job and house location in Beijing has largely remained unchanged on a large spatial scale in the past five years, but the functional areas within the city are undergoing a slow variation, and the area where stations serving both commuting and living passengers are hot spots in the evolution of urban structure.

keywords: rail transit network; travel behavior; city spatial function; dynamics

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市域铁路站点布局的多目标规划方法

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摘要: 提出一个基于城市内部节点重要度的市域铁路站点多目标布局规划模型。从六项发展指标对城市节点重要度进行定性和定量的评价, 进而确定备选站点集。基于备选集, 综合考虑建设运营方和乘客以及城市远期发展三方面的利益, 提出一个以站点枢纽建设成本最小、居民出行节省时间价值最大和站点土地增值效益最大的多目标站点布局规划模型, 并采用遗传算法工具箱进行求解。成蒲铁路算例表明: 市域铁路站点备选集的确立要求城市节点整体经济发展状况良好, 并且经济产业结构均衡协调, 基于多目标规划模型的站点布设方案能够兼顾节点交通、经济及社会效益的发挥, 同时均衡各规划子目标, 实现站点布局规划的综合效益最大化及对城市空间拓展的有效引导。

关键词: 市域铁路; 节点重要度; 站点规划; 土地增值; 多目标; 遗传算法

Multi-Objective Planning Method for Layout of Suburban Railway Stations

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Abstract:

This paper proposes a multi-objective layout planning model for suburban railway stations based on the importance of urban internal nodes. The importance of urban nodes is evaluated qualitatively and quantitatively from the six development indicators, and then the set of alternative sites is determined. Based on the alternative set, considering the interests of construction operators and passengers as well as the long-term development of the city, a multi-objective site layout planning model with the minimum construction cost of the site hub, the maximum time-saving value of residents' travel and the maximum land value-added benefit of the site is proposed and solved by using genetic algorithm toolbox. The example of Chengdu-Puxian Railway shows that the establishment of the alternative set of suburban railway stations requires the overall economic development of urban nodes to be in good condition and the economic and industrial structure to be balanced and coordinated. The station layout scheme based on the multi-objective planning model can give full play to the traffic, economic and social benefits of the nodes, and balance the planning sub - goals, so as to maximize the comprehensive benefits of the station layout planning and effectively guide the expansion of urban space.

keywords: suburban railway; node importance degree; station planning; land value increment; multiobjective; Genetic algorithm

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对多线共走廊结构在广州轨网规划中作用的思考

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摘要:目前我国大城市轨道网规划基本上为网格状布局,虽然能在中心城区实现较高的轨道站点覆盖率,但不能充分反映不均衡区段的客流需求。难以支撑超大客流走廊的高水平运作、容易产生超高换乘量的站点、不利于超长线路的运作。本文分析了国外大城市轨网多线共走廊结构的特点和实现路径,提出了对广州轨网的应用分析。

关键词: 城市轨道交通; 多线共走廊; 城市规划

Discussion About the Multi-Line Corridor in Guangzhou Urban Railway Planning

Jiang Xuefeng

(Guangzhou Transport Development Annual Report)

Abstract:

At present, China's urban rail network planning is basically grid layout. This model makes a high fraction of coverage, but can not meet the different traffic demand. For example, it can not support the excessive passenger flows, it causes the high transfer and it is not good for Ultra long line. This paper analysis the Multi-line corridor in foreign cities, and discusses about the use in Guangzhou.

keywords: urban railway, Multi-line corridor, Urban planning

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北京地铁 13 号线运营优化措施量化分析

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摘要:城市轨道交通不断增加的客流量与城市轨道交通基础设施不能满足出行需要的矛盾日益突出,通过调整运营方法,能在一定程度上缓解了城市轨道交通拥堵状况,改善市民的出行体验。以城市轨道交通实际客流数据为基础,使用 UTPS 仿真系统对运营方法调整前后的客流进行仿真分析,并通过 UTPS 系统提供的一系列拥堵评价指标对调整措施进行可行性评价,确定符合实际情况的调整措施。

关键词: 交通拥堵; 运营管理; 计算机仿真; 客流分析

Quantitative Analysis of Operation Optimization Measure for Beijing Metro Line 13

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Abstract:

The increasing contradiction between urban rail transit and urban rail transit infrastructure can not meet the needs of travel. The adjustment of operational methods can alleviate the congestion of urban rail transit and improve the travel experience of citizens. Based on the actual passenger flow data of urban rail transit, the UTPS simulation system is used to simulate and analyze the passenger flow before and after the adjustment of the operation method, and the feasibility adjustment of the adjustment measures is carried out through a series of congestion evaluation indicators provided by the UTPS system to determine the adjustment according to the actual situation.

keywords: traffic congestion; operation management; computer simulation; passenger flow analysis

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基于灰色关联度-TOPSIS 法的夕发朝至列车开行方案比选

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摘要: 综合分析全线矩形天窗、分段矩形天窗及等线、下线、下-上线 3 种开行模式下的高速铁路夕发朝至列车开行方案, 给出开行方案比选方法, 为我国编制高速铁路夕发朝至列车开行方案提供参考依据。以始发终到时刻满意度、旅客出行费用、区段通过能力、运输组织难度为目标函数, 对各开行方案量化分析, 提出灰色关联度和逼近理想解排序 (TOPSIS) 的比选方法, 并以京广高速铁路为例验证模型的可行性。结果表明: 最佳方案为 4h 分段垂直天窗速度等级 250km/h 下-上线模式, 我国京广高速铁路夕发朝至列车可通过提高运行速度、采用分段垂直矩形天窗、下-上线模式周期性天窗等措施提高列车运行效率。

关键词: 高速铁路夕发朝至列车; 综合维修天窗; 开行模式; 灰色关联度; TOPSIS 方法

Comparison and Selection of Operation Plan of Sunset-Departure and Sunrise-Arrival Train by Grey Correlation Analysis and TOPSIS Method

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Abstract:

Three organization modes, i.e., waiting for integrated maintain time (IMT) on a high speed railway (HSR) station (WHRS), transfer from HSR to conventional railway (CR) before IMT and from CR to HSR after IMT (HCCH), were propose according to the vertical rectangle skylight and segmented skylight on high-speed railway train operation plan. Quantitative analysis is carried out on the sunset-departure and sunrise-arrival train with passenger satisfaction on departure and arrival moments, passenger travel expenses, section carrying ability and difficulty of transportation organization adjustment as the objective function. And the gray correlation analysis and similarity to ideal solution (TOPSIS) method are applied to carry out the train plan for the Beijing-Guangzhou high-speed railway Compared with the selection. The results show that the best solution is the 4 hours segment vertical skylight and speed of 250km/h transfer from HSR to CR before IMT. The sunset-departure and sunrise-arrival train in China can improve the train operation efficiency by improving the operation speed, adopting subsection vertical rectangular skylight, adopting subsection vertical rectangular skylight and other measures.

keywords: sunset-departure and Sunrise-arrival Trains on high-speed railway; comprehensive maintenance skylights; operation mode; grey correlation; technique for order preference by similarity to ideal solution (TOPSIS)

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铁路客运枢纽行人交通组织问题研究

——以西安北站为例

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摘要: 铁路客运枢纽是指以铁路运输方式为主, 包含城市轨道交通等多种交通方式, 实现旅客的集散换乘功能的大型综合交通场站。作为城市对内对外大运量运输方式的换乘节点, 其行人交通组织的优劣制约着枢纽运行效率和服务水平。本文以西安北站为例, 借助 Anylogic 仿真软件对枢纽的换乘系统进行仿真优化。同时基于仿真结果评价枢纽流线组织与设备设施设置存在的问题, 并提出具体优化措施实现枢纽运行效率和服务水平的提高。

关键词: 铁路客运枢纽; 西安北站; 行人交通组织; Anylogic 仿真

Study on Pedestrian Traffic Organization of Railway Passenger Transport Hub-Taking Xi'an North Station as an Example

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Abstract:

Railway Passenger transport hub refers to the large-scale integrated traffic station with the main mode of railway transportation, including urban rail transit and other modes of transportation, to realize the distribution and transfer function of passengers. As the transfer node of the city's internal and external mass transportation mode, the advantages and disadvantages of its pedestrian traffic organization restrict the operation efficiency and service level of the hub. Taking Xi'an North station as an example, this paper simulates and optimizes the transfer system of the hub with the help of Anylogic simulation software. At the same time, based on the simulation results, the problems existing in the setting of hub flow line organization and equipment facilities are evaluated, and the concrete optimization measures are put forward to realize the improvement of hub operation efficiency and service level.

keywords: railway passenger transportation hub; Xi'an North Station; pedestrian traffic organization; Anylogic simulation

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高铁客运枢纽通行能力研究

——以哈西站为例

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摘要: 高峰时段高铁客运枢纽所能容纳的换乘客流量主要受枢纽的通行能力限制。论文引入枢纽通行能力的概念, 定义了枢纽内换乘通道、楼扶梯、站台、检票设施等换乘设施的通行能力。通过数据调查, 分析了各换乘设施客流密度和速度的关系模型, 以此确定换乘设施通行能力的影响因素, 另外通过分析枢纽内各类换乘流线的冲突强度, 确定了高铁客运枢纽通行能力的影响因素。类比网络最大流问题, 通过最大流量最小截量定理和“拉链效应”理论, 构建了枢纽通行能力计算模型。最后以哈西站为例, 通过调查出站客流量和枢纽内布局组织流线以及换乘设施的基本情况, 运用模型计算出哈西站的通行能力, 分析其出站客流量与枢纽提供的运力是否匹配。

关键词: 高铁客运枢纽; 换乘客流; 换乘设施; 通行能力

Study on the Capacity of High-Speed Rail Passenger Hub-Taking Haxi Station as an Example

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Abstract:

The passenger flow that can be accommodated in the high-speed rail passenger hub during peak hours is mainly limited by the capacity of the hub. The paper introduces the concept of hub capacity and defines the capacity of transfer facilities such as transfer passages, floor escalators, platforms, and ticket checking facilities. Through data survey, the relationship model between passenger flow density and speed of each transfer facility is analyzed to determine the influencing factors of the transfer capacity of transfer facilities. In addition, the factors affecting the capacity of high-speed railway passenger transport hub are determined by analyzing the conflict intensity of various transfer routes within the hub. The calculation model of hub capacity is constructed by the maximum flow minimum intercept theorem and the "zipper effect" theory. Finally, taking haxi railway station as an example, through investigating the basic situation of outbound passenger flow, layout and flow lines within the hub and transfer facilities, the model is used to calculate the capacity of haxi railway station and analyze whether the outbound passenger flow matches the transport capacity provided by the hub.

keywords: high-speed rail passenger hub; passenger flow; transfer facilities; traffic capacity

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基于前景理论的高速铁路差异化定价策略研究

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(中南大学)

摘要: 针对我国高速铁路单一票价下, 缺乏灵活性导致客流剧烈波动、收益难以增长的问题, 根据旅客乘车选择行为影响因素对高铁旅客进行市场细分, 利用旅客购票心理, 以期望出行成本为参照点, 运用前景理论, 以售票收入最大化为目标, 构建了弹性需求下的差异化定价模型, 并针对模型特点, 设计模拟退火算法, 在低峰期、高峰期两种客流强度下, 对模型进行求解。通过对京沪高铁实例分析, 结果表明, 在考虑旅客出行决策的基础上对各列车实行差异化定价, 低峰期时降价吸引客流, 售票收入增长 10.41%, 高峰期时抬价保持客流, 售票收入增长 7.98%, 提高旅客期望对售票收入的影响较大。本研究为高速铁路管理部门制定票价提供了理论和方法支撑, 并为进一步提升高速铁路售票收入提出了合理建议。

关键词: 差异化定价; 旅客期望; 前景理论; 模拟退火

Research on Pricing Strategy of High-Speed Railway Passenger Ticket Based on Prospect Theory

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(Central South University)

Abstract:

In view of the single fare of high-speed railways in China, the lack of flexibility leads to the problem of violent fluctuations in passenger flow and difficulty in increasing revenue. According to the influencing factors of passengers' choice behavior, the market segmentation of high-speed rail passengers is carried out. Using the psychology of passengers to purchase tickets, taking the expected travel cost as the reference point and maximizing the ticket sales revenue, the prospective theory is used to construct the differential pricing model under the elastic demand. A simulated annealing algorithm is designed for the characteristics of the model. The model is solved under the off-peak period and peak period of two passenger flow intensities. Through the analysis of the Beijing-Shanghai high-speed rail example, the results show that the differential pricing is implemented on the basis of passenger travel decision-making, and the price reduction at off-peak period attracts passenger flow, and the ticket sales revenue increases by 10.41%. During the peak period, the price was increased to maintain the passenger flow, and the ticket sales revenue increased by 7.98%. Increasing passenger expectations has a greater impact on ticket sales. This study provides theoretical and methodological support for the development of fares for high-speed railway management departments, and provides reasonable suggestions for further increasing the ticket sales revenue of high-speed railways.

keywords: differential pricing; Passenger Expectation; Prospect Theory; Simulated annealing

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基于收益管理的高铁票价与票额联合优化方法

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摘要:我国高速铁路已经得到市场和旅客的高度认可,但是仍存在部分动车组列车上座率随时间波动较大而导致运力不足或运力浪费的现象。针对目前高速铁路票价单一,不能引导调节客流和增加收益的问题,引入收益管理的相关理论,提出了考虑旅客弹性需求的多列车多停站的高铁动态定价和票额分配联合优化方法,以各售票时段的票额限制和动态票价为决策变量,同时考虑各列车的票价上下限、列车运输能力等约束,以客票总收益最大化为目标构建优化模型,设计了基于蜂群算法的求解方法。最后,以京沪高速铁路为例进行计算分析,表明在不增加运力的情况下,所提出优化方法能使高铁客票期望收益最高提升4.28%,从而能为高速铁路票价和票额联合优化提供理论和方法支撑。

关键词: 铁路运输; 联合优化; 人工蜂群算法; 高速铁路; 弹性需求; 收益管理

Joint Optimization Method of High-Speed Rail Ticket Price and Seat Allocation Based on Revenue Management

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Abstract:

China's high-speed railway has been highly recognized by the market and passengers, but there are still some lines with large fluctuations in the seat rate with time, resulting in inadequate capacity or capacity waste phenomenon. In view of the fact that the current high-speed railway fare is fixed and cannot guide the problem of regulating passenger flow and increasing revenue, the related theory of revenue management is introduced, and the joint optimization method of high-speed railway dynamic pricing and seat allocation for multi-train and multi-stop stations considering passenger elasticity demand is proposed. The optimization model was constructed with the goal of maximizing the total expected revenue, and took the seat allocation limit and dynamic fare of each ticketing period as the decision variables, and considered the constraints of the upper and lower limits of the price and the train transportation capacity. A solution method based on bee colony algorithm was designed. Finally, taking Beijing-Shanghai high-speed railway as an example, it was shown that under the condition of no increase in capacity, the proposed optimization method could increase the expected revenue by up to 4.28%, thus providing theoretical and methodological support for the joint optimization of high-speed railway ticket price and seat allocation.

keywords: railway transportation; joint optimization; artificial bee colony algorithm; high-speed railway; elastic demand; revenue management

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A Priority-Based Heuristic Approach for Demand-Oriented Train Timetabling

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Abstract: Passengers' train-choice based on a train timetable can be viewed as a feedback of train timetabling, and its application to assist scheduling trains can make train timetable closely fit the travel demands. For combining with passengers train-choosing to optimize the train timetable, this paper firstly formulated a bi-level programming model for their integrated optimization on a rail network. Its upper-level model is to optimize train's arrival and departure times at each visited stations with the aim of reducing passengers' total travel cost, while its lower-level model aims to decide passengers' train-choices based on a given train timetable for calculating the objective of upper-level model, namely, the total travel cost of passengers. Then a priority-based heuristic algorithm is designed to solve this model. It firstly generates an initial train timetable, and then repeatedly improves it according to passengers' train-choices obtained by a passenger distribution sub-algorithm. In the process of improving a train timetable, we first schedule each train one by one according to its distributed passengers, in which all safety headway constraints among trains are temporarily shelved. After that, a sub-algorithm based on a proposed weighted directed graph is designed to make all trains satisfy all considered safety headway constraints. The performance, convergence and practicability of the proposed method are analyzed based on the Changsha-Zhuzhou-Xiangtan intercity rail in China.

Key words: train timetabling; Passenger's train-choice; Demand-oriented; Priority-based heuristic algorithm; Weighted directed graph

Performance Analysis of Two Kinds of Car Assembling Queuing Models

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Abstract: The assembly mode determines the end condition of a car assembly process. Time-fixed assembling is a highly efficient mode, which is propitious to improve transport quality. For the problem of cars assembling in a marshalling station in the time-fixed mode with soften terms, two types of discrete-time single-server finite-buffer batch arrival and batch-service queuing models were established and comparatively analyzed. Both queue length distributions at departure epochs and arbitrary epochs were obtained. Based on these probabilities, various performance measures of interest such as the mean queue length, the mean accumulation delay, busy period probability, traffic volume in one day were discussed though some numerical examples by comparing these two models. Finally, the optimum minimum number of cars with the increasing arriving intensity was also analyzed.

