

Analysis of the Application of Windbreak and Sand Fixation Technology in Desert Roads

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Abstract: In order to solve the problems in the construction of desert roads and improve the quality of desert roads in China, this paper discusses the current windbreak and sand fixation technologies in desert areas in China, and puts forward relevant suggestions and corresponding solutions for each problem. This paper is written with hopes of contributing to the development of windbreak and sand fixation technologies in China as well as the development of the economy, society and environment in China's deserts.

Keywords: Desert; Windbreak and sand fixation; Road construction

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1. Introduction

Desert roads are unique because they are designed for special climate and landform of deserts. Deserts are abundant in resources, but they also come with major ecological problems. Due to their unique climate and landform, deserts are also prone to desertification. Therefore, it is important to address the issue of desertification in our country. Road construction in desert areas is a good solution to this problem. Reasonable design of desert roads can effectively improve the ecological environment of deserts in China thereby promoting the harmonious development of China's economy and society^[1-4]. Therefore, it is crucial to analyze the problems in the construction of desert roads in our country and propose corresponding solutions.

2. Problems with desert roads

2.1. Sand damage

Sand damage refers to some sand piles and sand ridges that appear on both sides of roads in deserts. These sand piles and sand ridges not only affect the quality of the road, but also cause serious damage to the ecological environment around the road. Secondly because deserts are dry and have huge areas, sandstorms are bound to occur. Sandstorms have a serious impact on desert roads. Therefore, this problem must be taken into account when constructing desert roads, and corresponding countermeasures should be taken. Deserts in China are also prone to strong winds, which will also seriously affect the desert road. Therefore, this issue should also be taken into account while constructing desert roads^[5-7].

2. 2. Wind erosion

Our country's desert roads are mainly distributed in the northwest region, where the natural environment and climate is relatively harsh. This makes the construction of desert roads in the northwest region extremely challenging. An important issue that should be taken into account during desert road construction is wind erosion. The problem of wind erosion mainly refers to the uneven subsidence of the road surface under the action of wind and sand, forming potholes and grooves. This phenomenon is mainly because the road sections selected in the process of desert road construction are often relatively wide and flat areas. Besides, these sections all have relatively high wind speed, and the wind speed varies from time to time. If these areas are not well-protected, wind erosion will occur. Wind erosion is mainly caused by wind-blown sand, which will damage the road surface to some extent^[8-11]. The problem of wind erosion can be solved by properly designing the subgrade, setting up corresponding slope protection, and improving the drainage system.

3. Application of windbreak and sand fixation technology on desert roads

Currently, sand damage and wind erosion on desert roads are mainly countered by windbreak and sand fixation by planting trees. This method is mainly aimed at various types of sand damage, different methods are used for different types of sand damage. Usually, the following plants are used windbreaking and sand fixation: parsnips, reeds, licorice, etc. These plants are very effective in controlling sand damage and wind erosion. In addition, plants that are selected for these roles should be extremely adaptable. For example, shrubs are planted on the sides of roads to prevent the sand from moving around too much.

3. 1. Highway slope protection technology

Desert road slope protection mainly adopts plant protection technology, in which the plants are used to reduce wind erosion on desert road slopes. Generally speaking, the slopes on desert roads are generally sandy, so plants that are planted on the slopes should have strong wind resistance. At present, the main sand control measures adopted in our country are as follows: grass seeds, plant fence, plant grids, etc. Among them, the grass are planted to prevent sand dunes from moving and stabilize the slope of the desert road, so as to reduce the damage to the road caused by wind and sand. Plant fences are installed to prevent the vegetation on the mobile sand dunes from being blown away, so as to prevent soil erosion. Plant grids are used to prevent the movement of sand dunes, so as to maintain the stability of the road. In addition, a new type of protection technology, spraying technology, can also be adopted. This technology can make the soil and seeds form a new layer of soil in a short time, thus playing a very good role in protecting the vegetation, thus improving the quality of desert road slope protection.

3. 2. Sand barrier

Sand barrier can be built on both sides of the road, which can effectively protect the road and reduce the impact of wind and sand on the road. Usually, sand barriers are placed on both sides of the road, the barriers would be covered with and some sods, straw curtains, and plastic films. This can effectively block wind and sand, thereby ensuring the safety of the road. Besides, the sand barrier needs to be of a suitable height. If the sand barrier is too high or too low, the desert road will be affected to a certain extent. In addition, we can also use some other methods to prevent the sand from moving around, such as by planting some trees. Through these methods, the safety and stability of the desert road can be effectively improved, and the impact of wind and sand on the road can also be minimized.

3. 2. 1. Sand fence with grass and firewood

The “tree branch wall has been used for hundreds of years. The raw materials are cheap and can be found locally, such as branches, *Achnatherum splendens*, reeds, and straws (corn, sorghum, etc.). The softer part of the stem faces upward, while the roots are generally buried about 20 cm beneath the ground, with an exposed portion of 50–100 cm above the ground, achieving a density of approximately 35%. The walls can be arranged in the form of rows or columns. The row-column intervals of the walls shall be determined according to the slope and height of the gravel.

