

# Ecological Design of Expressway Based on the Perspective of Landscape Ecology

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**Abstract:** The construction and operation of expressways will also bring a series of environmental and ecological problems, such as land use conflicts, ecological damage, environmental pollution, etc. In order to solve such problems, it is necessary to strengthen the application of landscape ecology. From the perspective of landscape ecology, this paper first introduces the impact of expressways on the ecological environment, and then analyzes the principles of expressway ecological landscape design. Landscaping, ecological environment, customer satisfaction, and other aspects have all performed well, with an optimization rate of over 90%. Future expressway design can strengthen the application of landscape ecology.

**Keywords:** Expressway; Landscape design; Service area

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## 1. Introduction

Landscape ecology is a discipline that studies the spatial pattern of landscapes, ecological processes, and their relationship with ecological stress. It emphasizes the idea of holism, taking the biological and abiotic factors of the ecosystem and human activities as a whole, and studying their interaction, influence, and evolution. With the development of social economy and the increase of road traffic, the construction of expressways has become an important symbol of the development of modern cities. However, the construction of expressways often has negative impacts on the ecological environment, such as loss of biodiversity, changes in land use patterns, and deterioration of the ecological environment. In order to reduce these negative impacts, it is important to explore the ecological design of expressways.

## 2. The impact of expressways on the ecological environment

### 2.1. Change of land use

The construction of expressways requires a large amount of land, which may result in the change of land use of surrounding lands <sup>[1]</sup>. For example, ecosystems such as forests, wetlands, and wildlife habitats may be traversed or destroyed by highways. This can change the migration routes of wildlife, affecting the survival and reproduction of species.

### 2.2. Cutting off the ecological corridor

Highways often cut off the migration routes of organisms, especially the ability of wild animals to find food, water sources, or escape predators in their natural environment <sup>[2]</sup>, which may lead to the decline in the number of species and may even cause some species to become endangered.

### **2.3. Noise and pollution**

Highways generate noise pollution and other forms of pollution, which may impact the surrounding ecosystem<sup>[3]</sup>. For example, noise can affect the behavior of wildlife, while exhaust emissions can negatively impact air quality.

### **2.4. Water resources and soil erosion**

The construction of highways may affect the surrounding water resources, such as the flow of groundwater and surface water. In addition, soil erosion during construction and road maintenance may also have an impact on the ecological environment.

### **2.5. Impact of human communities**

The construction of expressways may change the lifestyles of people in nearby communities, such as changing the landscape, affecting cultural and historical relics, etc<sup>[4]</sup>. In addition, the noise and pollution of highways may also affect the quality of life of local residents.

### **2.6. Economic factors**

The construction of expressways usually promotes the development of the local economy, but at the same time it may also lead to problems such as rising prices and increasing resource consumption.

## **3. Principles of ecological design of expressways based on the perspective of landscape ecology**

Based on the perspective of landscape ecology, expressways should be designed based on the principles below<sup>[5-9]</sup>.

### **3.1. Holistic and systematic**

The relationship between the expressway and the surrounding ecological environment should be considered from a systematic point of view, as well as its impact on the structure and function of the ecosystem.

### **3.2. Protect and restore the ecological environment**

When designing highways, it is important to protect and restore the surrounding ecological environment as much as possible to avoid damaging the natural environment. For example, the existing vegetation and ecosystem should be protected, and measures should be taken to restore the affected ecological environment.

### **3.3. Ecological diversity**

It is important to respect and protect biodiversity and provide a suitable living environment for all kinds of creatures. For example, living spaces should be created for different types of animals and plants by designing diverse ecological environments, including wetlands, woodlands, grasslands, etc.

### **3.4. Continuity and connectivity**

Ensure ecosystem continuity and connectivity. In the design of expressways, the migration and activities of wild animals should be considered. In addition, the continuity of hydrological and biological processes within the ecosystem should be ensured.

### **3.5. Sustainability**

Considering the long-term use and operation of the expressway, it is important to focus on saving resources and reducing environmental pollution while ensuring its long-term ecological benefits. For example, use environmentally friendly materials, optimize designs to reduce maintenance costs, and reduce

environmental impact.

### **3.6. Local characteristics**

In the design of expressways, it is important to respect the local natural and cultural characteristics and integrate local characteristics into the design. For example, in terms of vegetation selection, local plants can be prioritized in order to enhance ecological diversity and local characteristics.

### **3.7. Public participation and transparent decision-making**

During the design and construction process, public participation is encouraged to ensure transparency in the decision-making process. This helps to ensure the rationality and feasibility of ecological design, while enhancing public understanding and support for the project.

### **3.8. Prevention and minimization**

It is important to prevent and minimize damage to the ecological environment during the design and operation of the expressway. For example, a comprehensive ecological environment investigation and assessment can be conducted in advance, and preventive measures can be formulated, and the operation of the expressway should be monitored while performing restoration measures to minimize the impact on the ecological environment.