Key words: railway transportation; time-fixed assembly mode with soften terms; queuing system; batch arrivals; batch service; minimum number of cars

基于大小交路的城市轨道交通网络开行方案优化研究

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摘要: 根据城市轨道交通客流分布不均衡特点, 以企业的列车运行成本、乘客换乘等待时间费用为目标, 综合应用大小交路结合多编组的运营模式, 构建了城市轨道交通网络开行方案多目标优化模型。模型的考虑因素包括发车间隔、满载率、可用车辆数、线路通行能力等。最后, 以北京市轨道交通网络为算例, 分析得到平峰期 17 条地铁线路开行方案, 并对满载率和乘客的时间成本进行了灵敏度分析, 结果表明: 4 号线-大兴线以及 10 号线的换乘成本和企业运营成本分别减少了 17.75% 和 12.19%; 随着满载率以及时间成本的增加, 换乘成本在总成本中的比例提高。

关键词: 城市轨道交通; 大小交路; 多编组; 开行方案; 双目标

Optimization for Train Plan of Urban Rail Transit Network Based on Full-Length and Short-Turn Routing

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Abstract:

According to the properties of disproportional distribution of passenger flow in urban railway transit, we develop a multi- objective optimization model of train plan for transit network by integration of full-length and short-turn routing mode and flexible length of train formation, where the objective functions are minimum passenger transfer waiting time for the whole network, and running kilometers of rolling stocks. And the constraints are departure interval, load rate, available number of trains, railway capacity, etc. Finally, Beijing's URT network is explored in a numerical experiment, and the train plans of 17 railway lines during off-peak were analyzed, the sensitivity analysis of the full load rate and the time cost of passengers were also carried out. The results indicate that the passenger generalized travel costs and enterprise operating costs were respectively reduced by 17.75% and 12.19% by this optimization train plan for line 4-Daxing and line10. Moreover, with the increase of load ratio and time cost, the ratio of transfer cost to total cost is increasing.

keywords: urban rail transit; Full-length and short-turn routing; Multi-length of train formation; train plan; Bi-objectives

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基于区间速度控制的列车到达追踪间隔压缩方法及仿真

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摘要: 高速铁路列车追踪间隔是制约线路通过能力的关键, 车站的到达间隔是列车追踪间隔的瓶颈。本文以压缩列车追踪间隔为目的, 通过分段制动的方式, 研究通过速度控制的方法平衡列车区间和到达追踪间隔, 从而优化列车到达追踪间隔时间。在速度控制条件下的列车区间和到达追踪间隔时间计算公式推导的基础上, 分析了速度控制值和速度控制位置对区间及到达追踪间隔的影响, 总结相应规律并设计了不同的区间速度控制方案。以上海虹桥为例进行仿真实验, 分析了一、二、三接近速度控制方案下列车区间、到达追踪间隔以及区间运行时间的变化情况, 研究了较优的区间速度控制策略, 实验结果表明合理的速度控制方案能够显著优化列车到达追踪间隔, 在仿真试验中最多可压缩到达间隔近 80 秒。

关键词: 追踪间隔压缩; 分段制动; 速度控制; 仿真验证

Train Tracking Interval Compressing Method Based on Speed Control in High-Speed Railway Line

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Abstract:

The high-speed railway train tracking interval is the key to restrict the passage capacity. The arrival interval is the bottleneck of the train tracking interval. In order to compress the train tracking interval, this paper studies the speed optimization control method of balancing train section interval and arrival interval by sectional speed reduction. Firstly, the calculation formula of train section interval and arrival interval time under the condition of speed optimization control is derived. Based on this, the influence of speed control value and speed control section on compression tracking interval is analyzed, and the rules are summarized and different speed optimization control schemes are designed. By the simulation experiment of Shanghai Hongqiao, the section interval, arrival interval and increase time of interval travel were obtained for each speed optimization control scheme. The optimal speed optimization control strategy is summarized. The experimental results show that the reasonable speed optimization control can significantly compress the train arrival tracking interval, and the maximum compression can reach nearly 80 seconds.

keywords: train tracking interval compression; sectional braking; speed control; simulation verification

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基于到发线运用的高速铁路列车追踪间隔时间压缩研究

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摘要：压缩列车追踪间隔时间是提高车站通过能力的必要措施。我国高速铁路列车追踪间隔时间相对于日本、法国等国家有进一步优化的空间，而合理的到发线运用方案能够有效压缩追踪间隔时间，对于提高运输能力具有重要的意义。本文首先分析了到发线运用影响追踪间隔时间的机理，随后基于固定到发线运用和不固定到发线运用两种不同的方案，构建压缩列车追踪间隔时间的整数线性规划模型。最后以某高速铁路车站为实例进行分析，运用 cplex 求得两种方案下列车的到发线运用方案，验证模型的有效性。同时进行对比分析得，在不固定到发线运用方案下，到发线运用更均衡，进路冲突疏解更优，压缩追踪间隔时间效果更显著，进而车站通过能力越高。

关键词：到发线运用

Research on Tracking Interval Compression of High Speed Railway Train Based on Track Occupancy

Pan Mingxuan, Lu Gongyuan, Ning Jia
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Abstract:

Compressing train tracking interval is a necessary measure to improve the station's ability. China's high-speed railway train tracking interval has further optimized space compared with Japan, France and other countries, and a reasonable track application scheme can effectively compress the tracking interval time, which is of great significance for improving transportation capacity. This paper first analyzes how the track occupancy influence the tracking interval. Then, based on two different schemes of fixed and unoccupied track occupancy, the paper constructs an integer programming model for compressing train tracking interval. Finally, a highspeed railway station is taken as an example for analysis. Cplex is used to obtain the scheme of track occupancy based on the two schemes, and the validity of the model is verified. At the same time, the occupancy is more balanced, the approach conflict is better, and the compression tracking interval effect is more significant, thereby the station passing ability is stronger.

keywords: track occupancy

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多干扰下的高速铁路列车运行调整优化模型

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摘要: 高速铁路运行图调整优化工作一直是行车调度指挥工作中的重要核心任务之一。本文针对在有多种行车故障(初始晚点、列车限速及到发线不可用)干扰情况下的列车运行图实时调整问题,运用替代图理论,建立混合整数线性优化模型,以列车变更到发线次数和列车晚点延误时间和最小为目标函数,同步实现了列车速度、开行顺序、运行时间及到发线占用调整及优化等问题。针对此复杂数学模型,设计了快速高效的求解算法,并将其应用于武广高速铁路的运行图调整过程中,论证了模型的可行性和有效性,并计算分析了不同类型的干扰下造成的列车晚点时间及变更到发线次数。

关键词: 列车运行调整

Train Rescheduling for High-Speed Railway Under the Influence of Multi-Disturbances

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(长安大学)

Abstract:

It is one of critical tasks to adjust timetable timely in high-speed railway (HSR) operation system. Multi-disturbances, i.e., primary delay, speed limitation or blockage of dwell lines, are considered in this paper, where a mixed integer linear programming is formulated based on the alternative graph to minimize the sum of times of changing dwell lines and secondary delay. Therefore, train real-time speeds, train orders, running times and occupations on dwell lines are adjusted and optimized simultaneously. In order to solve this complex model within a limited time, a new-designed solving algorithm applied in an actual case, i.e., timetable of Wuhan-Guangzhou high-speed railway, and it is able to provide an acceptable solution efficiently, and the validity and feasibility are demonstrated as well during the computation process. At last, delay times and frequencies of changing dwell lines caused by different disturbances are computed and analyzed during the experimental tests.

keywords: train rescheduling

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城市轨道交通区间中断下列车运行调整

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摘要: 为了降低由于城市轨道交通列车在区间发生行车中断干扰对行车造成的影响, 本文探讨了由于行车区间中断造成列车不能运行时的列车运行调整方法。采用集合的思想, 将列车在城市轨道交通线路上运行简化成事件-活动网络模型。采用组织“分段交路”的列车运行调整方式, 基于城市轨道交通的行车特点建立混合整数规划模型, 通过优化软件 Lingo 求解调整后的列车运行时刻表。

关键词: 城市轨道交通; 分段交路; 列车运行调整; 混合整数规划模型

The Train Operation Adjustment of Interval Interruption

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(Chang'an University)

Abstract:

In order to reduce the impact of disruption on urban rail transit trains in the interval, this paper study the train operation adjustment method when the train cannot run due to the interruption. Using the idea of set, the train on the urban rail transit line is simplified into an event-activity network model. Based on the adjustment method of changing route, the paper establish a mixed integer-programming model according to the characteristics of urban transit. The optimization software Lingo solves the adjusted train-running schedule.

keywords: urban rail transit; sectional intersection; train operation adjustment; mixed integer programming model

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高速铁路动态定价与票额分配协同优化研究

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摘要: 基于运输市场的供需关系以及旅客的出行选择行为, 研究高速铁路动态定价与票额分配协同优化方法。考虑旅客的价格需求弹性, 本文以期望收益最大化为目标, 建立高速铁路动态定价与票额分配协同优化模型, 通过设计一种分步求解算法对模型进行求解, 确定不同时段下不同列车的最优票价与票额分配方案。最后通过京沪线算例的优化计算进行验证, 结果表明: 本文采用的模型, 能够根据不同列车的开行特点, 制定合理的时段票价与票额分配方案, 避免长途席位过早裂解, 并将足量的席位留给拥有更高支付意愿的旅客, 从而提高铁路运输企业收益水平, 为我国高速铁路动态票价与票额分配方案的制定提供参考。

关键词: 高速铁路; 动态定价; 票额分配; 协同优化; 收益管理

Study on Collaborative Optimization of Dynamic Pricing and Ticket Allocation for High-speed Trains

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Abstract:

Based on the supply and demand relationship of the transportation market and passengers' travel choice behavior, this paper studied the collaborative optimization method of dynamic pricing and ticket allocation for high-speed railway. Considering the price elasticity of passengers' demand, this paper aimed at maximizing the expected revenue, and established a collaborative optimization model for high-speed railway dynamic pricing and ticket allocation and we designed a fractional steps method to solve and determine the optimal price and ticket allocation for different trains in different time periods. Finally, the optimization calculation of the Beijing-Shanghai High-speed Rail illustrated that the model adopted in this paper can formulate a reasonable time-based price and ticket allocation according to the characteristics of different trains and can avoid premature cracking of long-distance seats, leaving a sufficient number of seats to passengers with higher willingness to pay, so as to improve the revenue of railway transportation enterprises, which could provide a reference for the formulation of dynamic pricing and ticket allocation for high-speed railways in China.

keywords: high-speed railway; dynamic pricing; ticket allocation; collaborative optimization; revenue management

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基于降低传导性干扰策略的道岔跳线设置优化方法

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摘要: 牵引电流对铁路信号系统存在传导性干扰问题, 即不平衡牵引电流干扰。在站内道岔区段, 由于道岔内部设置多跳线、翼轨及岔内绝缘, 牵引电流对轨道电路接收设备及机车信号均有明显干扰影响。本文深入解析道岔结构特点, 通过建立站内道岔区段轨道电路综合仿真模型, 仿真牵引网—机车—钢轨回流完整系统, 分析站内道岔区段传导性干扰形成机理, 并在此基础上提出道岔跳线设置优化方法。主要研究平台为 Multisim 及 MATLAB/Simulink。仿真结果表明: 道岔结构导致两钢轨阻抗不同及道岔区段存在机车感应信号在岔心处被旁路的情况为牵引电流在站内道岔区段形成传导性干扰主要原因, 不同跳线位置下牵引电流干扰强度不同, 故实际工程中可通过合理设置道岔跳线在一定程度上减小干扰。

关键词: 道岔跳线; 牵引电流; 传导性干扰; 站内道岔区段; 轨道电路

Optimization Method of Switch Jumper Setting Based on Strategies for Reducing Conductive Interference

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Abstract:

The traction current has conductive interference to the railway signal system, which is also known as unbalanced traction current interference. In the switch section within station, the traction current has obvious interference on the receiving equipment of track circuit and cab signals due to the installation of multi-jumpers, wing rails and insulation joint inside the switch. This paper analyzes the structural characteristics of switches in depth. By establishing a comprehensive simulation model of switch section track circuit within station and simulating the complete system of return current on traction network - locomotive - rail, the mechanism of traction current conductive interference in the switch section within station is analyzed. Based on this, an optimization method of switch jumper setting is put forward. The main research platform is Multisim and MATLAB/Simulink. The simulation results show that the main reason for the conductive interference of traction current in the switch section within station is that switch structure results in different impedance of two rails and the induction signal of locomotive is bypassed in the switch section. Besides, different jumper location leads to different interference intensity of traction current. Therefore, in practical engineering, it is possible to reduce the interference to a certain degree by reasonably setting the switch jumper.

keywords: switch jumper; traction current; conductive interference; switch section within station; track circuit

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基于数据驱动的 ZPW-2000A 轨道电路故障预警方法研究

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摘要: 文章基于 ZPW-2000A 无绝缘轨道电路的集中监测模拟量数据, 对区间轨道电路的常发故障实现预警。根据集中监测系统所监测的各模拟量数据与设备基本故障之间的映射关系, 使用数据趋势分析的方法, 由历史监测数据预测将来一段时间内的各模拟量数据, 对轨道电路设备可能出现的故障情况提前警报。对现代铁路实行“状态修”综合管理及智能运维的目标有着积极的作用。

关键词: ZPW-2000A 无绝缘轨道电路; 故障预警; 趋势分析

Research on Early Warning Method of ZPW-2000A Joint-Less Track Circuit Based on Historical Data

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Abstract:

Based on the centralized monitoring data of the ZPW-2000A jointless track circuit, this paper realizes the early warning for the frequent faults of the track circuit of the high-speed railway. According to the mapping relation between the monitoring data and the basic equipment faults indoors and outdoors, the data trend analysis method is used to predict the monitoring data in the future period from the historical data, and the possible faults in the track circuit equipment can be early warned. It plays a positive role in the implementation of comprehensive maintenance and intelligent operation and maintenance of modern railways.

keywords: faults prediction; ZPW-2000A jointless track circuit

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地铁车站工程 BIM 正向设计实践

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摘要: 近年来, 轨道交通行业发展迅猛, 行业信息化程度却较为低下。随着 BIM 技术的发展, 给行业的信息化带来新的机遇。这对设计的质量、设计协同方式等均提出了重大的挑战。以某轨道交通工程为例, 详细阐述地铁车站工程在 BIM 正向设计中组织模式和成果应用, 探索了 BIM 技术在正向设计中的设计流程和协同方式, 并应用于工程实践。

关键词: 轨道交通车站; BIM; 正向设计; 正向设计协同

Positive Sequence Design Practice of BIM in Metro Station Engineering

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Abstract:

In recent years, the rail transportation industry has developed rapidly, but the degree of industry informatization is relatively low. With the development of BIM technology, new opportunities are brought to the informatization of the industry. This poses a major challenge to the quality of design and the way to design synergies. Taking a railway traffic engineering as an example, this paper expounds the problems and processing methods of the subway station project in the forward design of BIM, and probes into the design process and cooperation mode of BIM technology in the forward design. And applied to engineering practice.

keywords: rail transit station; Building Information Modeling; Positive sequence design; Positive sequence design coordination

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轨道交通乘客上下车意愿模型

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摘要: 轨道交通飞速发展,为保障行车效率和安全,需对车站站台乘客进行快速疏散。而乘客快速上车是保证站台疏散的关键。本文提出了轨道交通乘客上下车意愿的概念,并建立基于最小二乘的城市轨道交通乘客上下车参数模型,最后根据西安地铁实测数据,计算了西安地铁乘车上车意愿,结果证明乘客上车意愿的存在。最后,为轨道交通站台管理提供依据。

关键词: 上下车意愿; 参数模型; 最小二乘法

Rail Transit Passengers' Willingness to Get On and Off Model

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Abstract:

The rapid development of rail transit, in order to ensure the efficiency and safety of traffic, requires rapid evacuation of passengers at the station platform. Passengers getting on the train quickly is the key to ensuring the evacuation of the platform. This paper puts forward the concept of the willingness of rail transit passengers to get on and off, and establishes the model of urban rail transit passengers getting on and off based on least squares. Finally, according to the measured data of Xi'an subway, the willingness of Xi'an subway to get on the train is calculated. The existence of will is proved. Finally, it provides the basis for the management of rail transit stations.

keywords: willingness to get on and off; parametric model; least squares

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Identifying the Passenger Travel Behavior of the Metro System Using Wi-Fi Information

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Abstract: In order to accurately identify the passenger travel characteristics in urban rail transit with the network operation environment, a distributed traffic behavior identification system with Wi-Fi information is designed. The information detection technology can effectively identify the passenger travel behavior in urban rail transit, avoiding a great deviation between the deductive travel behavior and the actual travel behavior. This paper utilizes Wi-Fi information detection technology to obtain the passenger travel information on urban rail transit stations. The travel characteristics, such as travel time distribution and travel route choice inferred from the Wi-Fi information detection data is shown in field experiment in Xi'an Urban Rail Transit to be consistent with those inferred from AFC data. The result shows travel characteristics can be identified by Wi-Fi information technology with relatively high accuracy, Sampling rate and matching degree, which might provide some basic evidence for improving metro operation management and fare clearing.

