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Research on the Construction Technology of Spliced and Widened Roadbed in the Construction Process of Highway Reconstruction and Expansion Project

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Abstract: With the rapid development of the economy and the sustained growth of vehicle retention, road traffic in our country is facing great pressure. The expressway, as an important traffic trunk, its traffic capacity has become a bottleneck in regional economic development. In order to solve this problem, highway reconstruction and expansion project came into being, among which the construction technology of splicing and widening roadbed has become the key. This paper focuses on the construction technology of spliced and widened roadbed in the construction process of highway reconstruction and expansion engineering, aiming at improving the traffic capacity and carrying capacity of highways to meet the needs of modern traffic. In the highway reconstruction and expansion project, the construction of splicing and widening roadbed faces many challenges, such as uneven settlement of new and old roadbed, poor roadbed stability, and great difficulty in construction. In order to solve these problems, this paper first analyzes the construction preparation before the reconstruction and expansion, and provides scientific basis for the subsequent construction. Then, the construction technology of spliced and widened roadbed is deeply discussed. In the subgrade splicing construction process, this paper focuses on the subgrade splicing method and the technical points of the splicing surface treatment: in the subgrade splicing process, the methods of low fill section treatment, soil subgrade treatment, subgrade filling and compaction are put forward; In the treatment of splicing surface, the construction is carried out through elevation adjustment, joint treatment and rolling. In addition, this paper also discusses the problem of settlement control in the construction process, by observing and calculating the residual settlement, timely measures are taken to adjust the construction scheme, to ensure that the construction of the road or road bed is carried out within the allowed settlement range. At the same time, according to the special geological conditions such as soft soil foundation, the specific technical measures are put forward to ensure that the post-construction settlement of the newly widened roadbed can meet the design requirements. The research in this paper not only improves the technical level of the roadbed construction, but also provides strong support for the smooth advancement of our country's road reconstruction and expansion project.

1. Introduction

With the continuous rapid growth of China's economy and the acceleration of the urbanization process, the demand for transportation is increasingly strong. As an important link between cities and regions, the carrying capacity and traffic efficiency of expressways are directly related to the development of the national economy and the quality of people's lives. However, the early construction of highways is limited by design concepts and construction standards, and it is gradually difficult to meet the current and future growing traffic needs. Therefore, the reconstruction and expansion of existing expressways, especially the splicing and widening of roadbed, has become an important way to improve road capacity and extend service life.

2. Overview of highway reconstruction and expansion projects

2.1. Background and significance

In the past few decades, China's highway network has expanded at an unprecedented speed, which has greatly promoted the interconnectivity of regional economy and the rapid development of society. However, with the acceleration of urbanization, the surge of car ownership and the growing demand for logistics transportation, some highways built in the early stage have gradually exposed the problem of insufficient traffic capacity. Especially in economically developed and densely populated areas, the capacity of expressways has approached or reached saturation, and even overloaded operation during peak hours. The road traffic efficiency and traffic safety are seriously affected. Facing this severe challenge, in order to effectively cope with the growing traffic demand, optimize the layout of the traffic network, and improve the carrying capacity of the overall traffic system, the implementation of the existing highway reconstruction and expansion project has become an important direction of the current and future transportation infrastructure construction. The reconstruction and expansion project can not only directly relieve traffic pressure and improve road traffic capacity, but also improve the service level and safety performance of roads through technological upgrading and transformation, which is of great significance to promoting regional economic integration and enhancing the vitality of social and economic development.

2.2. Purpose of subgrade splicing and widening

The primary and direct purpose of subgrade splicing and widening is to significantly improve the traffic capacity of expressways through the expansion of physical space, that is, increasing the transverse width of roads. Its success is directly related to the overall quality, traffic efficiency and long-term benefits of the entire project[1]. Through the subgrade splicing and widening, not only can significantly widen the road width, provide more driving space for vehicles, so as to directly improve the highway capacity and alleviate traffic congestion; At the same time, scientific and reasonable construction technology and quality control measures are adopted to ensure a good connection and integration between the new and old roadbed, effectively reduce the road surface diseases caused by settlement differences, material differences and other factors, ensure the smoothness and durability of the road, and then extend the service life of the road and reduce the later maintenance and maintenance costs (see Figure 1).

