Study on the Causes and Treatment Measures of Pockmarked Surface of Semi-flexible Asphalt at Intersection

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Abstract: Semi-flexible pavement is a new type of composite pavement formed by filling cement-based grouting material into asphalt mixture with large void. Semi flexible pavement has the advantages of good bearing capacity and strong shear deformation resistance, and is an effective means to solve rutting problems at intersections, bus stops, and other road sections. From the current usage situation, this type of road surface performs well in terms of resistance to rutting. However, in the construction and application process in the northern seasonal freezing zone and wide area conditions, traditional materials and structural design may exhibit varying degrees of top-down cracks, longitudinal joints, and a small amount of surface looseness. In this paper, the structure and mixture ratio of semi-flexible pavement are designed, the performance of semi-flexible pavement is evaluated, and the causes of loose diseases of semi-flexible pavement are analyzed in combination with engineering examples, and relevant maintenance and treatment measures are proposed to provide reference for the implementation of similar projects.

Keywords: Semi Flexible Pavement; Looseness; Cause Analysis; Disease Treatment

1. Introduction

Road intersections, as the locations for parking and starting car brakes, are prone to rutting. In some areas of our country, high temperatures and rainy summers have led to various diseases at road intersections, such as ruts, waves, and bumps [1-3]. Regular maintenance has increased road congestion and also increased financial pressure. Therefore, a rigid and flexible pavement material has become the best material for road intersections and channelized traffic, which is formed by the combination of asphalt mixture and cement-based materials [4-6]. The strength of this material is formed using the principle of aggregate compression, and is improved by the composite effect of asphalt and cement-based materials. Its high-temperature stability performance is higher than that of ordinary flexible materials, and it has characteristics such as anti slip, wear resistance, crack resistance, heat resistance, and waterproofing [7, 8].

Semi flexible pavement is an economical, wear-resistant, thermally stable, and long-lasting pavement that can be used in areas with high road surface requirements such as heavy highways, underpass tunnels, bridge paving, military bases, airport runways, toll stations, gas stations, etc [9-11]. However, in recent years, engineering applications have shown that some semi flexible pavements used in surface layers have developed diseases such as cracks, looseness, and peeling [12, 13]. Based on this, this article conducts relevant technical research based on an example of a semi flexible pavement project at an intersection in Shandong Province.

2. Project Overview

Considering the high proportion of large and oversized trucks in this project, rutting is a typical disease. According to the distribution characteristics of old road diseases, the rutting problem on asphalt pavement is particularly prominent at intersections due to frequent brake activation of vehicles. Seriously affecting driving comfort and safety. Therefore, in order to solve the problem of rutting at

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intersections, targeted engineering application research is conducted on semi flexible anti rutting pavement. From June to July 2020, semi flexible anti rutting road tests were conducted at three major road intersections (as shown in Figure 1).

1) Cement-based Grout is Scraped

2) The Pavement after Grouting is Completed

Figure 1. Construction of Semi Flexible Pavement and Finished Pavement

2.1 Pavement Structure Form

The pavement structure of the anti rutting test section of the project is: 8cm (large particle size crushed stone+high-strength fast hardening cement grouting)+adhesive layer+3cm fine-grained asphalt concrete (AC-13F)+sealing layer.

2.2 Raw Material

Binder: SBS modified asphalt; Coarse aggregate: basalt 11-18mm, basalt 6-11mm; Fine aggregate: basalt 0-3mm; Filler: mineral powder; Additives: fiber, high viscosity agent ma100.

2.3 Mixture

The design first screens the raw materials using the water sieve method, and tests various technical indicators of the raw materials. In the design process of skeleton asphalt mixture, the grading range specified in the "Technical Specification for Permeable Asphalt Pavement" CJJ/T 190-2012 was used. Three gradations were debugged for Marshall testing, with 50 double-sided compaction and 4.2% asphalt content. The maximum theoretical density of the designed asphalt mixture was calculated using the calculation method. The designed porosity of asphalt mixture is 22% - 28%, and the connected porosity is 18% -26%. Based on the results of the volume index, combined with the characteristics of the grading and raw materials, the grading is determined to be (basalt 11-18mm: basalt 6-11mm: basalt 0-3mm: mineral powder=79:13:6:2), with a high viscosity agent content of 0.6% of the mixture quality and a fiber content of 0.3% of the mixture quality. Taking into account the types of asphalt and additives used in the project, as well as previous engineering experience, the indoor mixing temperature of asphalt mixture is determined to be 180-185 ℃, and the compaction temperature (suitable for laboratory specimen forming and initial rolling temperature on site) is determined to be 170-175 ℃. The optimal ratio has a relative density of 2.009, a porosity of 24.9%, a connected porosity of 18.5%, a stability of 5.7kN, a leakage loss of 0.2%, a flying loss of 9.4%, a freeze-thaw splitting strength of 86.7%, and a dynamic stability of 21470 times/mm for the grouted rut specimen.