Key words: Wi-Fi information; urban rail transit; travel characteristics; travel time distribution

基于系统动力学的地铁站客流主动调控

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摘要: 针对地铁车站高峰时段内普遍存在的地铁站内客流拥堵问题, 将系统动力学与行人交通流理论相结合, 建立地铁站的设施与客流的系统动力学模型, 识别地铁站客流拥堵位置及成因。通过模型分析, 设定客流主动调控方案, 并运用仿真手段评价和比选方案效果及效率。研究表明, 根据地铁站的系统动力学模型仿真分析, 可对其客流主动调控方案提出针对性建议。

关键词: 地铁站; 系统动力学; 主动调控; 行人交通

Research on Active Management of Metro Station Passenger Flow Based on System Dynamics Modeling

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Abstract:

Aiming at the problem of passenger congestion in metro station during rush hour, the system dynamics model is established to model the facilities layout and passenger flow, combined with the pedestrian traffic flow theory. With the simulation model, the location and causes of the metro station congestion are identified. Through system dynamics, the active passenger flow management is established and simulated to evaluate the effectiveness and efficiency of the schemes. The results show that the model based on system dynamics is effective in passenger flow active management and organization. The results show that some effective suggestions could be put forward on the active passenger flow control scheme of the metro station, according to the simulation analysis of its system dynamics model.

keywords: metro station; System dynamics; Active management; Pedestrian traffic

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基于客票数据的沪宁高铁客流特征分析

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摘要: 将2016年7月至2017年7月的沪宁高铁客票数据作为基础统计数据, 据此对沪宁高铁沿线各个城市的流联系强度、联系方向指数、集中度系数以及城市吸引力这四个指标进行了计算, 由此得出基于客流强度的沪宁高铁沿线城市等级体系, 在新的城市等级划分基础上, 对沪宁高铁一年内不同时期的客流特征进行分析, 包括节点客流、区间断面客流、出行OD、时段客流量、旅客平均运距等内容。最后从运输组织、票价制定这两个角度对沪宁高铁的运营管理给出了相关建议。

关键词: 沪宁高铁; 大数据; 客流分析; 城市等级划分

Analysis of Passenger Flow Characteristics of Shanghai-Nanjing High-Speed Railway Based on Passenger Ticket Data

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Abstract:

The annual ticket data from July 2016 to July 2017 of Shanghai-Nanjing high-speed railway is used as the basic statistical data. Based on this, the four indicators of the flow connection strength, the contact direction index, the concentration coefficient and the urban attraction of each city along the Shanghai-Nanjing high-speed railway are calculated. Based on the urban grading system of Shanghai-Nanjing high-speed railway based on passenger flow intensity, the characteristics of passenger flow in different periods of Shanghai-Nanjing high-speed railway are analyzed based on the new urban classification, including node passenger flow, section passenger flow, travel OD, and time passenger flow. Volume, average passenger distance and other content. Finally, from the two perspectives of transportation organization and fare formulation, relevant suggestions are given for the operation and management of Shanghai-Nanjing high-speed railway.

keywords: shanghai-Nanjing high-speed rail; passenger flow analysis; city classification; Big Data

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基于客票数据的郑西高铁客流特征分析

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摘要: 选取郑西高铁为研究对象, 提取了2016年8月1日至2017年7月31日期间一年的客票数据, 从客流时空分布特征和旅客出行行为特征入手, 分析了郑西高铁的客流特征及其变化规律。其中, 客流时空分布特征分析包含日均小时客流量、客流变化规律、上下行客流、节点客流、客流 OD、区间断面客流量及客流运距分析; 旅客出行行为特征分析包含出行时刻与旅行时间的规律以及席别选择与乘车区间之间的联系分析。基于郑西高铁的客流特征及变化规律, 从加强客运营销、优化运输组织和完善换乘服务系统三个角度出发, 为郑西高铁的运营策略优化提出建议。

关键词: 郑西高铁; 客票数据; 客流特征; 运营建议

Analysis of Passenger Flow Characteristics of Zhengzhou-Xian High-Speed Rail Based on Ticket Data

Hao Lina, Qin Jin, Tan Yuchao

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Abstract:

Taking Zhengzhou-Xian high-speed railway (HSR) as the research object, the passenger ticket data of one year between August 1, 2016 and July 31, 2017 were extracted. From the characteristics of the spatio-temporal patterns of passenger flow and the travel behavior of passengers, the passenger flow characteristics and their changing rules of Zhengzhou-Xian HSR were analyzed. Among them, the analysis of spatio-temporal patterns of passenger flow includes daily hourly passenger flow, passenger flow change rule, upstream and downstream passenger flow, node passenger flow, passenger flow OD, section passenger flow and passenger flow distance analysis. The analysis of passenger travel behavior characteristics includes the law of travel time and travel time and the analysis of the relationship between seat choice and travel interval. Based on the passenger flow characteristics and change rules of Zhengzhou-Xian HSR, this paper puts forward suggestions for the operation strategy optimization of Zhengzhou-Xian HSR from three perspectives of strengthening passenger transport marketing, optimizing transportation organization and improving transfer service system.

keywords: zhengzhou-Xian high-speed railway; passenger ticket data; passenger flow characteristics; operational advice

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Crowded Treading Warning System for Urban Rail Transit Stations Based on Video Detection Technology

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Abstract: Based on the rapid development of rail transit and the large crowded treading dangers of rail transit stations, this paper proposes to construct a crowded treading warning system for urban rail transit stations based on video detection technology, which uses video detection technology to passenger flow in rail transit stations. The passenger flow, velocity and density data of the bottleneck channel are collected, the passenger flow prediction neural network model is trained and the traffic flow density is predicted by the three-parameter relationship of the traffic flow, and the SPSS software is used to fit and analyze the passenger flow parameters. The limit value of the flow-density polynomial model passenger flow is predicted, and the pedestrian flow mutation model based on the catastrophe theory is input to realize the definition of the critical passenger flow density. On this basis, the real-time predicted value of the passenger flow density is compared with it. Analysis, set the corresponding early warning coefficient, early warning level and early warning measures, so as to truly realize the real-time warning of crowding and trampling of rail transit stations based on passenger flow density prediction.

Key words: video detection; crowded stepping; passenger flow; warning level

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地铁碰撞事故站姿乘员头部损伤评估

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摘要: 随着人口增长和城市发展,地铁交通发展越来越迅猛。地铁碰撞事故中的乘员安全也被愈加重视。本文选取地铁站姿乘员作为研究对象,针对碰撞事故中最为危险的乘员头部进行损伤评估。本文根据某型地铁车厢布局和常见站姿乘员站姿在 MADYMO 软件中建立车厢-乘员-吊环/横杆耦合碰撞动力学模型,进行乘员碰撞动力学响应分析;建立头-地板耦合碰撞有限元模型,选取颅内压力、脑组织 Von-mise 应力和颅骨 Von-mise 应力对地铁碰撞事故中不同站姿的站姿乘员进行了头部损伤分析。结果表明:地铁碰撞事故中站姿乘员头部损伤情况比较严重,甚至存在致命危险;基于有限元仿真参数的头部损伤分析可以准确判别头部损伤的位置、严重程度,有效的预测站立乘员头部碰撞损伤。该研究可为地铁车辆站立乘员碰撞保护提供基础数据和研究思路。

关键词: 地铁碰撞事故

Evaluation of Head Damage of Standing Crews in Subway Collision Accidents

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Abstract:

With population growth and urban development, subway traffic is developing more and more rapidly. The safety of occupants in subway crashes has also received increasing attention. In this paper, the subway station occupant is selected as the research object to evaluate the damage of the most dangerous occupant's head in the collision accident. In this paper, the car-occupant-loop/crossbar coupling collision dynamics model is established in MADYMO software according to the layout of a certain type of subway car and the common standing attitude. The occupant collision dynamics analysis is carried out. The head-floor coupled collision finite element model is established. The intracranial pressure, the Von-mise stress of the brain tissue and the Von-mise stress of the skull were used to analyze the head injury of the standing occupants in different standing positions in the subway collision accident. The results show that the head injury situation of the occupant in the subway collision accident is serious and even fatal; the head damage analysis based on the finite element simulation parameters can accurately determine the position and severity of the head injury, and effectively predict the standing occupant head. Partial collision damage. This research can provide basic data and research ideas for the collision protection of subway vehicles standing occupants.

keywords: subway crash

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中低速磁浮铁路桥上疏散平台设计参数对疏散时间的影响

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摘要: 中低速磁浮铁路高架区间的人员安全疏散问题一直受到广泛关注, 桥上疏散平台设计参数对桥上乘客紧急疏散用时有重要影响。基于多智能体人员疏散仿真平台 Pathfinder, 构建中低速磁浮铁路高架线路区间疏散仿真模型, 模拟了疏散平台主要设计参数入口宽度 d_1 和平台宽度 d_2 在 90 种不同取值匹配条件下对桥上区间人员疏散用时的影响规律。研究表明, 建议将疏散区域进行划分并将疏散时间评价指标由疏散总时间增加至全部乘客离开列车用时 t_1 , 全部乘客离开危险区用时 t_2 , 全部乘客离开车站用时 t_3 等 3 个指标, 并以 t_2 时间作为疏散平台设计的参考依据。高架线路区间乘客双向自由疏散场景下, 相同疏散人数的疏散时间 t_1 、 t_2 、 t_3 会随疏散平台通道宽度 d_2 的增大而减小, 增加疏散通道宽度平台的入口宽度 d_1 会导致乘客疏散时间的变化趋势不同。此外, 合理匹配疏散平台入口宽度和通道宽度可有效缩短人员疏散用时, 建议在相关设计规范中增加对疏散平台入口宽度这一设计参数的规定。

关键词: 中低速磁浮; 疏散; 高架桥; 仿真模拟; 参数设计

Study of Influence Between Evacuation Time and Evacuation Walkway Design Parameter of Medium and Low Speed Maglev on Viaduct

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Abstract:

Passenger evacuation of Medium and Low Speed Maglev on viaduct has aroused wide concern. The design parameters of Evacuation walkway has shown a significant impact on passenger's evacuation time since it is the main evacuate facility in an emergency. To clarify the influence between evacuation walkway design parameters and evacuation time for interval evacuation on a viaduct, a multi-agent evacuation simulation model of Medium and Low Speed Maglev is built up based on Pathfinder Simulator. With this model, the evacuation time of 90 match conditions of entrance wide d_1 and platform wide d_2 of the evacuation walkway are calculated. The main results show that evacuation time on the viaduct is better to be divided into 3 stages during one evacuation process. Besides, the change rules of egress time in different match conditions of walkway parameters shows that reasonable match of entrance wide d_1 and walkway wide d_2 will significantly decrease evacuation time on viaducts. From the perspective of actual demand in evacuation on the viaduct. Entrance wide d_1 should be taken into consideration in evacuation walkway design specification and recommended match values of d_1 and d_2 are discussed in this research.

keywords: Mid and Low Speed Maglev; Evacuation; Viaduct; Simulation; Parameter Design

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磁浮铁路乘客疏散心理及行为调查及分析

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摘要: 磁浮铁路作为新型城市轨道交通系统, 其突发事故下的乘客安全疏散问题已得到广泛关注。由于磁浮铁路在车辆轨道结构和疏散环境、疏散设施等方面具有特殊性, 因此了解突发事故条件下特殊环境中的乘客群体心理和行为特点对完善磁浮铁路系统应急疏散工作具有重要意义。对国内两条客流量交大的磁浮线路上的乘客开展问卷调研, 获得 338 份有效分卷, 对乘客的安全疏散常识及疏散中可能出现的心理反应和行为进行了统计分析, 并利用卡方检验对结果相关性进行分析。研究结果表明, 磁浮铁路内乘客在疏散过程中的心理反应与行为与性别、受教育程度、是否经历过疏散演习及是否熟悉车站等因素显著相关, 磁浮铁路系统应急疏散的有关研究应考虑疏散环境和疏散设施对乘客心理因素所带来影响, 增强疏散过程引导、增加疏散标志数量和内容清晰程度、扩大安全疏散演习公共参与程度等措施可有助于提高磁浮铁路系统应急疏散安全性。

关键词: 磁浮铁路; 应急疏散; 心理; 问卷调查; 相关性分析

Investigation and Analysis on Passenger Psychology and Behavior of Evacuation of Maglev Transit

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Abstract:

As a new type of urban rail transit system, emergency evacuation on Maglev railway has attracted widely attention recently. It is important to understand the characteristics of passenger's psychology and behavior in emergency circumstances for improving emergency evacuation on Maglev railway lines. A questionnaire survey was implemented on two main Maglev lines in China and 338 valid volumes questionnaires were obtained. Statistical analysis was conducted on passengers' opinions on emergency evacuation facilities, common sense of safe evacuation, psychological reflection of evacuation and possible evacuation behaviors, and the correlation between the results was analyzed by using Chi-square test. The results show that passenger's psychological activities and actual evacuation movement are significantly correlated with the gender, the level of passengers' education as well as related to the status that whether the passengers have experienced evacuation drills or be familiar with the station surroundings. Therefor passengers' psychological activities and potential evacuation movement, which are strongly influenced by evacuation environment and facilities, should be taken into consideration in evacuation study for Maglev transit system. Meanwhile, strengthening guidance in evacuation, increasing the number of evacuation marks and the content comprehensibility and expanding

public participation in safety evacuation drills can help improve emergency evacuation safety for maglev railway system.

keywords: Maglev Transit; Emergency Evacuation; Psychology; Questionnaire Survey; Correlation analysis

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基于大地震风险分析的川藏铁路线路方案评价模型

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摘要: 川藏铁路途经的道孚、甘孜地区是我国著名的高地震烈度区, 区内地震活动强烈, 频次高、震级大。因此, 开展针对川藏铁路的基于大地震风险分析的线路方案评价研究, 对于川藏铁路的选线设计和安全运营具有重要作用。本文首先提出铁路大地震风险的定义及计算方法; 然后通过改进铁路传统的评价方法, 建立了大地震风险区铁路线路方案评价模型, 并利用联合概率模型计算大地震的复发概率; 再利用 ALARP 准则将风险分为可接受风险、可容忍风险及不可容忍风险三类, 通过利用改进的方案评价方法和汶川大地震实震统计数据提出了相应铁路大地震风险的分类标准, 并建立了通过方案比选作业从宏观层面实施铁路大地震风险调控的技术体系。实例分析表明: (1) 炉霍段铁路的大地震经济风险属于可容忍风险范围; (2) 桥隧比例低的线路方案, 考虑了大地震风险后的年换算工程-期望运营费增加不多, 这应是具有普适性的现象。

关键词: 川藏铁路; 大地震; 方案评价; 风险调控; 风险标准; ALARP 准则

Scheme Evaluation Model of Sichuan -Tibet Railway Based on Large Earthquake Risk Analysis

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Abstract:

Research purposes: The area of Daofu and Ganzi along the Sichuan-Tibet railway are the most famous area of high seismic intensity in china. Seismic activity in the area is strong, the frequency is high and the magnitude is large too. Therefore, the study on the evaluation of the route scheme based on the large earthquake risk analysis is of great importance to the route selection design and safe operation for the Sichuan-Tibet railway.