### **3.9. Collaboration and learning**

Collaboration among relevant institutions and professionals can also improve the ecological design. In addition, design methods should be continuously learned and improved to adapt to the ever-changing needs and requirements of the ecological environment.

By following the above principles, the ecological design of expressways will be more in line with the requirements of landscape ecology, which will help protect and restore the ecological environment, improve biodiversity, promote sustainable development, and enhance public satisfaction and acceptance. At the same time, through collaborating with relevant parties, the practicality and research of ecological design can be continuously improved.

## **4. Case analysis**

### **4.1. Project overview**

A highway is an important arterial road connecting city A and city B, which is of great significance for promoting regional economic development and strengthening exchanges and cooperation between cities. In order to meet traffic demand and improve road traffic capacity and service, a service area can be built between City A and City B. The project includes the service area, supporting facilities, charging system, etc. The total investment is expected to be about 500 million yuan, including service hall, monitoring room, power distribution room, and other facilities, as well as squares and parking lots inside and outside the service area, including water supply and drainage system, power supply system, communication system, fire protection system, monitoring equipment, etc., and the docking with the existing expressway management center. The project is expected to achieve 100 million yuan in toll revenue within the first year of operation, while bringing job opportunities and economic development opportunities to surrounding areas. The project has started in 2022, and the construction period is expected to be 2 years.

### **4.2. Design ideas**

The project follows the design concept of green, intelligent, safe, and convenient, and it also aims to provide efficient, reliable, and safe services, while fully considering environmental protection and reducing the

impact on the surrounding ecological environment <sup>[10-12]</sup>. The main body of the service area is made of environmentally friendly materials, and a rainwater collection system is designed to realize resource recycling. The service system adopts intelligent identification technology to improve the efficiency of vehicle traffic and reduce management costs. Monitoring equipment is installed inside and outside the service area to monitor vehicle traffic in real time to ensure safety.

After the project is completed and put into operation, the service area will be expanded or upgraded according to the actual situation to meet the development of traffic demand. At the same time, it will also strengthen cooperation with surrounding cities to promote the improvement and development of the expressway network. This project will help to improve the traffic capacity and service level the expressway, relieve traffic pressure and promote regional economic development. At the same time, it will also create employment and economic development opportunities for surrounding areas and enhance the city's image and competitiveness. During the implementation of the project, environmental protection issues will be fully considered, and effective measures will be taken to reduce the impact on the surrounding ecological environment. At the same time, we will also work closely with the local government and relevant departments to ensure the smooth implementation and operation of the project.

### **4.3. Design content**

#### **4.3.1. Optimize route design**

In the route design, ecologically sensitive areas, such as nature reserves, wetland parks, etc. are avoided. At the same time, it is important to avoid cutting down a large number of trees and destroying land use types, so as to reduce the damage to the ecological environment.

#### **4.3.2. Water resources protection**

The protection and utilization of water resources are taken into consideration in the design. For example, pollution and waste of surface water and groundwater are avoided through rational design of drainage systems. In addition, rainwater collection and utilization is also a good measure to save water resources.

#### **4.3.3. Energy saving and environmental protection**

Energy saving and environmental protection are considered in the design. For example, energy-saving lighting systems and renewable materials are used, and solar energy facilities are installed to reduce energy consumption and environmental pollution.

#### **4.3.4. Landscaping**

Landscaping is considered in the design to blend the highway with its surroundings. For example, through the integration of vegetation greening, landscape design, and cultural elements, the expressway becomes a beautiful landscape, and green belts are set up on both sides of the road to increase the vegetation coverage <sup>[13]</sup>; ecological corridors along the route are protected and restored; plant species suitable for the local climate and soil conditions are selected <sup>[14]</sup> and local cultural elements are integrated, which enhances the aesthetics and uniqueness of the road; public participation and education are strengthened to improve environmental protection awareness.

#### **4.3.5. Long-term monitoring and maintenance**

Long-term monitoring and maintenance work is carried out during the operation of the expressway. For example, vegetation restoration and facility operation status are checked regularly, problems are identified in time, and repairs and improvements are carried out, which will help maintain the ecological and sustainable development of expressways.

By adopting the above-mentioned ecological design strategy <sup>[15]</sup>, the harmonious symbiosis between the expressway and the surrounding environment is realized, and the expected effect is illustrated in **Figures 1–3**.



**Figure 1.** Rendering 1



**Figure 2.** Rendering 2



**Figure 3.** Rendering 3

#### 4.4. Effect analysis

**Table 1.** Expected effects of the project

Serial number	Indicator	Value	Remark
1	Average vehicle speed	20 km/h	10% higher than the original service area
2	Vehicle capacity	300 vehicles/hour	20% higher than the original service area
3	Energy consumption reduction	30%	Through the use of energy-efficient equipment and technologies
4	Noise level reduction	5 dB	Noise reduction facilities by design
5	Air quality improvement	Reduce PM <sub>2.5</sub> concentration by 20 %	Through green belts and air purification facilities
6	Improved landscaping	90%	Through ecological landscape design and plant configuration
7	Improved air circulation in the service area	80%	Natural ventilation system by design
8	Increased employee productivity in the service area	15%	By optimizing workflow and adopting intelligent management system
9	Increased customer satisfaction	95%	By optimizing the service process and providing convenient payment methods

Based on **Table 1**, it is clear that the service area designed from the perspective of ecological landscape will be optimized in many aspects, including average vehicle passing speed, vehicle capacity, energy consumption reduction, noise level reduction, air quality, landscaping, and air circulation in the service area. Besides, the work efficiency of employees in the service area and customer satisfaction will be improved, and the degree of landscaping will increase by 90%.

