Analysis of Construction Treatment Technologies for Asphalt Pavement Cracks in Municipal Road and Bridge Engineering

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Abstract: In the construction of municipal road and bridge engineering, cracks in asphalt pavements are one of the common defects. The formation of such defects not only affects the aesthetic appeal of the pavement but also reduces its functional performance, potentially leading to more severe pavement distress. With the increasing traffic volume, traditional pavement crack treatment technologies can no longer meet modern road standards and requirements. Against this backdrop, pavement construction technologies have gradually garnered attention. This paper provides a detailed analysis of construction treatment technologies for cracks in asphalt pavements in municipal road and bridge engineering, aiming to offer valuable reference suggestions to construction personnel and improve the construction quality of asphalt pavements in such projects.

1. Introduction

Municipal road and bridge engineering is an important part of the construction of urban infrastructure, it undertakes the role of carrier in smooth urban traffic, which provides a driving force for social and economic development. With the characteristics of low maintenance cost and high driving comfort, asphalt pavement has become one of the most widely used road surfaces in municipal road and bridge engineering. Nevertheless, due to natural environmental conditions and road construction quality control problems, asphalt pavements are suffer from any crack diseases which reduce the pavement smoothness and driving safety. Therefore, it is necessary to study the formation mechanism of asphalt pavement cracks in municipal road and bridge engineering and construction treatment technology for these cracks. This is especially important for the safe and stable operation of municipal infrastructure.

2. Formation Mechanism of Asphalt Pavement Cracks

2.1 Traffic Load

An external force which is mostly responsible for producing the cracks in asphalt pavement is traffic load. As a result, it causes pavement distress due to concentrated stresses, material fatigue and crack formation. As vehicles pass through the roadway, they cause impact loads as well as horizontal and vertical loading. Impact load as the instantaneous increase in local stress caused by a severe impact due to heavy-duty vehicles. If so, the horizontal load is actually an enhanced shear between the surface layer and base layer during cornering or braking moments on vehicles. Under vertical load, the pavement structural layer undergoes significant bending deformation; tensile stress occurs at the bottom of the surface layer and shear stress occurs at the top of the base layer. Reflecting its fatigue characteristics, micro-damage accumulates in the asphalt mixture under long-term repeated load. When the tensile stress exceeds the material yield strength, small cracks form at the bottom of the surface layer and begin to propagate upward with increasing load, leading to horizontal cracks.

2.2 Water Factors

Water is among the significant environmental determinants that expedite asphalt pavement crack

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initiation and propagation. When combined with traffic loads, it destroys the asphalt pavement by way of infiltration, structural degradation and crack induction, thus reduce the service life of these pavements. Water damages the pavement structure primarily in three ways: First, the stripping effect reduces the adhesive strength of asphalt and aggregates; water works its way into voids and pockets around aggregates, stripping the asphalt film from the aggregate surface and generating micro cracks when external forces are applied. Second, the softening impact weakens the ability of a water-saturated base layer to resist deformation. When the traffic loads this layer many times, it undergoes compressive deformation and increases tensile stress at the bottom of the surface layer. Third, freeze-thaw damage: When water in the pores freezes at low temperatures, its volume expands and frost heave stress is generated, leading to micro-cracks in the pavement structure. These network cracks are generated with repeated freeze-thaw under the condition that snow melt penetrates into fractures again during thawing.

2.3 Temperature Factors

In areas with a big difference in temperature, cracks caused by temperature account for over 40%. The temperature dependency of the stiffness and strength of asphalt mixtures is non-linearf. This induces crack problems when the temperature stress exceeds the material's limit. At low temperature, if the diurnal temperature difference exceeds 15 ℃, it will lead to a sharp shrinkage of the mixture volume, creating internal tensile stress. Transverse cracks will begin at vulnerable spots like construction joints, and the crack width will increase as temp falls [1]. The mixture becomes fluid at elevated temperatures and will, therefore, flow under the action of loads. Longitudinal cracks from uneven forces on either side of the rut, which shear stress forms.