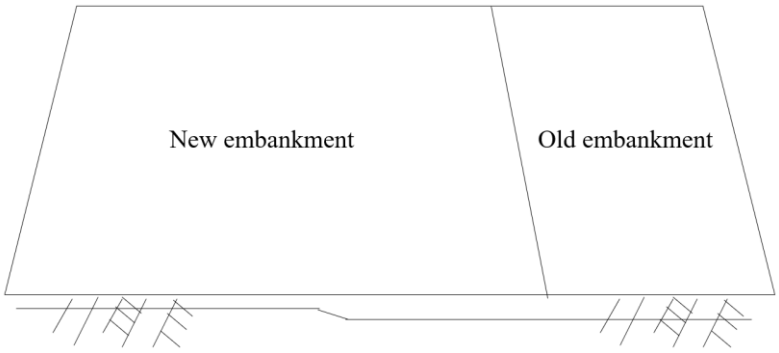

Figure 1: Combination of new and old subgrade

3. Preparation before construction

3.1. Investigation of the condition of the old roadbed

Before highway reconstruction and expansion, it is necessary to conduct a detailed investigation of the condition of the old roadbed, which is not only directly related to the formulation of the construction plan, but also plays a decisive role in the safety and quality assurance of the subsequent construction process. The investigation includes the analysis of filling materials, and in-depth understanding of the types, physical and mechanical properties and distribution of materials used in the old roadbed, such as gravel, sand, clay, etc., whose properties have a direct impact on the splicing effect and overall stability of the new and old roadbed[2]. At the same time, through the site investigation and data review, the use of the old roadbed and the degree of loss were comprehensively evaluated, including the loss and disease distribution caused by traffic flow, vehicle type, load distribution and other factors. Technicians carefully investigate types of diseases such as cracks, subsidence, slippage, and water damage, record specific information about the diseases in detail, and analyze their causes, providing a solid basis for the formulation of subsequent treatment measures and basic data support for subsequent splicing and widening construction, ensuring the pertinence and effectiveness of the construction plan[3].

3.2. Laboratory Tests

In order to ensure the quality of subgrade fill, the liquid-plastic limit test and compaction test of soil should be carried out before construction. Among them, the liquid-plastic limit test aims to determine the liquid limit and plastic limit of the filler, and then calculate the plasticity index, which, as an important evaluation standard of soil physical properties, can reveal the deformation ability of the soil with the change of water content, so as to determine whether the filler has appropriate plasticity and stability, and meet the roadbed construction requirements[4-5]. The compaction test simulates the actual compaction process and determines the maximum dry density and the best water content of the subgrade soil under different water content. These data are the core basis for controlling the compaction degree, ensuring the construction under the best water content state to obtain the best compaction effect, and providing scientific basis for the field compaction operation.

3.3. Lofting and measurement

Before construction, high-precision measuring equipment such as total station instrument is used to accurately lofted the outer edge points of the old subgrade according to the design drawings, and the pile number is marked with spray paint to ensure that the site construction personnel can

accurately locate the construction boundary and position and effectively avoid construction deviations. Subsequently, the old roadbed and widened roadbed surface are retested to ensure that the measured data is consistent with the design scheme data, which is crucial for the accuracy and reliability of construction, and any data discrepancies or errors need to be immediately identified and corrected. In order to further improve the measurement accuracy, it is also necessary to encrypt and periodically retest the wire points and level points along the highway, strengthen the accuracy and reliability of the measurement by increasing the density and frequency of the control points, and ensure the continuity and consistency of the construction measurement work.

4. Subgrade splicing and widening construction technology

4.1. Subgrade splicing method

4.1.1. Low fill road section treatment

For the low fill section, in order to effectively alleviate the uneven settlement between the new and old roadbed due to the difference in material properties and construction time, the technical measures of laying geogrid can be adopted. With its excellent tensile strength and good deformation adaptability, the geoglass forms a strong supporting layer at the bottom of the roadbed, which can effectively disperse the upper load and limit the lateral displacement of the roadbed, thus significantly reducing the settlement difference between the new and old roadbeds and improving the overall connectivity[6].

4.1.2. Soil subgrade treatment

For soil subgrade, slope clearing and step excavation are the key steps to ensure splice quality. Usually, the slope clearing degree is 30 ℃to maintain the natural stable state of the slope. Step excavation follows the principle of bottom-up, step by step, and synchronously fill to the bottom of the road bed to ensure the effective combination of the old and new subgrade. For the roadbed containing fly ash and other special materials, special measures need to be taken, such as cement mortar quickly poured after excavation to seal, to prevent the step from being washed by rain and instability, to further ensure the stability of the roadbed structure.

