STUDY ON EVALUATION SYSTEM OF HIGHWAY SAFETY ENHANCEMENT PROJECT IN CHINA

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ABSTRACT

In early 2004, the Ministry of Transport of China launched the "Highway Safety Enhancement Project" (HSEP) themed at "Eliminate Potential Danger, and Cherish Life" for national and provincial highways. HSEP planned to use traffic engineering and other comprehensive measures to deal with the sharp curves, steep slopes, poor sight, and dangerous roadside on national and provincial highways. Since then, a lot of potential highway safety hazard sections have been remedied and the highway safety has been improved.

According to the implement status of HSEP, the evaluation system of HSEP is proposed and the corresponding target level, criteria level and index level are established. The traditional method of evaluating the HSEP only from safety is changed. The implement status, measures, effect, safety benefit and public reception included into the evaluation scope of the HSEP. Moreover, the determination method of each indicator is also proposed.

1. INTRODUCTION

In order to enhance the highway safety, Ministry of Transport of the People's Republic of China launched Highway Safety Enhancement Project (hereinafter referred to as HSEP) with the theme of eliminating potential danger and cherishing life for national and provincial highways in early 2004. It was planned to take comprehensive measures such as traffic engineering measures to tackle potential danger threatening traffic safety and improve guidance and safety protection facilities of highways to reduce fatality rate of traffic accidents and occurrence of serious traffic accidents as many as possible and safeguard traffic safety with good highway conditions [1]. After that, to give directions on the implementation of HSEP nationwide, Ministry of Transport compiled *Guideline for implementation of Highway Safety Enhancement Project*. In 2006, rural roads were included in the scope of HSEP. With the implementation of HSEP, lots of potential hazards on highways have been remedied and highway traffic safety has been safeguarded and enhanced effectively.

The Guideline for implementation of Highway Safety Enhancement Project specifies the necessity of evaluating the effect of HSEP but does not put forward evaluation systems and evaluation approaches. As relevant evaluation technologies and approaches are not available, tracking, summary and evaluation of HSEP have generally been missing in many regions. The existing evaluation is only about the decrease and increase in the number of fatalities in highway traffic accidents before and after the implementation of HSEP. Such calculation involves no necessary analysis and evaluation and thus cannot reveal the exact effect of HSEP. It cannot give support for later decisions on highway safety enhancement or basis for the revision of measures for HSEP. It is therefore needed to build evaluation system and evaluation approach for HSEP to objectively and comprehensively reflect the benefits of HSEP.

2. EVALUATION SYSTEM OF HSEP

2.1. Principles of evaluation system

The implementing principles of HSEP focus on safety, economy, environmental protection, and effectiveness. Comprehensive measures are taken to address the main factors undermining traffic safety in regulated highway section and to avoid mere passive protection such as improper protection or overprotection that damages environment and landscape. The guiding thought that “no damage is maximal protection” is followed and highway traffic safety is constantly improved [1,2]. Therefore, HSEP is complex and systematic, so is benefit evaluation of HSEP. The evaluation involves disciplines such as automobile engineering, traffic engineering, environmental engineering, man-machine engineering and statistics, and lots of factors play their roles. It is impossible and unnecessary to examine, analyze, and evaluate these factors one by one. Therefore, benefit evaluation system of HSEP should be in accordance with the following basic principles [3]:

(1) Evaluation index system should comprehensively and objectively reflect the actual implementation and show the effects of HSEP.

(2) To streamline benefit evaluation index system of HSEP as much as possible, major elements that exert large effects on HSEP should be analyzed while minor elements should be ignored.

(3) Considerations only give to the more important one among those interrelated elements, and the systematic analysis should be simplified.

2.2. Identification of evaluation system

HSEP is intended to regulate and remedy potentially hazardous highway sections threatening traffic safety to improve highway traffic safety. *The Guideline for implementation of Highway Safety Enhancement Project* contains the common types of potentially hazardous highway sections to be intensively regulated in HSEP, including: a single sharp bend, consecutive sharp bends, small-radius curve linking bridgehead, steep slope, consecutive downgrade sections, poor-sight sections, sections with hazardous roadside, tunnel section, level crossing with no signal, level crossing with signal, sections near school, town, and village, sections with changing road conditions, and highway-railway overpass.

During the course of the implementation of HSEP, the number of potentially hazardous sections and the mileage of the total regulated highway sections are critical to the overall effects of the project. If potentially hazardous sections have not been remedied, HSEP will eventually not lead to better outcome, even with nearly perfect remedial measures. Since the existence of potential hazards on the highway poses traffic safety problem under certain conditions, highway traffic safety cannot be effectively safeguarded. Thus, the benefit evaluation system of HSEP should include improvements of potentially hazardous sections remedied. Measurement of improvements of potentially hazardous sections remedied should consist of two indexes, i.e. rate of the number of potentially hazardous sections remedied and rate of the mileage of potentially hazardous sections. The two indexes are equally important, because the number of potentially hazardous sections remedied is not necessarily tantamount to the mileage of potentially hazardous sections. In other words, the completion of the mileage needed to be remedied does not necessarily mean the completion of the number of potentially hazardous sections to be remedied.

