Design Methods for Structural Reinforcement of Municipal Road Bridges

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Abstract: In the new era, with the rapid socio-economic development, the construction of municipal road bridges has become a crucial driving force for the sustainable development of the national economy. Only through ensuring that the structural design of municipal road bridges is met with rationality, can a good city image be formed and people's lives and properties can be protected. This paper attempts to provide more explanation about the principles and methods of structural reinforcement design for municipal road bridges with specific aims to greatly strengthen the bridge performance in order to enable urban traffic flow smoother.

1. Introduction

Municipal road bridge is one of the key components of urban transportation networks which plays a carrier role in guaranteeing the steady development of city and raising the regional economic levels. As the scale of urban construction expands and traffic load continues to increase, road bridges constructed earlier have begun to suffer from degraded structural performance. Many of them have acquired a number of diseases that threaten the security of urban traffic. Based on this, scientific structural reinforcement design methods can be adopted to prolong the service life of bridges and maintain the stability and continuity of the operation of transportation system.

2. Necessity of Structural Reinforcement Design for Municipal Road Bridges

2.1 Improving Structural Load-Bearing Capacity

In the operation and maintenance of municipal road bridges, improving structural load-bearing capacity is one of the goals of reinforcement design, which can resolve the contradiction between traffic upgrades and the weakening of bridge performance. With the acceleration of urbanization, the volume of urban traffic has increased significantly, and the frequency of large passenger buses and heavy-duty trucks has continued to rise. The current traffic loads far exceed the load standards designed for early bridges. Due to factors such as vehicle model specifications in the early design, the upper limit of their load-bearing capacity is low. Long-term exposure to overloading pressures can easily lead to structural damage, such as bearing deformation. If reinforcement is not carried out in a timely manner, it will seriously threaten traffic safety. Structural reinforcement design for municipal road bridges can enhance load-bearing capacity, enabling bridges to meet current and future traffic demands, gradually restore structural strength, reduce the likelihood of environmental erosion, and provide necessary support for the stable operation of the urban transportation system while avoiding safety accidents caused by insufficient load-bearing capacity.

2.2 Enhancing Structural Disaster Resistance

Municipal Road Bridges, as critical components of the urban transportation system, have a great influence on traffic smoothness and emergency rescue in disasters. The rationale behind reinforcement design is to improve disaster resistance. During service life, urban bridges are subjected to several natural disaster threats as well as accidental impacts such as vehicular collisions or road accidents. Because of its bad anti-disaster ability, bridge will restrict the smooth transport relief supplies when a disaster occurs and cause the disaster mitigation work which in turn causes secondary disasters, then it leads to big losses on city development. For example, a fundamental

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structural reinforcement design for the municipal road bridges that may be an important part of disasters mitigation. Optimized structural performance will consist of reinforcement approaches using fire-resistant materials and corrosion-resistant materials with different type of disasters. It not only enhances the structural integrity of bridges in disasters, but also decreases the likelihood of damage to bridges and enable normal operation after natural disasters.

2.3 Meeting Changing Traffic Demands

The rapid acceleration of urbanization has brought about changes in people's travel patterns, and the traffic demands facing municipal road bridges continue to change. Designing reinforcement that can satisfy these changes is probably the most requisite. The number of cars in cities still grows, meanwhile bridge traffic volumes in the morning rush hours also raise. Many bridges constructed at early stages are prone to traffic snarl-ups, which impacts urban movement quality [1]. Conversely, the rapid development of urban transportation has also brought about some emerging modes such as subways, while the logistics industry continues to expand and start to use heavy-duty freight vehicle traffic requirements are more frequent, but also for load-bearing capacity and adaptability. By exploiting advantageous configurations, fastener stress can be transformed using reinforcement design so that it is possible to reinforce bridge decks and widen lanes, increasing the traffic capacity of bridges, solving urban transportation problems and satisfying the demand for heavy-duty freight vehicles in terms of vehicular passing power. This not only allows bridges to function as a traffic node, but also enables their continual operation under fluctuating urban traffic demands.

3. Principles of Structural Reinforcement Design for Municipal Road Bridges

3.1 Safety Principle

For municipal road bridge reinforcement design, the main principle is safety, which should be carried out in every link of the whole reinforcement process. The essence is to prevent safety risks at the same time of bridge reinforcement and in later period through effective design, and guarantee the stability and reliability of bridge structures as well as vehicles passing on it. The first stage (the process of site inspection) in the design analysis of reinforcement must combine rigorous and detailed survey to evaluate bridges applied in order to accurately recognize bridge structural pathologies and possible risk points such as preventing reduction of the targeted nature of the design scheme and remaining hidden safety hazards due to holes in examination. The principle of safety is manifested in the reinforcement design process by optimizing the stress system and establishing reliable reinforcement measures to ensure that important structures are fully capable of withstanding load actions. And meanwhile, the selected reinforcement materials also need to have certain durability and strength performance to ensure that the structural stability will not be affected due to material quality problems. The law of safety also states that after reinforcement, bridge structures should be able to meet the future requirements for disaster resistance and traffic load demands in the face of sudden risks.

