Analysis and Practice of Jiangsu Expressway Centralized Maintenance Mode

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Abstract. Under the traditional maintenance mode, the contradiction between maintenance operations and traffic has negative effects on maintenance safety, efficiency, quality and benefits, and the centralized maintenance mode can effectively solve this problem. Based on the practical experience of the Jiangsu Expressway Centralized Maintenance Project, this paper summarizes the significance of carrying out the centralized maintenance of expressways, and systematically analyzes the applicability of the centralized maintenance mode from the two aspects of project requirements and external conditions. Not all expressway maintenance projects are applicable. In order to adopt the centralized maintenance mode, it is necessary to combine the construction operation content of the project and the external construction environment to make scientific decisions. Finally, taking the Shanghai-Nanjing Expressway Centralized Maintenance Project as an example, it introduces the construction organization and management characteristics of the Shanghai-Nanjing Centralized Maintenance Mode and the successful experience of the design scheme for traffic diversion of high-volume expressways, in order to provide a certain reference value for similar projects.

1. Introduction
After more than 20 years of development, the highway network in Jiangsu Province is basically perfect, with few new projects, mainly maintenance. One of the most prominent problems of maintenance engineering is the contradiction between maintenance operation and traffic, which is mainly reflected in the following four aspects: safety, efficiency, quality and benefit[1-3]. Especially under the condition of large traffic flow, the contradiction between maintenance operation and traffic flow caused by traditional maintenance mode is particularly prominent[4-5]. Therefore, it is urgent to explore a new maintenance mode to alleviate the adverse impact of this contradiction.

In view of this, under the guidance of the "Su-style maintenance" concept, Jiangsu Communications Holding Co., Ltd. is based on the background of the gradual development of "large traffic" expressways in Jiangsu Province[6-8], in order to improve the maintenance efficiency and quality of the province's large traffic expressways, to ensure the safety of construction, learn from the experience of the Hanshin Expressway centralized maintenance and take the lead in proposing a large-volume expressway centralized maintenance model nationwide, which will be implemented in multiple maintenance projects from 2019 to 2020. Based on the practical experience of Jiangsu expressway centralized maintenance, this paper summarizes the significance of developing expressway centralized maintenance, systematically analyzes the applicability of centralized maintenance mode, and hopes to provide a certain reference value for similar projects.
2. Significance of centralized maintenance
Under the traditional maintenance mode, in order to avoid the adverse social impact of construction operation in traffic, the traffic organization scheme without interruption is generally adopted. In this traffic organization mode, construction operation is affected by traffic, and has adverse effects on safety, efficiency, quality and benefit. The centralized maintenance makes the maintenance construction more efficient and flexible because of its highly concentrated operation content. The centralized maintenance mode has important practical significance for the maintenance of expressway asphalt pavement.
(1) Guarantee the engineering quality of the maintenance section
For the traditional maintenance mode, there are a series of problems that are difficult to completely solve, which have adverse effects on the quality of the project. Centralized maintenance can effectively solve the typical weak links existing in the traditional maintenance mode: the paving and rolling affected by the limited construction working face; the longitudinal construction cold joint; seriously congested road section, and untimely transportation of asphalt mixture.
(2) Ensure the safety of passing vehicles and construction operations
The traffic accidents in the traditional maintenance construction area have the following characteristics: rear end collision is the main type of accidents, collision between driving vehicles and construction equipment in the construction area, collision between vehicles and construction personnel on site, scratch and collision of vehicles in the same direction, which are also the long-term security risks in the traditional maintenance construction. Under the centralized maintenance mode, the construction area is closed in one direction, and there is no social vehicles passing through. Through "remote induced diversion, near end forced diversion", congestion is avoided, and the safety of vehicles, machinery and personnel in the construction area is effectively guaranteed.
(3) Improve the efficiency of highway maintenance
Under the traditional maintenance mode, subject to various pressures such as on-site traffic and safety, traffic police departments often put forward strict restrictions on the number of lanes occupied by construction, road length and construction operation time, and the operation time under the condition of large traffic flow is even limited to night and early morning. Under the centralized maintenance mode, through the single fully closed traffic organization mode, multiple operation contents can be constructed in parallel and cross operation, which can significantly improve the maintenance efficiency.
(4) Meet the needs of fast and comfortable public transportation
The traditional maintenance mode generally adopts the "half closed" traffic organization design, which is easy to lead to congestion, big driving risks, poor feeling of drivers, slow speed and high cost. The centralized maintenance mode generally adopts the traffic organization design of "half full closed", which fundamentally solves the traffic congestion caused by maintenance operation through "remote induced diversion and near end forced diversion", and meets the requirements of people's travel satisfaction to the greatest extent.