When potentially hazardous highway sections have been remedied, the effect of highway safety enhancement project depends on remedial measures. Benefit evaluation system of HSEP should include remedial measures taken to enhance highway safety. Remedial measures should be evaluated from two perspectives. One is whether the kinds of potentially hazardous highway sections are remedied and improved according to the *Guideline for implementation of Highway Safety Enhancement Project* and other relevant standard regulations. The other is whether remedial measures for specific highways are scientific and reasonable and in line with the requirements and concepts of HSEP. The two perspectives are indispensible and inseparable, as the former is to check whether remedial measures are the best one, while the latter is to see whether remedial measures are reasonable.

The purpose of HSEP is to reduce the occurrence rate of serious traffic accidents and fatality rate as much as possible. The effect of HSEP shows itself when we check whether highway traffic safety has been improved effectively and whether the occurrence rate of serious traffic accidents and fatality rate of highway traffic accidents have decreased sharply after the implementation of the project. Therefore, benefit evaluation system of highway safety enhancement project should include safety benefits. According to the objectives of HSEP, evaluating the effect of the project should be based on the occurrence rate of serious traffic accidents and fatality rate of traffic accidents. The number of fatal traffic accidents and the number of deaths in traffic accidents should be chosen as evaluation indexes. Safety benefits lie in the contrast and changes of the two equally important indexes before and after the HSEP.

Besides traffic accidents index, highway users' view on HSEP is the most important factor in evaluating the project. If highway users feel that traffic safety has improved with the implementation of the project, the project has then achieved its desired outcome. Otherwise, the project fails to reach its goal. Therefore, benefit evaluation system of HSEP should include highway-users' assessment of the project. Besides drivers, highways users should include residents along highways who have lived near highways for long and have gained first-hand experience of the changes in highway traffic conditions and highway traffic safety before and after the implementation of the project. The assessment of residents along highways can more objectively reflect the effect of the project.

As mentioned above, benefit evaluation system of HSEP should include four aspects that can better reflect the effects of the project, shown in Tabel 1. They are the status of remedy, remedial measures, safety benefits, and social response. The first two play a key role in ensuring the project to achieve the expected result. Safety benefits show the effect of the project with indexes. Social response refers to the evaluation of the project from the perspective of highway users.

Table 1 - Benefit evaluation system of Highway Safety Enhancement Project

Goal	Principles	Indexes
Benefit Evaluation of HSEP	Status of Remedy	Number of Potentially Hazardous Sections
		Mileage of Potentially Hazardous Sections
	Remedial Measures	Perfectness of Remedial Measures
		Reasonableness of Remedial Measures
	Safety Benefits	Number of Fatal Accidents
		Number of Death
	Users' Response	Drivers' Response
		Response of Residents along Highway

3. MEASUREMENT OF EVALUATION INDEXES

3.1. Status of remedy

3.1.1 Number of potentially hazardous sections

The rate of the number of potentially hazardous highway sections is selected as an evaluation index. The ratio is the proportion of the number of the potentially hazardous highway sections that have actually been remedied to the total number of the potentially hazardous highway sections in total. That is,

$$B_1 = \frac{N_1}{N_0} \times 100\%$$

In the above formula, B_1 refers to the rate of potentially hazardous highway sections remedied. N_1 refers to the number of potentially hazardous highway sections that have actually been remedied. N_0 refers to the total number of potentially hazardous highway sections that have actually been remedied, and the number can be determined by examination of the potential hazards.

3.1.2 Mileage of potentially hazardous sections

The rate of the mileage of potentially hazardous sections remedied is selected as an evaluation index. The rate of mileage of potentially hazardous sections remedied is the proportion of mileage of potentially hazardous sections that has actually been remedied to the total mileage of potentially hazardous sections. That is,

$$B_2 = \frac{L_1}{L_0} \times 100\%$$

In the above formula, B_2 refers to the rate of mileage of potentially hazardous sections remedied. L_1 refers to the mileage of potentially hazardous sections that has actually been remedied. L_0 refers to the total mileage of potentially hazardous sections which can be determined by examination of potential hazards.