3.2 Economy Principle

The essence of economy principle is to make the best use of resource and control cost within an effective range while meeting safety and functional requirements, avoid extensive waste of resources, and provide economic technical scheme for municipal engineering construction. The control of bridge reinforcement is the key research content in the operation and maintenance of municipal infrastructure. Economical, effective, and realizable designs need to be selected according to the budget planning of urban construction. Thus, economy principle must fit within the whole re-inforcement design [2]. In the first step of reinforcement design, this principle states that it is more advantageous to use low-cost and targeted reinforcement schemes based on bridge inspection results. In the middle phase of outlining support, this guideline necessitates a correlation among the cost –, availability – and performance-related aspects of various materials for accomplishing the plan objective(s) within as far as possible.

3.3 Feasibility Principle

This case study, furthermore, highlights the need to abide by a fundamental principle of structural design: feasibility when performing structural rehabilitation design within municipal road bridges. At its heart is to ensure that the reinforcement regime is practical in terms of environmental and technological adaptability. When reinforce bridge structure site, also full consideration of the practice situation. An excessive pursuit of technology by alienating feasibility will make it difficult for an rational implementation, which increases the cost of engineering. Technical having to do with the idea of compatibility with existing levels, using mature and reliable construction processes and materials that ensure a certain method of supply chain recycling as well as some level of construction ability for the people/organization involved in the areas where project implementation is necessary. I hope so that construction feasibility should be based on real traffic scenarios and the land area of bridges. For example, where it is necessary to reinforce bridge structures in urban core areas, temporary traffic diversion schemes shall be developed in such a way that narrow construction areas do not impair the orderly progression of the measures.

4. Design Methods for Structural Reinforcement of Municipal Road Bridges

4.1 Section Reinforcement Method

Section reinforcement technique is a mature technology that is widely used in structural strengthening of municipal road bridges. The essence of its mechanism is to improve the bearing and service life of large load-bearing structural components such as main beams and cover beams by increasing their structural size and adding other materials, so that it effectively avoids the problem of structural performance degradation due to the aging of carrying performancematerial. It is applicable to the early construction of reinforced concrete bridges or prestressed concrete bridges, whose main beams often have low flexural capacity due to problems such as corrosion of steel bars after long-term use. For specific reinforcement design, the section reinforcement method is further divided into the enlarged section method and the concrete-encased method. The method of enlarged section strengthens members by enhancing the area of their cross-section in compressive zone through the pouring of new concrete and arranging stressed steel bars. For horizontal load-bearing components, the concrete-encased method is appropriate. It consists of wrapping the original component in a steel bar mesh and pouring concrete on it; this establishes a system with which the old component, new concrete and newly added steel bars together bear the loads, significantly improving the ductility and compressive performance of components and changing bridge cracking issues. The sectional reinforcement method has relatively mature construction technology and considerable reinforcement effects [3]. In the practical application of reinforcement, people should pay attention to the connection and anchoring between the newly laid steel bars and original steel bars and analyze how to treat the bonding surface between new concrete and old concrete so as to avoid causing local stress concentration damage new structure. Not only can the problem of component section defects in bridges be solved through reasonable section reinforcement design, but it can also form a complete complementary reinforcement system with other reinforcement methods and ensure that bridge structures can meet the requirements of changing traffic demands and disaster resistance demands during long-term use, providing technical support for safe operation of municipal road bridges.

4.2 Arch Rib Reinforcement Method

Arch rib reinforcement method is a kind of municipal road arch bridge reinforcement method, including concrete arch bridge and so on, mainly aimed at solving the problem of load-bearing ability reduction and section damage, providing necessary guarantee for the safe passage of arch bridge. Arch ribs are the primary structural elements in an arch bridge structure, which transfer vertical loads exerted by the bridge deck and translate them into horizontal components acting along the arch axes. Arch ribs are susceptible to diseases such as exposed steel bars and cracks due to long-term use, which greatly reduce the load-bearing capacity of arch bridges and even cause bridge