Research conclusions: Firstly, the definition of railway large earthquake risk is proposed based on risk analysis theory, and the joint probabilistic model is used to calculate the occurrence probability of large earthquake. Then, the risk is divided into three categories of acceptable risk, tolerable risk and intolerable risk. By analyzing the Chinese railway safety conditions and the risk criteria of other related industries, the related parameters are pertinently demonstrated and analyzed and the F-N curves of life risk standard are built too. Combined with the life risk standard curve and the railway economic evaluation method, a relative standard and absolute standard of economic risk is put forward respectively. The final example analysis shows that: (1) The economic risk of large earthquakes in the Luhuo section railway belongs to the tolerable risk range; (2) The conversion engineering - expected operating expenses increases less after considering the large earthquake risk for the low proportion of bridge and tunnel line scheme, and this should be a universal phenomenon.



keywords: Sichuan -Tibet railway; large earthquake; risk control; risk criteria; scheme selection

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成都轨道交通 6 号线金府路无柱车站结构与修建技术

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摘要: 结合成都轨道交通 6 号线金府站紧邻交大路下穿金府路城市道路隧道和金府与长久机电城的工程环境, 首次在成都地区砂卵石地层中设计和采用了无柱拱形的轨道交通地下车站, 分析了车站基坑围护和无柱拱形结构的设计特点, 并总结了车站基坑的围护结构形式及车站主体所采用的施工方法。工程实践表明金府站基坑围护结构和车站主体结构的设计和施工是合理可行的, 可供类似复杂城市工程环境下轨道交通地下车站结构的设计与施工提供借鉴。

关键词: 城市轨道交通, 无柱拱形车站, 基坑, 半盖挖顺做法, 非完整异形钻孔桩

Design and Construction of Underground Station with No-Pillar in Jinfu Road on Chengdu Rail Transit Line 6

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Abstract:

On the basis of the urban surroundings in which Jinfu metro station closely adjoins Jiaoda road tunnel passing through Jinfu road as well as Jinfu and Changjiu trade building for selling mechanical and electronic instruments, an arch-shaped urban rail transit underground station with no-pillar is firstly designed on Chengdu metro line 6 in sandy cobble strata. The characteristics of designing the retaining piles for foundation pit of Jinfu station as well as the arch-shaped station with no-pillar is analyzed. Meanwhile, the type of retaining structure for foundation pit along with construction method to build the metro station is also summarized in this paper. Engineering practice shows that the design and construction technique presented in this paper turns out to be both rational and feasible and can be used to design and build urban rail transit underground station under both similar and complex urban environment.

keywords: urban rail transit; arch-shaped station with no-pillar; foundation pit; semi-cover and cut method; incomplete heterotypical bored pile

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地铁车站附属基坑支护体系研究及典型布置

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摘要: 轨道交通作为从根本上改善城市公共交通状况的有效途径,在城市公共交通中起着越来越重要的作用。合肥市的目标是成为“区域性特大城市”,“十三五”期间也将加快轨道交通建设。结合合肥市轨道交通1~5号线的设计和施工情况,从围护形式选择及嵌固深度、支撑水平及竖向布置、换撑处理、管线悬吊以及膨胀土处理等方面研究车站附属围护结构设计要点,并归纳几种典型形状的附属围护结构平面布置,以增加对附属基坑的理解与认识,有利于在建线路设计工作的标准化、科学化、合理化,从而不断提高工作效率与质量。

关键词: 车站附属; 基坑工程; 支护体系; 典型布置

Research and Typical Arrangement of Foundation Pit Support System of Subway Station

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Abstract:

As an effective way to fundamentally improve the urban public transportation situation, rail transit plays an increasingly important role in urban public transportation. The goal of Hefei is to become a “regional mega city” and will accelerate the construction of rail transit during the “13th Five-Year Plan” period. Combined with the design and construction of Hefei Rail Transit Lines 1 to 5, the station perimeter is selected from the aspects of enclosure form selection and depth of consolidation, support level and vertical arrangement, changing support, pipeline suspension and expansive soil treatment. The main points of the design of the retaining structure, and the layout of several typical shapes of the auxiliary retaining structure, to increase the understanding and understanding of the auxiliary foundation pit, is conducive to the standardization, scientific and rationalization of the design work in progress, so as to continuously improve the work efficiency and quality.

keywords: station attachment; foundation pit engineering; support system; typical arrangement

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高速铁路线路方案动力学评估研究

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摘要: 针对我国承担的某海外高速铁路项目线路设计需求, 对线路方案采用动力学方法进行评估及分析, 研究得到: (1) 基于动力学的 PCT 评价方法考虑了列车运行过程中车体跟随轨道面的不同步性, 可较为客观反映乘客舒适性; (2) Sperling 指数和 UIC513 评价方法未完全涵盖线形引起的低频振动, 难以区分线路比选方案在舒适性方面差异性, 而 PCT 评价主要考虑了线形引起的振动量, 能较好区分不同线路方案对舒适性的影响程度; (3) 车体加速度和行车安全性指标频次统计可反映不同线路条件下列车对线路动力作用的强弱程度, 可用于评估不同线路方案在运营中的效果。(4) 本文提出的线路方案动力学评价方法能推广应用于其他类似项目。

关键词: 高速铁路; 线路; 动力学; 评估

Research on Dynamic Evaluation of Route Alignment Scheme for High Speed Railway

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Abstract:

The route alignment scheme were evaluated and analyzed using vehicle track dynamic method , based on the design requirements of a overseas high speed railway project in China. (1) Based on the PCT dynamic evaluation method, the non-synchronization of the car body following the track surface is considered in the course of running train operation, which can reflect the comfort of passengers objectively; (2) Sperling index and UIC513 evaluation methods are not fully evaluate low frequency vibration induced by route alignment, so it's difficult to distinguish the comfort differences between route alignment schemes. But the PCT method mainly evaluated low frequency vibration and passenger comfort, which can distinguish the influencing degree of comfort between different route alignment schemes preferably; (3) Carbody acceleration and traffic safety index frequency statistics can reflect the dynamic effect of train on track, which can be used to evaluate the effect of different route alignment schemes in operation; (4) The dynamic evaluation method of route alignment scheme proposed in this paper can be applied to other similar projects.

keywords: High speed railway; Route alignment; Dynamics; Evaluation

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The Finite Element Analysis of Pile-Soil Stress Ratio in Geogrid-Reinforced and Pile-Supported Embankments Under High-Cyclic Loading

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Abstract: The pile-soil stress ratio in geogrid-reinforced and pile-supported embankments may change under high-cyclic loading, especially the low subgrade (the height less than 3 meters). Currently, the finite element analysis of pile-soil stress ratio in geogrid-reinforced and pile-supported embankments under high-cyclic loading is rare. In the view of this, a new method (called “the implicit-explicit method”) is applied in the finite element software. Based on the further development platform provided by ABAQUS, this implicit-explicit method is programmed by FORTRAN into the user-defined material subroutine (UMAT). The finite element model is established by ABAQUS to simulate the field test, in order to confirm the validity of the finite element model. Using this verified finite element model, pile-soil stress ratio under high-cyclic train loads is analyzed.

Key words: elastoplastic; geogrid-reinforced and pile-supported embankments; high-cyclic loading; pile-soil stress ratio

高速铁路隧道压力波传播特性与研究方法综述

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摘要: 当列车高速穿过隧道时, 由于隧道内的空间受限, 列车前方产生明显的压力瞬变; 由于车厢有限的密封性, 列车内部会同时发生相应的变化。目前我国对隧道压力波的研究仍大量停留在数值模拟和模型试验等方面。本文结合现阶段国内外关于隧道压力波的数值模拟与现场实测研究方法现状, 归纳了适合数值模拟采用的方法; 提出了一种较传统方法更为适合隧道压力波特点的现场实测方案。通过相关方法对隧道压力波进行研究, 结果显示, ThermoTUN 模拟分析软件进行压力波数值模拟具有可行性; 采用 PCB 压电式微气压计和 CRONOS 多功能测量系统对压力波进行实车测量能更加精确地反映出高速列车通过隧道时列车内部的压力变化情况, 可为数值模拟和模型试验提供可靠的实验论证。

关键词: 隧道压力波; 高速列车; 数值模拟; 实车测试

Review of Pressure Wave Propagation Characteristics and Research Methods in High Speed Railway Tunnels

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Abstract:

When the train passes through the tunnel at high speed, obvious air pressure transients occur due to the limited airspace in the tunnel. The pressure variations will also be observed inside the train due to limited sealing performance. At present, the research on tunnel pressure wave in China still hangs on numerical simulation calculation and model test. This paper combines the current situation of numerical simulation and field measurement research methods of tunnel pressure waves at home and abroad, and summarizes the methods suitable for numerical simulation. It also proposes a field measurement scheme which is more suitable for tunnel pressure wave characteristics than traditional methods. The tunnel pressure wave is studied by related methods. The results show that the Thermo TUN simulation analysis software is feasible for numerical simulation of pressure wave. The PCB piezoelectric micro-barometer and CRONOS multi-function measurement system can accurately measure the pressure wave. It reflects the change of pressure inside the train when the high-speed train passes through the tunnel, and provides reliable experimental demonstration for numerical simulation and model test.

keywords: tunnel pressure wave; high speed train; numerical simulation; vehicle testing

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Improvement of Vibration Reduction of the Ladder Track by Different Supporting Forms

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Abstract: In order to improve vibration reduction of the ladder track, three different supporting forms are introduced in this paper. Firstly, mode shapes and natural frequencies of these three ladder tracks are studied by FEM. Secondly, the vibration acceleration at the longitudinal sleepers and the ground under the impulse force is measured. Finally, the vibration-reduction ability of ladder tracks is analyzed. The results show that the supporting form, i.e. adding extra bearing pads under the sides of the longitudinal sleepers based on the commonly used ladder track, has the higher natural frequencies than the other supporting forms. It makes the ladder track more stable and has the better vibration-reduction ability in 1~80 Hz.

Key words: underground railway; floating-slab track; ladder track; modal analysis; vibration measurement

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The Effect of Soil Reinforcement on the Train-Induced Vibration of the Railway Embankment-Metro Tunnel Intersection

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Abstract: The authors conduct an in-situ measurement of the train-induced the vibration response at the intersection of the Beijing-Shanghai Railway embankment and the Shanghai Metro Line 11 tunnel. The measuring points are arranged on the railway sleepers, the railway shoulders and the ground surface, the vibration acceleration was monitored when the train passing. The effect of the soil reinforcement on the environmental vibration is studied through using the established FEM. The results confirm that with the spreading of the vibration, the maximum of the ground vibration acceleration induced by the train attenuates with fluctuation. The measured results are consistent with the simulated results, which verify the correction of the model. The results of the tests indicate that the elastic modulus increases with the soil reinforced, the acceleration of ground vibration increases with fluctuation, which is unfavorable to control the ground vibration.

Key words: Embankment-tunnel intersection

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城市轨道交通大跨连续梁桥线形变化引起的行车动力响应分析

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摘要: 针对某城市轨道交通大跨连续梁桥(跨径 75.5m+129m+75.5m), 首先分析了该桥梁的变形发展趋势, 并建立考虑桥梁线形变化的地铁 A 型车列车一承轨台式轨道结构一大跨连续梁桥耦合动力学模型, 开展了连续梁桥线形变化(边跨上拱、中跨下挠)对列车运行性能和扣件系统受力影响的研究。研究表明: 某主跨为 129m 的城市轨道交通大跨连续梁桥自建成后呈中跨大幅度下挠、两个边跨略有上拱的“海鸥型”变形形状, 建成 4 年后, 轨面最大下沉量为 72.0mm, 但桥梁现状线形在单双线行车情况下, 各控制截面竖向位移和加速度仍可满足规范限值要求; 在城市轨道交通列车运行速度范围内(120km/h 以下), 桥梁中跨跨中徐变下挠量不超过 100mm, 列车运行安全性指标均远小于地铁设计规范限值, 当车速增至 100km/h 时, 桥梁线形变化成为列车运行舒适性的主控指标; 大跨连续梁桥边跨上拱值达到 25mm 时, 扣件上拔力超过 8kN 限值, 而中跨下挠量并不引起扣件上拔力显著增长。

关键词: 轨道交通; 大跨连续梁; 线形变化; 列车运行; 扣件受力

Analysis of Dynamic Response of the Large Span Continuous Beam Bridge in Urban Rail Transit and Train Operation

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Abstract:

Taking a large span continuous beam bridge (75.5m+129m+75.5m) of the Rail Transit as the research object, Firstly, the deformation development trend of the bridge was analyzed. Then a three-dimensional finite element coupling dynamic model of type A metro train-supporting block track-large span continuous beam bridge, which considered the girder deformation, was established and verified. Finally the influence of the deflection/camber of girder on the train running performance and the fastener force was studied. The research conclusions can provide reference for making the scientific alert threshold for large span continuous beam bridges of urban rail transit. The research shows that: the large-span continuous beam bridge with a main span of 129m gradually developed into a “seagull-shaped” deformed shape (upward deformation in the side span, downward deformation in the middle span). The maximum track settlement was 72mm 4 years after the actual bridge was built, but the vertical displacement and acceleration of the bridge control sections are in accordance with the specification. Within the operating speed range of urban rail transit trains (below 120km/h), when the mid-span deflection is less than 100mm, the train running safety indicators are far less than the specification limits, only when the train speed increases to 100km/h, the girder deformation becomes the decisive factor to determine train running comfort. When the side-span camber of the continuous beam bridge reaches 25mm, the

uplift forces of the fastener exceeds the limit of 8kN, and the mid-span deflection does not cause a significant increase in the uplift forces of the fastener.

keywords: urban rail transit; large span continuous beam bridge; girder deformation; train operation; fastener force

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磁流变阻尼半主动隔振的钢弹簧浮置板轨道动力响应分析

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(西南交通大学)

摘要: 为了提高钢弹簧浮置板轨道的低频减振效率, 借鉴磁流变阻尼半主动控制技术, 研究建立了车辆-磁流变阻尼半主动隔振钢弹簧浮置板轨道的垂向耦合动力学模型与磁流变阻尼地棚半主动开-关 (On-Off) 控制的数值模拟方法, 并仿真分析了磁流变阻尼半主动隔振浮置板轨道的非线性动力响应特征。研究结果表明: (1) 磁流变阻尼力能够提高浮置板轨道垂向变形的安全余量, 但是过大的磁流变阻尼力易引起钢轨出现上拱现象; (2) 磁流变阻尼半主动隔振能够重新调整浮置板轨道下部振动能量的频域分布, 既能有效分担浮置板轨道下部 1-16Hz 的低频振动能量, 也能将人体敏感频率 (4-8Hz) 的能量转变为极低频的能量 (低于 1Hz) 向外传播; (3) 应用磁流变阻尼后, 增大了浮置板轨道支承刚度的下调余量, 可进一步提高浮置板轨道的隔振效率。

关键词: 钢弹簧浮置板轨道; 磁流变阻尼; 半主动控制; 车辆-轨道耦合动力学; 非线性动力响应

Vibration Response Analysis of Spring-Steel Floating Slab Track with the Semi-Active Vibration-Isolation Magneto-Rheological Dampers

Wei Kai, Xie Meng

(Southwest Jiaotong University)

Abstract:

In order to improve the low-frequency vibration-reduction efficiency of steel-spring floating slab track (FST), Semi-active magneto-rheological (MR) damping technology is embedded under FST. A vertical dynamic model involving vehicle and steel-spring FST isolated by MR dampers is established, and a numerical simulation method for semi-active On-Off ground-hook control strategy of MR damper is also proposed. Based on the dynamic model and simulation method, the non-linear vibration response characteristics of steel-spring FST supported by semi-active MR dampers are investigated. The results show that MR damping force can increase the safe allowance of vertical FST deformation, but too much MR damping force easily make steel rail arch up. Semi-active MR damping force can readjust the frequency-domain distribution of vibration energy under FST. In other words, semi-active MR damping force can not only effectively share the vibration energy between 1Hz and 16Hz under FST, but also transform the propagating vibration energy at the sensitive frequencies (4~8Hz) of human beings into the one at the frequencies less than 1Hz. After application of MR damping, FST supporting stiffness is allowed to reduced, and the vibration-isolation efficiency of steel-spring FST can be also further improved.

keywords: steel-spring floating slab track; magneto-rheological damper; semi-active control;



vehicle-track coupled dynamics; nonlinear dynamic response

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钢轨扣件弹性垫板的动态黏弹塑性力学实验及理论表征研究

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(西南交通大学)

摘要: 以 Vossloh300 钢轨扣件弹性垫板为研究对象, 利用配有温度箱的力学试验机, 并结合基于温频等效原理与 WLF 方程的分数阶 Zener 模型以及 Berg 摩擦模型, 测试与表征了该弹性垫板随温度、频率、振幅非线性变化的黏弹塑性动力特征。研究发现, (1) 动载较大且频率较低时, 扣件弹性垫板的滞回曲线具有超弹性与塑性非线性力学特征, 但当频率提高后, 该滞回曲线将接近线性黏弹性的椭圆形滞回曲线; (2) 扣件弹性垫板温/频变的黏弹性动力特征与动载大小基本无关, 但随预压力的增加而显著增大; (3) 基于温频等效原理与 WLF 方程的分数阶 Zener 模型能快速获取扣件弹性胶垫任意温度与任意频率下的黏弹性动力特征, 而且在铁路轮轨振动主频带内更适合描述低温环境下损耗因子的频变特性。

关键词: 钢轨扣件弹性垫板; 黏弹塑性动力特征; 温变、频变与幅变动力特征; 动力试验; 动力模型

Experimental Investigation and Theoretical Model of Viscoelastic and Plastic Dynamic Properties of Rail Pads

