Evaluation of safety management responsibility system for highway maintenance

Jina Lv¹, Weiwei Hong¹, Beiyan Ding², Yuanqing Wang*¹

¹School of Highway, Chang’an University, Xi’an City, Shaanxi Province, 710064, China;
²Municipal Institute, Chengdu Institute of Architectural Design, Chengdu, Sichuan Province, 610000, China
*Corresponding author’s e-mail: wyq21@vip.sina.com

Abstract. In order to evaluate the implementation effect of highway maintenance safety management responsibility system, this paper constructs a performance evaluation index system of highway maintenance safety management responsibility system based on Hall’s three-dimensional structure theory. The system includes three aspects: organizational effect, economic effect and social service effect. We designed a questionnaire consisting of three parts: implementation survey, implementation effect survey and satisfaction survey, and selected the historical dynamic comparison method to evaluate the implementation effect of the system in Shaanxi Province. The results show that after the implementation of the responsibility system of highway maintenance safety management, the indicators of safety management personnel allocation compliance, the clarity of risk source disposal measures and other indicators have been significantly improved, and the number of casualties and responsible accidents has been significantly reduced. “System” has been recognized and supported by the industry. The evaluation index system constructed in this paper can quantitatively evaluate the implementation effect of the responsibility system of highway maintenance safety management, which is of great significance to improve the level of highway maintenance safety management.

1. Introduction
With the development of economy and society, people's demand for security is rising. The key to realize the safety development lies in strengthening the responsibility system construction of production safety management and supervision [1]. The implementation of safety production responsibility system should be carried out from the aspects of ideological understanding, safety management, supervision and inspection, accountability and so on [2].

Highway industry is a frequent production of safety accidents in the industry. With the improvement of China’s road network and the increasing number of motor vehicle ownership, highway maintenance projects will be significantly higher than the proportion of new projects, and the system, dynamics and complexity of its safety management will become increasingly prominent [3]. Therefore, it is very important to make scientific evaluation and continuous improvement on the implementation of the responsibility system of safety production in highway industry.

Performance evaluation is an effective way to test the implementation of safety production liability system [4]. Performance evaluation has feedback function and guiding function [5]. Reasonable performance evaluation can fully mobilize the work enthusiasm of employees, so as to ensure the implementation of the responsibility system of production safety.
In order to ensure the safe production of road maintenance and improve the road maintenance safety production responsibility system, we completed the construction of the road maintenance safety management responsibility system in 2015, and then carried out promotion tests in Shaanxi Province [6]. In order to evaluate the implementation effect of Shaanxi Highway Maintenance Safety Management Responsibility System, based on Hall's three-dimensional structure theory, this paper constructs a road maintenance safety management responsibility system from three perspectives: performance organization, economic effect and social service effect. The performance evaluation index system was designed and the questionnaires including the implementation situation survey, the implementation effect survey and the satisfaction survey were designed. In the Shaanxi province, 1,272 questionnaires were collected to evaluate the implementation effect of the Shaanxi Highway Maintenance Safety Management Responsibility System. Finally, the recommendations for safety work improvement are proposed for the evaluation results, aiming to provide important experience for the optimization and improvement of road maintenance.

2. Evaluation system construction

The evaluation index system is an important part of the performance evaluation system, which should be able to reflect the situation of all aspects of the research object comprehensively and truthfully. Performance evaluation of safety responsibility system focus on foresight, systematization and people-oriented [7]. The evaluation of the responsibility System of highway maintenance safety management involves a large number of work. Each content is not separate, independent existence, but mutual restriction, interconnection of an organic whole. Therefore, whether the analysis results of implementation effect evaluation are true and accurate depends on the extent of information mastery, the narrow horizon of concern and the correct selection of methods. A.D Hall, an American scholar, used structural analysis to present the famous hall three-dimensional structure theory in 1969. Hall's three-dimensional structure includes time dimension and logical peacekeeping knowledge dimension, which provides a scientific thinking method for solving large system problems with large scale, complex structure and many factors involved. Based on this, considering fully the characteristics of highway maintenance work, this paper considers that the evaluation content of implementation effect of highway maintenance safety management responsibility system can be determined by Hall three-dimensional structural system engineering analysis method.

