Trenchless Technology Used in Curing Asphalt Pavement on Expansive Soil Subgrade

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ABSTRACT: In order to cure asphalt pavement distresses caused by expansive soil subgrade, a new maintenance technology based on trenchless technology with the macromolecule polymer grouting was adopted. The technique principle of the macromolecule polymer grouting, grouting construction method, cold patch repair technology, and the evaluation of engineering treatment were studied. The results showed that the macromolecule polymer grouting technology is feasible used in asphalt pavement maintenance.

INTRODUCTION

Expensive soil widely distributes in Nanyang China, which is an unsaturated cohesive soil with characteristics of high plasticity expansibility under the effect of water, shrinkage losing water, multiple fractures, and over-consolidation. They always cause highway distresses, such as the subgrade subsidence, slippage, longitudinal cracks and slope collapse. Therefore, this soil has been called the “cancer in engineering” (Li et al, 2014; Yang et al, 2006). In addition, there is a rich water system and abundant rainfall in Nanyang China. When asphalt pavements produced cracks, rain infiltrated subgrade and expansive soil subgrade expanded under the effect of water and traffic loads, then erosion damage and longitudinal cracks appeared (Yang et al., 2014).

A large number of studies have been conducted on the repair technology of cracks in asphalt pavement and different technology measures have also been proposed, such as crack paste, asphalt joint pouring, crack seal glue to repair the cracks, solvent modified asphalt materials filling and fly ash cement grouting, excavation filling mend, road milling technologies to severe fractures (Gao et al., 2010; Ji et al., 2011, Guo et al, 2008; Costas, 2005; Rimantas, 2013). However, the treatment effects were unsatisfactory. Meanwhile, previous treatment methods for the new subgrade project included replacement, modification, setting the retaining structures, and strengthening the process in construction of rain infiltration. The treatment techniques of cracks in the built subgrade and pavements caused by expansive soil's deformation are few.
studied (Hu et al, 2014; Wang 2014; Wu et al, 2015). Polymer grouting technology has an advantage in low energy consumption, no pollution emission, and having very good economic benefits, which can be used in cracking treatments caused by the having built expansive soil subgrade. So, a polymer grouting trenchless technology was conducted and cold repair paving material technology for asphalt pavement treatment was applied in this study.

DISTRESS INVESTIGATIONS

S103 road is the main connecting line from Xinye country (pile K287+384) to the Longbei town (pile K305+500), which passes several towns in turn, such as the Chewan, Jiaodian, Shayan town, and terminates in Longbei town. The total length is 18.16 km. The above sections were investigated using geological radar. The investigation results found that traffic volume and weight applied to expansive soil subgrade asphalt pavement were dramatically increasing. Subgrade dry-wet conditions alternated frequently generated longitudinal cracks with a length of several tens or hundreds of meters and width of 2 to15 cm. Individual sections of subgrade severe deformation, cracks, pit slot, digging and repair were common, as shown in Fig.1. The main reason may expansive soil subgrade dry-wet alternated frequently, the degree of compaction low and settlement large in the late, leading to the longitudinal cracks. But the form of longitudinal cracks has no direct relationship with expansive soil subgrade, it tends to be caused by water damage and accelerated by expansive soil subgrade.

If these distresses are not treated in time, pavement structure will appear slurry and the bottom of plates become empty under the effect of traffic loadings when pavement surface water infiltrates pavement structure through cracks. With the empty cavity increasing, the sections of pavement subsidence present net cracking, following by a series of small pit slots, as shown in Fig.2.
Figure 2. Repeated presenting pavement distresses.

SELECTION OF TREATMENT TECHNIQUES ON PAVEMENT DISTRESSES

The traditional treatments on subgrade cracks need to excavate pavement structures. However, the combining of the technology of macromolecule polymer grouting with micro-surfacing can apply well, which not only can strengthen the subgrade soil stability, but also eradicate the distresses and recover the road service function quickly. The practice has proved that the technology of macromolecule polymer grouting can save 45% to 53% of maintenance cost compared with traditional pressure injection fly ash cement slurry, and traditional subgrade crack maintenance methods, respectively. It belongs to trenchless technology with a little damage and fast construction. Therefore, road can open quickly after one hour of construction finish. In addition, this technology does not need to change the drainage systems and reduces road height, so road surface can keep horizontal, and improve the pavement smoothness.

The technique principle of the macromolecule polymer grouting on curing expansive soil subgrade

Polymer grouting technology is originated in Japan in the 1960’s used in infrastructure engineering rapid maintenance, promoting spread to Europe and the United States in the 70s, which has been applied within the scope of the world more than 75000 projects, mainly solving the uplift and the soil stability in the cement concrete pavement and the asphalt surface, its technical principle as shown in Fig. 3, Fig. 4.