4.1.3. Subgrade filling and compaction

In the process of subgrade filling, the quality of filling materials is strictly controlled to ensure that all fillers meet the requirements of engineering specifications. For the narrow area with a width of less than 3m, graded gravel or medium coarse sand is preferred as the filler, and small vibration tamper is used for compaction to ensure the compaction effect. For areas with widths greater than 3m, conventional packing and compaction equipment are used for construction. In the compaction operation, the settlement observation is carried out simultaneously, and the compaction parameters are adjusted in time to ensure that the compaction degree of the subgrade meets the design requirements and provides solid support for the pavement structure.

4.2. Splicing surface treatment

4.2.1. Elevation adjustment

When the new and old road surfaces are splicing, the elevation adjustment is an important link to ensure the smoothness of the road surface and the driving comfort. It is necessary to adjust the vertical and horizontal elevation of the new spliced pavement in the middle surface layer and all levels below

it strictly according to the design requirements. The new road shall be paved according to the selected design elevation, and the joint position shall be connected with the original road surface.

4.2.2. Joint treatment

Joint treatment is directly related to the overall performance of the splicing surface. Before construction, it is necessary to thoroughly remove impurities such as loose aggregates and dust from the joint surface, and then evenly spray adhesive layer oil to prevent the joint surface from being exposed and flowing, and enhance the bonding force of the joint[7]. According to the actual situation of the project, a variety of joint treatment methods such as coating emulsified asphalt, hot asphalt and other adhesives after fire baking or no treatment can be selected. Among them, emulsified asphalt and hot asphalt are widely used in joint treatment because of their good bonding properties and construction convenience, which can significantly improve the durability and driving safety of joints.

4.2.3. Rolling construction

The rolling of the joint position is a key step to ensure the degree of compaction and the smoothness of the road surface. By using the advanced technology of cross-seam rolling and extrusion compaction, the joint position can be fully compacted by reasonable roller combination and rolling pass arrangement. Because of its ability to effectively eliminate the compaction difference between the two sides of the joint and improve the overall compaction degree of the joint, the cross-seam rolling method is widely used in the rolling construction of the joint position.

4.3. Settlement control

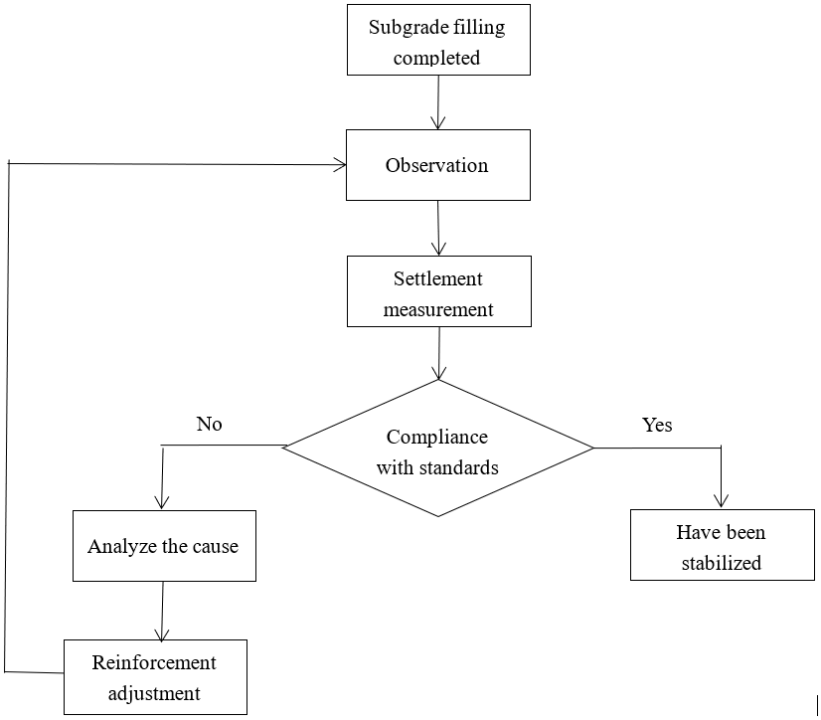

Figure 2: Settlement control flow chart

After the completion of subgrade filling construction, it is necessary to observe the subgrade that has been completed and calculate its settlement. Through regular measurement and data analysis, the settlement of roadbed can be accurately grasped. The residual settlement is predicted according to the

observed data. If the predicted value is within the allowable range or the settlement rate is less than 1mm/ month in the next three consecutive months, the subgrade can be regarded as being stable and the subsequent pavement or road bed construction can be safely carried out[8]. If the above conditions are not met, it is necessary to deeply analyze the cause of settlement and take necessary reinforcement or adjustment measures until the subgrade settlement meets the construction requirements (see Figure 2).