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Abstract:

The viscoelastic and plastic dynamic properties of a Vossloh 300 rail pad were measured by the mechanical testing machine equipped with a temperature control box. Then a fractional derivative Zener model based on Time-Temperature Superposition and WLF formula, in parallel with Berg friction model, was used to describe the frequency-, temperature- and amplitude-dependent dynamic properties of the test rail pad. It is found that (1) the dynamic hysteresis curve of the test rail pad has a super-elastic and plastic mechanical characteristic under a low-frequency large-amplitude dynamic load. However, as the frequency increases, the dynamic hysteresis loop would approach the linear viscoelastic elliptic hysteresis loop. (2) The frequency- and temperature-dependence of the dynamic viscoelastic properties of the test rail pad have little relationship with the amplitude, but apparently increase with the increase of preloads. (3) The fractional derivative Zener model based on Temperature-Time superposition and WLF formula could represent dynamic viscoelastic properties of the test rail pad in any temperature and frequency, and the model is more suitable to describe the frequency-dependent loss factors of rail pads within the dominant frequency-band of railway wheel - rail vibrations at low temperatures.

keywords: rail pad; viscoelastic and plastic dynamic properties; temperature-, frequency- and amplitude-dependent dynamic properties; dynamic experiment; dynamic model

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扣件胶垫频变动力性能对钢轨垂向振动特性影响分析

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摘要: 本文利用配有温度箱的万能力学试验机, 结合温频等效原理与 WLF 方程的分数阶 Zener 模型测试与表征了 Vossloh300 钢轨扣件弹性垫板随频率非线性变化的粘弹性动力性能, 并基于有限元方法研究考虑胶垫频变特性对钢轨垂向振动及传递衰减的影响规律。研究表明:(1) 在双对数坐标系下, 扣件胶垫刚度和阻尼系数与频率近似呈线性正相关和负相关。

(2) 胶垫阻尼频变主要增强中低频范围内的钢轨垂向振动, 并能激发出钢轨一阶垂向共振频率; 胶垫刚度频变能更准确预测钢轨一阶垂向共振频率; 而胶垫频变特性对钢轨 pinned-pinned 共振频率无影响。(3) 考虑胶垫频变特性后, 在一阶垂向共振频率以下, 钢轨振动在激振点附近快速衰减, 超过该频率钢轨振动主要沿钢轨纵向衰减。

关键词: 扣件胶垫; 频变特性; 钢轨振动; 位移导纳; 衰减率

Influence of Frequency-Dependent Dynamic Properties of Rail Pad on Vertical Vibration Characteristics of Rail

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Abstract:

In this paper, the frequency-dependent dynamic properties of the rail pad of the Vossloh 300 fastener were tested by universal mechanic machine and temperature box, which characterized by the temperature-frequency equivalent principle and the fractional-order Zener model of the WLF equation. Then the influence of the frequency-dependent properties of the rail pad on the vertical vibration and transmission attenuation of the rail was analyzed based on the finite element method. The results show that: (1) In the double logarithmic coordinate system, the stiffness and damping coefficient of the rail pad are linearly positively or negatively correlated with the frequency. (2) The frequency-dependent damping of the rail pad mainly enforces the vertical vibration of the rail in the middle and low frequency range, which excites the first-order vertical resonance frequency of the rail. The frequency-dependent stiffness of the pad can predict the first-order vertical resonant frequency of the rail more accurately. The pinned-pinned resonance frequency of the rail is not affected by the frequency change characteristics of the pad. (3) Considering the frequency-dependent dynamic properties of the rail pad, the rail vibration below the first-order resonance frequency of rail could reduce near the excitation point, while high frequency vibration of rail will not attenuate rapidly and spread along the rail in a long distance.

keywords: rail pad; frequency-dependent dynamic properties; rail vibration; displacement admittance; decay rate

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High-Frequency Random Vibration Analysis of a High-Speed Vehicle-Track System with the Frequency-Dependent Dynamic Properties of Rail Pads Using a Hybrid SEM-SM Method

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Abstract: A hybrid SEM–SM method for high-efficiency computation of the high-frequency random vibrations of a high-speed vehicle–track system with the frequency-dependent dynamic properties of rail pads is presented. First, the Williams-Landel-Ferry (WLF) formula and Fractional Derivative Zener (FDZ) model were respectively applied for prediction and representation of the frequency-dependent dynamic properties of Vossloh 300 rail pads frequently used in China’ s high-speed railway. Then, the proposed hybrid SEM–SM method was used to investigate the influence of the frequency-dependent dynamic performance of Vossloh 300 rail pads on the high-frequency random vibrations of high-speed vehicle – track systems at various train speeds or different levels of rail surface roughness. The experimental results indicate that the storage stiffness and loss factors of Vossloh 300 rail pad increase with the decrease of dynamic loads or the increase of preloads within 0.1–10000 Hz at 20° C, and basically linearly increase with frequency in a logarithmic coordinate system. The results computed by the hybrid SEM–SM method demonstrate that the frequency-dependent viscous damping of Vossloh 300 rail pads, compared with its constant viscous damping and frequency-dependent stiffness, has a much more conspicuous influence on the medium frequency (i.e., 20–63 Hz) random vibrations of car bodies and rail fasteners, and on the mid- (i.e., 20–63 Hz) and high-frequency (i.e., 630–1250 Hz) random vibrations of bogies, wheels and rails, especially with the increase of train speeds or the deterioration of rail surface roughness. The two sensitive frequency-bands can also be validated by Frequency Response Function (FRF) analysis of the proposed infinite rail – fastener model. The mid- and high-frequencies influenced by the frequency-dependent viscous damping of rail pads are exactly the dominant frequencies of ground vibration acceleration and wheel rolling noise caused by high-speed railways, respectively. Even though the existing time-domain (or frequency-domain) finite track models associated with the time-domain (or frequency-domain) Fractional Derivative Viscoelastic (FDV) models of rail pads can be also used to reach the same conclusions, the hybrid SEM–SM method in which only one element is required to compute the high-order vibration modes of infinite rail is more appropriate for high-efficiency analysis of the high-frequency random vibrations of high-speed vehicle – track systems.

Key words: vehicle-track system; high-frequency random vibrations; frequency-dependent dynamic property of rail pad; spectral element method; symplectic method

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A Theoretical Study on the Train-Induced Vibrations of a Semi-Active Magneto-Rheological Steel-Spring Floating Slab Track

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Abstract: In order to further improve the vibration-reduction effect of a steel-spring floating slab track (FST), especially at the inherent frequency of a steel-spring FST, semi-active magneto-rheological (MR) dampers were applied to support a floating slab in a traditional steel-spring FST. Based on the experimental study and the proposed theoretical model of the MR dampers with a simple semi-active control method, a vertical vehicle-magneto-rheological steel-spring FST coupled dynamic model was established. The proposed dynamic model was used for a safety analysis and a vibration-reduction evaluation to theoretically validate the feasibility of semi-active magneto-rheological steel-spring FST. It was concluded that the introduction of semi-active MR dampers to support a floating slab in a traditional steel-spring FST has no impact on the security of subway vehicles running on FST. MR dampers with a semi-active control strategy can effectively not only improve the vibration-reduction effect at the basic frequency of a steel-spring FST, but also they can also suppress the vibration-amplification negative effect under a floating slab above the basic frequency of a steel-spring FST. There are the two key parameters of the maximum MR damping force and the displacement threshold in a semi-active magneto-rheological steel-spring FST. The larger MR damping force can deteriorate the negative vibration-suppression effect under a floating slab above the inherent frequency of the FST, while the higher displacement threshold can decrease the vibration-attenuation velocity of the FST supporting force.

Key words: semi-active vibration control; magneto-rheological damper; spring-steel floating slab track; vehicle - track coupled dynamics

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基于波数有限元-边界元法的无砟轨道声辐射特性分析

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摘要:为研究无砟轨道声辐射特性,建立了 CRTSI 型板式无砟轨道的波数有限元振动模型。在钢轨顶部施加单位谐波荷载,以求出的钢轨及轨道板的振动速度响应为边界条件,再采用声学波数边界元法计算出钢轨、轨道板及轨道整体结构的声辐射特性。分析结果表明:钢轨、轨道板及轨道整体结构的声功率级在一阶峰值频率前随频率增大而近似线性增加,在一阶峰值频率后,声功率级波动较大且出现多个峰值。在轨道整体结构一阶峰值频率前轨道板的声辐射贡献量占主导,而在该峰值频率后钢轨声辐射的贡献量逐渐占主导作用。扣件刚度主要影响一阶峰值频率前轨道整体辐射声功率,随着扣件刚度的增加,轨道整体结构声功率级幅值明显降低。CA 砂浆层弹性模量的变化对轨道板辐射声功率级影响较大,但对轨道整体结构辐射声功率级的影响较小。

关键词: 无砟轨道; 峰值频率; 声辐射; 波数有限元; 波数边界元

Analysis of Acoustic Radiation Properties of Ballastless Track by Using Wavenumber Finite Element and Boundary Element Method

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Abstract:

In order to study the acoustic radiation characteristics of ballastless track, a wavenumber finite element vibration model of the CRTS I slab ballastless track is established. Applying a unit harmonic load on the rail top, vibration velocities of rail and slab are gained and then taken as the boundary conditions, acoustic radiation characteristics of rail, slab and integral track are calculated by using the wavenumber boundary element method. The results indicate that the sound power level of rail, slab and integral track in the frequency range below the first order peak frequency increase linearly with the increase of frequency, but it has multiple peak peak after the first order peak frequency. Before the first order peak frequency of integral track, contribution of acoustic radiation of slab is dominant, but after this peak.

keywords: ballastless track; peak frequency; acoustic radiation; wavenumber finite element; wavenumber boundary element

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钢轨滚动接触疲劳多裂纹相互影响

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摘要: 通过 X 射线计算机断层扫描得到曲线外轨轨距角-轨肩多条滚动接触疲劳裂纹的内部形态, 采用栅格法得到真实裂纹的开口和尖端边界点, 建立真实裂纹形态数学模型。以我国某重载线路通过总重约 62MGT 时小半径曲线外轨轨肩-轨距角裂纹为例, 分析了多条裂纹存在下的裂纹尖端应力强度因子变化及裂纹数量对其的影响。结果表明: 裂纹最容易沿与轨顶纵向呈 $10^{\circ} \sim 30^{\circ}$ 的角度向钢轨内部扩展; 轮轨接触斑以作用在裂纹中部的方式通过裂纹区域时, 裂纹尖端各点的应力强度因子 $K1 < 0$ 、 $K2 > 0$, $K3$ 沿裂纹尖端从轨距角一侧到轨顶中心一侧呈由正到负的趋势, 表明此时裂纹的扩展形式主要由滑开型和撕开型复合而成; 多裂纹的存在会抑制裂纹的张开效应, 促进裂纹的滑开和撕开效应, 且该抑制和促进作用随裂纹数量的增加而增强。多条裂纹的存在会使得裂纹尖端的应力强度因子增大, 中间裂纹受到两侧裂纹的影响较明显。在进行裂纹扩展预测时, 应至少考虑 3 条裂纹。

关键词: 滚动接触疲劳

Interactive Influence on Multiple Head Checks Propagation in Rail

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Abstract:

Head checks (HCs) at rail gauge corner and shoulder were inspected by X-ray Computed Tomography scan technology (CT scanning). The boundary points of at the mouth and tip of the real HCs were obtained by grid method to establish the numerical model of the real HCs. Taking the HCs at the gauge corner and shoulder of the high rail in a heavy-haul railway sharp curve with traffic gross tonnage of about 62MGT as an example, the transformation of the stress intensity factors (SIF) at the tips of multiple HCs and the effect of the crack number on them were analyzed. The results show that the HCs were more likely to extend with an orientation of $10^{\circ} - 30^{\circ}$ with respect to rail longitudinal direction. The SIFs of $K1$ was less than 0, $K2$ was greater than 0, and $K3$ was reduced from positive to negative along rail gauge corner to crown when contact patches pass by the crack central mouth, which shows the HCs mainly propagated as Model II (sliding) and III (tearing). The existance of multiple HCs would suppress crack propagating as Model I (opening), but promote their propagating as Model II and III, and the influence would be enhanced as the numbers of HCs were increased. Comparing to single crack, SIFs at the tips of multiple cracks would increase. The SIFs at the tip of the middle crack were greatly influenced by adjacent cracks. Therefore, at least 3 cracks were recommended in crack propagation modeling for crack prediction.

keywords: rolling contact fatigue

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车-轨-桥耦合系统混合数值模拟技术及应用

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摘要: 本文提出了针对车-轨-桥耦合系统的混合数值模拟技术 (HNST)。其采用客户端-服务器原理, 将车-轨-桥系统以轮轨接触为界, 划分为车辆子结构、轨-桥子结构和轮轨接触关系。两子结构通过 OpenSees 模拟并被包装成服务器, 各服务器间地位相等, 无主次之分; 轮轨接触关系被处理成客户端。客户端和服务器通过网络通讯技术实现数据交互。HNST 能够显著降低子结构间的交互数据量, 同时能够充分利用 OpenSees 软件丰富的材料库、单元库、非线性及地震分析等优势功能, 从而快速、高效、灵活的实现车-轨-桥问题求解。

关键词: 耦合系统; 混合数值模拟技术; 车-轨-桥系统; 客户端-服务器原理; OpenSees

A Hybrid Numerical Simulation Technique for Train-Track-Bridge Coupled Systems and Its Application

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Abstract:

A hybrid numerical simulation technique (HNST) for Train-Track-Bridge (TTB) Coupled systems is presented in this paper. Using the client-server theory, the TTB coupling system is divided into train and track-bridge substructures. Each substructure is simulated by OpenSees and packaged as an independent server; the coupling contact relationship is handled as client. And the client and server achieve data transmission through network communication technology. Then, HNST can make full use of the advantages of the OpenSees software, so as to it is able to quickly, efficiently and flexibly complete the TTB coupling system solution.

keywords: coupled system; hybrid numerical simulation technique; train-track-bridge system; client-server technique; OpenSees

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基于轮轨非 Hertz 接触的货运铁路钢轨磨耗仿真分析

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摘要: 随着铁路运营的发展, 货车车辆轴重不断增加, 导致钢轨磨耗异常严重, 为了使车辆安全平稳通过, 必须对钢轨的磨耗进行研究分析。本文采用 UM 动力学软件, 建立了三维铁路钢轨磨耗模型, 并计算了红柠铁路专用线部分线路条件下的钢轨磨耗情况, 对比实测结果, 验证了模型的正确性。结果表明: 在相同车辆通过下, 假定车速为 60km/h 时, 曲线中点处外轨的侧磨量大于垂磨量; 线路直线左右钢轨的磨耗相差不大且磨耗很小; 缓和曲线段内轨磨耗主要分布于距轨头中部 10mm 左右走行面处, 外轨磨耗主要分布在内侧半径为 80mm 弧段; 圆曲线段外轨磨耗明显, 主要分布在轨头内侧半径为 80mm 的弧段上; 内轨磨耗主要分布在轨头 300mm 的弧段上。

关键词: 钢轨磨耗

Simulation Analysis of Rail Wear in Freight Railway Based on Wheel-Rail Non-Hertz Contact

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Abstract:

With the development of railway operation, the axle load of freight cars is increasing, which leads to abnormal rail wear. In order to make the vehicles pass safely and smoothly, it is necessary to study and analyze the rail wear. In this paper, a three-dimensional rail wear model is established by using UM dynamics software, and the rail wear situation under the condition of some lines of Hongning Railway Special Line is calculated. The correctness of the model is verified by comparing the measured results. The results show that under the same vehicle passing speed, assuming the vehicle speed is 60 km/h, the side wear of the outer rail at the middle point of the curve is greater than the vertical wear; the wear difference between the left and right rails in the straight line is not big and the wear is very small; the wear of the inner rail in the transition curve section mainly distributes at the running surface about 10 mm from the middle of the rail head, and the wear of the outer rail mainly distributes at the inner radius 80 mm arc section; and the wear of the outer rail in the circular curve section is obvious. Obviously, it mainly distributes on the arc with 80 mm inner radius of rail head, and the wear of internal rail mainly distributes on the arc with 300mm inner radius of rail head.

keywords: rail wear

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Iterative Computation Method of Train-Load-Induced Uneven Settlement of High-Speed Railway Transition Zones

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Abstract: The subgrade uneven settlement associated with rail deflections mainly occurs in bridge-embankment transition zones of high-speed railways. In order to predict the uneven settlement in these regions, an iterative computation method of train-load-induced uneven settlement of the transition zone is proposed. In this method a vehicle-track-subgrade model is employed to investigate the vehicle track interactions and the deviator stress field of the transition zone. Combined with soil cumulative plastic strain model, the deterioration process of the uneven settlement of the transition zone is obtained. The results indicate that the uneven settlement of the transition zone induced by train loads tend to be steady when the number of repeated load applications is larger than 40000. The settlement of the subgrade changes abruptly at first 5 m measured from the abutment as well as 22 m to 28 m from the abutment. These two regions should be adequately strengthened and more attentions should be given to these regions for track maintenance.

