

Study on safety risk warning index for highway construction project

Jianhua PENG

China Academy of Transportation Sciences, Beijing, China

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ABSTRACT: Establishment of safety risk warning system of highway construction project can prevent accident effectively. Four warning situations have been ascertained, such as low safety capacity of highway construction project, reduction of safety capacity of highway construction project, existence of major safety defect in highway construction project, and existence of repetitive safety defect in highway construction project. Based on safety risk assessment of highway construction project, warning indexes toward four warning situations have been put forward respectively, providing technical support to the establishment of safety risk warning system of highway construction project.

INTRODUCTION

Because of the heavy highway construction tasks and the high risk of the project itself, China's highway construction project safety production situation is grim, the task is very arduous. Establishment of highway construction project safety risk early warning system, forecasting the possible situation of the highway construction project timely and accurately, and taking corresponding measures, will be able to avoid the occurrence of accidents effectively. In this paper, combined with the highway construction project safety risk assessment, the highway construction project safety risk early warning indicators are studied, providing technical support for the establishment of highway construction project safety risk early warning system.

SAFETY RISK ASSESSMENT OF HIGHWAY CONSTRUCTION PROJECT

The key scientific basis for the safety risk early warning of the highway construction project is to evaluate the safety production level of the highway construction project accurately and beforehand. From the safety system elements of highway construction project, highway construction project safety risk assessment should accord to the inherent risk(G), safety management level of construction unit(M1), safety management level of project owner(M2), and safety management level of supervision unit(M3). These factors are refined to determine the evaluation index and criteria. Using the fuzzy comprehensive evaluation method, the safety level of highway construction project can be evaluated. The value of evaluation index can use centesimal system [100,0]. Safety grade division for highway construction project can adopt the experience mode (see Table 1).

Table 1. Safety grade division for highway construction project

Safety grade	I	II	III	IV
Level	Safe	Relatively safe	Relatively dangerous	dan- Dangerous
Values range	[100,90]	(90,75]	(75,60]	(60,0]

THE DETERMINATION OF WARNING SITUATION

According to the characteristics of highway construction project safety production, the following four kinds of monitoring and forecasting situation are identified.

Low safety capacity of highway construction project

Highway construction project safety capacity is the basic attribute of highway construction project, revealing its ability to ensure safety and to resist risk accidents. When the highway construction project safety capacity is insufficient, the risk of potential accidents is greater.

Reduction of safety capacity of highway construction project

Along with the progress of highway construction project and the change of construction task, the safety capacity of highway construction project is constantly changing. When the safety capacity of highway construction projects is weakened, the risk of potential accidents is increasing.

Existence of major safety defect in highway construction project

Safety production of highway construction project is a complex and multi factor system. When safety management level of construction unit, project owner, or supervision unit is very vulnerable, it can be regarded as a major safety defect in highway construction project. Its impact can be extended to the overall safety of highway construction project.

Existence of repetitive safety defect in highway construction project

If major safety defect of the highway construction project has not been corrected timely, it can be regarded as a repetitive safety defect in highway construction project. The influence of defect on the safety production of highway construction project will be further deepened, and the impact may be multiple and malignant.

EARLY WARNING INDEX

According to the above four kinds of warning situation, the following warning indicators are identified.

Safety level of highway construction project(S)

The safety level of highway construction project is the direct expression of safe capacity of highway construction project. When the value of safety level is lower than a certain critical value(L), it can be used as a warning sign of the lack of safety capacity of highway construction project. Safety level of highway construction project is also the comprehensive safety risk assessment index of highway construction project.

According to safety grade division for highway construction project based on Table 1, when S value is at [100,75], highway construction project safety production is in a controlled state, don't issue a warning(or warning degree is no warning). when S value is at(75,60], safety capacity of highway construction project is insufficient, warning degree is medium warning, and L is 75. when S value is at(60,0], safety capacity of highway construction project is severely insufficient, warning degree is severe warning, and L is 60. The division criteria of safety level warning line for highway construction project is shown in Table 2.

Table 2. Division criteria of safety level warning line for highway construction project

Warning degree	No warning	Medium warning	Severe warning
S	[100,75]	(75,60]	(60,0]
Description of warning situation	Highway construction project safety production is in a controlled state	Safety capacity of highway construction project is insufficient, accident risk is relative higher	Safety capacity of highway construction project is severely insufficient, accident risk is higher
Control method	Daily management and normal monitoring	Measures must be taken to improve safety capacity, reduce risk, and strengthen monitoring	Must attach great importance, and take measures to improve safety capacity immediately

Variation range of safety level of highway construction project(ΔS)

The safety level of highway construction project is an inherent attribute value of highway construction project. Along with the progress of the project, the safety level of highway construction project is also in constant change. When the highway construction project begin its first safety risk assessment, it will get the initial value of safety level of highway construction project(S_0). After each complete monitoring and safety risk assessment, there will be a reflection of the current stage of highway construction project safety level(S_i). The difference between two adjacent safety risk assessment of highway construction project(See Equation 1) is variation range of safety level of highway construction project(ΔS).

$$\Delta S = S_i - S_{i-1} \quad (1)$$

where S_i =safety value of highway construction project in the i-th safety risk assessment; S_{i-1} =safety value of highway construction project in the (i-1)-th safety risk assessment.

