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Case Analysis of the Highway Development Project in Inner Mongolia

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Abstract

This article takes the Wushi Expressway, Angong Expressway, and Zhungeer Banner transportation projects implemented in Inner Mongolia Autonomous Region in recent years as typical cases, and deeply analyzes their innovative practices in intelligent construction, green construction, and regional coordinated development. Research has found that Inner Mongolia has significantly improved the quality and efficiency of highway construction through a full chain intelligent technology system, ecological protection measures, and the application of "four new" technologies. At the same time, it has solved problems such as funding shortage, ecological fragility, and uneven regional development. The case shows that highway construction needs to balance technological innovation and ecological protection, and achieve sustainable development through policy guidance, diversified financing, and regional coordination mechanisms. This article proposes targeted solutions to provide reference for highway construction in similar regions.

Keywords

Inner Mongolia Highway; Intelligent construction; Regional collaborative development; Wushi Expressway; Angong Expressway.

1. Introduction

As an important energy and strategic resource base in northern China, Inner Mongolia Autonomous Region's road transportation network is a key link connecting the east and west, and linking the north and south. In recent years, with the in-depth implementation of the national "the Belt and Road" initiative and the acceleration of regional economic integration, highway construction in Inner Mongolia has ushered in new development opportunities. However, due to factors such as complex geographical environment, fragile ecology, and local financial pressure, the construction of highways in Inner Mongolia still faces many challenges. This article takes the G1816Wushi Expressway,G5511Angong Expressway, and Zhungeer Banner Urban and Rural Transportation Upgrade Project as case studies to analyze their practical experience in technological innovation, ecological protection, and socio-economic benefits. Targeted solutions are proposed to provide reference for highway construction in similar regions.

2. Case Introduction of Inner Mongolia Highway Development Project

2.1. Wushi Expressway: a benchmark for intelligent construction

The Wushi Expressway is the Wuhai Bayintaohai Shizuishan Huinong section of the G1816 Rongwu Expressway Wuhai Maqin Connection Line, with a total length of 18.761 kilometers and a total investment of 2.379 billion yuan. The project, with "Smart Beam Field" as its core,

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has built a full chain intelligent technology system, becoming a model for the intelligent transformation of highway construction in Inner Mongolia[1].The Wushi Expressway has two smart beam yards, which have achieved a high degree of automation in beam production by introducing equipment such as robot automatic welding and hydraulic template automatic disassembly and assembly. In the smart beam field, sensors are like sharp nerve endings, monitoring every process of beam production from raw material selection, steel bar processing to beam pouring, curing, and other links. All data is collected and recorded in real time, forming a large and accurate database. This not only provides data support for quality traceability and process optimization, but also increases the production efficiency of the beam yard by 40%, and controls the accuracy error of template installation within ± 1 millimeter.

The Wushi Expressway strictly implemented fully enclosed construction during the construction process, effectively preventing dust dispersion and construction waste from entering the Yellow River, and protecting the ecological security of the Yellow River Basin[2]. At the same time, by optimizing the construction plan, the project has reduced the damage to the national level precious wild protected plant, the Four Harmony Tree, and achieved green, environmentally friendly, and safe construction. The Wushi Expressway, as the "last kilometer" of the national expressway network Rongwu Expressway connection line from Wuhai to Maqin Expressway, is an important transportation channel connecting the economically developed central and eastern regions in the northwest region. After the completion of the project, it will greatly promote the high-quality development of the Yellow River Basin in the region, promote the interconnection of the national highway network, and improve the service level of regional highway infrastructure and highway network.

2.2. Angong Expressway: A Model of Green Construction

Angong Expressway is a highway project of the G5511 Second GuangzhouExpressway Jining Arong Banner connecting line from Anye to Gongzhugeng, with a total length of 178.9 kilometers and a total investment of 6.28 billion yuan. The project is led by the "four new" technologies (new technology, new process, new material, new equipment), achieving an organic combination of green construction and high-quality development.

During the construction process of Angong Expressway, a large amount of old road waste and demolition materials for old protective and drainage masonry were generated. The project has achieved 100% reuse of these waste materials by optimizing the construction plan and improving the construction process[3]. For example, milling cement stabilized crushed stone base or subbase is used to replace some aggregates in cement stabilized crushed stone for auxiliary road surface subbase and road improvement base; The milled asphalt concrete surface layer is used to harden the base layer and road improvement surface layer of service areas, toll stations, and other station sites. This not only reduces resource consumption and waste emissions, but also lowers carbon emissions by about 120000 tons.