Key words: transition zone; uneven settlement; vehicle-track interaction; cumulative plastic strain

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小净距浅埋盾构隧道相互影响机制与控制措施研究

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摘要: 工程实践表明,小净距浅埋盾构隧道施工时,后行隧道施工显著影响先行隧道的安全。依托广佛城际铁路陈村2号隧道工程,针对浅采用精细化数值模拟技术,建立小净距浅埋盾构隧道施工模型,分析小净距浅埋盾构施工相互影响,并分析不同净距下盾构隧道施工相互影响规律。结果表明:双线浅埋盾构隧道施工时,双线净距与地表沉降槽宽度呈线性正相关,与沉降峰值、管片附加变形、接头张开量和附加拉应力负相关;上软下硬地层且封顶块置顶时,先行隧道受后行隧道影响显著,浅覆软弱地层盾构施工时应避免将封顶块置顶;对于陈村2号隧道始发段净距小于5 m时先行隧道管片内力不满足条件,采取“隔断墙+水泥土搅拌桩”安全控制措施,实测和数值结果均表明控制效果明显。研究成果可为后续工程设计和施工提供参考。

关键词: 软弱地层;盾构隧道;相互影响;精细化数值模拟;控制

Interaction and Control of Small Spacing Shallow Buried Shield Tunnels

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Abstract:

Practical application shows that the construction of the second shield tunnel in shallow soft stratum affects the safety of the first shield tunnel, especially when the spacing of the two tunnels is very close. Based on Chencun Tunnel No. 2 of Guangzhou to Foshan intercity railroad, a number of refined numerical models were built to simulate the shield construction. According to the numerical results, the interaction mechanism of shield construction and the interaction law under different spacing of the double-line parallel shield tunnel were analyzed. The results show that there is a linear positive correlation between the spacing and the width of the surface subsidence trough, and a negative correlation between the spacing and the peak value of settlement, additional deformation of segment, joint opening and additional tensile stress. Up-soft/low-hard stratum and the top block are located at the top of the segment, resulting in low disturbance resistance on the upper part of the segment. As a result, the influence of the second shield tunnel construction on the first shield tunnel is significant. Therefore, the top block should not be placed on the top of the segment in the future shield construction. Since the additional tensile stress of the segment is sensitive to the spacing. The safety control measures of “partition wall + cement-soil mixing pile” were adopted for Chencun Tunnel No. 2. The measured results show that the control effect is obvious.

keywords: soft stratum; shield tunnels; interaction; refined numerical simulation; control

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考虑温度变形的高速铁路 CRTSI 型双块式无砟轨道-钢桁梁桥动力响应分析

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摘要: 为研究温度变形对高速铁路 CRTSI 型双块式无砟轨道-钢桁梁桥系统动力响应影响规律, 以某钢桁梁桥为例, 采用 MATLAB 平台编制程序开展列车-无砟轨道-桥梁耦合系统振动响应研究。采用有限元方法建立无砟轨道-桥梁子系统三维精细化模型; 采用刚体动力学方法建立 35 自由度车辆子系统模型。首先分析了温度变形对无砟轨道轨道不平顺的影响; 然后研究了温度变形对桥梁以及列车动力响应的影响。结果表明: 梁体的温度变形对轨道的平顺性影响显著; 温度变形引起轨道不平顺改变而导致的桥梁动挠度和加速度响应较小几乎可以忽略不计; 车体竖向加速度差异局部为 15%~25%; 建议在无砟轨道-桥梁系统动力响应分析时考虑梁体温度变形对列车走行性的影响。

关键词: 高速铁路; 温度效应; 车-桥耦合振动; 无砟轨道; 钢桁梁桥

Dynamic Response Analysis of the High-Speed Railway CRTSI Ballastless Steel Trussed Girder Bridge Considering the Temperature Deformation

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Abstract:

To study the influence of temperature deformation on the dynamic responses of CRTSI ballastless Steel Trussed Girder Bridge coupled system traversed by high-speed train, one railway bridge is taken as a numerical example, a calculation program based on MATLAB is developed to calculate the dynamic responses of train-ballastless-bridge coupled system. a three-dimensional model of ballastless -bridge subsystem is established using the finite element method, each vehicle of the train is modeled as 35 degrees of freedom model by applying the rigid-body dynamics theory. Firstly, the effect of temperature deformation to ballastless vertical irregularity is analyzed. Then the influence of temperature deformation on dynamic response of vehicle and bridge are calculated. The result shows: beam temperature deformation has significant effect on irregularity. The bridge dynamic deflection and acceleration response caused by track irregularity change caused by temperature deformation are almost negligible. The difference of vertical acceleration can reach 15-25% locally. It is suggested that the influence of beam temperature deformation should be considered in the dynamic response of ballastless steel trussed girder bridge.



keywords: high-speed railway; temperature deformation; train-track-bridge coupled system; ballastless; steel trussed continue girder bridge

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地铁隧道注浆对地表建筑物的影响及安全评价

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摘要: 城市地铁施工中隧道过量注浆往往导致地层隆起和上部建筑物损坏。为研究注浆引起的上部建筑物位移变形规律, 以深圳某地铁下穿过程中注浆隆起引起建筑物破坏为背景, 采用现场实测方法对隧道下穿过程中建筑物的位移变形过程进行分析, 主要取得以下认识: 注浆在下穿过程中起到主导作用, 其对建筑物的影响程度远大于隧道开挖, 建筑物表现为整体隆起; 注浆期间, 建筑物竖向位移迅速增大, 注浆结束后由于卸压、浆液凝固以及土体固结作用建筑物竖向位移出现衰退; 由于浆液劈裂地层, 注浆量与注浆速率异常增大, 建筑物隆起相应表现为在该几日剧烈增长, 最大单日隆起量达 41.55mm; 与隆起趋势类似, 建筑物倾斜在注浆期间迅速增长, 并与注浆结束后出现衰退; 此外, 建筑物不均匀隆起是倾斜和裂缝发生的主要原因, 水位变化对裂缝发展影响较大。

关键词: 地铁隧道; 砂卵石地层; 下穿建筑物; 注浆; 隆起变形; 安全评价

Influence and Safety Assessment of Surface Structure by Grouting in Subway Tunnel

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Abstract:

In urban subway construction, excessive grouting often leads to uplift of stratum and damage of superstructure. In order to study the law of displacement and deformation of superstructure caused by grouting, the failure of a building caused by grouting in a subway in shenzhen which the stratum is dominant by sand pebble, is taken as the background, the displacement and deformation of the building in the process of tunnel undergoing are analyzed by field test and the measured data, main perspective are got as following: Grouting plays a leading role in the process of undergoing, and its influence on the building is much greater than that of tunnel excavation. During grouting, the vertical displacement of the building increases rapidly, after grouting, the vertical displacement declines due to pressure relief, slurry solidification and soil consolidation. Because the slurry splits the cracks in the formation, the amount and rate of grouting increase abnormally, the uplift of the building correspondingly increased dramatically in these days, with the maximum one-day uplift reaching 41.55mm. Similar to the uplift trend, the building inclination increases rapidly during grouting and declines after grouting. Moreover, non-uniform uplift is the main cause of inclination and crack, the change of water level has great influence on the development of fractures.

keywords: subway tunnel; sandy cobble stratum; crossing under the existing building; grouting;

uplift deformation; safety assessment.

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CRTS III型无砟轨道板温度场演化规律研究

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摘要: 为研究 CRTS III型无砟轨道板在环境温度、太阳辐射强度和风速等共同作用下温度场的分布及演化规律, 基于昌吉赣高速铁路 CRTS III型无砟轨道板现场温度分布实测的数据, 运用传热学基本原理和考虑气象资料条件下, 提出一种轨道板温度场预估模型; 根据该模型, 计算出不同地区轨道板的温度梯度代表值。研究表明: 轨道板上表面温度与环境温度变化基本同步, 下表面存在约 2 小时滞后; 在距轨道板上表面 0~0.12m 内温度梯度变化较为明显, 越靠近底部温度梯度变化越为迟缓; 日最大温度梯度出现的时间基本相同, 但不同季节温度梯度大小存在明显的差异, 最大正负温度梯度均出现在夏季, 分别高达 93.3°C/m 和-44.1°C/m。对比实测数据, 本方法得到的计算结果同实测数据吻合较好; 综合考虑不同地区所在省份代表性, 提出了不同地区轨道板正负温度梯度建议值, 该研究成果可为 CRTS III型无砟轨道板的设计、施工及运营维护提供参考。

关键词: 高速铁路

Study on Temperature Field Evolution Law of a CRTS III Ballastless Track Slab

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(East China Jiaotong University)

Abstract:

To evaluate the temperature field distribution and evolution within a CRTS III ballastless track slab, accounting for factors including the climate temperature, solar radiation and wind speed, a predicting formulation is proposed. Based on the measured data of the on-site temperature distribution of the CRTSIII ballastless track slab of Chang-Ji-Gan high-speed railway line, a prediction model of the temperature field of the track plate is proposed based on the basic principles of heat transfer and the consideration of meteorological data. According to the model, the temperature gradient representative values of the track plates in different regions are calculated. It shows that the variation of temperature field of a slab is generally in accordance with environmental temperature variation at the top and about 2 hours delay at the bottom. The variation in temperature gradient is evident only within 0~0.12m, and being weak with depth. According to the formulation, the largest daily temperature gradient occurs at the same time, but its amplitude changes with season. The largest annular positive and negative temperature gradient occurs in summer season, which is 93.1°C/m and -44.1°C/m respectively. The calculated data agrees well with the measured temperature data; Considering the representativeness of the provinces in different regions, the recommended values of the positive and negative temperature

gradients of the track plates in different regions are proposed.The research results can provide reference for the design, construction, operation and maintenance of CRTSIII ballastless track plates.

keywords: high-speed railway

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高速铁路无砟轨道路基颗粒材料动力响应细观分析

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摘要: 基于 FDM-DEM 耦合方法建立了高铁无砟轨道路基结构实尺数值模型, 并通过与现场实测数据对比验证了模型合理性, 并对不同车速条件下路基颗粒材料的细观动力响应进行了分析, 主要结论: 1) 颗粒振动响应的特征主频与列车车体结构的特征长度具有密切联系, 但随着列车速度增加, 颗粒振动频谱中的高频成分逐渐显现, 从而引发颗粒振动加剧。2) 列车速度提高时, 基床表层颗粒在高、低频段的振动响应均呈现增加趋势, 但基床底层颗粒的振动响应仅在 20Hz 以内的频段明显增长, 更高频段内颗粒振动响应无明显变化。3) 列车高速运行时, 基床表层与底层界面附近的颗粒会出现振动放大现象。

关键词: 高速铁路; 无砟轨道路基; 颗粒材料; FDM-DEM 耦合模型; 细观分析

Mesoscopic Analysis of Dynamic Response of Granular Materials of High-Speed Railway Ballastless Track Subgrade

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Abstract:

Based on the FDM-DEM coupling method, the real-scale numerical model of the high-speed rail-free track subgrade structure is established, which verified by comparing with the measured data on site. By using this model, The mesoscopic dynamic response of subgrade granular materials under different vehicle speed conditions was analyzed. The main conclusions are as follows: 1) The main frequency of the particle vibration response is related to the characteristic length of the train body structure. However, as the train speed increases, the high-frequency components gradually appear in the particle vibration spectrum, which causing more mesoscopic movement of particles. 2) When the train speed is increased, the vibration response spectrum of the surface layer particles of subgrade bed shows an increasing trend in the high and low frequency bands; but the vibration response of the particles of the bottom layer is only increased significantly in the range below 20 Hz, the vibration response of the particles in the higher range is not obvious. 3) When the train runs at high speed, an increase in vibration response of particles in the interface region between surface layer and bottom layer was discovered.

keywords: High speed railway; Ballastless track subgrade; Granular material; FDM-DEM coupling model; mesoscopic analysis

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两级循环加载下路基土附加变形特性的试验研究

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摘要: 为研究既有路基运营变形稳定后, 在新增加交通荷重情况下路基的附加变形发展趋势, 基于动三轴仪, 设计了两级动荷载的循环加载试验方案, 在第一级动力加载变形稳定后, 通过施加不同的循环荷载幅值、频率分析后续动力加载条件下路基土的附加变形。结果表明, 路基土的附加变形随第二级循环荷载幅值增加显著增大, 随第二级循环荷载频率的增大而减小; 第一级循环荷载幅值越大或频率越低, 第二级循环荷载作用下路基土的附加变形越小。路基土经历第一级循环荷载作用变形稳定后, 再次受更大幅值水平的第二级循环荷载作用, 由此产生的新的附加变形较第一级循环荷载引起的塑性变形小许多。试验结果为路基永久变形计算和评估提供了数据基础。

关键词: 路基; 附加变形; 两级循环加载; 动三轴试验

Experimental Study on Additional Deformation Characteristics of Subgrade Subjected to Two-Step Cyclic Loading

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Abstract:

The additional deformation will be induced with the new traffic load on the subgrade, despite the deformation is stabilized during operation. In this study, a two-step cyclic dynamic loading test was performed to study the additional deformation trend. Using dynamic triaxial apparatus, different cyclic loading amplitudes and frequencies were applied to analyze the additional deformation under the second-step loading, on condition that the first-step deformation was stabilized. The results showed that: higher amplitude or lower frequency of the second-step loading resulted in larger additional deformation; higher amplitude or lower frequency of the first-step loading resulted in less additional deformation in the second step. When the subgrade deformation was stabilized after the first-step loading, larger load amplitude in the next step was applied. This led to much less additional deformation of the second step than the plastic deformation in the first step. The tests results may assist in the calculation and evaluation of subgrade permanent deformation.

keywords: subgrade; additional deformation; two-step cyclic loading; dynamic triaxial test

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高速铁路荷载作用下坎儿井地基路基沉降特性研究

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(西南交通大学)

摘要: 为保障坎儿井地区高速铁路的建设与安全服役, 对坎儿井地基的沉降特性进行了数值模拟研究, 进一步研究了坎儿井埋置深度、坎儿井形状、坎儿井支护类型对路基面沉降量最大值的影响。研究表明: 坎儿井埋置深度对路基面沉降影响较大, 且存在一个临界埋置深度, 使坎儿井沉降量最大。当坎儿井埋置深度较小时, 路基面沉降值较小; 当坎儿井埋置深度增大到一定值时, 路基面沉降值达到最大; 当坎儿井埋置深度继续增大时, 路基面沉降值开始减小。坎儿井形状对路基面沉降量影响显著, 四种形状中, 横椭圆形的坎儿井上方的路基面沉降最大。坎儿井支护类型对路基面沉降量影响显著, 三类支护中, 素土坎儿井上方的路基面沉降最大。该研究可为坎儿井地基工程场地评价、高速铁路修建提供技术依据和参考。

关键词: 高速铁路; 坎儿井地基; 路基沉降; 数值模拟

Research on Settlement Characteristics of Subgrade of Karez Foundation Under High-Speed Railway Load

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Abstract:

In order to ensure the construction and safe service of the high-speed railway in the Karez area, the numerical simulation of the settlement characteristics of the Karez foundation was carried out. The influence of the buried depth of the Karez, the shape of the Karez and the type of the Karez support on the maximum settlement of the subgrade was further studied. The results show that the buried depth of the Karez has a great influence on the settlement of the subgrade, and there is a critical depth of embedding, which makes the settlement of the Karez the largest. When the buried depth of the Karez is small, the settlement value of the subgrade is small; when the buried depth of the Karez increases to a certain value, the settlement value of the subgrade surface reaches the maximum; when the buried depth of the Karez continues to increase, the settlement value of the subgrade begins to decrease. small. The shape of the Karez has a significant influence on the settlement of the subgrade. Among the four shapes, the subgrade above the Karez with the horizontal ellipse has the largest settlement. The Karez support type has a significant impact on the settlement of the subgrade. In the three types of support, the subgrade above the plain soil well has the largest settlement. This research can provide technical basis and reference for the evaluation of the site of the Karez foundation and the construction of the high-speed railway.

keywords: High-Speed Railway; Karez Foundation; Subgrade Settlement; Numerical Simulation

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泡沫轻质土在高速铁路软土路基中的应用

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摘要: 利用 ABAOUS 软件建立能够模拟填土堆载的二维有限元模型, 将泡沫轻质土填筑高速铁路软土路基和常规填料填筑所产生的工后沉降进行有限元计算, 并对比和分析了两种不同填筑路基的方式产生的软土路基固结沉降的差异。计算结果表明: 采用泡沫轻质土替代常规填料的路基, 对于路基自身重量和软土地基附加荷载的减小是显著的, 利用泡沫轻质土填筑软土路基可以控制软土路基的工后沉降并减小固结沉降。