3. Applicability analysis of centralized maintenance
Compared with the traditional maintenance mode, the centralized maintenance mode has obvious advantages in construction quality, safety, efficiency and benefit[9-10], but these advantages are also based on fine preparation and strict process control[11-12]. For example, the construction time of the centralized maintenance project is very short, and the construction efficiency is significantly improved, but it needs a long time of careful preparation in the early stage in order to accurately prepare the construction plan. In the process, it needs to strictly control the construction period according to the plan and control the construction period by sections, so as to ensure that the overall project is completed on schedule.

From the practice of centralized maintenance in Jiangsu Province, the traffic organization scheme of "single fully enclosed construction" has been adopted. This traffic organization scheme has significantly improved the quality and safety of construction, but this traffic organization scheme has caused more adverse social impact in the short term. In addition, the "centralized characteristic" of centralized maintenance project also puts forward higher requirements for all participating units. It can be seen that not all expressway maintenance projects are suitable for adopting centralized maintenance mode. It is
necessary to make scientific decisions based on the construction content of the project and the external construction environment to select a more appropriate maintenance mode. Combined with the characteristics of centralized maintenance mode, the applicability of centralized maintenance can be analyzed from two aspects of project demand and external conditions.

3.1. Project requirements

Project demand refers to the demand based on the particularity of operation content and operation environment of maintenance project. When expressway maintenance project has the following characteristics, centralized maintenance mode can be considered:

1. Large traffic flow
   The larger the traffic flow, the greater the adverse impact of traffic on the maintenance construction. The more significant the improvement of the quality, safety, efficiency and benefit of the maintenance construction is in the traffic organization scheme of single traffic interruption construction than single traffic construction, and the greater the necessity of adopting the centralized maintenance mode.

2. Various assignments
   The centralized maintenance mode can provide working surface for a variety of construction contents in space. The more diverse the maintenance construction contents are, the more significant the centralized maintenance mode can improve the construction efficiency, and the advantages of centralized maintenance can be brought into full play.

3. Special process requirements
   In the highway maintenance and repair plan, some technical plans should be constructed in the condition of interrupted traffic in order to improve the construction quality, such as pavement overlay engineering; some technical plans must be constructed in the mode of interrupted traffic, such as the maintenance of bridge expansion joints. If the maintenance and repair plan includes these technical solutions that need to be interrupted to implement traffic, the centralized maintenance mode can be adopted in accordance with the needs of other projects.

3.2. Outside condition

In view of the particularity of the centralized maintenance project, in addition to meeting the above project requirements, the following external conditions must be met when making the centralized maintenance mode decision:

1. Complete road network facilities
   In view of the fact that the centralized maintenance project requires a single block of traffic interruption, the road network (including the highway network and the ordinary road network) and the traffic service level of the construction area need to be analyzed before the maintenance mode decision, so as to meet the requirements of parallel diversion roads and strong diversion capabilities; Diversion nodes such as intercommunication have sufficient dredging capacity, and the intercommunication ramp connected with ordinary roads is well connected; the diversion road and bridge facilities are intact, which can withstand the load of diversion vehicles and ensure that good traffic conditions are provided for vehicles to bypass during construction.