Based on the characteristics of highway maintenance work and the opinions of relevant experts, according to Hall's three-dimensional structural system engineering analysis method, a performance evaluation index system of highway maintenance safety management responsibility system is constructed by using three-dimensional structural model. The index system includes three dimensions: implementation organization, economic effect and social service effect. As shown in the table in Figure 1, the index system is divided into three aspects, totaling 62 single indicators.
Figure 1. Three-dimensional structure diagram of performance evaluation index system of highway maintenance safety management responsibility system

Table 1. Highway maintenance safety management responsibility system performance evaluation index

| Primary | Secondary | Three-level indicator |
|---------|-----------|-----------------------|
| Organization | Establish a safety production committee or a safety production leading | Safety production responsibility |
| Job Responsibilities | Safety Production Committee Clearness | Information delivery work timeliness |
| | Establishment and improvement of the safety production management | Hidden risk check frequency compliance |
| | Operational procedures establish sound conditions | Frequency hazard assessment for major hazard sources |
| | Implementation of the safety production management system | Hidden danger rectification timeliness and effectiveness |
| | Operational procedures | Risk source disposal measures clarity and facility compliance |
| | Security management staff configuration compliance | Safety production work meeting to conduct frequency compliance |
| | | Security Council meeting to conduct frequency compliance |
| Safety Education | Safety production education training investment time | |
| | Emergency training investment time | |
| Facilities and Equipment Management | Device Configuration | |
| | Safety protection tool | |
| | Device file management | |
| Supervision and Inspection | Supervisory agency | |
| | Discover hidden dangers and deal with them in a timely manner | |
| | Safety production supervision and inspection content | |
| Accountability | Accident report and investigation | |
| | Accident rectification tracking and learning | |
Emergency management

- Emergency plan and supplies
- Qualitative assessment, revision and protective equipment
- Emergency plan propaganda training activities
- Emergency drill situation
- Incident information reporting time rate

Accident Situation

- Heavy and extra large safety production liability accidents (times)
- Large safety production responsibility accident (times)
- General safety production liability accident (times)

Casualties

- Number of deaths of safety accident personnel (person)
- Number of serious injuries in safety accidents (person)
- Light accidents for people with safety accidents (person)

Economic Effect

- Direct economic loss
- Indirect economic loss
- Road property loss

Funding and use of funds

- Safety and security investment
- Capital Achievement rate
- Security fund expenditure

Social service Effect

Employee Satisfaction

- Overall satisfaction of implementation effectiveness
- Work efficiency
- Cognition of the dangers of the position and the safety response measures
- Concerns in safety production management
- Impact on life
- Safe production environment
- Safety production awareness
- Safety production promotion training
- Participate in the contingency of the emergency plan drill
- Ability to respond to actual incidents

(1) Functional dimensions. Functional dimension mainly refers to the function and function of the system, which is composed of five aspects: organization, work, supervision, accountability and emergency rescue. Organizations are the core of functions, coordinating and coordinating the operation of the other four aspects. Other functions provide support and security for the organization. Relevant institutions and personnel organizations carry out maintenance and safety management work. The work content is clear and personnel supervision is in place. There will be serious accountability after the accident. Emergency rescue provides support.

(2) Time dimension. According to the development of time, the system described by Time dimension should be changing with time, and it is irreversible. Therefore, the evaluation of the implementation effect of the responsibility system of highway maintenance safety management can only be used to describe the development process of the system from the implementation to the present and the future, and to carry out performance analysis.

(3) Effect dimension. It is the combination of functional and peacekeeping time dimension, which is the description of the gradual benefit of the function with the change of time. This paper combs and classifies the effect of the responsibility system of highway Maintenance safety management, which is divided into the implementation of organizational effect, economic effect and social service effect.