关键词: 高速铁路; 软土路基; 泡沫轻质土; 固结沉降; 工后沉降

Application of Foamed Light Soil in Soft Soil Subgrade of High-Speed Railway

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Abstract:

ABAOUS software is used to establish a two-dimensional finite element model which can simulate the filling and fill. The finite element method is used to calculate the settlement of the soft soil subgrade filled by high-speed railway and the conventional filling. The difference between the two different embankment consolidation settlement is compared and analyzed. The results show that the foam lightweight soil is used instead of the conventional filler. For the roadbed, the weight of the roadbed and the additional load of the soft soil foundation are significantly reduced. Using the lightweight foam soil to fill the soft soil roadbed can control the post construction settlement of the soft soil subgrade and reduce the consolidation settlement.

keywords: high-speed railway; soft soil roadbed; foamed lightweight soil; consolidation settlement; post construction settlement

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低温条件下铁路路基沥青混凝土防水封闭层受力特性研究

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摘要: 本文选用广义 Maxwell 模型作为沥青混凝土粘弹性本构关系建立沥青混凝土防水封闭层轨道结构模型, 研究低温条件下沥青混凝土防水封闭层的受力特性。计算结果表明, 路肩位置沥青混凝土防水封闭层纵向应力较小, 其应力值直接与外界温度相关; 伸缩缝位置对应的沥青混凝土层因受到底座板在温度作用下变形的影响, 其纵向拉应力较大, 存在开裂风险。结合工程实际, 提出在伸缩缝附近铺设复合土工膜滑动层及选择合适的施工温度等措施来改善沥青混凝土防水封闭层的受力状态, 降低其开裂风险。

关键词: 沥青混凝土防水封闭层; 粘弹性模型; 温度场; 接触关系

Numerical Study on Asphalt Concrete Waterproof Sealing Layer for Subgrade Under Low Temperature Conditions

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Abstract:

In this paper, the generalized Maxwell model is adopted for asphalt concrete to establish the track structure model and study the mechanical characteristics of asphalt concrete waterproof sealing layer under low temperature. The results indicate that the longitudinal stress of the waterproof sealing layer of asphalt concrete at the shoulder is small and directly affected by the external temperature. However, the longitudinal stress of asphalt concrete layer in the position of expansion joint is larger because of the deformation of support layer under the low temperature. So there is a risk of cracking in the position of expansion joint. Combining with practical application, this paper puts forward some measures to improve the state of the asphalt concrete waterproof sealing layer and reduce the risk of cracking, such as laying composite geomembrane sliding layer at the position of expansion joint and choosing proper construction temperature.

keywords: asphalt concrete waterproof sealing layer; viscoelastic model temperature field; contact relationship

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新建重叠盾构隧道施工顺序、加固措施探究

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摘要: 国内重叠隧道大部分采用“先下后上”的施工顺序来控制重叠隧道施工安全。本文以某重叠隧道工程为例,结合工程地质、工期工筹、施工组织进分析,认为该工程重叠段隧道“先上后下”施工顺序可行,而且采用“先上后下”施工比“先下后上”施工有利。通过盾构隧道纵向螺栓抗弯、抗剪检算,得出“先上后下”施工顺序需要对先建上部隧道采取刚性支撑来承担后建隧道施工引起先建隧道产生的临时弯矩、剪力。

关键词: 重叠隧道; 施工顺序; 先下后上; 刚性支撑

Study on Construction Order and Reinforcement Measures of New Overlapped Shield Tunnel

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Abstract:

Most overlapping tunnels in China adopt the construction sequence of "first down then up" to control the construction safety. Taking an overlapping tunnel project as an example, combined with the analysis of Engineering geology, construction schedule and construction organization, this paper considers that it is feasible to adopt the construction sequence of "first up and then down", and that the construction sequence of "first up and then down" is better than that of "first down and then up". Through the calculation of bending and shearing resistance of longitudinal bolts in shield tunnels, it is concluded that the construction sequence of "first up and then down" requires rigid support for the upper tunnels to bear the temporary bending moment and shearing force caused by the construction of the first tunnels.

keywords: overlapping tunnel; construction sequence; first down and then up; rigid support

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软土地区地铁基坑承压水抽灌一体化模拟与分析

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摘要: 地铁基坑施工中, 承压水的控制对于基坑自身安全和周边环境保护至关重要。本文结合宁波轨道交通4号线儿童公园站基坑工程承压水控制实例, 提出了抽灌一体化的承压水控制方案。首先基于地下水三维非稳定渗流模型对承压水水位降深进行预测, 以指导设计优化; 进而基于抽水验证试验结果反分析承压水层的水文地质参数, 研究抽灌一体化方案下基坑周边环境水位变化; 最终利用数值模拟进行止水帷幕插入比和回灌井位置等设计参数影响分析。

关键词: 基坑; 抽灌一体化; 设计优化; 反分析

Simulation and Analysis of Integrated Water Pumping-Recharge for Subway Foundation Pit in Soft Soil Area

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Abstract:

In the construction of foundation pit, it is essential to control confined water in order to ensure the safety of foundation pit and surrounding environment. Taking the confined water control in the foundation pit project of Ningbo Rail Transit Line 4 Children's Park Station for demonstrating, a confined water control scheme for pumping-recharge integration is proposed in this paper. Firstly, based on the three-dimensional unsteady seepage model of groundwater, the depth of the confined water level is predicted to guide the design optimization; Then, the hydrogeological parameters of the confined water layer are back analyzed using the results of the pumping verification test and the variation of environmental water level around foundation pit under the pumping and irrigation integration scheme is further studied; finally, numerical simulation is used to analyze the influence of design parameters such as water stop curtain insertion ratio and recharge well position.

keywords: Foundation pit; pumping-recharge integration; design optimization; inverse analysis

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路堤荷载下高速铁路膨胀土路基的胀缩变形试验分析

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摘要: 膨胀土体积会随着气候变化和降雨作用而产生变化, 因此膨胀土地区道路和铁路路基设计的重要性无法忽视。本文以云桂客运专线现场试验为基础, 对膨胀土的胀缩变形行为进行研究。在膨胀土地区建造不同填高 (0.9m、1.9m、2.7m、4.88m 和 7.49m) 的全尺寸现场试验设施。所有试验路堤均设置仪表以监视整个填筑阶段(堆载期、静置期和工后铺轨期)沉降和基础土壤体积含水量的变化。现场试验结果证明了在膨胀土地区通过设计路堤高度来满足高速铁路严格的长期和短期沉降要求是可行的。最终提出了考虑地基相对膨胀量为 0 时的临界路基填高值。

关键词: 高速铁路; 路堤; 膨胀土地基; 胀缩变形; 现场试验

Swelling-Shrinkage Deformation of an Expansive Soil Foundation Under High Speed Railway Embankment Loads: a Case Study

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Abstract:

Designing and constructing road and railway embankments over expansive soils is not trivial because those soils may experience significant volume changes upon drying and wetting related to seasonal climate changes. This paper presents a case study of the swelling-shrinkage behaviors of an expansive soil ground under high speed railway embankment loads at a test site along Kunming-Nanning High-speed rail line (KNHR). A full-scale field test facilities was built for the site filling test in expansive soil ground, of which consist of embankments with five different heights (0.9m, 1.9m, 2.7m, 4.88m and 7.49m). All the test embankments were fully instrumented to monitor the ground deformation and the change in volumetric water content profiles of the foundations during the entire filling process (base filling period, placement period and track laying period). Field test results demonstrate the feasibility of constructing embankments with appropriately de-signed heights over the expansive soil ground to satisfy the strict requirements in short and long-term deformations for high-speed railways. Finally, a simple method for estimating the critical filling height of a subgrade was proposed, which protect the top surface of subgrade from swelling-shrinkage behaviors of an expansive soil ground.

keywords: high-speed railway; embankment; expansive soil foundation; swell-shrinking behavior; field test

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严寒地区风积沙改良土热力学性质研究

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摘要:在严寒地区以风积沙改良土作为筑路材料,受气温影响,路堤表面常发生横向裂缝。本文对以水泥和粘土为外掺剂的风积沙改良土试样进行室内热力学试验,研究了不同配比风积沙改良土的导热系数、比热容和线膨胀系数,实验结果表明:在恒定温度条件下,风积沙改良土比热容的变化趋势与导热系数的变化趋势大致相反,两者是一个此消彼长的过程;导热系数随着粘土掺入比的增加呈现先减小后增大的变化;随着水泥的掺入量增加,呈现整体增大的趋势;比热容的变化规律与此相反;在变温条件下,不同配比风积沙改良土试样的比热容随温度的变化过程大致相同,总体趋势都是随着温度的升高,比热容变大;随着粘土和水泥含量的增加,风积沙改良土的线膨胀系数均呈降低趋势。

关键词: 严寒地区; 风积沙改良土; 导热系数; 比热容、线膨胀系数

Study on Thermodynamic Properties of Modified Aeolian Sand in Cold Regions

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Abstract:

There are many transverse cracks in the surface of the embankment which was made of modified aeolian sand in cold regions because of drastic changes in temperature. Cement and clay were used as additives of modified aeolian sand in the paper. Then, thermodynamic tests are conducted on the modified aeolian sand samples with different content of cement and clay, and the relationship between thermodynamic properties and the content of cement and clay was analyzed. According to the tests, the change trend of specific heat capacity of modified aeolian sand is roughly opposite to that of thermal conductivity under the condition of constant temperature. The thermal conductivity decreases first and then increases with the content of clay in modified aeolian sand, and increases with the content of cement. Under the condition of variable temperature, the change process of specific heat capacity of modified aeolian sand samples with different mixing proportions is roughly same, and the general trend is that the specific heat capacity increases with the increase of temperature. With the increase of clay and cement content, the linear expansion coefficient of modified aeolian sand samples decreases.

keywords: Cold regions; Modified aeolian sand; Thermal conductivity; Specific heat capacity; Coefficient of linear expansion

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Analysis of Influence of Deep Foundation Pit Dewatering Based on ABAQUS

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Abstract: The development of underground space at home and abroad has been plagued by groundwater problems, and safety accidents caused by deep foundation pits are also common. In order to study the law of groundwater seepage and analyze the influence of urban foundation pit dewatering construction on surrounding buildings, based on the Shenzhen GangXia North Comprehensive Transportation Hub Project, the precipitation of this project was simulated by numerical simulation and on-site methods. In the process of precipitation construction, the seepage law of groundwater and the stress and deformation of the soil are obtained. It is found that within the scope of influence, the layered settlement of the soil meets the characteristics of “three-stage”; in addition, we analyze the numerical model and analyze the difference. Under the precipitation speed and the depth of the different water curtains, the surface settlement of the soil shows that the groundwater seepage path is different under different precipitation speeds, resulting in different soil stress states, thus producing different deformations and settlements; Curtain, in a certain depth, the deeper the water stop curtain, the smaller the groundwater seepage flow outside the foundation pit, the smaller the groundwater flow velocity, and the smaller the ground surface settlement.

Keywords: Deep foundation pit; Precipitation construction simulation; Effect of precipitation speed; Analysis of water curtain depth

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变截面抗滑桩内力计算方法及变形特性研究

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摘要:为研究变截面抗滑桩在滑坡推力和桩前土抗力作用下的变形及承载特性,针对抗滑桩所用悬臂法在滑动面处上下位移不连续问题,选取圆形抗滑桩作为研究对象,考虑变径比、变径位置及桩间距等因素的影响,进行变截面抗滑桩内力及变形特性研究。根据抗滑桩受力形式,将桩在滑动面以上部分视为弹性定向铰支的悬臂梁,将桩在滑动面以下部分视为“Winkler”弹性地基梁,采用幂级数法推导变截面抗滑桩锚固段的内力计算公式,并用Matlab编制全桩段内力计算程序,可视化分析变截面抗滑桩全桩段在不同因素影响下内力变化的结果。研究表明:将上部桩视为弹性定向铰支的悬臂梁,可使得桩身位移在滑面处连续;在相同剩余抗滑力的作用下,随着变径比的增加,桩身最大弯矩会随之增加而桩顶位移会减小,但一味增加变径比加固效果并不明显;随着变径位置的下移,桩身最大弯矩和桩顶位移改变均较小;随着桩间距的改变,桩身最大弯矩和桩顶位移都会等比例的改变。

关键词: 边坡工程

Study on Internal Force and Deformation Characteristics of Variable Section Anti-Slide Piles

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Abstract:

In order to study the deformation and bearing behavior of the variable-section anti-slide pile under the action of landslide thrust and pile front soil resistance, the circular anti-slide pile is selected as the research object for the problem of the displacement of the up-and-down displacement of the anti-slide pile used in the sliding surface. Considering the influence of factors such as reduction ratio, variable diameter position and pile spacing, the internal force and deformation characteristics of variable cross-section anti-slide piles are studied. According to the form of the anti-slide pile, the pile above the sliding surface is regarded as the cantilever beam with elastically oriented hinge. The pile below the sliding surface is regarded as the “Winkler” elastic foundation beam, and the variable series resistance is derived by the power series method. The internal force calculation formula of the anchorage section of the slide pile is used, and the internal force calculation program of the whole pile section is compiled by Matlab, and the internal force change of the whole section of the variable section anti-slide pile under the influence of different factors is visually analyzed. The results show that the upper pile is regarded as the cantilever beam with elastically oriented hinge, which can make the displacement of the pile continuous at the sliding surface; under the same residual anti-sliding force, the maximum bending of the pile with the increase of the reduction ratio The moment will increase and the displacement of the pile top will decrease. However, the reinforcement effect of the variable diameter ratio is

not obvious. With the downward movement of the reduction position, the maximum bending moment and the displacement of the pile top are smaller; The change of the pile spacing, the maximum bending moment of the pile body and the displacement of the pile top will change in proportion.

keywords: Slope engineering

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基于 Lamb 波的 CRTS II 型板式无砟轨道层间伤损检测方法

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摘要: CA 砂浆层间伤损直接影响 CRTS II 型板式无砟轨道的服役性能。通过建立刚性边界条件下 Lamb 波在 CRTS II 型板式无砟轨道中传播能量泄漏的理论模型, 研究了无砟轨道板空气耦合频散特性与激励参数。通过实验室等比例模型试验对所提 CA 砂浆层间伤损空耦 Lamb 波检测方法进行验证。结果表明: 激励 CRTS II 型无砟轨道板 Lamb 波的探头中心激励频率为 28kHz、入射角 3.5° , 可激发 A3 模态进行轨道板层间伤损检测; 随 CA 砂浆层间脱空伤损尺寸增加, 能量泄漏减少, 接收的 Lamb 波 A3 模态能量增加, 幅值增大, 呈现线性变化规律; 采用非接触式空耦 Lamb 波可实现 CRTS II 型板式无砟轨道层间伤损的快速定量检测。

关键词: CA 砂浆伤损; 无砟轨道; 空耦超声; Lamb 波

CRTS II Type Slab Ballastless Track Interlayer Damage Detection Method Based on Lamb Wave

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Abstract:

CA mortar interlayer damage directly affects the service performance of CRTS II slab ballastless track. The air-coupled dispersion characteristics and excitation parameters of ballastless track slab are studied by developing a theoretical model of Lamb wave propagation energy leakage in CRTS II slab ballastless track with rigid boundary constrains. The method to detect the void of the CA mortar interlayer is verified by the laboratory scale model test. The results show that the excitation center frequency of the laser probe of the CRTS II ballastless track plate is 28kHz and the incident angle is 3.5° . It can stimulate the A3 mode to detect the interlayer void damage of the track plate. With the increase of void damaged size between CA mortar layers, the energy leakage decreased and the received Lamb wave's energy of A3 modal increased as well as the amplitude, also shows a linear variation law; The non-contact and air-coupled Lamb wave can realize the fast quantitative detection of the interlayer damage of CRTS II type slab ballastless track.

keywords: CA mortar damage; Ballastless Track; Air-coupled ultrasonic; Lamb wave

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基于高分子材料化学解粘的整体道岔无砟道床纠偏修复技术研究

刘竞

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摘要: 针对渡线道岔无砟轨道结构发生较大偏移影响了线路平顺性的问题,为实现在天窗时间内对偏移的渡线道岔实施纠偏修复以恢复线路平顺性,通过理论分析、试验验证和工程实践,分析了渡线道岔纠偏修复的技术难点,研究了基于高分子材料结构界面解粘抬升的渡线道岔无砟轨道结构纠偏修复关键技术、工艺流程以及轨道动态性能同步监测技术。结果表明:(1)底座板与基床表层间黏结系数对纠偏时千斤顶横向顶推力值影响显著,黏结系数从0.5逐渐增加到1.0,2.0,5.0时,千斤顶横向顶推力最大值增幅分别为62.1%,144.9%,290.2%;(2)创新通过新型高聚物化学解粘,确保了轨道结构与掺水泥级配碎石层的界面解粘脱离,显著降低了底座板与基床表层间的粘结与摩阻,为纠偏的成功实施创造了条件;(3)首次实现了天窗时间内对道岔无砟轨道的无损伤纠偏,线形控制良好,线路平顺性改善显著,纠偏修复后道岔无砟轨道动态性能响应满足动车组高速运行时的安全性和平稳性要求。

关键词: 注浆;抬升;混凝土结构;无砟轨道;修复

Key Technology of Deviation Correction of Turnout Ballastless Track Structure Based on High-Polymer Chemical Desorption

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Abstract:

The large deviation of the turnout ballastless track structure affected smoothness of the railway line. It was necessary to correct the deviation of ballastless track structure to restore the smoothness of the line. The technical difficulties of deviation correction of turnout ballastless track structure were analyzed, the key technology process of deviation correction based on high-polymer chemical desorption and air cushion lifting was studied, the track dynamic performance synchronization monitoring technology was applied. Results showed that the bond coefficient between the base plate and the roadbed surface had a significant effect on the lateral thrust value of the jacks. When the bond coefficient increases from 0.5 to 1.0, 2.0 and 5.0, the maximum increase of lateral thrust value is 62.1%, 144.9% and 290.2%. The high-polymer chemical technology ensured the complete separation between track structure and graded broken stone layer, therefore, the adhesion and friction were reduced significantly which created a prerequisite for the successful implementation of the deviation correction. The smoothness of the line was improved significantly, and the dynamic performance response of the ballastless track after the deviation correction was satisfied to meet the safety and stability requirements of the high-speed train operation.

keywords: Grouting; Uplift; Concrete structure; Ballastless track; Rehabilitation

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Efficient Impedance Model for the Prediction of Train-Induced Vibrations in Over-Track Buildings

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Abstract: Rapid growth of the urban development of Chinese mega cities lead to land utilization challenges resulting in the need for over-track buildings above metro depot. However, the high frequency of subway operations into and out of depots can generate excessive vibrations that transmit into the over-track buildings, with radiate noise within the buildings. The adversely affect the living quality is the dominant concern of building occupants. In order to predict building vibrations to provide reference for vibration mitigation design prior to construction, the impedance model was proposed. The model was validated by applying to two filed buildings over a metro depot that comprises of more than 50 over-track buildings.