2.4 Construction Control

2.4.1 Milling and cleaning

First, the original pavement is milled and cleaned, then the base asphalt mixture is paved, the cement paste is made, the slurry is poured, and the surface cleaning and maintenance work is carried out. During the milling process, the milling depth of the road surface is strictly controlled and the vertical flat joint is handled well. After milling, the scattered sand, particles and other impurities are quickly cleaned, and subsequent construction can be carried out.

2.4.2 Spray through layer oil and sticky layer oil

In the construction of the semi-flexible pavement, the base layer and surface layer adhesive layer oil are mainly emulsified asphalt material. It is recommended that the oil sprinkling amount of emulsified asphalt adhesive layer be 0.7~1.2L/m^2 at semi-rigid base layer, 0.4~0.7L/m^2 between surface layer, and the spraying amount at the interface with curb and other pavement should be appropriately increased to about 1.5L/m^2.

2.4.3 Paving of base asphalt mixture

The paving process of the base asphalt mixture is the same as that of normal paving, that is, the mixture is mixed first, and then transported to the designated area to complete the spreading and rolling, and finally the strength is tested. In the actual engineering construction, it can be controlled according to the existing construction requirements of permeable asphalt pavement. The parameters that need to be controlled in the construction are: the loose paving coefficient is controlled at 1.15 ~ 1.18, the rolling selection of 12t steel wheel roller, the rolling frequency is controlled at about 6 times, the compaction degree is controlled at more than 97%, the maximum flatness is below 10mm, and the average is below 5mm.

Where the flatness does not meet the requirements, the roller is static rolled again until the requirements are met. It is recommended to start leveling and rolling when the mixture temperature is reduced to about 80℃ to eliminate wheel marks. It should be noted that in the paving operation, the temperature of the different stages of the material should be strictly controlled, such as: asphalt heating temperature is controlled at 150~165℃; Mineral temperature is controlled at 175~185℃; Transport temperature shall not be lower than 160℃.

2.4.4 Slurry preparation and perfusion

The preparation method of grout slurry is mainly on-site preparation and ready-mix preparation, and the slurry is transported to the designated location by pumping. Before grout, it should be sealed around with wood cube and blowing agent to avoid contamination caused by slurry outflow. Grouting construction can only begin when the temperature of asphalt mixture with large void is reduced to below 50℃. During construction, the prepared cement slurry is pumped to the asphalt pavement with large void, and the slurry can self-flow and permeate under the action of gravity until the cement slurry no longer penetrates and bubbles and fills the void.

2.4.5 Surface treatment

After grouting is completed, the surface must be scraped to remove the residual slurry until the uneven surface of the mixture is exposed, in order to avoid the residual slurry caused by the loss of skid resistance.

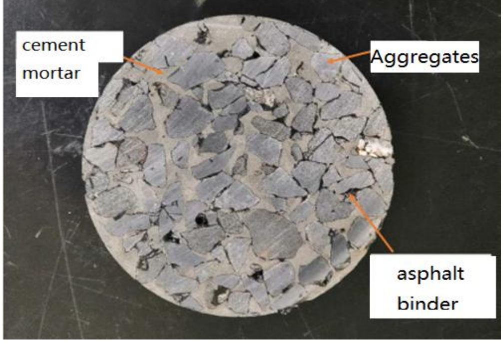
2.4.6 Maintenance

Maintenance work is carried out in combination with environmental temperature science. When the ambient temperature is below 30℃, there is no need to take special maintenance methods; when the ambient temperature is above 30℃, the way of sprinkling water is adopted for maintenance. The health time depends on the temperature at the time of construction and the nature of the grout material. Usually 1~3h after the end of grouting can start maintenance, maintenance period strictly closed traffic, prohibit all personnel and vehicles, but also to prevent rain erosion.