2. Sufficient maintenance resources
   In view of the great demand of people, machines and materials for the centralized maintenance project in the short term, it is necessary to investigate the distribution of maintenance resources along the project, especially the fixed resources such as mixing station, before the maintenance mode decision-making, so as to ensure the sufficient supply of maintenance resources during the maintenance construction and ensure the successful development of the centralized maintenance project.

3. High professional level of construction personnel
   The centralized maintenance project is "multi-point and wide-ranging", and the implementation of the project is difficult. All the construction personnel need to have a high level of business to ensure that they can successfully complete the work during the high-intensity construction operation.

4. Sufficient technical reserves
In view of the difficult and long construction period in the maintenance project, especially the process with long maintenance time, new technology reserves are needed to significantly shorten the construction period, so as to effectively guarantee the construction efficiency.

(5) Perfect multi-party collaboration mechanism

In view of the difficulty of centralized maintenance project coordination, it is necessary for all participating units, traffic police, comprehensive law enforcement departments and local transportation authorities to form a coordination organization, which is unified in thought and consistent in action, to escort the successful implementation of centralized maintenance.

4. Practice of Shanghai-Nanjing Expressway centralized maintenance project

4.1. Project overview

The Shanghai-Nanjing Expressway is an important expressway between Shanghai and Nanjing, the capital of Jiangsu Province. It is also the first expressway constructed in Jiangsu Province, connecting Shanghai, Suzhou, Wuxi, Changzhou, Zhenjiang and Nanjing. It is in the Yangtze River Delta. The regional and even national highways play a very prominent role as the backbone and have the reputation of "golden transportation channel". The Shanghai-Nanjing Expressway started construction in 1991 and opened to traffic in 1996. It was constructed in accordance with the design speed of 120km/h and the two-way four-lane expressway standard. The total length of the Jiangsu section is 248.629km. The traffic volume has increased rapidly after opening to traffic. Due to the congestion conditions in China, the expansion and reconstruction of two-way eight-lane lanes was carried out, which was completed and opened to traffic in 2006. The road has become one of the busiest highways in my country.

This intensive maintenance is in the direction of Nanjing-Shanghai, starting from the east bridge of the Shanghai-Nanjing Expressway. The traffic volume of the section is 150,000 vehicles per day in 2019. The traffic volume of the expressway is increased to 190,000 vehicles per day, which is affected by COVID-19. Under the condition of super large traffic flow, in order to ensure the successful implementation of the centralized maintenance project, relying on the successful experience of centralized maintenance of Guangjing Xicheng Expressway in 2019, combined with the characteristics of super large traffic flow, the traffic organization and construction organization management measures of centralized maintenance are re-optimized.

Figure 1 Centralized maintenance of Shanghai-Nanjing Expressway

4.2. Characteristics of traffic organization

Through several surveys on the Suzhou section of the project area, and comprehensive analysis and research on collecting regional traffic network conditions and traffic operation data, the overall characteristics of the traffic operation of the construction section are as follows:① The traffic flow is the highest in the whole province, with more than 190000 vehicles / day at shuofangdong bridge in March 2020. ② The proportion of yellow brand trucks is large, with 27.25% of trucks from Shuofang
hub to Suzhou north hub, 21.69% of yellow brand trucks, and more than 40% converted into standard passenger cars. ③ The peak period is long. In the hourly flow distribution from Shuofang hub to Suzhou north hub, the peak period is from 10:00 to 18:00 in the whole day. The section flow at 16 o'clock is the largest, reaching 14306 PCU / h

4.2.1. General characteristics of traffic operation
According to the overall traffic organization plan of “one-way fully enclosed, no through”, and following the overall principles of ensuring smooth traffic flow, minimizing social impact, and facilitating organization and implementation, diversion is carried out according to the following ideas:

4.2.2. Traffic diversion scheme design
The first is the combination of induced diversion and forced diversion, which is implemented in the whole road network, and forced diversion is implemented at the local section nodes; the second is the combination of outlet diversion and inlet diversion, and the exit diversion is implemented around the construction section while setting up traffic signs at the interchange entrance to effectively reduce the number of vehicles on the construction section; the third is to divert traffic mainly on expressways to minimize the impact on local roads. Traffic organization diversion is mainly divided into three levels, namely: level 1 full road network forecast large-scale diversion, level 2 regional induced diversion and level 3 partial forced diversion.

4.3. Characteristics of construction organization and management
The 2020 Shanghai-Nanjing Expressway centralized maintenance project is the promotion and application of Guangjing Xicheng centralized maintenance mode in 2019. Its construction organization and management draw lessons from the successful experience of the first centralized maintenance, but it is also the further improvement of maintenance mode, quality, progress and safety control. Its relevant characteristics are mainly reflected in the following aspects:

(1) Further deepening of maintenance mode
Under the centralized maintenance mode, due to the need of closed construction, a large-scale traffic diversion scheme is needed within the maintenance section, which can significantly reduce the downstream traffic volume. Taking the centralized maintenance of Suzhou section of Shanghai Nanjing Expressway as an example, this paper analyzes the impact of traffic diversion on the downstream traffic volume in the centralized maintenance stage through the statistics of the daily average traffic volume changes of two sections in Shanghai before and during the centralized maintenance construction, as shown in Table1.
Table 1 Centralized maintenance data of downstream traffic volume before and during construction

| Section area                | Average daily traffic volume/(vehicles) | Traffic volume reduction ratio (%) |
|-----------------------------|----------------------------------------|-----------------------------------|
|                             | Before centralized maintenance         | During centralized maintenance    |
| Sujiahang to Industrial Park| 55578                                  | 9219                             | 83                                |
| Lujia to Huaqiao            | 59443                                  | 38058                            | 36                                |

Theoretically, the closer the section to the centralized maintenance diversion point, the more significant the reduction in traffic volume. From Table 1, it can be seen that the section from Sujiahang to the industrial park, which is the closest to the centralized maintenance section, reduces the traffic volume by more than 80%, even if the section from Lujia to Huaqiao, which is the farthest from centralized maintenance, will reduce the traffic volume by more than 1/3.

In view of the fact that centralized maintenance traffic diversion can significantly reduce the traffic volume of downstream sections, in order to make full use of the convenience brought by traffic diversion during centralized maintenance, on the basis of overall arrangement, this paper further deepens the centralized maintenance mode of Guangjing Xicheng, and puts forward a combined maintenance mode of traffic interruption centralized maintenance mode and non-interruption traditional maintenance mode. Under the guidance of this combined maintenance mode, the centralized maintenance project of Shanghai-Nanjing Expressway takes advantage of the opportunity of traffic diversion in the centralized maintenance stage to reduce the downstream traffic volume, and adopts the traditional maintenance mode of "no traffic interruption, construction by way" to carry out special maintenance for the downstream sections. In the downstream special construction, due to the reduction of traffic flow, it can reduce the possibility of traffic congestion, alleviate the adverse impact of the traditional maintenance mode of construction, at the same time, it can also improve the vehicle driving safety and construction safety.

For Suzhou section of Shanghai-Nanjing Expressway, under the condition of super large traffic volume, in order to ensure smooth operation, special maintenance can only be implemented at night in the past. This time, with the opportunity of upstream diversion to reduce downstream traffic volume, special maintenance is implemented in the daytime for K1142+260~K1188+802 section, which has the largest traffic volume, breaking the forbidden zone that was difficult to construct in the daytime in the past.