The sand fence with grass and firewood is an effective sand control method that prevents wind and fixes sand. However, it requires a lot of materials, and it collapses easily, thus needing frequent repairs. Therefore, this method cannot be used at a large scale. This method can be applied in many areas, such as residential areas, livestock pens, road sand outlets, and other places.

3. 2. 2. Grass grids

Grass grids are a semi-concealed sand barrier, which is usually made of wheat straw, rice straw, or soft crop stalks. Rice straws and other materials are buried at a depth of 10–15 cm, with an additional 20 cm layer above the surface, structured in grid units of 1 meter. Grass grids have sand-fixing and wind-proof functions. Based on measurements taken at Ningxia Sand Wave Peak, the grass grids measuring 1×1 m effectively reduce the internal airflow speed to 1 m/s when it makes contact with the ground at a wind speed of 6.5 m/s. This slowdown in airflow speed helps prevent the movement of quicksand.

This approach offers benefits such as simple operation, abundant raw materials, cost-effectiveness, wind and erosion resistance, and no harm to vegetation. However, due to a growth cycle of 3–5 years, it requires collaboration with suitable local vegetation for effective sand control. As a result, aeolian sand subgrade construction often involves utilizing multiple varieties of unique willows for effective sand control.

3. 2. 3. Cohesive sand barrier

The sand in many areas of the Hexi region is cohesive sand, and there are more sand in the hilly areas, which can be used as the material for sand barriers. The installation process involves creating soil ridges with a height of 15–20 cm along the windward slope of the sand dune. These ridges have a triangular cross-section and are spaced at intervals of 2–3 m, aligned with the primary wind direction. Cohesive sand barrier has sand-fixing effect and is stable. However, a gelatinous layer can form on the small sand layer's surface, hampering rainwater infiltration and vegetation growth. Constructing cohesive sand barriers proves more efficient and cost-effective in areas with accessible cohesive soil; for distant locations, more resources, manpower, and costs are required.

3. 2. 4. Nylon grids

Nylon grids have a similar working principle as grass grid sand barriers. The grids are made of nylon, with a diameter of 20 cm and a density of more than 20%, making it a tight sand and gravel barrier. During installation, the pre-prepared pillars are first positioned on the sand surface at intervals of 1×1 m. Subsequently, a grid of 1×1 m is formed by wrapping nylon tape around the pillars, followed by securing the grid to the pillars on the sand surface using thin steel cables. However, this method is costly and leads to land pollution after degradation. Although it has found application in many projects such as those in Minqin, Gansu, Shapotou, Ningxia, and the Qinghai-Tibet Railway, its usage remains limited.

3. 2. 5. Geotextile sand barrier

Geotextile is used as a protective barrier in a way similar to traditional cohesive sand barriers. This

involves creating 20 cm bags from nylon cloth, filling them with sand on-site, and placing them in rows or grids on the sand surface to control quicksand movement. However, this method is still being tested and has not been widely used yet.

4. Application of desert road windbreak and sand fixation technology

Windbreak and sand-fixation technology is crucial to ensure the smooth construction of desert roads. The utilization of windbreak and sand-fixation technology can effectively alleviate the problem of wind and sand in the process of desert road construction. Many windbreak and sand fixation technologies have been used in our country in the process of desert road construction, such as plant sand fixation technology and chemical sand fixation technology. These wind-proof and sand fixation technologies have played an important role in the construction of desert roads. However, their improper application and environmental consequences have considerably hindered the progress of such projects.

4.1. Scientific and reasonable planning of desert road construction scheme

Incorporating windbreak and sand-fixation technology into desert road construction should adhere to the principle of “adaptation to local conditions, starting with the easier aspects and then tackling the more challenging ones.” This approach entails considering local climate, environmental conditions, and other factors to meticulously design a scientifically and logically sound desert road construction strategy. Plant sand fixation method should be applied while considering local natural conditions and vegetation characteristics, so as to avoid unnecessary troubles in the road construction.

4.2. Reasonable selection of windbreak and sand fixation plants

Plants are an important part of desert road construction, and the quality of road construction can be effectively improved through reasonable selection of windbreak and sand-fixing plants. Plants such as caragana, sea buckthorn, willow, and licorice have strong drought resistance and well-developed root systems, which can effectively fix quicksand. In the process of desert road construction, it is necessary to select suitable windproof and sand-fixing plants. Besides, the plants have to be highly adaptable and can be planted on both sides of the road to provide support for the construction of desert roads. Moreover, sandy shrubs and sandy herbaceous plants can also be used in desert road construction, which can improve the stability of desert roads and avoid sand flow in windy and sandy weathers.