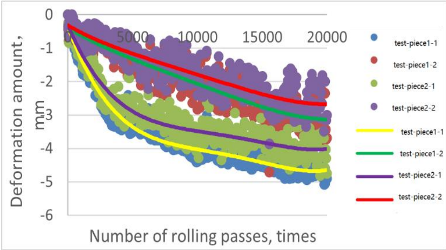
2.5 Finished Pavement Products

After the paving is completed, the conventional technical indicators of the road surface will be tested, with the average maximum gap of smoothness being 3mm, the average depth of construction being 1.0mm, the average compaction being 98%, and the average permeability coefficient being 0ml/min. At the same time, core samples of the finished road surface were drilled and tested using the Hamburg wheel rut tester from the United States. The test requires 20000 rounds of rolling at a water temperature of 50 ℃, with a deformation of no more than 12mm. The test results of this project are shown in Figure 2.

The test results show that all indicators of the finished pavement structure layer meet the technical requirements of JTG F80/1-2017. The maximum depth of Hamburg wheel ruts is 5mm, and there are no inflection points. The road core sample has good resistance to high temperature and water damage.



1) The Core Sample of the Road after Grouting is Completed



2) The Relationship between Hamburg Wheel Rutting Deformation and Rolling Times

Figure 2. Hamburg Wheel Rut Curve of Core Sample

3. Investigation on Surface Loose Diseases of Semiflexible Test Sections

After 2 years of operation, project team members conducted a survey on the surface usage of three experimental road sections at intersections. No loose diseases were found in the straight traffic areas of Tianzhuang intersection, Mingcun intersection, and Laixi intersection, while serious loose diseases were found in the intersection area of Laixi intersection (Figure 3), as follows:

(1) There are serious loose and aggregate peeling phenomena on the road surface in the intersection area of Laixi Experimental Intersection, with an area of about 140m2 and a local peeling depth of about 2cm;

1) Loose Pavement Surface

2) The Material Falls off the Pavement Edge

Figure 3. The Road Surface in the Intersection Area is pitted, with Loose and Peeling Aggregates at the Edges Where it Overlap with the Ordinary Road Surface

(2) The central area of the semi flexible test section and the overlapping edge of the ordinary road surface have the most severe degree of loose and peeling of aggregates;

(3) The loose development form of the semi flexible structural layer on the road surface is: loss of fine aggregate and slurry → roughness of the road surface and increase in structural depth → peeling of coarse aggregate on the road surface → edge gnawing and local potholes.

4. Analysis of Causes of Loose Diseases and Treatment Measures

The aggregate particles of the asphalt concrete pavement surface fall off, the road surface is rough, pockmarked, the surface spalling, and the pit is formed when it is serious. These phenomena are called asphalt concrete pavement loose. When the asphalt concrete pavement is loose, it will cause driving discomfort. If the treatment is not timely, it will continue to develop from the asphalt concrete surface layer down, and even destroy the base and subgrade. It will affect the driving speed, increase the vehicle wear, and even affect the driving safety in serious cases, and shorten the service life of asphalt concrete pavement. Semi-flexible pavement not only has the characteristics of asphalt pavement, but also has the characteristics of rigid pavement, and the generation of loose diseases is different from asphalt pavement, so it is necessary to analyze the actual project:

4.1 Analysis of Causes of Loose Diseases

(1) No fine aggregate loss, looseness or spalling occurred in the straight running area of the three test sections and the intersection area of the other two junctions. Through the comparison of vehicle loads in the straight section and the turning area, it can be seen that the heavy vehicles have slow channeling turns in the intersection area, and each point in the central intersection area will also bear the shear loads from the other three directions of right-turning or left-turning vehicles when subjected to the action of straight going vehicles (Figure 4).

Therefore, the torsional shear force of vehicle load is the direct external cause of fine aggregate loss, rough surface, and even loose spalling of coarse aggregate.

