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Maintenance, Repair, and Reinforcement Measures for Dilapidated Small and Medium-Sized Bridges

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Abstract: The paper initiates by exploring the importance of maintaining, repairing, and reinforcing bridges. Subsequently, it delves into routine and preventative maintenance measures tailored for small to medium-sized bridges. Additionally, the paper examines repair and reinforcement techniques specifically designed for deteriorated small and medium-sized bridges, encompassing methods for fortifying both the bridge foundation and upper and lower structures. Lastly, the paper proposes suggestions aimed at fostering discussions and exchanges on the development of maintenance and repair processes for deteriorated small and medium-sized bridges.

Keywords: Dilapidated small and medium-sized bridges; Maintenance; Repair and reinforcement

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1. Introduction

In the long-term use of bridges, various issues may arise due to the combined effects of natural environmental factors and traffic loads. Consequently, it becomes imperative to maintain, repair, and reinforce bridges to curb the progression of issues, enhance the stress state of the bridge, and safeguard its stability. Based on this, the maintenance and repair of deteriorated small and medium-sized bridges have become necessary. Improving the stability of these bridges and extending their service life is crucial. Maintenance and repair processes can eliminate potential safety hazards, ensuring the safety of public transportation to the greatest extent and providing a secure transportation environment for the general public.

2. The importance of bridge maintenance, repair, and reinforcement

Bridge maintenance and repair processing are vital for improving the durability and safety of bridges, promptly eliminating potential safety hazards, and maintaining a safe and orderly public transportation environment. The importance of bridge maintenance and repair processing is reflected in the following aspects.

Firstly, enhancing the safety and stability of the bridge is paramount. Maintenance, repair, and reinforcement can contribute significantly to improving safety and stability. Issues such as cracks, rust, wear, and tear may manifest during the bridge's usage, affecting its safety and stability. Timely intervention is essential to prevent these issues from expanding and causing safety accidents. Regular maintenance, repair, and reinforcement are, therefore, necessary to eliminate potential safety hazards and effectively enhance the stability and safety of the bridge.

Secondly, extending the service life of the bridge is crucial. In China's public transportation system, bridges play a pivotal role in improving traffic efficiency. Maintenance, repair, and reinforcement can effectively prolong the service life of bridges. The service life of a bridge is closely tied to its design and construction quality, necessitating regular maintenance, repair, and reinforcement upon its utilization. This proactive approach is vital to prevent issues in the bridge and ensure that problems are addressed in a timely and scientific manner, ultimately extending the service life of bridges and enhancing their economic and social benefits.

3. Maintenance measures for small and medium-sized bridges

3.1. Routine maintenance measures

Routine maintenance of aging small and medium-sized bridges is crucial for ensuring their safety and stability. Specific maintenance measures include the following aspects:

(1) Bridge deck maintenance: Focus on preserving the smoothness of the bridge deck and facilitating proper drainage to prevent damage caused by water accumulation. Regularly cleaning the bridge deck and removing dirt and debris are essential to maintain its cleanliness.

(2) Railing maintenance: Regular inspections of bridge railings are imperative during routine maintenance to ensure their firmness and detect any damage. If damage is identified, prompt repair or replacement is necessary to prevent safety accidents.

(3) Drainage system maintenance: Regularly clean the drainage system of small and medium-sized bridges to ensure unobstructed water flow. Particularly before the rainy season, conduct a comprehensive inspection and cleaning of the drainage system to ensure its optimal functioning.

(4) Support maintenance: Conduct regular inspections of the bearings of small and medium-sized bridges to identify any issues such as loosening or rust. Timely repair or replacement is required for any abnormalities discovered during these inspections.

3.2. Preventive maintenance measures

Preventive maintenance is essential for small and medium-sized bridges to effectively prevent and delay damage, thereby extending their service life. This measure primarily targets older small and medium-sized bridges. The specific preventive maintenance measures are outlined below:

(1) Regular checks: Maintenance personnel are required to conduct routine inspections of small and medium-sized bridges. The scope of inspections encompasses appearance, structure, materials, and other relevant aspects. This ensures that potential issues and safety hazards are promptly addressed.

(2) Maintenance planning: A comprehensive maintenance plan must be formulated for preventive maintenance of small and medium-sized bridges. This involves conducting a scientific assessment of bridge usage, fully understanding the current operational status and future development trends, and formulating and implementing plans accordingly. These plans should be tailored to the actual conditions of the bridge, encompassing maintenance, minor repairs, enhancements, and overhauls. During the maintenance phase, attention should be given to selecting appropriate materials and maintenance techniques to enhance the bridge's durability and load-carrying capacity.

