Application of non-excavation technology in the transition section of highway deep soft foundation road and bridge

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Abstract. Highway road and bridge transition section for the bridge and general roadbed combined with the lot, due to stiffness and deformation differences triggered by the bridge head jump phenomenon. For the deep soft foundation section, it is more serious. For the operation of highway bridge head jump phenomenon, the use of traditional excavation treatment measures can no longer meet the high traffic volume of road preservation needs. Non-excavation treatment is the technology developed under the demand, in the premise of not affecting the vehicle traffic, the bridge transition section treatment, for the high traffic volume of the in-service highway incessant treatment has a greater advantage. This paper proposes the non-excavation technology applicable to the transition section of highway road and bridge, and conducts comparative analysis on its economy, technology and feasibility, which can provide relevant engineering reference for the treatment of deep soft foundation section of bridge head jumping without continuity.

Keywords: Deep soft foundation;road and bridge transition section;non-excavation technology; bridge head jump; non-stop treatment.

1. Introduction

As the bridge section stiffness and settlement is small, deep soft foundation section stiffness is small and settlement is large, the combination of the two differences in settlement is large. Bridge head jump phenomenon is the vehicle traveling through the bridge head jump phenomenon due to differential settlement. Especially in deep soft soil areas, soft soil layer thickness of tens of meters, subject to technical, construction period, economic and other factors, after the opening of the roadbed settlement is still occurring, and then triggered a serious bridge jump phenomenon, affecting traffic safety and comfort. If the use of traditional treatment techniques such as excavation and replacement, the need for the operation of the highway after the construction of the cut-off. However, as a major traffic artery, the pressure of highway maintenance is large, while the general break construction time is long, but also greatly reduce the highway operating income. In order to solve a large number of operating highway bridge head jumping disease in China, scholars have proposed many new treatment techniques, such as the use of gravel piles, high-pressure rotary piles, bubble mixture of lightweight soil and other treatment techniques. However, these methods will more or less interrupt the traffic, and the construction period is long. Therefore, there is an urgent need to develop and study the treatment technology without interrupting the traffic, so as to realize the effective control of soft foundation settlement and deformation without interrupting the traffic or interfering too much with the traffic operation, and to realize the purpose of coordinating the deformation of the excessive section of the road and bridge.

2. Analysis of the causes of bridge jumping at the transition section of road and bridge

Most of the bridge head jump phenomenon is a combination of factors, the main reasons are:

1) engineering geological causes: usually deep soft soil layer section bridge head jumping phenomenon is serious, due to the soft clay layer is thick, long drainage path, long consolidation time under load, technical processing difficulties.

2) Design program causes: for soft ground generally use pre-pressure, plastic drainage board, etc. for treatment, but deep soft foundation section soft soil thickness is deep, drainage board often can not penetrate the soft soil layer, thus reducing the drainage efficiency, in the preset time can not achieve the design requirements effect, resulting in the continuous development of post-work settlement.

3) Causes of construction period and post-work maintenance: If the pre-pressure load or pre-pressure time does not meet the requirements, it will lead to poor results. Once the more obvious settlement occurs, if the traditional asphalt paving program, with the growth of the paving thickness, in the growth of the additional load, after-work settlement will continue to occur.

4) roadbed filling causes: bridge head roadbed section filling materials are not qualified, compaction is not enough, etc.

5) other causes: such as by the traffic load, rainstorm and other external factors, resulting in the bridge head lap plate fracture or decoupling, the loss of roadbed filler, and then affect the smoothness of the road and bridge transition section.

3. Non-excavation treatment technology for bridge head jumping in road and bridge transition section

For the deep soft foundation bridge transition section of the bridge head jump phenomenon treatment is ultimately the treatment of the bridge head section of the roadbed, the use of appropriate measures to accelerate the rate of consolidation of the foundation, so that it tends to stabilize. In summary, there are two major treatment techniques, one is to improve the foundation deformation parameters, increase the stiffness; the second is to reduce the load of the roadbed, reduce settlement. The corresponding non-excavation treatment techniques are mainly as follows.

3.1 Foundation treatment

This program aims to enhance and improve the physical and mechanical parameters of the foundation under the embankment to form a composite foundation, so that the settlement can be better controlled under the overlying embankment load. The main options of this measure are:

1）Tilt rotary spray pile technology

Lateral rotary spray pile is lateral drilling at the original embankment slope, drilling into the embankment and continue drilling along the foundation until it reaches the design elevation, and then start rotary spraying, through the slurry, air cutting the soil to achieve full mixing and curing with the soil. Inclined rotary pile technology can work deep underground without damaging the existing pavement excavation to achieve the effect of reinforcement and improvement.

2) Lateral radiation grouting

The technology is drilled laterally at the slope of the original embankment, and continues to drill along the foundation after drilling into the embankment until it reaches the design elevation, using the sleeve valve split grouting method to inject the solidified slurry into the cracks or pores of the soil, the slurry fills all the cracks in the ground, forming many dendritic or plate-like solidified bodies in the foundation, and the soil around the solidified body within a certain range is squeezed dense due to the high pressure of the slurry This solution can form a composite foundation, so that the bearing capacity of the foundation soil is increased and the compressibility is reduced. The solution has little damage to the original embankment and does not affect the normal operation of the highway.

