



Research on Maintenance and Operation Management Modes for Typical National Expressways in Southeast Asia

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Abstract. In order to help China effectively avoid risks in expressway construction and operation management in Southeast Asia, improve expressway maintenance management level, further consolidate and expand the market of expressway construction, maintenance and operation in Southeast Asia, introduce new market management mode, and change the status quo of expressway maintenance management, we proposed new ideas for design scheme and management system framework of maintenance management mode for expressways in Southeast Asia based on the status quo and existing problems of typical expressway projects in some Southeast Asian countries, with a view to providing support for promoting high-quality development of expressways in Southeast Asia.

Keywords: Maintenance of Expressways in Southeast Asia; Operation Management Mode; Maintenance Management Experience; Maintenance Management Level

1 Introduction

To establish and strengthen the connectivity partnerships among the countries in Asia, Europe and Africa and realize diversified, independent, balanced and sustainable development in these countries, the National Development and Reform Commission, the Ministry of Foreign Affairs and the Ministry of Commerce jointly issued the *Vision and Actions on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road* on March 28, 2015, which proposed that connectivity projects of the Initiative would help align and coordinate the development strategies of the countries along the Belt and Road, create demands and job opportunities, enhance people-to-people and cultural exchanges, and mutual learning among the peoples of the relevant countries. Transportation infrastructure underlies facilities connectivity, while highway

construction spearheads facilities connectivity and should play a leading role in this process. Located near China and characterized by its geographical location as a maritime “crossroads”, the Southeast Asia is an important pillar for promoting sustainable development of China’ economy and deepening regional cooperation in the future ^[1]. According to the framework of the “Belt and Road Initiative”, Southeast Asia, as the southern route of the “Silk Road Economic Belt”, is one of the primary and key nodes in the implementation of the major national strategy under the “Belt and Road Initiative”. The proposal of “building China into a strong power in the transport sector” ^[2] at the 19th National People’s Congress (NPC) of the Communist Party of China, the issuance of the *Outline for Building China’s Strength in Transport* in 2019 and the *National Comprehensive Three-dimensional Transportation Network Planning Outline* in 2021 by the Central Committee of the Communist Party of China and the State Council, and the proposal of “redoubling efforts to build China into a country with great transport strength” at the 20th NPC, all denote that China has embarked on a new journey from a major transportation power to a country with strong transportation network.

Expressways have accelerated the rapid development of economy. However, the continuous increase of expressways and the improvement of their technological content have also posed more and more new challenges to the maintenance of expressways ^[3]. Currently, except for Malaysia, Southeast Asian countries such as Cambodia, the Philippines, Vietnam, Indonesia, and Myanmar are relatively backward in economic development ^[4], where the highway infrastructure, especially expressways, are developed unevenly. Some countries even have no experience in expressway maintenance management. In view of this, based on the investigation and analysis of existing laws, regulations, policies and measures in highway construction, maintenance and management in Southeast Asian countries, the national conditions and the actual situation of highway construction and management, as well as the experience of China, Singapore, Malaysia and other countries in regulations, systems, operation and management of expressways, the paper studied and proposed a maintenance and operation management mode suitable for BOT expressway and bridge projects in Southeast Asia, which provides technical support for expressway maintenance and operation management and provides an important guarantee for China to continuously consolidate and expand overseas markets.

Based on the projects contracted by China Road & Bridge Corporation (CRBC) in Southeast Asian countries such as Cambodia, Philippines, Vietnam, Indonesia, Malaysia, and Myanmar, this paper studied and constructed an operation management mode suitable for the expressways in Southeast Asian countries by systematically investigating the laws and regulations related to highways and the operation management mode of expressways, and by drawing on the experience of China, Singapore, Malaysia and other countries in expressway maintenance and operation management. The specific research framework of this paper is shown in Fig. 1. This paper is of great significance in helping China effectively avoid the risks in expressway construction and operation management, improve the maintenance management level, and further consolidate and expand the market of expressway construction, maintenance and operation in Southeast Asia.