(3) Monitoring and documentation management: During the use of small and medium-sized bridges, emphasis should be placed on strengthening monitoring and archival management. Various monitoring methods must be comprehensively employed to detect any abnormal conditions promptly. This includes routine maintenance to identify bridge issues and maintain its condition. Additionally, it is crucial to document the maintenance and repair processes of small and medium-sized bridges, truthfully recording the content of each inspection, repair, and reinforcement. This documentation serves as a reference for subsequent maintenance work, ensuring the stability of small and medium-sized bridges during their operational phase.

4. Repair and reinforcement measures for dilapidated small and medium-sized bridges

4.1. Bridge foundation reinforcement methods

During the repair and reinforcement stage of dilapidated small and medium-sized bridges, the priority is to reinforce the bridge foundation to ensure the safety and stability of these structures. The following methods can be adopted:

(1) Expand foundation reinforcement: If there is an uneven settlement in the foundations of dilapidated small and medium-sized bridges, and the soil quality in the bridge's location is relatively solid, foundation reinforcement can be achieved by expanding the foundation. This method involves increasing the area and depth of the original foundation, thereby enhancing its bearing capacity and stability.

(2) Pile foundation replacement and reinforcement method: This method is employed to repair and reinforce dilapidated small and medium-sized bridges facing issues like insufficient foundation-bearing capacity or excessive foundation deformation. The process involves reinforcing the original pile foundations by driving additional piles into specific areas. The load of the bridge is then transmitted through the bearing capacity of these reinforced pile foundations, thereby increasing overall foundation capacity and stability.

(3) Pressure grouting reinforcement: Another effective method for repairing and reinforcing dilapidated small and medium-sized bridges is pressure grouting reinforcement. This involves injecting cement slurry or chemical slurry into the foundation. This process increases the density of the foundation, thereby improving the bearing capacity of the bridge foundation. This method is particularly suitable for reinforcing foundations composed of materials such as sand, silty clay, and cohesive soil.

4.2. Superstructure reinforcement methods

During the repair and reinforcement phase of dilapidated small and medium-sized bridges, it is crucial to focus on reinforcing their superstructures. This is essential for ensuring the normal use of these bridges and preventing safety accidents. Various methods are commonly employed to repair and reinforce the superstructure of dilapidated small and medium-sized bridges.

One method is the external bonded steel reinforcement. This involves affixing steel plates to the exterior of the concrete components of dilapidated small and medium-sized bridges. This operation enhances the bearing capacity and stability of the components [1].

Another method is the prestressed reinforcement. By utilizing this approach to repair and reinforce the superstructure, prestressed steel tie rods or steel braces can be incorporated within the concrete components. This alteration changes the internal stress structure of the component, ensuring its internal stress stability. This, in turn, helps maintain the overall stability and bearing capacity of the bridge structure.

The third method involves increasing cross-sectional reinforcement. This approach aims to expand the

cross-sectional area of the component, thereby improving the bearing capacity and stability. This measure contributes to strengthening the bridge and achieving the goal of enhancing its overall structural integrity.

4.3. Substructure reinforcement methods

During the repair and reinforcement of dilapidated small and medium-sized bridges, special attention must be given to reinforcing the substructure. This is crucial for ensuring the safety and stability of these bridges. The specific methods for repairing and strengthening substructures are as follows.

One method is grouting. The crack grouting method is typically employed to address cracks in dilapidated small and medium-sized bridges. In this specific operation, materials such as cement slurry or epoxy resin need to be injected into the cracks to seal them, thereby improving the overall stability of the bridge structure [2].

The second method involves expanding the foundation. If there is an issue of insufficient foundation-bearing capacity when dilapidated small and medium-sized bridges are in use, the foundation can be expanded for reinforcement. This method includes adding concrete or reinforced cushion to the original foundation. This operation enhances the bearing capacity and stability of dilapidated small and medium-sized bridges.

The third method is the use of anchor static pressure piles and deepening foundations. During the repair and reinforcement of dilapidated small and medium-sized bridges, anchor static pressure piles can be employed. This method involves pressing the anchor static pressure piles into the bridge foundation, thereby increasing the bearing capacity of the bridge foundation through the piles. In addition, if the original foundation depth of the bridge is insufficient, the bridge's bearing capacity can be increased by deepening the foundation. This method requires excavation on the original foundation of the bridge, thereby increasing the depth and area of the bridge foundation to ensure its bearing capacity and stability meet usage requirements.

5. Development suggestions for the maintenance, repair, and reinforcement of dilapidated small and medium-sized bridges

5.1. Establish a comprehensive bridge archives management system

To ensure the systematic maintenance, repair, and reinforcement of dilapidated small and medium-sized bridges, and to guarantee their safety and service life during the operational phase, it is crucial to implement scientific design planning for these activities. Documenting and managing the progress of this work is essential. This measure ensures that all records of maintenance, repair, and reinforcement work are accurately documented, providing data support for subsequent bridge maintenance and reinforcement efforts [3].