(2) Resource integration and re-optimization

In 2019, the output value of Guangjing Xicheng Expressway centralized maintenance project reached 110 million in 15 effective working days, and in 2020, the output value of Huning Expressway centralized maintenance project reached 90 million in 8 effective working days. The allocation of materials, machinery and equipment, personnel and other resources has been further optimized and improved. The average daily output value of the centralized maintenance project of Shanghai-Nanjing Expressway in 2020 is 50% higher than that of the centralized maintenance project of Guangjing Xicheng Expressway in 2019.

(3) Re-expansion of "Four new" technologies

On the basis of the application of “Four new” technologies such as "non stick wheel emulsified asphalt" and "ultra fast hard concrete" in the centralized maintenance project of Guangjing Xicheng Expressway in 2019, this centralized maintenance project closely follows the development pulse of the maintenance industry and introduces new ideas, new ideas and new technologies into the project. For the first time, the combination mode of 1-lane and 2-lane paving modified asphalt concrete, 3, 4-lane and emergency lane paving high-strength asphalt concrete was implemented. For the first time, 45 new asphalt mixture transport vehicles were introduced, and the carrying rate, heat preservation rate and handling rate were greatly improved. For the first time, the new in situ geothermal recycling combination was implemented, and the far-infrared heating mode was adopted, and the energy efficiency was
increased by 30%. The application of these "four new" technologies in the centralized maintenance project significantly improves the construction quality, progress and safety benefits, and provides technical support for the successful completion of the centralized maintenance project.

5. Conclusion

(1) Centralized maintenance mode can effectively solve the adverse impact of the contradiction between maintenance operation and traffic on maintenance safety, efficiency, quality and benefit under the traditional maintenance mode, which has important practical significance for the maintenance of expressway asphalt pavement.

(2) The applicability of centralized maintenance mode is systematically summarized from two aspects of project demand and external conditions. Not all expressway maintenance projects are suitable for centralized maintenance mode, and scientific decision-making should be made based on the construction operation content and external construction environment of the project.

(3) Taking the centralized maintenance project of Shanghai Nanjing Expressway as an example, this paper introduces the construction organization and management characteristics of the centralized maintenance mode of Shanghai Nanjing Expressway and the successful experience of the traffic diversion design scheme of large flow expressway, so as to provide some reference for similar projects.

References

[1] Liu Jianmin. Highway engineering construction management [M]. Beijing: People's Communications Press, 2002:30-32.
[2] Qian kunrun, GE Junpu, Zhang Xing. Highway construction organization design [M]. Nanjing: Southeast University Press, 2000:47-49.
[3] Lai Shaowu, Li Wenhua. Highway construction organization and management [M]. Beijing: People's Communications Press, 2002: 56-58.
[4] Li Jun. research on expressway construction organization design [D]. Chengdu: Southwest University of Finance and economics, 2014.
[5] Liu Jun. study on organization and management efficiency of large bid section mode of expressway construction [D]. Wuhan: Huazhong University of science and technology, 2014.
[6] Lv Shiming. Study on Optimization of plane layout of highway engineering construction site [D]. Chongqing: Chongqing Jiaotong University, 2015.
[7] Wang Hui. Application of flow shop method in highway engineering construction organization [J]. Transportation world (construction and maintenance. Machinery), 2008 (05): 128-129.
[8] Zhang Yuqin. Optimization design of asphalt concrete pavement construction organization of Expressway [D]. Tianjin: Hebei University of technology, 2006.
[9] Wang Jin. Study on Optimization of highway maintenance construction organization scheme [D]. Xi'an: Chang'an University, 2012.
[10] Liu Jinlin. Study on dynamic management of highway construction project progress [D]. Tianjin: Hebei University of technology, 2006.
[11] Li Shaosen. Research and Practice on safety management of expressway maintenance construction [D]. Wuhan: Huazhong University of science and technology, 2015.
[12] Zhang Yongqin. Study on safety management of expressway construction [D]. Chongqing: Chongqing University, 2009.