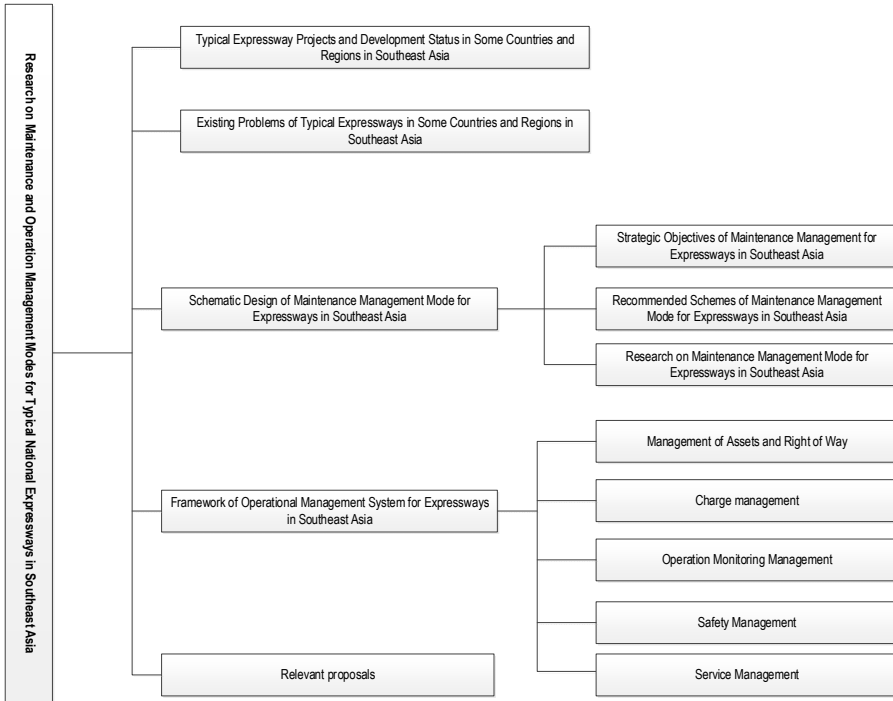


Fig. 1. Research Framework

2 Typical Expressway Projects and Development Status in Some Countries and Regions in Southeast Asia

At present, China has undertaken a number of expressway construction projects in Southeast Asia, of which Phnom Penh-Sihanoukville Expressway, Central Luzon Link Expressway and Surabaya–Madura Bridge are typical expressway projects in Southeast Asia.

Phnom Penh-Sihanoukville Expressway is the first expressway in Cambodia, which spans the five administrative regions of Phnom Penh City, Kandal Province, Kampong Speu Province, Koh Kong Province and Sihanoukville City. It is a BOT (build-operate-transfer) project invested by CRBC, using Chinese design and quality standards, as shown in Fig. 2. At present, the Cambodian government is preparing to build the second expressway in the country, and has signed an agreement with CRBC on the expressway from Phnom Penh City to Bavet City in Svay Rieng Province. In June 2023, the Phnom Penh–Bavet Expressway, invested and constructed by China Road & Bridge Corporation (CRBC), started construction. The main project is designed as a two-way four-lane expressway with a total length of 135.1km and a design speed of 100 km/h. The project construction period is expected to be 4 years. Upon completion, the project will be operated by CRBC for 50 years. It is expected to play a crucial role in driving the

development of Cambodia's national economy and the connectivity of the ASEAN region, as well as promoting the integrated development of Southeast Asia [5].

