

Countermeasures for the Maintenance Management of Expressway Bridges and Tunnels

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Abstract: In order to improve the maintenance of expressway bridges and tunnels as well as to maximize the utilization rate of expressway bridges and tunnels, this paper studies the countermeasures for the maintenance management of expressway bridges and tunnels. Through theoretical analysis, this paper expounds the problems existing in the maintenance management of expressway bridges and tunnels as well as proposes corresponding solutions to these problems. By implementing the countermeasures for the maintenance management of expressway bridges and tunnels, it is possible to improve the maintenance effect of expressway bridges and tunnels as well as ensure the smooth and safe operation of expressway bridges and tunnels.

Keywords: Expressway; Bridges; Tunnel; Maintenance management

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1. Introduction

In China, the expressway is an important part of the road network system, which guarantees people's safety while travelling. However, with the ongoing development of various domestic expressways, the pavement of many expressway bridges and tunnels has developed defects of varying degrees after being put into operation, such as cracks and water damage, thus significantly increasing the traffic risk. Therefore, maintenance measures must be taken to effectively improve the structural quality of these pavements and ensure people's safety while travelling^[1-8]. Chen Tao believes that with the increase in traffic flow and vehicle speed on the expressway, the risk of pavement rutting, cracks, pits, and other defects is also increasing, thus traffic safety cannot be guaranteed^[9]. Therefore, some feasible maintenance measures should be applied, such as paving technology, local filling technology, and overlay maintenance technology, so as to ensure structural safety. The engineering construction quality of expressway bridges and tunnels is of great significance to promoting the development of China's infrastructure and ensure the safety of people's lives.

2. Problems existing in the maintenance management of expressway bridges and tunnels

2.1. Backward maintenance management mode

China has a large highway bridge and tunnel system; hence, a lot of energy and money need to be invested in the maintenance management of highway bridges and tunnels. The maintenance management mode is still backward. At present, there is no advanced concept and effective solution for the maintenance of highway bridges and tunnels. The maintenance mode is backward, and it lacks scientific and reasonable maintenance measures, effective maintenance specifications, as well as practical maintenance methods for employees.

2.2. Low overall quality of maintenance personnel

The maintenance management personnel are closely related to the use and management of highway bridges and tunnels. They not only implement the decisions of their superiors, but also have direct contact with the system. Therefore, the maintenance management personnel are responsible for the maintenance of highway bridges and tunnels. Their overall quality directly determines the quality and efficiency of their work. A low overall quality will have a great impact on the maintenance management of highway bridges and tunnels. For the maintenance management of highway bridges and tunnels, many employees do not maintain quality or inspect carefully. In addition, the maintenance manager's attitude towards the overall technical problems, the way of thinking about work, and learning new maintenance modes are also important factors that restrict the advancement of maintenance operation.

2.3. Lack of sound and efficient maintenance management mechanism

A sound maintenance mechanism is the basis for the smooth and efficient completion of work. Without a sound maintenance management mechanism, there will be many loopholes in the maintenance of highway bridges and tunnels. With the passage of time, these loopholes will continue to accumulate, causing damage to highway bridges and tunnels as well as seriously affecting the service life of these bridges and tunnels. In addition, the maintenance management mechanism with ambiguous rights and responsibilities will cause confusion in work management between departments and employees, as well as reduce work quality and efficiency. At present, China still lacks an ideal and efficient maintenance mechanism. Due to the long-term influence of maintenance methods and habits, departments and employees at all levels lack awareness of the importance of innovation and keeping pace with the times, in completing work scientifically and orderly, as well as in establishing and perfecting the maintenance mechanism. These rules and regulations have seriously restricted the development in maintenance of highway bridges and tunnels in China.

3. Countermeasures for the maintenance management of expressway bridges and tunnels

3.1. Preparation and improvement of the maintenance system

In the process of maintenance, it is important to first strengthen and implement the bridge management system and inspection system. Technicians and professional maintenance personnel should regularly and timely identify road, bridge, and time issues. At the same time, strengthening the resolution of existing highway bridge defects and formulating preventive measures for large-scale highway bridge defects and safety accidents are also important. In addition, the maintenance department should establish a reasonable bridge inspection system to carry out special inspection on highway bridges to prevent the occurrence of other defects. The maintenance management department should also establish a highway and bridge maintenance report system to ensure that professional technicians and maintenance personnel record down the defects and follow up with equipment maintenance, so as to provide strong data support for the continuous maintenance work in the future^[2]. Finally, the safety management responsibility system should be implemented to ensure a clearer division of responsibilities and work requirements of technical and management personnel. Each road and bridge should be managed by an assigned person, so that the person in charge of each road section will be able to detect the defects in a timely manner. Therefore, the construction and improvement of the technical management system of highway bridges can lay a foundation for ensuring the continuity and integrity of bridge maintenance, implementing various maintenance and management actions, as well as improving the maintenance quality of highway bridges.

