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Research on Evaluation Index System of Green Highway in Reconstruction and Expansion Projects

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Abstract: This study summarizes and condenses the core requirements of green road construction in the reconstruction and expansion project, systematically analyzes the three typical representative green road evaluation index systems of GreenRoads, INVEST and Green-LITES. A green highway evaluation index system including 7 first-level indicators, 20 second-level indicators, and 52 third-level indicators has been constructed, The analytic hierarchy process was used to establish a step-level model, the relative importance of each index is determined according to the judgment of experts, and the weight coefficient of each level of index is obtained. In terms of policy requirements, related technology applications, green highway development trends, and the actual construction of the Beijing-Shanghai Expressway reconstruction and expansion project, the three-level indicator scoring method was determined. The green highway evaluation index system and evaluation model were used to evaluate the reconstruction and expansion project of the Beijing-Shanghai Expressway from Laiwu to Linyi (Lu-Sujie). It was determined that the comprehensive score of the project was 81.2, which reaching an excellent level.

1 INTRODUCTION

The large-scale, high-speed sustainable development of the transportation industry will be restricted by resource and environmental conditions, and the green development needs of transportation industry has become more urgent. The "Guiding Opinions on the Implementation of Green Road Construction" issued by the Ministry of Transport in July 2016, which proposed that the main Characteristic of green road should good quality, resource conservation, ecological environment friendly, energy conservation, and service improvement. The "Guiding Opinions" clarified the construction goals and main tasks of green highways, but there has not been a systematic study of what conditions or standards should be met for green highways, especially for reconstruction and expansion projects.

In terms of green road evaluation indicators, some related research work has also been carried out. ‘Greenroads’ is the first green road rating system in the United States. It is a voluntary third-party evaluation system initiated by the University of Washington, including 11 mandatory requirements and 37 items. The Netherlands, Germany, France, Britain, Norway, Spain and other countries have also established corresponding energy consumption evaluation systems for the life cycle of road construction projects.

The green roads which derived from green low-carbon roads claimed that road construction should follows the green and low-carbon design concept through planning stage, construction stage, operation and management stage, and should adopting new technologies actively, to achieve the goals of reducing energy consumption and avoiding ecological damage, reducing carbon emissions, and improving environmental benefits during the entire life cycle of the road.

In recent years, researches have concerned about the evaluation index system of green roads. Sun Lei (2012) analyzed the basic connotation of green roads and their differences and connections with ecological roads and landscape roads. Presented core framework of the green highway evaluation index system in four aspects: energy utilization, environmental pollution, ecological destruction, safety and health. And take the environmental elements and ecological elements as the criterion level. Liu Jian (2016) based on the concept of life cycle and built a green low-carbon road evaluation system with 14 main control indicators as mandatory indicators and 21 general indicators as the evaluation framework. Using the evaluation system on a sample green low-carbon road and determine the grade of the green and low-carbon road.

Zhang (2011) adopted the green road evaluation index system established by the PRS model; Wang (2014) constructed a green low-carbon road evaluation system based on the analytic hierarchy process and multi-level fuzzy comprehensive evaluation method, and used it for the Yunnan Ma Zhao green road; Xie (2016) optimized the green and low-carbon highway evaluation index system and proposed the quantitative indicators and the qualitative indicators, and using the analytic hierarchy process to determine the weight of the indicators. The optimized index system was used to evaluate the green and low-carbon grade of Sanxi Expressway.

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The reconstruction and expansion project of the Laiwu-Linyi (Lu-Sujie) section of the Beijing-Shanghai Expressway is one of the only two reconstruction and expansion projects in the second batch of typical green highway demonstration projects of the Ministry of Transport. Different from the new road project, the green road construction of the renovation and expansion project has unique characteristics such as the high demand of keep traffic uninterrupted, high resource reuse requirements, and high resource reuse value. The green road construction of the renovation and expansion project has never been carried out before. the connotation and characteristics of green highways are still unclear and related research technologies are still under exploring, it is urgent to improve the evaluation method, proposed evaluation index system, carry out evaluation and guide the green roads construction of the reconstruction and expansion project.