3.2 Embankment load shedding

For weak foundation, the load caused by settlement is embankment fill load and vehicle load, embankment self-weight accounts for a relatively large. Due to the serious settlement of the roadbed at the bridge head, the road surface is paved for conventional maintenance, thus increasing

the self-weight of the embankment and aggravating the settlement. This program only on the embankment fill to reduce the weight of the treatment, not the deep treatment of the underlying foundation, through the replacement of lightweight soil to achieve a certain replacement rate, so that the underlying foundation soil subject to load reduction, to control the role of settlement. The main options of this measure are:

1) Embankment transverse borehole lightweight material replacement

For soft foundation, the load caused by settlement is embankment filler load and vehicle load, embankment self-weight accounts for a relatively large. Due to the serious settlement of the roadbed at the bridgehead, the road surface is routinely maintained by adding pavement, thus increasing the self-weight of the embankment and aggravating the settlement. This solution aims to treat the settlement by reducing the self-weight of the embankment, and the effect is achieved by replacing the embankment with light weight concrete.

The construction was carried out under the embankment slope by drilling small diameter holes laterally and using bubble mixed lightweight soil replacement. It can be implemented on existing highways, especially suitable for highway projects that cannot be closed, and has good socio-economic benefits.

2）Thin-walled pipe replacement of embankment soil

Through a certain construction method, the thin-walled pipe is placed into the embankment soil layer, and the embankment soil filled into the pipe is removed, so as to achieve the mass replacement of embankment soil, effectively reduce the overlying soil weight, and reduce the settlement of the underlying foundation. In terms of construction process, it can be divided into pipe jacking method, ramming pipe hammer method, etc.

(1) Pipe jacking method

Pipe jacking is a kind of non-excavation pipe laying technology, which is to overcome the friction between the pipe and the surrounding soil layer by the jacking force of the main jacking cylinder and the jacking cylinders between pipes and relays, to jack the tool pipe or roadheader from the working well through the soil layer, all the way to the receiving well, and then lift it up. While the tool pipe or roadheader is jacked in, the pipe to be laid is jacked and buried in the stratum between the two wells immediately after the tool pipe or roadheader to achieve the purpose of laying underground pipes without excavation.

(2) Ramming and hammering method

The ramming hammer method is a kind of technology that uses a ramming hammer to ram the steel pipe to be laid directly into the ground along the designed route to achieve non-excavation pipe laying. The basic principle is to compressed air or hydraulic oil as the power, the steel pipe to be laid along the design route directly rammed into the ground, with the advance of the steel pipe, the cut soil into the steel pipe, and so the steel pipe arrived at the target location, the soil core in the pipe will be excluded so as to achieve the laying of the pipe.

4. Comparison of bridge head jumping treatment solutions

4.1 Treatment design special points and difficulties

For the in-service highway deep soft foundation road and bridge transition section treatment, there are the following three aspects of the treatment of the important and difficult points.

1) Heavy traffic volume

Highways are often the arteries linking the provinces and cities, the traffic volume is large, with important if the treatment construction, is bound to cause a large range of traffic jams. Should choose in the side slope or bridge platform under the side of the construction, thus reducing the interference with the existing traffic.

2) Operation of the highway bridge transition section roadbed treatment

For the operation of highway bridge transition section roadbed treatment, construction quality, applicable environment, vehicle loading, management and maintenance measures and other aspects

of the impact of its bridge jump phenomenon formation mechanism and treatment program are very different from the new highway.

3) The treatment of deep soft base

For deep soft base area, often soft soil layer thickness up to 50m or more, its settlement and deformation mechanism is complex, construction is difficult, quality control is difficult, treatment is difficult.

4.2 Comparison of treatment plan

In order to discuss in detail the characteristics and applicability of the treatment program for the bridge head transition section bridge head jump phenomenon, the traditional excavation construction program and non-excavation program for comparison, respectively, from the impact of traffic, construction period, cost, construction difficulty, treatment effect, quality control difficulty, post-management and maintenance difficulty and other factors for comparison, the comparison results are shown in Table 1.

Table 1.Comparison of Treatment Options

Numble	Treatment options	Process Properties	Type of treatment	Duration and operational impact	Construction cost	Construction Difficulty	Treatment Effect	Quality Control	Maintenance costs
1	Lightweight material replacement	excavation	Embankment weight reduction	High	Lower	Average	Better	Easy	High
2	Rotary Spray Pile	excavation	Foundation treatment	High	Lower	Average	Good	Easy	Low
3	Lateral drilling replacement	Non-excavation	Embankment weight reduction	Low	Higher	Average	Better	Average	Low
4	Inclined rotary pile	Non-excavation	Foundation treatment	Low	Average	Higher	Good	Average	Low
5	Lateral radiation grouting	Non-excavation	Foundation treatment	Low	Average	Average	Average	Harder	Low
6	Ramming pipe hammer method	Non-excavation	Embankment weight reduction	Higher	Average	High	Better	Average	Low
7	Pipe jacking method	Non-excavation	Embankment weight reduction	Higher	High	High	Better	Hard	High

From the results in Table 1, we can see that the biggest advantage of non-excavation technology is not to interfere with the normal operation of the highway, and with the development of science and technology, the corresponding technology is more and more mature, the process quality is more and more reliable, and the project cost is more and more reduced. Based on this, a better foundation is laid for the application of non-excavation technology in the treatment of deep soft foundation road and bridge transition section of operating highway.

5. Summary

This paper analyzes the causes of the deep soft foundation section of highway and bridge transition section of the bridge head jumping, based on the characteristics of the operating highway, proposes a variety of non-excavation technology that does not interfere with the traffic, and introduces the treatment principle and construction technology of various non-excavation technology. Finally, the technical solutions of traditional excavation and non-excavation treatment

solutions are compared, and the factors such as passability, construction period, cost, construction difficulty, treatment effect, quality control difficulty and later management and maintenance difficulty are comprehensively analyzed, which can provide reference for the treatment of highway with high demand for traffic preservation.

Fund Projects

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