3.2. Road cracks repair

Load cracks not only affect traffic safety, but also may cause fatal damage to the durability of the bridge. Therefore, relevant units and maintenance management departments should attach great importance to and

adopt corresponding maintenance schemes for different types of load cracks. At the level of structural defects of the bridge itself, measures such as steel plate adhesion, prestressed reinforcement tensioning, and original structure reinforcement can be adopted to effectively solve the problems of load cracks and insufficient bearing capacity of the original structure, which can be confirmed by a load test ^[3]. In addition, in view of the load cracks and main reinforcement corrosion caused by the insufficient bearing capacity of the main beam, adhesives or anchor steel plates can be used at the tensile edge of the structure and weak parts of the bridge to form a relatively stable structure, so as to effectively solve the cracks and other defects caused by the increasing load on the bridge. These methods can improve the original structural stress state of the bridge to a certain extent.

3.3. Bridge deck maintenance

In terms of preventive measures, in order to effectively prevent the damage to highway bridge deck concrete, the maintenance unit must reasonably arrange the bridge deck pavement. First, before paving asphalt concrete materials, tools such as iron brush should be used to clean up road dust and sundries. The compaction of asphalt concrete can control the water permeability within a range and the slump of concrete to ensure the continuity and high strength of concrete materials.

In terms of maintenance measures, at this stage, the general maintenance and reinforcement scheme mainly includes local maintenance, overhaul, etc. Local repair mainly involves milling, supporting, melting rusty materials, and other processes for the damaged asphalt pavement of the bridge deck, followed by paving. A new pavement layer can be used to ensure that the laying thickness and weight meet the design load ^[4]. In addition, for bridges with potential safety hazards, such as large bridge deck damage, large span, and multiple pits, a backfill maintenance scheme should be formulated. Recasting requires the use of technology to remove the old road surface, smooth the surface, and fix the short rod. At the same time, it is necessary to lay an appropriate amount of wire mesh to strengthen the safety of the bridge deck, and finally pour concrete with appropriate thickness.

3.4. Drainage system maintenance

When the bridge drainage system is damaged or blocked, water will fill the bridge area, causing vehicles to slip and adversely affect the safety of drivers. This is also an important factor leading to traffic accidents. When ponding enters the concrete structure through the cracks of the drainage system, it not only corrodes the bridge deck, but also affects the service performance of the bridge deck. Therefore, if the drainage pipes and gutters on the bridge deck are blocked, they must be unclogged to ensure a smooth drainage system.

In addition, the damaged drainage pipe should be repaired in time. If the joint falls off or is not firm, it should be reinstalled and replaced. In real-life scenarios, the bridge deck drainage pipe joint may be damaged, causing water to seep into the beam floor when snow melts, which leads to the freezing of the beam floor concrete ^[8].

3.5. Expressway expansion joint maintenance

The bridge deck's expansion joint is usually found in the weakest area of the beam end, which plays an essential role in repeated traffic. Therefore, the regular maintenance of the bridge expansion joint should be strengthened, the garbage generated by the expansion joint should be cleaned regularly, and the bolts should be tightened to ensure normal functioning. However, if the expansion joint is damaged or defective, the maintenance personnel should determine the cause and repair or replace it with a new one. In terms of preventive maintenance, the time with the largest benefit-cost ratio is usually selected as the best maintenance time. When curing at different times, the benefit-cost ratio also varies ^[4].

3.6. Pier foundation maintenance

The basic purpose of pier foundation maintenance is to ensure the stiffness and stability of the bridge structure as well as to reduce the abrasion of running vibration by snow and water. The code for the maintenance of expressway bridges stipulates that the maintenance of pier foundation should focus on five aspects [5-10].

- (1) Before maintenance, pollutants should be removed to keep the surface of pier and abutment clean and tidy.
- (2) It should be emphasized once again that the contaminated working structure has been eroded by snow as a result of low temperature over a long period of time.
- (3) When the bridge deck concrete has eroded, defects such as honeycomb and scratched surface, as well as the surrounding chisels should be cleaned and then troweled with cement mortar.
- (4) If the veneer of block masonry has been damaged or weathered, it should be supplemented with stone and precast concrete blocks.
- (5) If the pier foundation has no runoff slope and the slope surface is uneven or cracked, cement mortar or concrete should be used to form a horizontal slope surface to facilitate drainage.

3.7. Portal maintenance

In the process of expressway construction and development, the end wall is the main structure of the tunnel portal, and the problem is usually targeted on this structure. For example, the problems of water leakage, cracking, and falling off of end wall decorative coating are under the category of common problems in civil structure construction, which increases the incidence of expressway tunnel operation risk. Due to the insufficient performance reliability of waterproof facilities and the actual effect of drain holes, the construction quality of tunnel civil structure is potentially threatened, resulting in cracks and uneven settlement, reducing the construction level of civil structure, burying potential safety hazards in the construction and application of expressway tunnel, as well as hindering the role of civil structure.