On the basis of summarizing and inheriting the existing research and experience, this study summarizes and condenses the core requirements of green roads construction of the reconstruction and expansion project, and proposes main indicators and scoring standards of the green road construction of the renovation and expansion project. Using expert scoring and analytic hierarchy process weight assignment method to determine the evaluation index weight, and further calculate the final index score, and then determine the green road construction score of the reconstruction and expansion project of the Beijing-Shanghai Expressway from Laiwu to Linyi (Lu Su Jie).

2 CONSTRUCTION OF GREEN HIGHWAY EVALUATION SYSTEM FOR RECONSTRUCTION AND EXPANSION PROJECTS

2.1 Selection and determination of index system framework

This research draws on the structure of the evaluation index system of the US GREENROAD green road index system, the INVEST index system, the Green-LITES, and the "Yunnan Province Green Road Evaluation Standard", the "Hubei Province Green Road Evaluation Index System", the "Jilin Province Green Road index system", center on the eight main characteristics of green roads (intensive resource conservation, optimized energy use, emphasis on ecological protection, pollution control, and cycle costs., Implement innovation-driven, improve project quality, expand service functions). Take ecological protection, pollution prevention, resource conservation, energy saving and carbon reduction, quality construction, service improvement, and innovation support as first-level indicators. Combine the characteristics of the reconstruction and expansion project of Beijing-Shanghai Expressway, screened 20 second-level indicators and 52 third-level indicators, and constructed an evaluation index system for the reconstruction and expansion projects.

2.2 Construction of Evaluation Index System

Based on the preliminary green road evaluation index system for the reconstruction and expansion project of the Beijing-Shanghai Expressway from Laiwu to Linyi (Lu-Sujie), we designed a questionnaire on the evaluation index weight and distributed it to experts of transportation, and received a total of 8 valid weight questionnaires. the analytic hierarchy process is used to index weighting. The evaluation index system is divided into 3 levels. The first level takes green road construction as the main goal, and the criterion level contained seven aspects: ecological protection, pollution prevention, resource conservation, energy saving and carbon reduction, quality construction, service improvement, and innovation support. The standard level is broken down into several indicators.

2.3 Indicators scoring

The evaluation indicators are scored based on the relative importance between indicators, and the comparison results of the criterion level and the indicator level in each questionnaire are summarized. Obtain the importance score table for the pairwise comparison of the index layer, construct and solve the judgment matrix, and verify the consistency of the results, and obtain the final evaluation index weight table.

2.4 Determination of evaluation index weight

According to the pairwise comparison results of the evaluation indexes of each level, they are substituted into the judgment matrix, and finally the weight assignment of each index is obtained.

3 EMPIRICAL RESEARCH ON GREEN HIGHWAY EVALUATION INDEX SYSTEM

A test evaluation questionnaire for the evaluation index system of the Beijing-Shanghai Expressway Green Highway was compiled, field surveys were carried out, and design documents, construction organization design, supervision documents and other materials were checked to determine the scoring method for the three-level indicators (omitted). According to the scoring method, determine the scores of each three-level index, and multiply the index weight to obtain the final score of each three-level index (Table 2):

Table 1 Scores of the third level indicators

Third-level index weight	**Score**	weight	**Final score**
Sensitive target avoidance	0.8	1	0.8
Road vegetation protection	1.0	0.60	0.60
High fill and deep excavation control	1	0.20	0.2