From Fig. 3 and Fig. 4 can be seen this technology needs to drill through the pavement surface to the distress location firstly, and then inject polymer materials with mixing reactions, volume quick increasing. During the reaction process of materials, the expanding is always more in the direction of small resistance, so the material always flows to the weakest place with expansion and consolidation to solve the problem of highway distresses.
The construction process for polymer grouting technology was as follows: traffic control → positioning in grouting sections → layout grouting holes → drilling holes → placing grouting pipes → install grouting caps → grouting → sealing holes → cleaning the debris → check quality → opening to traffic, as shown in Fig. 5 to Fig. 7.

1) Traffic control. Road traffic needed to control in accordance with the insurance schemes on grouting.

2) Positioning in grouting sections. Following the instructions of the construction unit, the ichnography distribution of distresses, and engineering supervision determined the distress treatments and arrange construction plans reasonably.

3) Layout grouting holes. Layout grouting holes were along the direction of cracks with spacing 0.6 m. During the layout grouting holes, if encountered the road surface frost boiling and mud destroy, the builders should find out the place of local disengaging in underground, adopt multiple holes grouting tube to fill underground interconnected pipes, and cut off the seepage pipings.

4) Drilling holes. Installing the length of 80 cm drill head to impact drill, holes needed to be drilled to the disengaging with underground or soft subgrade, about the length of 50 cm to 70 cm.

5) Placing grouting pipes. In order to better combination with grouting guns and the cleaned grouting caps, the concave edges of grouting caps should be cleaned using especial tools and fixed on the highway using a hammer.

6) Grouting. Fixing injection gun and injection cap together tightly using fixtures, A and B two kinds of polymer materials through transporting pipes respectively conveyed the injection gun muzzles and reached the pavement distress places in the end, and produced chemical reactions from liquid to solid state with materials volume rapid expansion.

7) Sealing holes. To prevent rain erosion and destroying pavements and keep a clean and tidy road surface needed to use slurry sealing grouting holes.
REPAIR TECHNOLOGY ON COLD PATCH MATERIAL

Macromolecule polymer grouting solved deep distresses of pavement structures, meanwhile, living a series of small pit slots on pavement surface. Repair technology on cold patch material was matched with macromolecule polymer grouting, which treated surface uneven and pit slot areas after grouting and could be used all days for any weather, environments and different pavement structure surface, such as asphalt pavement, cement concrete pavement, the parking lot, and airport runway.

The waiting repair pit slots and its around gravels, slags must be cleaned. Pit slots should not have mud sundries. Sufficient cold patch materials should be added into the pit slots above the ground about 1.5 cm. Meanwhile, for expressway and
general highway, the cold of the feeding amount could increase by about 10%. Having be filled pit slots should be taken on an arc groove and higher than the road surface. If the depth of pit slots were more than 5 cm, it should be layered compaction for each layer 4 cm. In addition, according to the repair environment, area size and depth of pit slots, appropriate compaction tools and methods should be selected. After compaction, a layer of powder or fine sand could sprinkle their surfaces and swept them back and forth using the cleaning tools to fill the pavement surface voids. For having been repaired pit slots, their surfaces should smooth, and flat without vehicle wheel tracks. The degree of compaction reached more than 93% for general highway, but for expressway the degree of compaction was more than 95%. The construction process of cold patch material repair technology was shown in Fig. 9.

Figure 9. Cold patch material repairing pit slots.

Repair technology on cold patch material has four-fold advantages. The first is low carbon and environmental protection since materials are mixed under the normal temperature. The second is low cost since surplus materials can be used next time and no wastes generate after construction. The third attributes to convenient construction, which is not restricted by time and temperature conditions, and can use mechanical paving and artificial paving. The fourth is to have a long life, which is 2-3 times compared with hot asphalt concrete pavements.

CONCLUSIONS

1) The effects of applying macromolecule polymer grouting treatment to Nanyang main highway to cure frost boiling, mud destroy, and cracks are obvious, which proves this technology can effectively drive out mud of road inside, fill the pavement cracks, compact around loose the base and increase the strength of pavement structure.

2) Macromolecule polymer grouting is a fast, efficient and nondestructive road maintenance technology. The grouting hole diameter is small and materials of sealing holes use asphalt, which impacts little on the pavement structures.

3) The technology of macromolecule polymer grouting can solve water-seepage problem effectively because macromolecule polymer material not only fills the voids but also eliminates ponding under pavements.

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