3.8. Lining structure maintenance

In the process of formulating and implementing the civil structure construction plan of expressway tunnels, the construction status of the lining structure will affect the application effect.

- (1) Due to longitudinal cracks, annular cracks, and oblique cracks, the stability of the lining structure is reduced. Under the influence of seepage, the application rate of the lining structure in practice is increased, which hinders the improvement of its construction level.
- (2) Due to the lack of scientific analysis of the geological structure and the application level of the lining of expressways, it is difficult to meet the requirements of the construction process of the tunnel lining.

3.9. Repair track maintenance

The channel facilities formed by the cable trench cover plate on the tunnel maintenance road will affect the quality in practice, increase the problems in the civil structure construction of expressway tunnels, adversely affect its application quality and tunnel construction effect, as well as threaten the application safety of expressways in practice. At the same time, influenced by inspection and repair issues, the hidden dangers in expressway tunnels are not handled in time, which reduces its construction quality level and leads to the application of civil structure of expressway tunnel.

3.10. Strengthen the construction of information platform

3.10.1. Improve work efficiency by using the disease database

The main tasks of maintenance informatization are data collection, query and management, data

configuration and management, as well as the establishment of shared database. The traditional daily maintenance management uses manual way to query, navigate, and reuse all kinds of data and pictures generated by maintenance management tasks, which are time-consuming and laborious. The maintenance information platform takes the disease database as the core and uses the database technology to classify, store, and organize maintenance data to form an information sharing platform^[10-14]. The platform allows administrators at all levels to query, retrieve, and reuse these maintenance data based on different access permissions, as well as export various maintenance daily worksheets, including daily maintenance and maintenance project plan, project progress report, and project settlement. It is necessary to quickly calculate the workload completed on time and avoid duplicate records, duplicate forms, and duplicate inspection records. At the same time, the high efficiency and reliability brought by automation help prevent errors and omissions of manual statistics as well as improve the level and efficiency of maintenance.

3.10.2. Support the establishment of a maintenance decision model

By importing various regular inspection data and test data into the maintenance information platform, it is possible to automatically evaluate road conditions, PQI, SCI, and other facilities, establish a long-term maintenance data management system, and regularly monitor the dynamic conditions. At the same time, big data should be used to mine all kinds of maintenance data, identify laws in massive data, establish damping models for technical status indicators of various facilities, predict the results of maintenance projects as well as medium and long-term maintenance decision-making and analysis models, change the current maintenance mechanism from manual to active, as well as improve highway maintenance in a more scientific and intelligent manner. Conservation data can genuinely assist in decision-making.

3.10.3. Active risk management

Maintenance informatization uses the maintenance data of traffic safety facilities such as railings to actively manage highway risks. If there are multiple maintenance records of traffic safety facilities in a certain section within a period of time, the system will automatically select them as risk candidates, prompt the maintenance personnel to complete the risk-closed loop, and remove risk information from the platform^[15].

3.11. Strengthen the emergency plan management

In order to ensure the orderly development of highway emergency rescue work and the improvement of safety management level in the rescue construction, it is necessary to enhance the awareness of emergency rescue safety management. Actions are guided by thoughts. Therefore, the highway management department should encourage relevant personnel to study relevant laws, regulations, and rules before carrying out emergency rescue work, so as to improve their ideological level. Through learning, the on-site construction personnel and management personnel can effectively improve their safety awareness, ensure the orderly implementation of civil air defense, material defense, and technical prevention, prevent disasters from occurring in the first place, as well as minimize the impact of human factors and natural disaster factors as much as possible. During the emergency rescue construction, the road administration department and the traffic police department should clean up along the way to ensure the smoothness of the road and control the impact of natural disasters within a controllable range. In engineering practice, it is crucial to put the basic interests of the people first, establish a high-standard, people-oriented safety management system, and ensure an efficient implementation of emergency rescue work. At the same time, a 24-hour manned system should be established to enhance the investigation of potential on-site safety hazards. Once problems are found, even minor problems should be handled in time to avoid further aggravation of the situation and unnecessary losses^[16].

4. Conclusion

In conclusion, expressway bridges and tunnels play an important part in transportation in China. In the maintenance management of expressway bridges and tunnels, the management mode is backward, the overall quality of the maintenance personnel is poor, and there is a lack of effective safety maintenance management mechanism. Several measures can be taken to improve the maintenance management of expressway bridges and tunnels, including preparing and improving the maintenance system, repairing load cracks on the bridge deck, maintaining the bridge deck and the drainage system, and strengthening the maintenance of the expansion joint and foundation, the tunnel portal, the lining structure, the access road, the construction of a maintenance platform, and the management of emergency plans.

Disclosure statement

The author declares no conflict of interest.

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