3. Evaluation method

The choice of performance evaluation method should be combined with the specific characteristics of the evaluation object, so as to truly reflect the actual performance as the goal. In order to eliminate the error caused by human subjectivity, there should be different evaluation criteria for quantitative index
and qualitative index. The performance evaluation of the safety responsibility system is a comprehensive evaluation of the maintenance safety of the highway industry after the implementation of the responsibility system, involving many evaluation contents. Different content involves different indicators, and the evaluation criteria of the index are often quite different. After comprehensive analysis of the characteristics of various performance evaluation methods, we believe that the general comprehensive evaluation method is not suitable for the performance evaluation of highway maintenance safety management responsibility system. Considering the practicability of the method and the reliability of the results, the historical dynamic comparison method can achieve simple and practical results. Through the single index calculation with or without comparison or before and after comparison, it can more clearly explain whether the implementation process of the system is smooth, whether the implementation effect meets the normative requirements, and whether the social and economic benefits are significant and specific[8]. Therefore, it is reasonable and feasible to choose the historical dynamic comparison method.

4. Case analysis

4.1 Project overview

In order to ensure safe production of road maintenance and improve the responsibility system for road maintenance safety production, we formed a research group together with the Shaanxi Provincial Highway Bureau, and completed the construction of the road maintenance safety management responsibility system in 2015. And then we carried out promotion tests in Shaanxi Province. In order to understand the actual operation effect of the system in the province, the research team carried out a special survey on the implementation evaluation of the road maintenance safety management responsibility system in the province in May 2016.

4.2 About the Responsibility System of Highway Maintenance safety management in Shaanxi Province

According to the requirements of “Party and party responsibility, one post and two work together”, the highway Bureau of Shaanxi Province has constructed the responsibility system of highway maintenance and Operation Safety management supported by work system, organization system, supervision system, emergency response system and accountability system. Among them, the work system is in the core position of safety production guarantee. The organization system is the foundation of safe production work. The supervision system is the guarantee of the implementation of safe production work. The accountability system is the promotion of continuous improvement of safe production work. And the emergency rescue system is a necessary supplement to the work of safe production. The system has formed a chain of safety responsibilities in which all people have management, layers of responsibility, consistent objectives, clear division of labor, clear responsibilities and unified action. And it established a long-term mechanism for safe production.

4.3 Data Collection

The index in this paper has both qualitative index and quantitative index, in view of the measurement of the validity of related factors, so the quantitative index is mostly. So the collection of index data mainly uses the form of questionnaire. Through the industry personnel on the relevant aspects of the personal feelings and opinions, it can be true and effective reflection of the relevant indicators of the situation.

The content of the questionnaire is designed on the basis of referring to a large number of safety-related literature research, and based on the evaluation index established above. Each problem corresponds to one or more evaluation indicators, and combines the accident characteristics of highway engineering and some specific safety activities of highway engineering, so as to measure the effectiveness of relevant performance indicators more pertinently. The questionnaire design is divided into three parts: The purpose of the survey is to understand the changes of relevant indicators before and after the implementation of the System, including 81 questions; the purpose of the survey of implementation effect is to collect the statistical data of specific indicators (such as the number of
casualties) changing with the year; and the Satisfaction Survey is to understand the public's views and opinions on the System with 13 questions, and each question has a full score of 10 points. We surveyed 1272 employees of 231 relevant departments in Xi'an, Baoji, Ankang, Tongchuan, Xianyang, Yan'an, Yulin, Hanzhong, such as the Highway Administration, Over-limit Detection Station, Road and Bridge Company, Road Banks, etc. Finally, 1272 questionnaires were collected.

4.4 Finding
By using the method of historical dynamic comparison, the safety production effects before and after the implementation of the responsibility system of highway maintenance and safety management are compared. It also counts the public's ratings on the views and opinions of the System. The results of the survey are as follows.