The Central Luzon Link Expressway (CLLEX) Project is located in the central part of Luzon Island, 150 kilometers north of Manila, the capital of the Philippines. It is designed as a two-way four-lane expressway with a total length of 6.4km and a design speed of 100km/h. The main works include one 1.4km-long grand bridge, two medium bridges, subgrade, pavement and transportation ancillary works. As the first toll-free expressway project in the Philippines, the CLLEX, upon completion, will effectively improve the highway capacity to several cities and towns in Tarlac and Nueva Ecija provinces, facilitate the flow of goods to and from the capital region and central Luzon, and play an important role in promoting the transportation and economic development in areas adjacent to the capital of the Philippines

Surabaya–Madura Bridge, also known as Suramadu Bridge, is located in the Madura Strait of Indonesia. Surabaya–Madura Bridge has a total length of 5,438m, of which the main bridge is an 818m-long cable-stayed bridge with a main span of 434m and bridge width of 30m. The bridge was opened to traffic on June 10, 2009. Surabaya–Madura Bridge is the first cross-sea bridge connecting Java Island, Indonesia's most economically developed island, and Madura Island, which is rich in resources but has a weak economic foundation. It is also the largest cross-sea bridge in Southeast Asia. As one of the largest infrastructure projects in Indonesia, it not only greatly facilitates the travel of people on both sides of the strait, but also plays an important role in expanding logistics and construction markets, developing trade and promoting the overall economic construction of Indonesia.

So far, CRBC has completed a number of major transportation infrastructure construction projects of the Vietnamese government, such as the MD1 section of the Mekong Transport and Flood Protection Project in Vietnam and the 1A section of the Ho Chi Minh–Long Thanh–Dau Giay Expressway Project, and built nearly 150 kilometers of expressways and 10 bridges in Vietnam.

Singapore is one of the earliest countries in Southeast Asia that built the network of expressways. Singapore opened its first expressway, the Pan Island Expressway (PIE) in the 1980s. Subsequently, Singapore built several expressways through cooperation and investment, the most important of which include the Changi Airport Expressway (42 km), the Central Expressway (26 km), and the East-West Expressway (26 km), with a total length of about 360 km. The well-developed expressways connect Singapore's busiest commercial areas, ports, airports and residential areas, providing fast, convenient, and safe transportation services for residents and tourists.

3 Existing Problems of Typical Expressway Projects in Some Countries and Regions in Southeast Asia

3.1 Lack of Top-Level Design in Expressway Construction Planning

Southeast Asian countries lack systematic and comprehensive overall strategic planning objectives for expressway construction. Except for Singapore, most of existing

highway networks are built on the basis of transitional roads connecting cities and towns without being planned in systematic manner. So, they have obvious deficiencies in terms of coverage and accessibility. In order to save land resources, rationally allocate construction funds, maximize the overall benefits of the highway network, and promote coordinated development among regions, it is necessary to formulate highway network plans, rationally design the national highway network, and scientifically schedule the construction. However, project employers have to adopt or set their own technical standards due to the lack of unified highway technical standards, making government regulation more difficult.

3.2 Incomplete Regulations and Systems for Expressway Maintenance Management

At present, the policies, regulations and systems in highway maintenance management in Southeast Asian countries are not yet complete, resulting in unclear modes for maintenance funding and financing, inadequate highway maintenance management regulations, ambiguous maintenance standards, etc., which will certainly have an impact on the operation management of expressways upon completion, as well as on the traffic capacity and service life of expressways to a certain extent.

3.3 Poor Technology and Professional Competence of Expressway Maintenance

Southeast Asian countries generally started building expressways very late and have a relatively low level of highway maintenance, especially the maintenance technology of expressways. Highway maintenance personnel have limited technical skills, insufficient maintenance expertise, and poor understanding of new technologies of expressway maintenance. Meanwhile, highway management enterprises in Southeast Asia have not yet introduced advanced maintenance equipment and only adopt traditional maintenance methods, which cannot meet the needs of expressway maintenance.