4.3. Scientific selection of windbreak and sand fixation technology

The selection of windbreak and sand fixation technology should be based on the actual conditions of desert roads, especially the climate and vegetation in the area where the project is located. The windbreak and sand fixation technology used should be selected after performing a comprehensive analysis to achieve the best results. In addition, care should be taken to avoid serious pollution to the environment when choosing windbreak and sand-fixation technologies, and environmentally friendly, economical, and practical technologies should be used. In addition, factors such as construction cost and construction quality should be considered when selecting windproof and sand-fixing technologies. In general, applying biological sand-fixation technology involves choosing drought-resistant plants, while chemical sand-fixation technology necessitates the use of environmentally friendly materials. Therefore, it is necessary to scientifically select windbreak and sand-fixation technology according to the actual situation of the area where the project is located.

5. Conclusion

To effectively apply windbreak and sand-fixation technology in desert roads in our country, it is necessary

to first clarify the problems in the construction of desert roads. Then solutions should be formulated for different problems. These technologies should be applied based of “prevention, then control.” Physical Engineering: This involves applying physical principles to enhance wind and sand flow resistance, leading to the deposition of sand particles. Common techniques include erecting tall vertical sand barriers, installing fences, and building sand-retaining walls. Several technical methods have been explored in this paper, which are describes below.

(1) Physical methods: This method involves enhancing wind and sand flow resistance, leading to the deposition of sand particles. Common techniques include erecting tall vertical sand barriers, installing fences, and building sand-retaining walls.

(2) Chemical methods: Chemical materials and techniques are used to create a consolidating layer on sandy surfaces or sand dunes prone to erosion. This layer prevents wind erosion, retains moisture, and enhances sand properties, thus managing and improving the sand-prone environment. Examples include the application of various chemical reinforcing agents, including asphalt compounds developed by the former Soviet Union.

(3) Plantations: This approach focuses on transforming desertified land by sowing hardy sandy plants to control and stabilize quicksand. The efficacy of this method arises from the robust root systems of sand-loving plants, which consolidate sand particles. The accumulation of organic matter from decomposed leaves further enhances the soil-formation of sand, making quicksand more stable. Examples of the application of this strategy includes creating shelterbelts, stabilizing sand by growing grass, and other similar techniques.

Lastly, it is necessary to strengthen the control of wind erosion on both sides of the road through sand fixation methods. Only in this way can we the problems in road construction in deserts of our country be resolved.

Disclosure statement

The author declares no conflict of interest.

References

- [1] Sun J, Li J, Liu Y, et al. , 2022, Numerical Simulation of Windbreak and Sand Fixation Effect of Sand Retaining Embankment-Sand Fixation Brick Comprehensive System. *Water and Soil Conservation Bulletin*, 42(04): 135–144 + 187.
- [2] Li J, 2022, The Establishment of a Composite Windbreak and Sand-Fixation System in the Desertification Area of Northern Hebei, dissertation, Hebei Institute of Architecture and Engineering.
- [3] Sun J, Li J, An Y, et al. , 2021, Numerical Simulation of Design Parameters of Zhangjiakou Highway and Driving Safety Windbreak and Sand Fixation. *Journal of Hebei Institute of Architecture and Engineering*, 39(02): 48–53.
- [4] Xue Q, 2021, Windproof and Sand-Fixing Measures for Sand Dunes with a Height of More than 15 Meters Near the Expressway. *China Highway*, 2021(01): 108–109+112.
- [5] Song H, 2015, Research on Ecological Protection Technology of Subgrade in the Desert Section of Yingshuang Expressway, dissertation, Chang’ an University.
- [6] Yuan H, 2011, The Application of Windproof and Sand-Fixing Grass Grids in Jiuhang Highway. *Gansu Science and Technology*, 27(09): 71–73.
- [7] Ren X, 2010, The 136th Regiment Huke Highway Phase III Windbreak Ecological Forest Started, *Shihezi Daily (Han)*, August 26, 2010.

- [8] Wu J, 2009, Research on the Mechanism and Benefits of Integrated Prevention and Control of Sand Disaster on Hunshandake Sandy Road, dissertation, Inner Mongolia Agricultural University.
- [9] Wang L, Wang Z, Shi W, 2009, Windbreak and Sand Fixation Design of Hunshandake Sandy Road Project. Traffic Energy Conservation and Environmental Protection, 2009(01): 43–44.
- [10] Chen Y, 2007, Application Research on Desert Road Windbreak and Sand Fixation Technology. Inner Mongolia Highway and Transportation, 2007(02): 7–11 + 58.
- [11] Dong Z, Li H, Hu C, et al. , 2006, Comparative Study on Benefits and Costs of Different Sand-Fixing Measures for Desert Roads to Prevent Wind and Sand Fixation. Soil and Water Conservation Research, 2006(02): 128–130.

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