The results show that since the implementation of the System for one year, good results have been achieved, especially in the following indicators:

- The compliance of safety management staffing increased by 16.32%.
- The frequency of major hazards investigation increased by 9.54%.
- The ratio of clarity and compliance of risk source disposal measures increased by 16.80% and 31.93%, respectively.
- The compliance of input time for emergency training was significantly improved, from 85.19% to 92.59%, and the increase rate was 7.41%.
- Accident correction, tracing and learning activities were carried out smoothly, from 80.83% before implementation to 90.00%.
- The proportion of units that set up emergency preparedness teams increased by 15.08% compared with those before implementation.
- 50.00% of the experts in the unit organization reviewed the emergency plan to ensure the rationality of the emergency plan, which was 16.10% higher than the pre-implementation.
- 89.83% of the units regularly evaluated and revised the emergency plan, which was 21.19% higher than before.
- The initiative of carrying out propaganda and training activities of emergency plans and emergency drills increased by 7.41% and 10.61%, respectively.
- The accident situation has improved markedly (from 2012 to 2016, there were 12, 10, 12, 9 and 3 accidents in Ankang city, respectively).
- The number of casualties in safety accidents has been greatly reduced, as shown in Figure 2.

Figure 2. The number of casualties from 2012 to 2016 in Ankang City

- Figures 3 show a downward trend in economic losses.
4.5 Discussion and Suggestion

In summary, since the implementation of the "System" for one year, the safety management personnel allocation compliance, the clarity of risk source disposal measures and other indicators have been significantly improved, and the number of casualties and liability accidents has been significantly reduced. The System has greatly improved the highway maintenance safety environment in Shaanxi Province, effectively reduced casualties, and played a positive role in improving the level of highway maintenance safety production management. However, there are also some indicators with low scores, such as inadequate implementation of special funds for safety expenses, inadequate implementation of rewards and penalties for safety production, insufficient attention to safety production assessment in enterprises, and lack of a unified assessment mechanism. This shows that the current situation of safety production responsibility in highway industry is insufficient and needs continuous improvement. The government should set up a safety supervision department to manage the work of safety production in an overall way and ensure the special use of funds for safety. Enterprises should further refine safety production measures and further clarify their responsibility for safety production; strengthen the identification, pre-control and investigation of potential safety hazards; establish and improve the mechanism of assessment, reward and punishment for safety in production, formulate reasonable and effective reward and punishment incentive system, and constantly improve the level of safety in production management of enterprises.

5. Conclusion

The actual evaluation results of the safety responsibility system of highway maintenance management in Shaanxi Province show that the safety responsibility system can effectively control the risk sources, reduce the occurrence of safety accidents, and improve the work of various safety supervision agencies. It has greatly improved the road maintenance safety environment in Shaanxi Province, and comprehensively upgraded the level of road maintenance safety management.

The evaluation index system constructed in this paper can evaluate the implementation effect of highway Maintenance safety management responsibility system well, and has reference and popularization significance to the performance evaluation of safety production responsibility of highway maintenance industry.

In the further promotion and application of highway maintenance safety management responsibility system, we can further solidify the experience and advantages in the application process of the system. At the same time, we should further refine and study the existing deficiencies of the system, and constantly improve the level of traffic infrastructure construction, maintenance and safety management.
References

[1] Liu X. (2009) Institutional Integration and Ethics Construction of Safety Production Responsibility. Journal of Chinese Safety Science (8): 46-53.

[2] Tao Y. (2004) How to strictly implement the responsibility system for production safety. Coal Mine Safety, 35(10): 20-21.

[3] Li S, Peng Y, Xiao L, et al. (2014) Status and trend analysis of research on the mechanism of road traffic accidents. Journal of Safety and Environment, 14(3): 14-19

[4] Duan W, Chen G. (2010) Modeling and Application of Performance Evaluation of Enterprise Safety Production Responsibility. Chinese Journal of Safety Science, 20(5): 53-61

[5] Najafi L, Hamidi Y, Ghiasi M, et al. (2011) Performance evaluation and its effects on employees' job motivation in Hamedan City health centers. Australian Journal of Basic & Applied Sciences, 5(12):1761-1765.

[6] Ding B, Wang Y, Su X, et al. (2017) Discussion on the construction of responsibility system for highway maintenance and operation safety management. Highway, (4):293-297.

[7] Ding H, Xie J. (2008) Construction of enterprise safety performance management system. Journal of Safety Science and Technology, 4(2):107-110.

[8] Ma S, Wang Y. (2011) Study on the effect evaluation system of highway maintenance project implementation. Journal of Chinese and foreign roads, 31(3):283-287.