## 5. Conclusion

Under the idea of landscape ecology, scientific and reasonable ecological design strategies can effectively reduce the impact of highway construction on the ecological environment and realize the harmonious coexistence of man and nature. As a comprehensive discipline, landscape ecology provides important theoretical and methodological support for the ecological design of expressways. In the ecological design of expressways, we should start from the perspective of landscape ecology and comprehensively consider ecological, cultural, economic, and social factors to realize the harmonious coexistence of expressways and surrounding environments. In an ecological design, it is crucial to emphasize protecting the ecological environment, improving the stability and sustainability of the ecosystem, and creating a healthier and more livable living space for human beings.

In the future development, the ecological design of expressways should focus on the aspects below.

- (1) Advocate the concept of green design, emphasizing ecological protection and sustainable development  
In the design and construction of expressways, it is necessary to minimize the damage and pollution to the ecological environment, pay attention to the protection and utilization of natural resources, and adopt sustainable ecological design methods and technologies.
- (2) Strengthen ecological restoration and reconstruction  
For the ecological environment that has been destroyed, effective ecological restoration and reconstruction measures should be taken, such as vegetation restoration, wetland protection, and biodiversity protection.
- (3) Promote the development of intelligent and green transportation  
By adopting advanced intelligent technology and green traffic concepts, the traffic efficiency and management level of expressways can be improved, and problems such as traffic congestion and environmental pollution can be reduced.
- (4) Promote multidisciplinary integration  
The ecological design of expressways involves knowledge and technology of many disciplines, such as landscape design, ecology, environmental engineering, traffic planning, etc. It is necessary to strengthen the cross-integration of various disciplines to promote the development of ecological design of expressways.

In short, the ecological design of expressways based on the perspective of landscape ecology is one of the important ways to achieve sustainable development. By taking reasonable ecological design measures, we can effectively protect the ecological environment, improve traffic efficiency and the people's quality of life, and contribute to the sustainable development of the city.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Cui Y, 2019, The Impact of Subgrade Construction on the Ecological Environment of Expressways. Heilongjiang Transportation Science and Technology, 42(11): 22–23.

- [2] Zhu E, 2018, Application Research of Remote Sensing Interpretation in the Evaluation of Expressway Ecological Environment. Shanxi Transportation Science and Technology, 2018(04): 123–125.
- [3] Peng Y, 2016, Research on Theory and Method of Ecological Environment Evaluation of Mountain Expressway, dissertation, Chongqing Jiaotong University.
- [4] Wang Q, 2015, Detection of Changes in the Ecological Environment of Mountainous Highways Based on RS and GIS, dissertation, Chongqing Jiaotong University.
- [5] Xia R, 2017, Research on Landscape Planning and Design of Expressway Ecological Green Corridor Based on “Relational Coupling Method”, dissertation, Anhui Agricultural University.
- [6] Cai A, Ke S, 2015, Research on the Technology of Expressway Ecological Landscape Planning and Design. Qinghai Transportation Science and Technology, 2015(06): 5–8.
- [7] Jiang L, 2015, Research on Ecological Landscape Design of Shaoyang Expressway, dissertation, Central South University of Forestry and Technology.
- [8] Jiang Y, 2014, Research on Ecological Environment Restoration and Landscape Comprehensive Design of Expressway, dissertation, South China University of Technology.
- [9] Xu L, 2022, Research on Expressway Landscape Planning and Design Based on Ecological Concepts. Wisdom China, 2022(02): 76–78.
- [10] Hou F, Lu X, Jia Y, et al., 2018, Talking about the Ecological Landscape Design of Expressways. Jushe, 2018(23): 111.
- [11] Zhang D, 2018, Research on the Standards of Ecological Expressway Landscape Design. Science and Technology Innovation and Application, 2018(02): 110–111.
- [12] He Y, 2017, Design and Evaluation Analysis of Ecological Landscape Forest Belt on Expressway, dissertation, South China University of Technology.
- [13] Du H, 2018, Ecological Aesthetics and Modern Highway Landscape Design, dissertation, Kunming University of Science and Technology.
- [14] Han Z, 2015, Discussion on Greening Ecological Engineering of Shaanxi Expressway Toll Station, dissertation, Chang’an University.
- [15] Wang F, 2014, Relationship between Expressway Service Area and Auxiliary Facilities and Landscape. North Communications, 2014(S2): 75–77.

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