5. Special foundation treatment

5.1. Soft soil foundation treatment

For the section of soft soil foundation, due to the low bearing capacity and large compressibility of the foundation, special treatment measures should be taken. Common treatment methods of soft soil foundation include silting replacement and filling, plastic drainage board treatment, etc.

5.1.1. Dredging and replacement

The physical and mechanical properties of soft soil, silt and peat in reed and other soft base sections are very poor, and it is difficult to meet the engineering requirements. Therefore, it is necessary to use the method of dredging and filling. The core of the method is to thoroughly excavate the upper bad soil layer, replace it with good performance materials such as sand and gravel soil, and improve the compactness and bearing capacity of the replacement layer by layering compaction. The dredging range and depth are determined according to the geological survey results, suitable excavation equipment and methods are adopted, and the excavation is carried out according to the prescribed slope coefficient to prevent the slope collapse. After the excavation is completed, clean the bottom of the foundation pit in time to ensure that no debris remains; Then, the sand gravel is backfilled by layers, and the vibration roller, rammer and other equipment are used for compaction to ensure that the compaction degree of each layer meets the design requirements. Finally, a layer of sand and gravel cushion is added to the bottom of the replacement layer to enhance the drainage performance and foundation stability.

5.1.2. Plastic drainage plate treatment

Plastic drainage plate treatment is an advanced method to improve the physical and mechanical properties of foundation by accelerating the drainage. This method uses the high permeability of the drainage plate to form an effective drainage channel in the soft soil foundation to promote the discharge of water inside the foundation, thus accelerating the consolidation process of the foundation and improving the bearing capacity and stability of the foundation[9]. The construction points are as follows: according to the foundation conditions and engineering requirements to determine the layout spacing, depth and other parameters of the drainage plate; Then, professional equipment is used to set the drainage plate vertically to the predetermined depth, and strictly control the verticality and depth accuracy during the setting process; After the installation is completed, check whether the drainage board is intact to ensure that the drainage channel is unimpeded; Finally, according to the needs of the project, measures such as preloading can be combined to further accelerate the foundation consolidation process.

5.2. Collapsible loess foundation

Collapsible loess, as a special soil type, is characterized by its rapid and obvious collapsibility deformation after encountering water. This process is due to the low clay content in loess, the large

pores, and the salt minerals that are easily soluble in water. When the soil is saturated with water, these minerals dissolve, resulting in a loose structure of the soil, which in turn produces volume reduction and subsidence. This kind of collapsibility deformation will not only cause the bearing capacity of the foundation to decrease significantly, but also may cause the pavement settlement and cracking, which poses a serious threat to the safety.

5.2.1. Cushion method

When the cushion method is implemented, the distribution range and depth of collapsible soil layer should be determined through exploration, and then mechanical equipment such as excavator should be used to dig the collapsible soil layer by layer under the foundation. In the process of excavation, the excavation depth should be strictly controlled to avoid over-excavation or under-excavation. The choice of backfill materials should be strictly controlled, such as sand, gravel, screened plain soil, lime soil, slag or cinder, etc., for layered backfill. In the backfill process, each layer of material needs to be strictly tamped down to meet the density standards required by the design, so as to ensure that the newly formed base has sufficient strength and stability to effectively resist possible future flooding.

5.2.2. Dynamic compaction method

The dynamic compaction method uses the huge impact force generated by the heavy weight from the free fall at high altitude to directly affect the foundation soil, and improves the compactness and bearing capacity of the foundation through physical compression and reshaping of the soil structure. The key is to select the appropriate weight mass and fall distance. In general, the weight of the weight needs to reach more than 8t, and the fall distance should be free to fall from 10m or higher. In the tamping process, the tamping frequency and energy should be adjusted according to the actual situation of the soil quality to ensure that the soil is fully compacted and consolidated. At the same time, it is also necessary to pay attention to monitoring the settlement and deformation of the foundation, and adjust the construction plan in time to avoid adverse effects on the surrounding environment.