3.4 Potential Risks in International Cooperation

Since most governments of Southeast Asian countries cannot afford the large-scale highway construction, most of their highways are currently built by domestic and foreign enterprises in BOT mode, or with financial assistance from foreign governments and international organizations. On the one hand, these governments are eager to improve domestic highway infrastructure by leveraging foreign funds. On the other hand, influenced by the international geopolitical environment, some highway projects may be delayed due to environmental protection, relocation, labor employment, etc., posing risks to international project cooperation. In addition, some countries still face such problems as decentralized highway management systems and relatively independent functions of competent departments, which further hinders the progress of international projects.

		per son nel cost s)			ip- me nt			mai nte- nan ce			(Score)	(%)	
		(C NY 10, 000)	(C NY 10, 000)	(C NY 10, 000)	(C NY 10, 000)	(C NY 10, 000)	(C NY 10, 000)	(C NY 10, 000)	(C NY 10, 000)				
1	Gui- zhou	31. 83	7.1 4	5.3 1	1.0 8	0.7 7	0.0 3	1.3 8	3.9 8	9.0 2	3.1 3	83	80
2	Gua ngxi	27. 39	9.2 4	1.6 5	10. 32	0.8 6	0.0 3	0.4 9	0.2 3	2.9 4	1.7 1	78	77
3	Yun nan	27. 42	20. 55	2.1 2	1.3 6	0.4 2	0.0 5	0.3 2	0.1 4	0.9 7	1.5 7	80	73
4	Si- chua n	40. 73	14. 28	11. 83	4.0 2	0.9 1	0.1 4	0.7 0	0.9 4	5.2 5	2.7 3	91	90
5	Cho ngqi ng	38. 65	14. 04	8.9 5	0.6 5	1.8 4	0.0 6	2.1 9	0.1 9	5.7 8	5.1 1	88	92
6	Gua ngd ong	64. 71	24. 60	14. 86	3.1 7	4.5 3	2.5 1	1.5 9	1.5 9	7.9 7	4.1 8	95	95
7	Jian gsu	84. 57	27. 29	6.9 9	24. 12	14. 01	1.4 7	3.3 4	1.8 2	4.3 1	1.2 2	97	98

As can be seen from Table 1 and Fig. 2, the maintenance costs per kilometer are relatively low in the three provinces in southwest China (Guizhou, Guangxi and Yunnan), moderate in Sichuan Province and Chongqing, and the highest in developed provinces such as Guangdong and Jiangsu provinces.

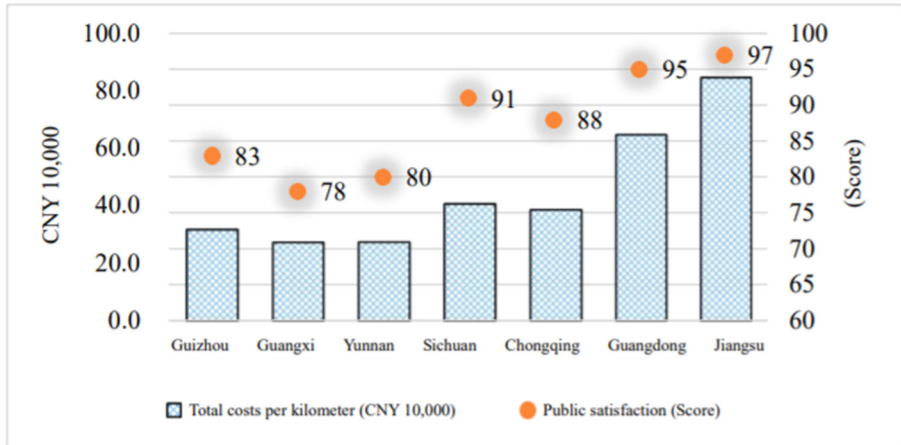


Fig. 2. Comparative Analysis of Cost per Kilometer and Public Satisfaction

4.2.2 Analysis and Assessment Method of Expressway Maintenance Factors

In this study, Delphi method was adopted to determine the indicator system, and Data Envelopment Analysis (DEA) was used to analyze and assess the factors of expressway maintenance [7]. Based on the characteristics of expressway maintenance projects, DEA model exhibits good practicality in assessing the maintenance factors of expressways, which is reflected in the following aspects:

(1) The maintenance costs for expressway are made up of the costs for various types of maintenance works, the costs for maintenance inspection and testing, the costs for emergency maintenance, which resemble a multi-objective and multi-output complex system and are suitable for using DEA model.