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Tunnel opening control	1	0.20	0.2
Vegetation restoration	0.8	0.16	0.128
Slope ecological protection	1	0.32	0.32
Ecological improvement of drainage facilities	Do not participate in evaluation	0.21	——
Ecological retaining wall application	0	0.32	0
The sewage treatment capacity of auxiliary facilities	Do not participate in evaluation	0.60	——
Rebuild and improve road (bridge) surface runoff collection and treatment facilities	1	0.20	0.2
Wastewater treatment during construction	0.8	0.20	0.16
Dust control during construction	1	0.60	0.60
Construction machinery pollution control	1	0.20	0.20
Asphalt flue gas control	Do not participate in evaluation	0.20	——
Noise pollution prevention	1	1.00	1
Layout of temporary land use	1	0.30	0.3
Zero discards, less debits	0.5	0.70	0.35
Recycling of old roads	0.6	0.50	0.3
Utilization rate of concrete materials for demolition of old roads	0.6	0.29	0.174
Traffic safety facility utilization	1	0.07	0.07
Bridge structure utilization	1	0.15	0.15
Real estate materials, industrial waste utilization	0.8	0.33	0.264
Template material utilization	1	0.33	0.33
Comprehensive utilization rate of tunnel spoil	0.2	0.33	0.066
Water reuse in service area	Do not participate in evaluation	1.00	——
Centralized power supply during construction	1	0.25	0.25
Mixture energy saving technology	0.6	0.55	0.33
Natural gas mixing station	1	0.13	0.13
Energy-saving construction equipment and technology	1	0.07	0.01
Tunnel ventilation and energy saving	1	0.14	0.14
Lighting energy saving measures	1	0.21	0.21
Building energy efficiency measures	Do not participate in evaluation	0.41	——
New energy utilization	Do not participate in evaluation	0.17	——
Power supply and distribution system energy saving	1	0.07	0.07
Steel structure bridge application	1	0.50	0.50
Functional road applications	0.6	0.50	0.3
Construction management information	1	0.20	0.20
BIM technology application	1	0.60	0.6
HSE management system	1	0.20	0.20
Process standardization	1	0.50	0.50
Site standardization	1	0.50	0.50
Traffic warning system	1	1.00	1.00
Information Service	Do not participate in evaluation	0.25	——
Improved tourism service functions	Do not participate in evaluation	0.25	——
Shared service area	Do not participate in evaluation	0.25	——
Humanized facilities upgrade	Do not participate in evaluation	0.25	——
Landscape display	Do not participate in evaluation	1.00	——
Scientific research	1	0.66	0.66
New Technology Application	1	0.33	0.33
Project implementation	1	0.60	0.60
Promotion training	1	0.20	0.20
Whole process environmental management	0.5	0.20	0.1

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Sum the third-level index scores under each second-level index to obtain the second-level index score (Table 3), summarize the second-level index scores under the corresponding first-level index, and multiply the first-level index weight to obtain the first-level index score. Then get the relative score of each first-level index, and get the final evaluation score after averaging (Table. 4)

Table 2 Scores of the second level indicators

Second-level index	Score	Weight	Score
Sensitive target avoidance	0.8	0.6	0.48
Vegetation and terrain protection	1	0.2	0.2
Ecological restoration	0.528	0.2	0.1056
Water pollution prevention	0.7	0.6	0.42
Air pollution control	1	0.2	0.2
Noise pollution prevention	1	0.2	0.2
Land resource conservation	0.65	0.27	0.1755
Utilization of old road facilities	0.694	0.58	0.40252
Material recycling	0.66	0.14	0.0924
Water conservation	Do not participate in evaluation	0.07	——
Energy saving during construction	0.78	0.5	0.39
Energy saving during operation	1	0.5	0.5
Durability	0.8	0.47	0.376
Intelligent management	0.8	0.13	0.104
Standardized construction	1	0.16	0.58
Smart Transportation System	1	0.14	0.88
Diversified services	Do not participate in evaluation	0.5	——
Landscape optimization	0.6	1	0.6
Technological innovation	1	0.5	0.5
Green construction concept	0.9	0.5	0.45

Table 3 Scores of the first level indicators

First-level index	Weight	Score	Relative score (full marks)
ecological protection A	0.26	22.5	0.98
pollution prevention B	0.22	18.0	0.82
resource conservation C	0.16	10.7	0.67
energy saving and carbon reduction D	0.10	8.9	0.89
quality construction E	0.12	10.4	0.87
service improvement F	0.06	3.6	0.60
innovation support G	0.08	7.6	0.95
Total score	**81.8**		

The comprehensive score of the green road construction of the reconstruction and expansion project of the Laiwu-Linyi (Lu-Sujie) section of the Beijing-Shanghai Expressway is 81.8 points, which meets the "excellent" level of green roads in this evaluation system. This score is calculated based on the current project progress and construction level. With the progress of the project, the final score of this project can be obtained.