The Angong Expressway applied 3D radar pavement paving technology in the process of paving cement stabilized base and subbase on the road surface. This technology uses laser to measure the ground elevation benchmark information and transmits it to the computer system, achieving precise control of the vertical elevation of the paving area according to the design elevation, and automatically completing real-time continuous processing of complex situations including transition sections, superelevation curves, and frequency variations of cross slope slopes. This not only eliminates the tedious process of measuring and setting up reference lines for the longitudinal edges of the roadbed before traditional paving, but also avoids errors that may occur during manual operation, ensuring the thickness and flatness of the paving.During the design and selection period, Angong Expressway reasonably avoided ecological red lines, basic farmland, and water sources, and utilized existing old roads according to local conditions, reducing the occupation of grasslands and ecological damage.

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At the same time, the project has taken measures of centralized mining and dumping in the soil acquisition and disposal site, and paid attention to the preservation of the original surface humus soil[4]. After taking and disposing of soil, timely land consolidation and vegetation restoration were carried out, covering humus soil and planting trees and grass for greening. Drainage and protective facilities were set up, and soil and water conservation work was done well.

2.3. Zhungeer Banner Transportation Project: The Engine of Urban Rural Integration

In 2025, Zhungeer Banner actively responds to the regional development strategy, vigorously promotes the construction of transportation infrastructure, and implements 13 transportation projects with a total mileage of 150 kilometers and a total investment of over 1 billion yuan. These projects focus precisely on the two key areas of "bottleneck road" transformation and industrial collaboration, deeply optimizing and upgrading traffic congestion nodes and road sections with limited traffic capacity, and breaking through traffic constraints and bottlenecks. At the same time, strengthen the close connection between transportation and industrial development, and improve transportation efficiency. Through a series of measures, Zhungeer Banner has successfully promoted the integrated development of urban and rural transportation, making the transportation connection between urban and rural areas closer, and laying a solid transportation foundation for the coordinated progress of regional economy and the integrated development of urban and rural areas[5].

The upgrade project of Xuejiawan No.2 Highway, as a key part of the transportation construction in Zhungeer Banner, has achieved significant results. Previously, two-way two lane highways were struggling to meet the increasing transportation demands of factories and mines along the route, with frequent congestion, severely restricting the production and transportation efficiency of factories and mines. This upgrade has widened the road to six lanes, greatly increasing the lane capacity, and also added overpasses to optimize traffic flow and achieve rapid vehicle diversion[6]. The upgraded highway has increased its daily traffic capacity by three times, making freight transportation smoother and more efficient, reducing logistics costs for enterprises, and effectively promoting the development of the factory and mining industry, providing solid and powerful transportation support for the regional economic takeoff.

As an important channel for coal transportation in Zhungeer Banner, the Qingda Highway has been severely congested in the past due to unreasonable traffic organization, long waiting times for vehicles, and low transportation efficiency, which have hindered the further development of the coal industry. The Qingda Highway Interchange Renovation Project has emerged, which has carefully planned and designed a new interweaving section between the main line and the ramp, allowing vehicles to flow and merge in an orderly and fast manner[7]. After the renovation, the traffic order has been revitalized, and the annual transportation efficiency has increased by 20%. Coal can be transported more efficiently to various places, reducing operating costs for enterprises and enhancing market competitiveness, effectively promoting the coal industry in Zhungeer Banner to move towards a new stage of large-scale and efficient development.

Zhungeer Banner continues to make efforts in the field of transportation construction, vigorously promoting the construction of rural and pastoral roads, and achieving remarkable results. Nowadays, 300 new natural villages have been connected to hardened roads, with flat and wide roads winding towards the corners of the countryside, allowing villagers to bid farewell to the travel dilemma of being covered in dirt on sunny days and mud on rainy days. At the same time, the proportion of third-class highway in Sumu Township is up to 94.9%, and the traffic network is more perfect[8]. These hardened roads are like links, closely connecting

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urban and rural areas, accelerating the flow of talent, capital, technology and other factors, allowing characteristic agricultural products from rural and pastoral areas to enter the market more smoothly, injecting a continuous stream of power into the balanced development of regional economy.