collapse in severe cases. In the arch rib reinforcement method is mainly divided into three technical paths I. Adhesive reinforcement This method uses the high strength of composite materials, which is commonly used to paste carbon fiber cloth or steel plates on the tension zone of arch ribs to improve its shear performance. This method has little effect on the original body, and is easy to build. It can be used in places where the local strength of arch ribs cannot reach. Second, concrete encasement reinforcement. In the case of severe section damage of arch ribs, steel sleeves can be wrapped on arch ribs to increase the cross-sectional area and play a supplementary role in stressed steel bars in a new type of load-bearing system formed by cooperatively bearing load with original arch ribs & treasure resources. Third, adding auxiliary components. This can be done by inserting new structure, such as two arch ribs or support below the original arch ribs to divide the loads of the arch ribs. As a typical application, reinforced concrete cross-braces could be adopted to reduce the possibility of the lateral deformation of arch ribs and to enhance the integral stability of such structures by constructing them between arch ribs for stone arch bridges [4]. It should be realized that the application of this method is to strengthening arch ribs bonding performance between original arch ribs and reinforcement materials, as well as coordination between reinforced arch ribs and bridge deck in order to avoid local stress concentration. Through the above design of reinforcement for section of arch ribs, we can treat diseases of arch ribs and restore load-bearing capacity of arch bridges which makes it being used in municipal transportation.

4.3 Longitudinal Beam Reinforcement Method

Longitudinal beams are the primary load-bearing elements of the girder types in municipal road bridges that carry vertical loads from bridge deck pavement and transfer it at piers as well as bearings [5]. Their structural behavior is one of the main factors affecting the global bearing capacity of bridges. After long-time usage, municipal road bridges are subjected to the consistent actions of traffic loads and the aging of material, which may lead to local crushing around bearings and other diseases. In case reinforcement intervention is delayd, the ability of longitudinal beams to bear load will be deteriorated which leads to settlement problems in bridges deck. In extreme instances, there is a risk of longitudinal beam cracking. In reinforcement design, the longitudinal beam reinforcement methods of implementation paths are are as follows：First, pasting reinforcing materials. Carbon fiber cloth is adhered in the tension zone of longitudinal beams, effectively utilizing its high strength to improve the tensile performance of longitudinal beams and compensate for their tensile capacity, set up for cases where bridge bending load-bearing capacity is insufficient. The construction period of this type of reinforcement is short, and has a relatively small influence on traffic. Second, external prestressing reinforcement. In the vicinity of the external longitudinal beams, prestressed steel strands are arranged outside their against longitudinal bends and tensile stress with functions to eliminate loads; thus enhancing crack resistance stability in large-span bridges. Third, enlarged section reinforcement. Supp Sv are inserted into sectional area of longitudinal beams in tension zone to increment cross-sectional dimensions and adequacy of longitudinal basic notion, which is monitored for large level of steel bar corruption. At the same time, when designing longitudinal beam reinforcement, traffic diversion schemes should be fully considered to ensure that construction does not significantly affect traffic passage. Also, focus on the combined compression of rehab materials and existing beams. Therefore, the bridge reinforcement design of longitudinal beams can not only meet the traffic load requirements in all periods but also improve the overall life span of bridges and prepare conditions for safe and smooth operation of municipal roads.

4.4 Adhesive Reinforcement Method

The adhesive reinforcement method is one of the most efficient and convenient structural reinforcements for municipal road bridges. The main principle is to use a new type of adhesive or adhesive method, by bonding high-strength materials such as steel plates on the tension zones of bridge components, forming a composite system with the original components in the damaged section through its high strength and parallel interspersed direction with respect to structural stress

direction difference (>30°) mechanism can greatly supplement the compressive and shear performance of bridge components, thereby enhancing their overall bearing capacity. This technique applies to cases when the shear load carrying capacity is inadequate, moderate localized cracking occurs but the aging of the materials were rather low [6]. In the specific implementation engineering of reinforcement, the adhesive reinforcement method must carry out a batch process: The surface of the original component treats and cleans weathering layer, laitance. After pressure injecting and fillings cracks the surface ground to a naked roughness of as process make certain, that the adhesive sticks absolutely. And lastly, reinforcing material is pasted. In case a steel plate is pasted, bolts may be utilized to facilitate fixation to ensure close bonding between the reinforcement material and the original component. Upon curing of the adhesive, a monolithic stress structure is created [7]. In contrast to other reinforcement approaches, the adhesive reinforcement method is relatively direct on bridge traffic and brief construction period additionally fulfill the requirement of various part shapes. In reinforcement design, staff should focus on the adhesive strength and durability, and select proper reinforcement materials. Reasonable adhesive reinforcement design can effectively treat diseases of bridge components, improve overall structural performance and provides an economic and safe technical scheme for the safe operation of municipal road bridges.

5. Conclusion

To sum up, according to the contexts of contemporary social development municiple road bridges have important significance. A large number of all kinds of diseases will appear as the use time increases, which can not normally use. Therefore, to solve diseases and improve the level of service performance here, analyze structural reinforcement measures for municipal road bridges carefully so that they can achieve a smooth road.

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