(2) DEA model assesses the factors by comparing the relative efficiency between multiple decision-making units. The study determined the decision-making unit with the highest relative efficiency by comparing the relative efficiency of costs for various types of maintenance works, public satisfaction and project quality, determined, providing a scientific basis for the selection of expressway maintenance modes.

(3) The assessment results of the DEA model can help analyze the sensitivity of all decision-making units, determine the appropriateness of the investment scale of a decision-making unit, indicate the adjustment direction and scope of the investment scale of a decision-making unit, and optimize and adjust the contents of the maintenance management mode for expressways.

(4) DEA model doesn't necessitate the linear relationship between input indicators and output indicators, eliminates subjective factors, therefore, the assessment results are highly scientific.

In Table 2, five regions (Guizhou Province, Guangxi Province, Yunnan Province, Sichuan Province and Chongqing Municipality) with humid and thermal environment similar to Southeast Asia and two provinces (Guangdong and Jiangsu) in China with relatively high level of economic development were selected for the study. By regarding the main costs for expressway maintenance in the above regions as the input

indicator, while taking public satisfaction and first-time acceptance rate of expressway maintenance works as the output indicators, the Data Envelopment Analysis (DEA) model was employed for assessment. With the model, the efficiency ratio of social benefits to project quality under different capital investment conditions is obtained. The results are as follows:

Table 2. Analysis Results of DEA Model

Region	crste	vrste	Overall efficiency
Guizhou	1	1	1
Guangxi	0.774	0.963	0.804
Yunnan	0.817	0.99	0.825
Sichuan	0.95	0.998	0.952
Chongqing	0.962	1	0.962
Guangdong	1	1	1
Jiangsu	1	1	1

4.2.3 Conclusions on the Analysis of Maintenance Management Factors of Expressways in Southeast Asia

According to the conclusions on the analysis of maintenance management factors of expressways in typical regions in China, the provinces with maintenance management costs less than CNY 350,000 per kilometer are Guangxi, Yunnan and Guizhou provinces. However, the overall efficiency of Guizhou Province is the highest as revealed by the comprehensive comparison of the public satisfaction and first-time acceptance rate of expressways. Compared with the developed provinces in China that have sufficient expressway maintenance funds and sophisticated maintenance methods, the public satisfaction and first-time acceptance rate of Guangdong and Jiangsu provinces are higher than those of Guizhou Province, but the maintenance costs per kilometer of the two provinces far exceeds that of Guizhou Province. Therefore, for countries and regions in Southeast Asia that are not yet developed and have insufficient funds, it would be challenging for them to invest in high maintenance costs. In conclusion, for expressways in Southeast Asia, the maintenance mode of Guizhou Province can be adopted from such aspects as capital investment, maintenance organization and maintenance methods [8].

4.3 Research on Maintenance Management Mode for Expressways in Southeast Asia

At present, the expressway construction in Southeast Asia is still in its early stages. With the continuous development of the economy and the improvement of the expressway network, the maintenance management mode of expressways will also change accordingly. Overall, the mode of expressway maintenance management will experience

three stages: self-management, management by objectives and market-oriented management.

4.3.1 Self-Management

Self-management refers to the mode of maintaining the expressway by oneself, which means that the expressway employer or operator shall, as the maintenance department, set up professional maintenance team, establish maintenance stations along the expressway, arrange maintenance machinery and equipment, and maintain the expressway directly. Expressway employer or operator manages the maintenance stations from such aspects as administration, finance, and procurement following a top-down approach^[9].

4.3.2 Management by Objectives

Management by objectives means that the maintenance department develop maintenance objectives based on the content, nature and purpose of the maintenance work, and the maintenance stations develop their own plans and implement them as per the objectives. The maintenance department is responsible for managing the maintenance project and disciplinary maintenance works of expressway, supervising all maintenance stations, applying new materials, new technologies, new processes and new equipment in the construction process, as well as developing short-term and long-term plans for maintenance.