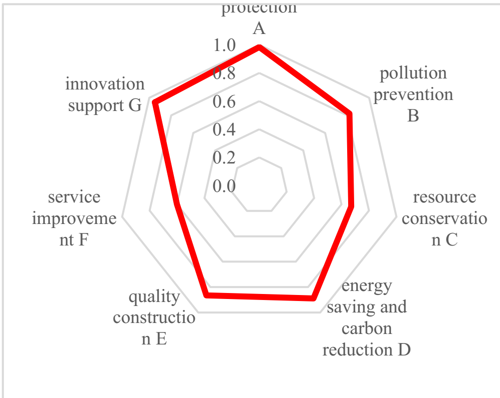

Figure 1 The first-level indicator scores of the effect evaluation of the Beijing-Shanghai high-speed reconstruction and expansion project

The relative scores of the first-level indicators were further analyzed. Among the 7 first-level indicators of the reconstruction and expansion project of the Beijing-Shanghai Expressway from Laiwu to Linyi (Lu-Su Jie), ecological protection and innovation support score the most prominent, and the scores account for 98% and 95% of the full marks, energy-saving and carbon-reduction and quality construction scores are also high, with scores accounting for 89% and 87% of the full marks, respectively, all of the above indicators reach the "excellent" level; the service improvement and resource conservation index scores are relatively low (Figure 1). The reason is that the project has not yet been completed and demolition of built roads have not been fully utilized. Due to the lag in the construction of the service area, the service improvement score is not the final score.

Among the second-level indicators, the indicators of durability, material recycling, and utilization of old roads facilities have low scores, accounting for less than 80% of the full marks. With the further implementation of the project, the above indicators have great potential for improvement (Figure 2).

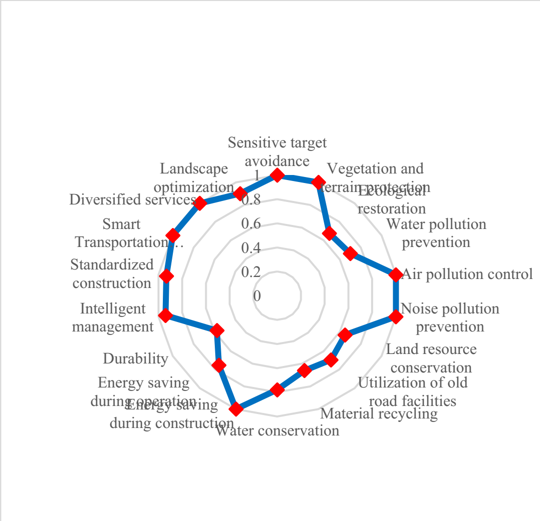

Figure 2 The second-level indicator scores of the effect evaluation of the Beijing-Shanghai high-speed reconstruction and expansion project

4 CONCLUSION

This research conducted a systematic analysis of the three typical and representative green road evaluation index systems of GreenRoads, INVEST and Green-LITES, and constructed Evaluation index system for green highways of Beijng-Shanghai Expressway. The first-level of index system were including ecological protection, pollution prevention, resource conservation, energy conservation and carbon reduction, quality construction, service improvement, innovation support, A total of 20 evaluation indicators constitute the second-level indicators, which including sensitive target avoidance, water pollution prevention, land resource conservation, construction energy conservation and carbon reduction, engineering durability, Diversified services, technological innovation etc. A total of 52 evaluation indicators constitute the third-level indicators, which including reuse of auxiliary facilities along the line, centralized power supply during construction period, intensive use of permanent land, etc.

The analytic hierarchy process was used to establish a hierarchy model, and the importance of indicators is quantitatively scaled according to the judgment of experts, and then the relative importance of each indicator is determined. On this basis, the judgment matrix is solved to obtain the relative weight coefficient. Explained 52 specific indicators, determined the content of indicator evaluation, and proposed specific scoring methods. Finally, the calculation method of the actual score of the green highway assessment is determined.

Based on the analysis of the construction characteristics of the Beijing-Shanghai Expressway, the green highway evaluation index system and evaluation model are used to evaluate the green road construction. It is calculated that the comprehensive score of the reconstruction and expansion project of Beijing-Shanghai Expressway is 81.2, reaching an excellent level.

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