3. Problems in the Development of Highways in Inner Mongolia

3.1. Shortage of funds and difficulties in financing

For a long time, the construction of highways in Inner Mongolia has been confronted with the dual predicament of a single funding structure and insufficient local matching capacity. Currently, the proportion of the autonomous region's fiscal input in the total funds for highway construction exceeds 70%, resulting in an investment pattern of "heavy on the top and light at the bottom", which has led to a continuous increase in the financial matching pressure on prefectural and municipal governments. Taking Alxa League as an example, the proportion of the autonomous region's fiscal input in the funds for provincial road projects reaches 85%, but due to the local fiscal self-sufficiency rate being less than 30%, there is often a shortage of matching funds, directly causing delays in project initiation or mid-construction halts.

In 2023, the S228 line reconstruction project implemented in the league was forced to suspend subgrade construction by the construction unit due to a four-month delay in the arrival of funds from the autonomous region, resulting in a cumulative delay of over 120 days. What is more serious is that after the implementation of the "Measures for the Classification and Strengthening of Government Investment Project Management in Key Provinces" by the State Council, provincial road projects need to obtain a commitment letter from the autonomous region's finance department before they can be upgraded for approval.

3.2. Ecological fragility and environmental protection

Inner Mongolia is vast but has a complex and diverse terrain, featuring vast grasslands, undulating hills, and large areas of deserts and Gobi. Its ecosystem is extremely fragile and once damaged, it is difficult to restore. During the construction of highways, ecological protection has become the top priority. For instance, in the design and route selection of the An Gong Expressway, repeated surveys and arguments were conducted to precisely avoid ecological red lines, basic farmlands, and water sources and other sensitive areas, striving to minimize the disturbance to the ecosystem. The Wushi Expressway is adjacent to the Yellow River. During the construction process, the discharge of waste was strictly controlled, and multiple protective facilities were set up to prevent construction waste from entering the Yellow River, fully safeguarding the ecological security of the Yellow River Basin. This undoubtedly places strict and meticulous requirements on construction techniques and environmental protection measures.

3.3. Insufficient technological innovation and talent cultivation

Although Inner Mongolia has actively introduced advanced technologies such as intelligence and greenness in the field of highway construction, for instance, by applying intelligent monitoring systems to ensure project quality and using eco-friendly materials to reduce ecological impact, certain achievements have been made. However, compared with developed regions, there is still considerable room for improvement in overall technological innovation levels. Some key technologies are still dependent on external introduction, and the capacity for independent innovation is insufficient. At the same time, the shortage of talents is becoming increasingly severe, especially the extreme scarcity of high-end compound talents who are proficient in both technology and management. The knowledge structure of current practitioners is outdated, making it difficult for them to adapt to the application of new

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technologies and new processes. This has become a key bottleneck restricting Inner Mongolia's highway construction from moving towards high-quality and sustainable development.

4. Suggestions

4.1. Diversified financing and policy support

Under the background of increasing demand for highway construction funds and increasing financial pressure in Inner Mongolia, innovative investment and financing mode has become the key path to break the bottleneck of funds. By promoting market-oriented models such as BOT (Build-Operate-Transfer) and PPP (Cooperation between Government and Social Capital), social capital can be effectively mobilized to participate in highway construction. For example, Inner Mongolia Communications Group can explore the operation mechanism of "exchanging projects for funds", and attract large construction enterprises, industrial investment funds and other social capital to participate in toll road projects with stable cash flow through franchise transfer and equity cooperation, so as to realize a virtuous circle of "less government investment, joint construction of enterprises and risk sharing".

At the same time, it is necessary to build a diversified financing system: first, actively strive for national special construction funds and investment subsidies, focus on supporting cross-regional trunk roads, road network reconstruction projects in ecologically sensitive areas, and optimize the fund allocation mechanism to improve efficiency; Second, deepen cooperation with policy banks, commercial banks and multilateral financial institutions, broaden medium and long-term financing channels and reduce financing costs by issuing tools such as project income bonds and asset securitization; Third, the transportation authorities take the lead in setting up the highway industry industrial fund, and adopt the mode of "government guidance+social capital leading" to attract long-term capital participation such as insurance funds and pensions, focusing on quasi-operational highway projects. Industrial funds can not only reduce the asset-liability ratio of enterprises through equity investment, but also improve the efficiency of capital use through market-oriented operation, forming a closed-loop ecology of "fund pool-project pool-industrial chain" and providing sustainable capital support for highway construction in Inner Mongolia.