(2) In the intersection area of the three test

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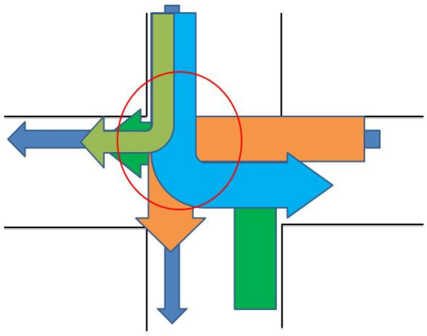
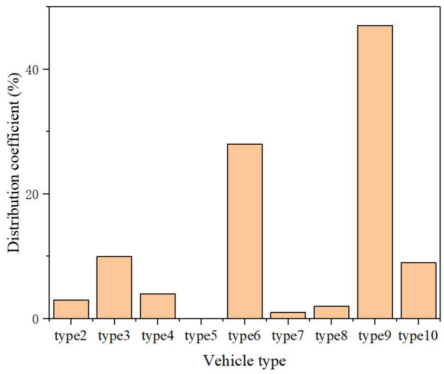
sections, serious loose spall of coarse aggregate occurred at the Laixi intersection. The comparison of plane sizes of the three intersections shows that the plane size of the Laixi intersection is the smallest, the turning radius of heavy-duty vehicles is smaller than that of the other two intersections, and the ratio of heavy-duty vehicles is heavier. The inside wheel of the six-axle vehicle at the Laixi intersection has the phenomenon of in situ torsion, which has greater secondary destructive force on the road form.



1) Level Crossing Traffic Flow Track Line



2) Proportion of All Types of Vehicles

Figure 4. Schematic Diagram of Vehicle Load Action and Distribution of Vehicle Types in the Central Intersection Area

4.2 Treatment Measures for Loose Diseases at Laixi Intersection

This repair takes into account the in-situ torsional shear force of heavy-duty vehicles at the Laixi intersection, and in combination with current technical specifications, it is recommended to perform a thin layer surface treatment with a surface finish milling of 2cm (Figure 5). The specific plan is as follows:

(1) Due to the difference of about 2cm in the unevenness of the road surface at the intersection of Laixi Road, it is recommended to first use precision milling equipment to smooth the loose semi flexible road surface.

(2) After cleaning the milled surface, apply a layer of SBS modified asphalt not less than 1.2L/m^2 as the binder, and then spread a layer of asphalt premixed crushed stone with a particle size of 5-10mm and a single size of 3-5 ‰ on it. Spreading crushed stone is 5-10mm basic hard rock crushed stone that has been cleaned and dried. After spreading the crushed stones, use a rubber wheel roller to compact and stabilize the crushed stones. The distribution amount of pre mixed crushed stone is generally 5-7m^3/km^2, and the specific distribution amount should be determined through trial distribution. When spreading, strict control of the dosage is required. The distribution of single particle sized crushed stones should be uniform and free from accumulation. For areas with high distribution and local overlapping crushed stones, they should be manually dispersed using an old broom.

(3) After the completion of the sealing layer construction, carry out the construction of 3-centimeter SMA-10 modified asphalt mixture. It is recommended to add 0.2% anti rutting agent or use high modulus asphalt as the binder for the design of SMA-10 modified asphalt mixture.

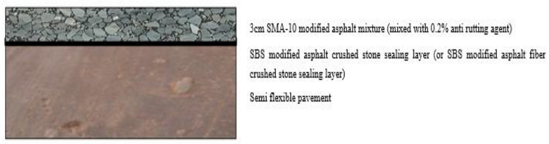


Figure 5. Pavement Structure Combination

5. Conclusions

Based on laboratory data and field engineering applications, this project analyzes the service performance, causes of diseases and prevention measures of semi-flexible pavement. Specific conclusions are as follows:

(1) Semi flexible pavement has high high-temperature stability and excellent service performance in the straight ahead area of the parking line. However, the intersection area is prone to loose diseases due to its large surface structure depth and complex stress, and the disease intensifies as the turning radius decreases. In subsequent design, differential design or control of surface structure depth should be adopted.

(2) The loose development form of the semi flexible structure layer road surface is as

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follows: loss of fine aggregate and slurry → roughness of the road surface and increase in structural depth → peeling of coarse aggregate on the road surface → gnawing of edges and local pits.

(3) The semi flexible poured asphalt pavement has the shortcomings of excess rigidity and weak low-temperature toughness in the seasonal freezing zone, and a systematic high modulus toughening collaborative design method needs to be proposed.

(4) The maintenance of semi flexible pavement after surface looseness should fully consider the interlayer shear force, and use modified or high elastic high viscosity asphalt as the bonding layer after precision milling and re laying.

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