Compared to direct management, management by objectives has significantly improved the maintenance efficiency and emergency response capability, but it requires higher level of management due to such factors as task coordination and funding allocation among maintenance stations.

4.3.3 Market-Oriented Management

Market-oriented management refers to fully outsourced maintenance, in which the maintenance department will not set up special maintenance team, but select eligible maintenance management enterprises through bidding for maintaining the expressway and its supporting equipment, structures, greening facilities, etc., and the rights of obligations of both parties will be clarified, and the maintenance management enterprises shall bear most of the risks. The market-oriented management mode completely separates the expressway maintenance function from the management function, which can make the maintenance and management more professional, systematic and precise, help define rights and responsibilities and improve the level of maintenance and management^[10].

From the development trend of the maintenance management mode at home and abroad, the market-oriented management is a maintenance mode commonly adopted when expressway operation becomes mature. This mode is mainly characterized by: (i) the maintenance project is outsourced to save the costs for labor and equipment; (ii) eligible social professional construction teams are selected, ensuring the quality of the maintenance project; (iii) the maintenance department is responsible for managing the

maintenance work. This mode of “separating management and maintenance” is conducive to improving management efficiency^[11].

Taking into account the actual situation of expressway construction undertaken by China in Southeast Asia, the market-oriented management mode under certain constraints is more suitable for the expressways upon completion. This is mainly based on the following considerations: First, the expressway management agency shall retain its own maintenance team, so that it can undertake some maintenance and emergency tasks, and can also promptly rectify and repair problems that occur during the expressway maintenance process; second, maintenance stations shall be in different sections of expressway, especially in the case that China’s current maintenance technology and means are significantly superior than those of Southeast Asian countries, so that the management personnel of the maintenance department can analyze the expressway conditions, reasonably formulate and adjust maintenance plans, make sustainable decisions and reduce misjudgments; third, greening and disciplinary maintenance works can be undertaken by eligible social organizations selected through bidding. Hiring specialized, large-scale, and highly efficient local maintenance contractors can reduce the costs for staffing, machinery and equipment, and maintenance work^[12]; fourth, the partially separated maintenance mode is beneficial for enhancing the emergency response capability of expressway. In the case of special circumstances such as floods, severe weather and road disasters, if the expressway company has the right of control, it can deal with the incident and reduce losses in a timely manner and ensure traffic capacity^[13].

5 Framework of Operational Management System for Expressways in Southeast Asia

5.1 Management of Assets and Right of Way

According to the current situation of management of assets and right of way, a special authority shall be established, and laws and regulations on management of assets and right of way shall be formulated. The authority shall manage and enforce the laws, regulations and rules on highway management, manage and protect the assets, carry out highway management inspection, and make compensation for any losses of assets.

5.2 Toll Management

(1) Establish a standard toll management system

According to the current construction situation of manual and electronic toll collection systems for expressways that have been put into operation, the well developed toll collection system construction standards in the world shall be directly referred to, and the technical standards and requirements for construction of expressway toll collection system, as well as the toll collection service specification, networked toll collection and settlement rules and other toll-related standard and specification systems^[14] shall be developed.

(2) Establish a toll expressway networked settlement system

According to the future expressway construction and management modes in various countries, corresponding toll stations and sectional (regional) toll centers shall be built for the expressways constructed by BOT or PPP modes based on the sections that have been put into operation, and a national expressway networked toll management center (which can be subjected to integrated construction together with the national expressway operation monitoring, command and dispatching center) shall be set up to be responsible for the splitting and settlement of tolls on expressways subjected to national networked toll collection, forming an overall framework of a three-level networked toll collection system consisting of a national expressway toll collection and settlement center, sectional (regional) toll centers, and toll stations^[15].

(3) Reasonably work out the toll period and standard

For expressways built with government investment or government financing, the toll standard can be reasonably determined based on the idea of long-term toll, taking into account such factors as the project investment scale, debt capital repayment, traffic volume, service level and price of alternative transportation mode, economic and price levels along the route, and maintenance and operation management costs.