3.2. Remedial measures

3.2.1 Perfectness of remedial measures

According to the implementation progress of HSEP, forms are to be filled in with the information about the remedial measures targeting the above-mentioned thirteen different types of potentially hazardous sections, for example, survey form of the perfectness of remedial measures for a single sharp bend is shown in Table 2. Then, perfectness of remedial measures is evaluated according to certain standards. Evaluation approaches can be found in reference [4]. Besides the evaluation of the perfectness of remedial measures of a single type of the potentially hazardous, the analytic hierarchy process (AHP) and fuzzy and comprehensive evaluation are also adopted [5-10]. As a result, evaluation can be conducted of perfectness of remedial measures for a single highway section with various kinds of potentially hazardous.

3.2.2 Reasonableness of remedial measures

According to the actual implementation progress of HSEP, forms are to be filled in by technical staff with the information about the remedial measures for a single highway section with various kinds of potentially hazardous, as is shown in Table 3. Then,

evaluation of remedial measures is conducted according to certain standards. Evaluation method can be found in reference [4].

Table 2 - Survey form of the perfectness of remedial measures for a single sharp bend

Remedial Measures	Checkup Standard	Implementation Progress
1. Setup warning signs of Sharp Bend	Two	
2. Setup centrelines along the sharp bend	Yes	
3. Setup delineators at roadside	Yes	
4. Setup the sign of No Overtaking, including release	Two	
5. Setup warning signs of Accident-Prone Sections	Yes	
6. Setup chevrons at roadside	Yes	
7. Setup the sign of Speed Limit, including release	Two	
8. Setup the control speed facilities	Yes	
9. Setup physical separation facilities	Yes	
10. Setup convex mirrors	One	
11. Broadening the roadway along of the sharp bend according to frequency of accidents	Yes	

Table 3 - Survey form of the reasonableness of remedial measures

Check-Up Contents	Check-Up Results			
	Excellent	Good	Up to Standard	Below Standard
1. Scientific and reasonable of guardrail type				
2. Scientific and reasonable of guardrail protection grade				
3. Reasonable location and length of guardrail				
4. Proper distance of signs placed ahead, size and text height of signs are in accordance with National Standards				
5. Way-finding signs are complete, scientific and standardized				
6. Scientific and conspicuous signs reminding of accident-prone sections, warning signs, forbidding signs, and combination of signs and markings				
7. Complete and scientific of the setup of facilities such as signs, markings and signals at level crossing				
8. Guidance markings are smooth, comfortable, complete and standardized				
9. Forbidding markings, warning markings are reasonable, conspicuous and standardized				
10. Warning posts, warning blocks and other vision induction facilities are reasonable, conspicuous				
11. Proper use of warning signs and forbidding signs and not numbing to drivers because of overuse				
12. Overall remedy of highway sections crossing towns and schools				

3.3. Safety benefits

3.3.1 Number of fatal accidents

The changed rate of fatal accidents before and after the implementation of HSEP is selected as an evaluation index. Data of fatal highway traffic accidents one year before and after the implementation of HSEP are obtained from public security and transport administration agencies. The changed rate of fatal accidents is the ratio between the number changes in fatal traffic accidents before and after the implementation of the project and the total number of fatal traffic accidents before the project. That is,

$$R_1 = \frac{A_1 - A_0}{A_0} \times 100\%$$

In the above formula, R_1 refers to the changed rate of traffic accidents. A_1 refers to the number of fatal traffic accidents one year after the implementation of highway safety enhancement project. A_0 refers to the number of fatal traffic accidents one year before the implementation of highway safety enhancement project.

3.3.2 Number of deaths

The number of deaths before and after the implementation of HSEP is selected as evaluation index. Data of the number of deaths one year before and after the implementation of highway safety enhancement project are obtained from public security and transport administration agencies. The changed rate of number of deaths is the ratio between changed number of deaths in traffic accidents one year before and after the implementation of HSEP and the number of deaths in traffic accidents one year before the implementation of the project. That is,

$$R_2 = \frac{F_1 - F_0}{F_0} \times 100\%$$

In the above formula, R_2 refers to changed rate of deaths in traffic accidents. F_1 refers to the number of deaths one year after the implementation of HSEP. F_0 refers to the number of deaths one year before the implementation of HSEP.

3.4. Evaluation of users' response

3.4.1 Drivers' response

Drivers passing by sections remedied are surveyed and enquired about whether they are more satisfied with the traffic conditions after implementation of HSEP.

3.4.2 Response of residents along highways

Residents along highways are surveyed and enquired about whether they are more satisfied with the traffic conditions after implementation of the HSEP.

CONCLUSIONS

According to the actual progress of HSEP, main elements concerning the benefits of the project are addressed, and evaluation system of highway safety enhancement project is established. Benefit evaluation of the project is conducted from four aspects such as remedial status, remedial measures, safety benefits, and users' response. This approach is different from the conventional approach that records decrease and increase in the

number of deaths in traffic accidents before and after the implementation of HSEP. It has formed measurement methods of all evaluation indexes and has made it possible to objectively and comprehensively evaluate the benefits of HSEP.

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