It is necessary to establish a bridge data information database, categorize and organize the collected bridge information, and create an information database. Management regulations for bridge maintenance and reinforcement information files should be formulated to clearly define requirements for the collection, arrangement, storage, and utilization of bridge-related files. This ensures the standardization and scientific management of various archive-related tasks. Simultaneously, during the archival management stage, attention should be given to regularly updating various archival information. After completing each maintenance, repair, and reinforcement task, accurate information must be recorded to facilitate subsequent bridge management activities in an orderly manner [4].

5.2. Strengthen policy support and financial investment

In the development stage, policy support and financial investment from regional governments are crucial to promote the maintenance, repair, and reinforcement of dilapidated small and medium-sized bridges. This, in turn, ensures the safety and stability of the bridges during the operational phase, allowing them to contribute to

social and economic development and construction with a steady stream of assistance [5].

Firstly, regional governments can introduce relevant policies that clearly emphasize the importance of maintaining, repairing, and reinforcing dilapidated small and medium-sized bridges. Corresponding management regulations and technical standards should be formulated around these activities. The government must also offer certain preferential policies to encourage the involvement of social capital in the repair and reinforcement of these bridges [6].

Additionally, the government needs to intensify financial investment and provide special financial support for the repair and reinforcement of dilapidated small and medium-sized bridges. Various financing methods, such as attracting social capital and issuing bonds, can be adopted to address the issue of insufficient funds. This approach effectively ensures the stability and safety of dilapidated small and medium-sized bridges during the operational phase.

5.3. Strengthen the training and education of bridge management personnel

Increasing the training and education of bridge management personnel is crucial for promoting the systematic maintenance, reinforcement, and repair of dilapidated small and medium-sized bridges. This initiative aims to achieve scientific and standardized management practices for such bridges while enhancing the professional quality and capabilities of the management team [7].

Therefore, implementing comprehensive training and education programs for bridge managers is essential. Firstly, it is necessary to develop a comprehensive training plan that clearly outlines the training objectives, content, and methods. Special attention should be given to cultivating practical skills during training, thereby enhancing the professionalism, ability, and skill level of bridge managers [8].

Secondly, establishing a complete training and education mechanism for bridge managers is imperative. This involves creating regular training plans, special lecture plans, practical operation plans, and other components. Through various forms of training, bridge managers should gain knowledge and skills related to bridge maintenance, repair, and reinforcement. This approach aims to improve the fundamental qualities and overall abilities of personnel, enabling them to play a more effective role in the maintenance and reinforcement of dilapidated small and medium-sized bridges. This, in turn, contributes to the orderly development of maintenance, repair, and reinforcement efforts for dilapidated small and medium-sized bridges.

5.4. Increase research and development of maintenance and reinforcement technology

Promoting the advancement of maintenance, repair, and reinforcement for dilapidated small and medium-sized bridges necessitates active research and development in maintenance and reinforcement technology. This effort aims to replace traditional and outdated methods with new technologies, ultimately enhancing the durability and service life of bridges [9].

Firstly, it is essential to establish a dedicated research and development team for bridge repair and reinforcement technology. This professional team is tasked with intensifying research and development efforts in technologies for repairing and reinforcing dilapidated small and medium-sized bridges. The team should possess extensive experience in bridge engineering and advanced technical proficiency to ensure the feasibility and reliability of all developed repair and reinforcement technologies [10].

Secondly, there is a need to bolster technical research and explore novel reinforcement technologies and methods related to the maintenance, repair, and reinforcement of dilapidated small and medium-sized bridges. It is crucial to draw lessons from advanced bridge maintenance and reinforcement technologies domestically, innovating and refining maintenance and reinforcement technology based on the specific conditions of dilapidated small and medium-sized bridges. This approach ensures that these bridges exhibit excellent

durability and safety during their operational phase.

6. Conclusion

In summary, the maintenance, repair, and reinforcement of dilapidated small and medium-sized bridges constitute a critical task. This undertaking is pivotal in ensuring the safety and stability of these bridges during their operational phase, mitigating safety risks, and preventing traffic accidents. Therefore, it is imperative to intensify the design and planning processes for the maintenance, repair, and reinforcement of dilapidated small and medium-sized bridges. Additionally, enhancing these measures is crucial to guarantee the safety of these structures. This paper has conducted in-depth research and exploration into the maintenance, repair, and reinforcement measures of dilapidated small and medium-sized bridges. The findings of this study provide a foundation for collective discussion and exchange of strategies to address the challenges associated with these bridges.

Disclosure statement

The authors declare no conflict of interest.

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