4.2. Green Construction and Ecological Protection

Inner Mongolia should continue to deepen the concept of green development in highway construction, comprehensively promote the "four new" technologies such as recycling of waste materials and intelligent paving, and reduce resource consumption and ecological disturbance from the source. Taking Angong Expressway as an example, its innovative application of rubber powder modified asphalt technology successfully consumed 1,800 tons of waste tires, which not only realized the recycling of waste, but also reduced carbon emissions by about 5,000 tons, setting a carbon reduction benchmark for the industry.

In the whole life cycle management of the project, we need to strengthen the principle of ecological priority: in the early planning stage, we should use GIS and other technologies to carry out ecological sensitivity analysis and scientifically avoid ecological red line areas such as nature reserves and water sources; In the construction stage, the "three simultaneities" system is strictly implemented, and measures such as closed construction and mud solidification treatment are taken to ensure zero discharge of waste and sewage; In the later stage of restoration, terraced reclamation will be carried out on the spoil ground, and local drought-tolerant plants will be planted to accelerate the natural succession of the ecosystem. At the same time, an ecological monitoring network of "air-space-earth integration" will be built to grasp the key indicators such as vegetation coverage and soil erosion modulus along the line in

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real time, provide data support for ecological protection and restoration, and build a strong ecological security barrier in the north of the motherland.

4.3. Technology Innovation and Talent Cultivation

In order to promote the highway construction in Inner Mongolia to a new stage of high-quality development, it is necessary to make two-way efforts in technological innovation and talent support. On the one hand, it is necessary to continuously increase investment in technological innovation, set up a special research fund for highway construction, and focus on supporting key areas such as intelligent construction, ecological restoration, and application of new materials. Encourage enterprises to form innovative consortia with universities and scientific research institutes to develop adaptable, low-carbon and environmentally-friendly construction technologies and equipment according to the special geological and climatic conditions in Inner Mongolia. By establishing a demonstration base for the transformation of scientific and technological achievements, the large-scale application of mature technologies such as intelligent compaction monitoring and drone inspection will be accelerated, and the level of refinement of engineering construction will be improved.

On the other hand, we should build a talent training system with deep integration of "Industry-University-Research's use". Support colleges and universities in the region to set up interdisciplinary subjects such as intelligent transportation and ecological engineering, and vocational colleges set up special courses such as assembled construction and subgrade and pavement maintenance to train applied technical talents in a targeted manner. Implement the introduction plan of "grassland talents", and attract domestic and foreign industry leaders to participate in major project construction through flexible introduction and project cooperation. Establish an incentive mechanism for technological innovation, give heavy rewards to the team that breaks through the "stuck neck" technology, form a clear orientation of "regarding heroes as innovation and talents as achievements", and inject lasting kinetic energy into highway construction.

5. Conclusion

The practical exploration of highway development projects in Inner Mongolia vividly demonstrates the key value and leading role of intelligence, greening and regional coordination in contemporary highway construction. The smart beam yard built by Wushi Expressway, with the help of advanced Internet of Things and big data technology, realizes the intelligent control of the whole process of precast beam production, which not only greatly improves the production efficiency and quality stability, but also significantly reduces labor costs and safety risks; During the construction of Angong Expressway, the recycling of waste materials was vigorously promoted, and the abandoned pavement materials and construction waste were put into use after scientific treatment, which not only reduced the waste of resources, but also reduced the disturbance to the surrounding ecological environment. Zhungeer Banner has broken down the traffic barriers between urban and rural areas by building an integrated road network between urban and rural areas, promoted the free flow and efficient allocation of factors between urban and rural areas, and injected strongimpetus into rural revitalization and urban-rural integration development. These successful practices have provided reproducible experiences for similar regions. However, there are still many challenges on the road ahead of highway construction in Inner Mongolia. The shortage of funds is prominent, and it is difficult to meet the needs of large-scale construction by relying too much on financial input; Ecological fragility determines that highway construction must seek a fine balance between development and protection; Unbalanced regional development leads to the lag of highway construction in some areas, which restricts the overall development efficiency.

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Facing the future, Inner Mongolia needs to unswervingly strengthen the deep integration of technological innovation and ecological protection, actively explore diversified financing channels, give full play to the role of policy guidance, establish and improve the regional coordination mechanism, and promote the gorgeous transformation of highway construction from "scale expansion" to "quality improvement". At the same time, we attach great importance to technological innovation and personnel training, build a collaborative innovation platform for Industry-University-Research, train a group of high-end compound talents who know both technology and good management, provide solid intellectual support and technical guarantee for highway construction, help highway construction in Inner Mongolia achieve sustainable development, and lay a solid foundation for high-quality development of regional economy and society.

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