5.3 Operation Monitoring Management

5.3.1 Establish an Expressway Operation Monitoring System

Technical requirements for highway network operation monitoring and service shall be worked out, construction of expressway operation monitoring facilities shall be enhanced based on the expressway construction projects, and highway operation monitoring and information release facilities shall be reasonably set up to form a complete highway network operation information monitoring network, realize the monitoring of highway sections, bridges and tunnels, and achieve real-time monitoring of expressway operation conditions by information approaches^[16].

5.3.2 Establish an Expressway Operation Monitoring, Command and Dispatching System

(1) Expressway operation monitoring, command and dispatching system architecture

To achieve efficient management of the expressway network, a three-level operation monitoring, command and dispatching system consisting of a national expressway operation monitoring, command and dispatching center, branch centers in various sections (regions), and on-site monitoring and information release facilities shall be established in various countries. The national expressway operation monitoring, command and dispatching center and the branch centers in various sections (regions) can be subjected to integrated construction together with the national expressway networked toll management center and sectional (regional) toll centers.

(2) Main systems and functions

The expressway network operation monitoring system shall mainly be designed to call the expressway videos, traffic volume and other data in a real-time manner, monitor

the traffic flow, analyze, identify and give early warning of abnormal events, and capture the information display and query content via the large monitoring screen, command terminal and mobile terminal.

The expressway network operation safety management and emergency command and dispatching system shall be designed to collect information on emergencies through event duty management, conduct comprehensive analysis of event level, scope of influence and extent of harm, assist in completing cross-business area resource allocation and disposal coordination decision making, and communicate various emergency resource dispatching plans and disposal plans to relevant departments and personnel via the communication dispatching platform to realize communication dispatching management of subordinate monitoring and command centers and on-site disposal personnel.

The expressway network operation analysis and decision support system shall be designed to analyze the operation condition of the expressway network and assist in the making of relevant decisions based on the historical data of the aforesaid two systems. To be more specific, it shall include three subsystems: infrastructure condition analysis system, traffic operation condition analysis system, and comprehensive expressway network operation condition analysis system.

The expressway travel information service system shall mainly be designed to, based on the above systems, provide expressway users with travel information services such as expressway condition information query, travel route planning, and toll information via the Internet, mobile APP, and hotline.

5.4 Safety Management

(1) Establish the expressway safety standard and emergency response plan system

The responsible entity for expressway safety management shall be determined based on the division of safety management responsibilities, the standard for types of vehicles entering expressways shall be developed, requirements for travel, overtaking, and cargo loading on expressways shall be raised, and safety and emergency response plans shall be developed for traffic accidents, dangerous goods transport accidents and natural disasters on expressways that may give rise to traffic interruptions^[17].

(2) Establish the emergency management and multi-department linkage mechanism

The emergency operation mechanisms such as the prediction and early warning mechanism, emergency management mechanism and information release mechanism shall be established and improved, and a rapid information reporting and joint response mechanism involving multiple departments such as the fire department, medical department and police department shall be established to ensure rapid response and timely management in the event of an emergency. An early warning mechanism shall be established, and emergency drills on expressways shall be regularly organized.

(3) Enhance construction safety management during expressway maintenance

On-site regulation of construction during expressway maintenance shall be enhanced, and traffic on the construction section shall be effectively organized and managed to ensure the safety and orderly passage of vehicles at the construction site. The

expressway operation regulatory agency and operation management agency shall carry out supervision and inspection in an intensified manner, and construction plans for maintenance of different sections of the same expressway shall be developed in a coordinated manner to avoid traffic jams caused by concentrated construction^[18].

5.5 Service Management

(1) Establish the expressway service standard and specification

The expressway service standard and specification and a rating system shall be developed and implemented, rest areas, convenience service stations and other facilities shall be improved, and the operational management of expressways and their toll stations and service areas shall be standardized to achieve 24h uninterrupted services at expressway toll stations and service areas.