When variation range of safety level of highway construction project(ΔS) is positive, it means that the highway construction project safety capacity has been strengthened. When variation range of safety level of highway construction project(ΔS) is negative, it means that the highway construction project safety capacity has been weakened. At this time, even if the highway construction project safety production is in a controlled state, it may be out of control in future, if the corresponding measures are not implemented in time. Therefore, it is necessary to carry out early warning.

According to safety grade division for highway construction project based on Table 1, when the ΔS value is in $[0,100)$, it means highway construction project safety capacity is not weakened, don't issue a warning(or warning degree is no warning). When the ΔS value is in $[-10,0)$, it means highway construction project safety capacity is weakened, warning degree is slight warning, and L is zero. When the ΔS value is in $[-25,-10)$, it means highway construction project safety capacity is weakened significantly, warning degree is medium warning, and L is -10. When the ΔS value is in $(-100,-25)$, it means highway construction project safety capacity is weakened sharply, warning degree is severe warning, and L is -25. The division criteria of the variation range of safety level of highway construction project is shown in Table 3.

Table 3. Division criteria of the variation range of safety level of highway construction project

Warning degree	No warning	Slight warning	Medium warning	Severe warning
ΔS	$[0,100)$	$[-10,0)$	$[-25,-10)$	$(-100,-25)$
Description of warning situation	Highway construction project safety capacity is maintained or strengthened	Highway construction project safety capacity is weakened	Highway construction project safety capacity is weakened significantly	Highway construction project safety capacity is weakened sharply
Control method	Daily management and normal monitoring	Pay attention, and strengthen monitoring	Pay attention, take measures to improve safety capacity, and strengthen monitoring	Must Attach great importance, and take measures to improve safety capacity immediately

Major safety defect in highway construction project

In the safety risk assessment of highway construction project, if safety management level of construction unit(M1), safety management level of project owner(M2), or safety management level of supervision unit(M3) is in $(75,0]$, it means major safety defect in highway construction project is existed. At this point, even if the highway construction project safety production as a whole is in a

controlled state, it is most likely out of control in future, if the corresponding measures are not implemented in time. Therefore, it is necessary to carry out early warning.

When all of M1, M2 and M3 are in [100,75], there is no major safety defect in highway construction project, don't issue a warning(or warning degree is no warning). When M1, M2 or M3 is in (75,60], there is a major safety defect in highway construction project, warning degree is medium warning, and L is 75. When M1, M2 or M3 is in(60,0], there is an extraordinarily major safety defect in highway construction project, warning degree is severe warning, and L is 60. The division criteria of major safety defect in highway construction project is shown in Table 4.

Table 4. Division criteria of major safety defect in highway construction project

Warning degree	No warning	Medium warning	Severe warning
M1, M2 or M3	[100,75]	(75,60]	(60,0]
Description of warning situation	No major safety defect in highway construction project	Major safety defect in highway construction project	Extraordinarily major safety defect in highway construction project
Control method	Daily management and normal monitoring	Pay attention, take measures to eliminate major safety defect, and strengthen monitoring	Must attach great importance, and take measures to eliminate extraordinarily major safety defect immediately

Among them: M1 corresponds to the major defect existing in the highway construction project construction unit, M2 corresponds to the major defect existing in the highway construction project owner, M3 corresponds to the major defect existing in the highway construction project supervision unit.

Repetitive safety defect in highway construction project

In the safety risk assessment of highway construction project, if safety management level of construction unit(M1), safety management level of project owner(M2), or safety management level of supervision unit(M3) is in (75,0] no less than twice in succession, it means repetitive safety defect in highway construction project is existed. At this point, even if the highway construction project safety production as a whole is in a controlled state, the safety production of highway construction project has not attracted enough attention and continuous improved, it is most likely out of control in future, if the corresponding measures are not implemented in time. Therefore, it is necessary to carry out early warning.

The division criteria of repetitive safety defect in highway construction project is shown in Table 5.

Table 5. Division criteria of repetitive safety defect in highway construction project

Warning degree	No warning	Severe warning
M1, M2 or M3	Be in (75,0] less than twice in succession	Be in (75,0] no less than twice in succession
Description of warning situation	No repetitive safety defect in highway construction project	Repetitive safety defect in highway construction project
Control method	Daily management and normal monitoring	Must attach great importance, and take measures to eliminate repetitive safety defect immediately

Among them: M1 corresponds to the repetitive defect existing in the highway construction project construction unit, M2 corresponds to the repetitive defect existing in the highway construction project owner, M3 corresponds to the repetitive defect existing in the highway construction project supervision unit.

CONCLUSIONS

(1) Four warning situations have been ascertained, such as low safety capacity of highway construction project, reduction of safety capacity of highway construction project, existence of major safety defect in highway construction project, and existence of repetitive safety defect in highway construction project.

(2) According to four kinds of warning situation, the corresponding early warning indexes are put forward, including safety level of highway construction project(S), variation range of safety level of highway construction project(ΔS), major safety defect in highway construction project, and repetitive safety defect in highway construction project.

(3) The division criteria of the four warning indexes are put forward respectively. According to different type and level of warning situation, the corresponding control method is put forward.

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