By comparing the predicted vibration responses with the measured responses, the impedance models successfully predicted the floor vibrations levels of a low-rise steel-framed building with walls and a high-rise reinforced concrete building with bearing walls. The vibration at the building base is different with the vibration on the soil near the building base due to it has a building coupling loss for vibration transmission from soil to building foundation. Impedance modeling of buildings is a powerful, efficient, and rapid way that can be used for floor vibration predictions.

Key words: Vibration; Prediction; Building; Impedance modeling

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基于神经网络的地铁车辆代系特征研究

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摘要:城市轨道交通车辆以其时速高、运量大、耗能省、占地少等突出优势,成为公共交通的重要组成部分。经过一百多年的发展,地铁车辆已具有明显的代系特征。本文基于系统的观点从地铁车辆顶层指标出发研究地铁车辆代系特征。首先,综合分析车辆运输能力、安全性、舒适性和环境友好性4大类45个具体指标,利用复杂网络方法凝练提取14个核心指标;然后,基于获取的14个核心指标,分析第一、二代地铁车辆,利用神经网络方法获取地铁车辆性能与指标间关系,预测下一代地铁车辆性能;最后,基于下一代地铁车辆性能及当前最新技术,预测下一代地铁车辆特征。本文指明了未来地铁车辆的发展方向,为下一代地铁车辆制造提供了理论基础。

关键词: 地铁车辆; 代系特征; 神经网络

Research on the Characteristics of Generations of Subway Vehicles Based on Artificial Neural Networks

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Abstract:

Urban rail transit vehicles have become an important part of public transport due to the outstanding advantages: high speed, large traffic volume, low energy consumption and less land occupation. Metro vehicles have been developed for over one hundred years and there is obvious generational characteristics. In this paper, the generational characteristics of metro vehicles are studied from the top index of metro vehicles based on the systematic view. Firstly, the paper synthetically analyzes 45 specific indicators of four categories: vehicle transport capacity, safety, comfort and environmental friendliness. And then 14 core indicators are extracted by employing the complex network method. Secondly, the first and second generation metro vehicles are analyzed based on the 14 core indicators. By employing the artificial neural networks the relationship between the performance and indicators of metro vehicles is obtained. And then the performance of the next generation metro vehicles can be predicted. Finally, the characteristics of the next generation of metro vehicles are predicted based on the performance of the next generation of metro vehicles and the latest technology. The future development direction of metro vehicles is pointed and the theoretical basis for the next generation of metro vehicle manufacturing is provided in this paper.

keywords: metro vehicle; characteristics of generations; key words: artificial neural networks

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标准动车组制动系统用关键气动阀泄漏故障再现方法

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摘要: 标准动车组制动系统用气动阀在长期服役过程中容易发生疲劳、老化、卡滞等性能降级现象, 甚至发生制动不缓解等功能故障, 严重影响运营安全与效率。本文以制动系统关键气动阀类之一的中继阀为例, 介绍了其工作原理, 分析了其常见的失效模式, 提出“泄漏”是其主要故障模式, 并进一步将泄漏分为内泄漏和外泄漏。运用 AMESim 软件建立了中继阀仿真模型, 基于故障再现的模型驱动仿真法模拟了中继阀内、外泄漏故障, 分析了泄漏对中继阀输出 BC 压力以及平衡状态的影响规律, 发现了中继阀存在“三态”位以外的“动态平衡”位, 并在泄漏故障模拟试验台上进行了故障对比试验。试验结果表明: 运用 AMESim 建立的中继阀模型能有效再现中继阀泄漏故障。本文所提方法也可用于再现制动系统其他气动阀类泄漏故障。

关键词: 标准动车组; 气动阀; 泄漏; 故障再现

Reproduction Method of Key Pneumatic Valves Leakage Faults for Standard EMU Brake System

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Abstract:

The pneumatic valves used in the standard EMU brake system are prone to fatigue, aging, stuck and other performance degradation during long-term service, and even functional failures such as braking not releasing, which seriously affects operational safety and efficiency. In this paper, the relay valve, one of the key pneumatic valves of the brake system, is taken as an example. Its working principle is introduced, and its common failure modes are analyzed. The "leakage" is proposed as the main failure mode, and it is further divided into internal leakage and external leakage. The relay valve simulation model is established by AMESim software. The internal and external leakage faults of the relay valve are simulated by the model-driven simulation method based on fault reproduction, and the influence of leakage on the BC pressure and balance state of the relay valve is analyzed. It is found that the relay valve has a "dynamic balance" position besides the "three-state" position, and the fault comparison test is carried out on the leakage fault simulation test bench. The test results show that the relay valve model established by AMESim can effectively reproduce the relay valve leakage faults. The method proposed in this paper can also be used to reproduce other pneumatic valves leakage faults in brake system.

keywords: standard EMU; pneumatic valve; leakage; fault reproduction

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覆冰闸片对高寒动车组制动盘应力特性影响研究

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摘要: 基于高寒冰雪环境下动车组制动盘发生严重划伤现象, 从覆冰闸片与制动盘出发, 以制动盘的应力特性为观察点, 运用 ANSYS/LS-DYNA 及 Ls-Prepost 建立覆冰闸片与制动盘接触摩擦模型。基于第四强度理论及切削原理, 研究不同闸片压力下, 闸片覆冰对制动盘应力特性的影响规律。结果表明, 就闸片覆冰对制动盘应力的影响, 正常情况相比覆冰情况制动盘应力峰值减小 41.68%, 最大轴向位移减小 4.5mm; 就闸片压力的影响, 列车在 250km/h 制动时, 制动盘应力峰值大且最大等效应力随闸片压力不同相差较小, 仅相差 43.22Mpa。盘面轴向位移随闸片压力的增加总体趋势是增加的。本文为改善极寒冰雪环境下制动盘异常划伤现象提供重要参考价值, 为工程提供理论依据。

关键词: 高寒动车组; 冰杂质; 制动盘; 应力特性; 数值模拟

Analysis on Influence of Ice-Covered Brake Pads on the Stress Characteristic of Alpine EMU Brake Disc

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Abstract:

According to the phenomenon of the abnormal wear of the brake disc of the high-speed train, taking the ice-covered pad and brake disc into consideration, ANSYS/LS-DYNA and Ls-Prepost are used to establish the contact friction model between pad and disc. Based on the fourth strength theory and cutting principle, the stress characteristics of the brake disc under different brake disc pressure are explored. It is found that peak value of stress of brake disc decreased by 41.68% under normal conditions and the difference of maximum axial displacement is nearly 4.5mm. The peak stress is larger and the maximum equivalent stress changes slightly with the change of gate pressure, only 43.22Mpa. The overall trend of disk axial displacement increases with the increase of gate pressure. The analysis provides important reference value for improving abnormal wear of the brake disc in extremely cold and snow environment and theoretical basis for engineering.

keywords: low-temperature EMU; ice impurity; brake disc; stress characteristics; numerical simulation

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高速列车转向架载荷特征分析

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摘要: 本文对某高速列车转向架载荷进行了研究, 在标定实验、线路测试的基础上, 对转向架浮沉载荷、扭转载荷和抗侧滚扭杆载荷的载荷特征进行了分析, 得到载荷变化与速度之间的函数关系。结果表明: 浮沉载荷与扭转载荷在直线与曲线工况下无明显区分, 但对于速度变化, 两种载荷较为敏感; 抗侧滚扭杆载荷对直曲线变化有较强识别能力, 直线运行时, 抗侧滚扭杆载荷在零点附近波动, 曲线运行时, 速度达到超高临界值时抗侧滚扭杆载荷最小。

关键词: 高速列车转向架; 载荷特征; 浮沉载荷; 扭转载荷; 抗侧滚扭杆载荷

Load Characteristic Analysis of High Speed Train Bogie

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Abstract:

In this paper, the bogie load of a high-speed train is studied. On the basis of calibration experiment and line test, the load characteristics of bogie floating and sinking load, torsion load and anti-rolling torsion bar load are analyzed. The functional relationship between load change and velocity is obtained. The results show that there is no obvious difference between floating load and torsion load under straight line and curve conditions, but they are more sensitive to speed change. The load of anti-roll torsion bar has strong recognition ability to straight curve change. When running in straight line, the load of anti-roll torsion bar fluctuates near zero. When running in curve, the load of the anti-roll torsion bar is the smallest when the speed reaches the ultra-high critical value.

keywords: high-speed train bogie; load characteristics; floating load; torsional load; anti-roll torsion bar load

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焊接工艺参数对高速动车组转向架侧梁焊接变形的影响

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摘要: 转向架是高速动车组上的重要承载部件, 其质量关系到轨道客车运行的平顺性及安全。转向架构架侧梁属于大型部件, 焊缝长、热输入量大, 焊后残余变形难以控制, 因此亟待研究最优的转向架焊接工艺参数, 减小转向架焊接的残余变形。为了节省计算成本, 本文从转向架侧梁结构中提取曲线 T 接头模型, 以焊接速度、焊接电流和电压为研究对象, 基于热机耦合方法和试验设计方法进行焊接仿真分析, 提出了最优的焊接工艺参数组合, 并进一步讨论了上述工艺参数对焊接热输入和焊接残余变形的影响。将最优焊接工艺参数组合应用至转向架侧梁后, 可以保证侧梁上下盖板焊接残余变形满足平面度 $\leq 1\text{mm}$ 的要求, 无需焊后调平。

关键词: 转向架侧梁; 曲线 T 接头; 焊接工艺参数; 焊接残余变形

Influence of Welding Process Parameters on Welding Deformation of Bogie Side Beam of High-Speed EMU

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Abstract:

Bogie is an important part of high-speed EMU, and its quality is related to the smoothness and safety of the rail car. The side beam of bogie frame is a large part, which has long welding seam and large heat input, the residual deformation after welding is difficult to control. Therefore, it is urgent to study the optimal bogie welding process parameters and reduce the welding residual deformation of bogie. In order to save the calculation cost, this paper extracted the curve T joint model from the bogie side beam structure. Taking welding speed and welding current, voltage as research objects, based on the thermo-mechanical coupling method and design of experimental method, the welding simulation analysis was carried out. As the result, the optimal combination of welding process parameters is proposed, and the influence of the above parameters on welding heat input and welding residual deformation is further discussed. After applying the optimal welding process parameters to the side beam of the bogie, the welding residual deformation of the upper and lower cover plates of the side beam can be guaranteed to meet the requirement of flatness 1mm without post-welding treatment.

keywords: bogie side beam; curve T joint model; welding parameter; welding residual deformation

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缓和曲线线型对悬挂式单轨车线动力响应的影响

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摘要: 基于车辆动力学理论, 通过动力学软件 Universal Mechanism 建立悬挂式单轨车辆-线路耦合动力学模型, 针对三次、五次、七次和九次抛物线、半波和一波正弦型这 6 种缓和曲线线型进行研究, 分析了各线型下动力响应特性的变化规律。结果表明, 对于运行速度不高的悬挂式单轨来说, 高次曲线型缓和曲线相比三次抛物线并不存在绝对的优势, 这与理论结果有一定差异。由于三次抛物线的有效长度更长, 其相比其他线型条件下低频晃动的起始振动点稍晚, 所有线型中, 五次抛物线和半波正弦型条件下的晃动周期历时最短。针对同一衰减周期内的车体横向晃动幅度, 七次和九次抛物线、一波正弦型最大, 三次抛物线其次, 五次抛物线和半波正弦型最小。综合来看, 五次抛物线和半波正弦型缓和曲线具有更优特性。

关键词: 缓和曲线; 悬挂式单轨; 动力响应; 起始振动点; 晃动周期

Influence of Transition Curve on Vehicle-Line Dynamic Response of Suspended Monorail

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Abstract:

Based on the theory of vehicle dynamics, the vehicle-line coupling dynamics model of suspended monorail is established through the dynamics software Universal Mechanism. It conducts research on six transition curve types including cubic, fifth, seventh and ninth parabola, half-wave and one-wave sine, and the variation regulation of dynamic response characteristics under each line style is analyzed. The simulation results indicate that the transition curves of high-order curve types have no absolute advantage over the cubic parabola for the suspended monorail with low running speed, which is different from the theoretical results. Because the effective length of the cubic parabola is longer, its initial variation point of low frequency sloshing is slightly later than other line styles. The sloshing period of the fifth parabola and half wave sine curves is the shortest among all line styles. For the lateral sloshing amplitude of the vehicle body in the same attenuation period, the seventh and ninth parabola, one wave sine curves are the largest, followed by the cubic parabola, the fifth parabola and half wave sine curves are the smallest. In general, the transition curves of fifth parabola and half wave sine have better characteristics.

keywords: transition curve; suspended monorail; dynamic response; initial variation point; sloshing period

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真空管道交通的基本特点与技术对策探讨

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摘要:真空环境用于交通不但具有熟知的阻力低优势以外,还具有需要可靠的真空环境边界,进入-退出真空环境具有较大开销等问题。针对真空管道交通的技术特点,作者与合作者提出了“承载密封分置”真空管道建设方案与“有速乘客交换”运行方案。“承载密封分置”将真空管道建设转化为建筑与装修相类似的工程,从而有效控制造价。“有速乘客交换”使一条真空管道可为对等地两个城市群中的多个城市提供高速直达交通,提高真空管道客运交通的性价比。本文还对真空管道交通“导入可行性”进行了初步探讨。

关键词: 承载密封分置; 有速乘客交换; 导入可行性

Discussion on the Basic Characteristics and Technical Countermeasures of Vacuum Pipeline Traffic

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Abstract:

The vacuum environment for transportation is not only has the well-known advantage of low resistance, but also has the problems of requiring a reliable vacuum boundary and large overhead for entering and exiting the vacuum environment. In view of the technical characteristics of vacuum pipeline transportation, the author and collaborators proposed the “Processing Bearer-Seal separately” vacuum pipeline construction scheme and the “Passenger exchange with no parking” passenger transportation operation plan. The “Processing Bearer-Seal separately” transforms the construction of the vacuum pipeline into a project the construction of RC and affiliated renovation works, thus the cost can be controlled. “Passenger exchange with no parking” enables a vacuum pipeline provide direct passenger transportation services on a reciprocal basis for many cities along the route, thus the performance and ratio can be improved. This paper also discusses the “introduction feasibility” of vacuum pipeline transportation.

keywords: processing Bearer-Seal separately; Passenger exchange with no parking; introduction feasibility

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