(2) Establish an expressway travel information service system

A unified national expressway operation service and complaints hotline shall be provided in various countries, and information on the extreme weather and traffic conditions on expressways shall be released in a real-time manner via the variable message sign, APPs, text messages, and other means to provide users with multi-channel, all-round, and three-dimensional comprehensive travel information services.

(3) Standardize the operation and management of service areas

Various operational management modes such as self-operation, franchising, and cooperative operation can be promoted in service areas. While strengthening the standardized management of service areas, the expressway operational management agency shall fully explore local characteristics and expand service contents based on the geographical and economic development conditions^[19].

6 Conclusion

(1) Improve the legal mechanisms and the standard system Establish and improve the highway maintenance and operation management regulations and systems to further improve the sustainability and standardization of maintenance management; establish and improve the maintenance project management procedures; strengthen the construction of a quality-centered technical standard system; improve the expressway operation and service regulation system, and explore and implement an expressway maintenance quality guarantee deposit system to collect a certain proportion of maintenance quality guarantee deposit from the toll revenue and urge and supervise the operating entity to ensure the maintenance investment and maintenance quality through regular quality assessment; establish an assessment mechanism that integrates maintenance management with local government assessment. Incorporate expressway maintenance quality, road network services and operational safety into the economic and social development assessment index system of local governments at all levels according to the powers and responsibilities of all departments, and develop an expressway maintenance regulation and assessment system.

(2) Establish a technical progress support system. Promote the construction of a scientific decision-making system for expressway maintenance, scientifically formulate expressway maintenance investment plans, and reasonably determine the technical schemes for maintenance; strengthen information construction, and gradually promote the deep integration of expressway maintenance business and information technology; enhance the promotion of green and low-carbon maintenance technology and promote the development of green and low-carbon maintenance industry; accelerate the process of mechanization of expressway maintenance, and guide and encourage the maintenance companies to increase investment to improve the level of maintenance mechanization; carry out preventive maintenance in an all-round way, ensure the preventive maintenance funds, clearly include preventive maintenance funds into the annual expressway maintenance expenditure plan, and allocate special funds for preventive maintenance.

(3) Improve the fund investment guarantee system. Establish an expressway maintenance fund guarantee system, explore an expressway maintenance quality guarantee deposit system, broaden source channels and raise funds from multiple sources to ensure highway maintenance fund investment; improve the efficiency of fund use, strengthen the process management of maintenance projects, reduce maintenance costs via various means such as technology and management, and improve the efficiency of maintenance fund use; establish an audit mechanism for fund use, and develop a reward and punishment system that integrates audit results with annual fund allocation, special project plans, and highway maintenance management evaluation to ensure that special funds are fully used for highway maintenance.

(4) Establish a personnel quality improvement system. Implement the professional qualification system for maintenance engineers, accelerate the construction of the standard and professional qualification system for highway maintenance technicians, and establish an assessment and certification system for engineering and technical personnel of all highway maintenance disciplines; improve the talent training and management mechanism, do a good job in the key links such as talent training, communication and use, and improve the quality of maintenance practitioners through education, training and technical exchanges; strengthen the training of professionals in highway maintenance technology and accelerate the cultivation of a group of maintenance experts with high innovation ability and professional quality; enhance the highway maintenance salary system and culture construction, improve the setting of types of work for highway maintenance and the salary system, and ensure that the wages of maintenance personnel are paid on time and in full; strengthen the cultural development, unite people with positive highway culture, and build a new type of maintenance workforce.

(5) Develop a coordinated and interactive work pattern. Deal with the relationship between market competition and appropriate support well to create a good environment for the marketization of expressway maintenance; deal with the relationship with local governments and enterprises well. Strengthen the communication and coordination with local governments and enterprises, promote the establishment of a sound maintenance quality evaluation system, give full play to different roles of the maintenance management department, the professional maintenance service enterprise, and

the supervisor, improve the expressway maintenance quality through full-process quality supervision in the early, initial, construction and later stages, and continuously enhance the influence and competitiveness of enterprises in the local highway maintenance market.

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