5.2.3. Pre-immersion method

The pre-immersion method can induce self-weight collapsibility by controlling the pre-infiltration of loess and releasing most of the collapsibility potential in advance. Although this method can effectively reduce the collapsibility deformation caused by natural precipitation in the future use process, the speed and scope of flooding should be strictly controlled in the implementation process to prevent the instability of the foundation and the negative impact of the surrounding environment caused by too fast or too large flooding. At the same time, it is also necessary to closely monitor the deformation of the foundation and adjust the flooding strategy in time to ensure the safety and effect of construction.

5.3. Expansive soil base

Expansive soil, as a soil type that is very sensitive to water changes, is characterized by significant expansion and softening after absorbing water, and shrinkage and cracking when water is lost. Such deformation characteristics of expansion and contraction have a great impact on construction and may lead to problems such as uneven foundation settlement[10]. Therefore, before the construction of the project on the expanded land foundation, priority should be given to the construction of drainage facilities such as drainage ditches, flood prevention ditches, interception ditches, etc., to ensure that the site drainage is unimpeded. At the same time, it is also necessary to pay close attention to weather

forecasts and rainfall conditions, and take timely measures to prevent rainwater accumulation and infiltration into the foundation. During the construction process, the operation should be avoided in the rainy season or continuous rainy weather to reduce the possibility of the expansive soil being affected by water.

5.3.1. Replacement method

As a direct and effective foundation treatment method, the core of replacement method lies in the comprehensive or local removal of expansive soil layer. By means of mechanical excavation or manual removal, the expansive soil layer with expansion and contraction characteristics is removed and filled with materials with stable properties and very low expansion and contraction, such as high-quality sand and hard gravel. These alternative materials can not only effectively resist the volume fluctuations caused by moisture changes, but also ensure the overall stability and load-bearing capacity of the foundation due to their good physical and mechanical properties. The implementation process of the replacement method is relatively direct and the effect is immediate, but it is necessary to strictly control the selection of new fill materials, laying thickness, compaction degree and the combination strength with the original soil layer to ensure that the replacement layer can play a long-term and stable role and form a coordinated and unified whole with the surrounding soil.

5.3.2. Modification method

The modification method uses a more refined chemical treatment to change the structure and properties of the expansive soil from the inside. By adding an appropriate amount of chemical modifier such as lime and cement into the expansive soil, these substances can produce remarkable curing and hardening effects after reacting with the moisture and minerals in the soil, thus effectively reducing the expansion and shrinkage of the expansive soil. This process not only enhances the bearing capacity of the foundation and improves its ability to resist deformation, but also extends the service life of the foundation and enhances the durability by improving the physical and chemical properties of the soil. However, the successful implementation of the modification method depends on accurate calculation of the modifier content, strict control of the construction process, and comprehensive assessment of the environmental impact to avoid new environmental problems caused by excessive use or improper operation.

5.3.3. Set the isolation layer

The isolation layer is set up between the expansive soil and the subgrade to block the water intrusion from the outside and reduce the expansion and contraction deformation of the foundation. It is usually composed of materials with good density, low permeability and certain strength, such as well-graded sand layers, gravel layers or special geosynthetics. These materials can effectively block the infiltration of external water sources such as rainwater and groundwater, and cut off the root cause of expansion and contraction deformation of expansive soil due to water changes. At the same time, the isolation layer also provides an additional protective barrier for the foundation by its own rigidity and stability, and enhances the overall stiffness and deformation resistance of the foundation. When setting up the isolation layer, it is necessary to fully consider its thickness, laying scope and connection with the original soil layer and the foundation of the building to ensure that it can effectively play a role in the long term.

6. Conclusion

In this paper, the construction technology of splicing and widening roadbed in the construction

process of highway reconstruction and expansion project is studied, but because there are many kinds of highway roadbed and pavement splicing construction technology, in the actual project construction process, we should choose the appropriate technical method according to the actual situation of the project. Through scientific and reasonable construction technology and management measures, the effective connection and overall stability between the new and old roadbed can be ensured, and the traffic capacity and service life of the highway can be improved. With the progress of science and technology and the continuous development of construction technology, the future highway reconstruction and expansion project will pay more attention to technological innovation and quality control. In the construction of subgrade splicing and widening, more advanced construction technologies and materials will emerge to provide strong support for the improvement of project quality and efficiency. At the same time, with the continuous development and improvement of intelligent transportation systems, highway reconstruction and expansion projects will pay more attention to the integration and coordination of intelligent transportation systems to achieve more efficient and safer transportation.

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