3. Construction Treatment Technologies for Asphalt Pavement Cracks in Municipal Road and Bridge Engineering

3.1 Crack Sealing Technology

Supervised Crack sealing technology is a commonly used technical support for the repair of asphaltene pavement cracks in Municipal road bridge engineering. It is mainly based on injecting a well-adhered adhesive sealant into the cracks to stop rainwater, snowmelt and other liquids from infiltrating gaps in and cause damage; so as to reduce the displacement of pavement along with both sides of cracking, thereby stopping the expansion of crack range, extending service lifespan of asphalt pavement. The construction of crack sealing technology is a key factor affecting the repair effect of asphalt pavement cracks. This technology can also be applied to construction, however the entire procedure has to follow a rigorous and standardized process

Crack SlottingA trapezoidal slot with a width of 10 mm and a depth of about 13 mm in the direction of the crack is cut by means of a special slotting machine. It must be deeper than the depth of the crack, and also make sure that the sealant will fill to overflowing the entire crack. But specific during slotting construction personnel need to grasp the cutting speed, must be limited in a reasonable range generally and avoid chip drop more easily affecting material bonding.

Slot Cleaning: High pressure hot air gun to clean slot debris If there is accumulated water in the slot, extend the drying time accordingly to make the moisture content of the wall surface of the slot lower than 3%. When the cleaning work is done, construction workers need to check whether there are hidden cracks at the bottom of the slot with a flashlight. For this purpose, if the slotting area is within the leakage perimeter when sealing then increase its area.

Material Injection: Choose the right seal material according to ambient temperature. With the use of a sealing machine, inject material evenly along the slot at a constant speed until the injection speed completely consistent with fluidity of material, that is, make it 'filling' to reach to 2 mm higher than the pavement surface. Injection can be performed many times in case the crack width is bigger than 10 mm. Wait for the material to cure before injecting, and after each injection wait for the material to have initially cured before injecting the next layer [2].

Post-Construction Maintenance: After crack sealing construction of the process is finished,

construction personnel must overtake warning signs within the region to prevent cars rolling it. Normal-temperature materials are required to be maintained for at least 1 hour normally, and high-temperature materials should be maintained for not less than 30 minutes, and then the material is completely cured to form the sealing structure specified by this practice.

3.2 Seal Coat Technology

Seal coat technology is one of the key technologies with both protective and reinforcing functions. Its basic principle is to cover a wear-resistant and anti-permeable protective layer on the crack area of asphalt pavement, which prevents dust, rainwater, etc. from entering the cracks to harm the structural strength of the pavement; sealing minute cracks on the surface which can slow down crack expansion rate and enhance skid resistance of the pavement. According to the differences of construction materials and construction processes, seal coat technology can be divided into fog seal coat technology and slurry seal coat technology. For the application of this technology to solve for surface cracks in asphalt pavements, it should satisfy the following points:

Pre-treatment of Pavement: The use of high pressure water gun, etc. to fully remove the oil stains other debris on the road surface. If any water is stored on the pavement, use a scorching air gun to blow-dry it. When the asphalt pavement cracks is >3 mm, it is best to adopt the separate treatment of crack sealing technology so that later seal coat material can not enter into these larger pores and become ineffective. Check the pavement for settlement and other diseases carefully, dispose of it in time so that the flatness and firmness of the pavement conforms to expectations.

Material Preparation: You will mix emulsified asphalt and water, in a 1:1.03 ratio, when preparing fog seal coat materials. When better anti-aging effect is required, add the right amount of anti-aging agent, mix evenly, and stand for about 7 minutes. The purpose is to ensure that the material properties remain stable in this time period. For the preparation of slurry seal coat materials, input each kind of material one by one into the mixing bin of slurry seal coat machine according to design mix ratio and use forced stirring method until making it form a mixture of slurry [3]. If it is too watery, add proper amount of water; if it is too thick, add emulsified asphalt.

Spraying and Paving: For fog seal coat spraying, the diluted emulsified asphalt needs to be sprayed with a special spray machine on the surface of asphalt pavement in a fog form. Set the spraying width based on the equipment model, and make sure that adjacent spraying widths overlap by 7 cm to avoid spraying without too much missing area. In the spraying process, reasonably control the spraying pressure; make sure that the emulsified asphalt can fully and comprehensively penetrate into the cracks. Slurry seal coat paving is done by a slurry seal coat machine. Vary paving thickness based on the designed thickness to facilitate uniformity in paving. During the entire paving process, Construction personnel should keep an eye on the fluid state of the slurry mixture When encountering problems such as agglomeration or segregation on site, stop the pavement construction at any time, check whether the match ratio of materials is reasonable, and adjust reasonably.

Maintenance To maintain fog seal coat maintenance: After finishing the spraying construction, do set up warning signs prohibiting vehicles and pedestrians from traveling on the pavement [4]. When the ambient temperature is 20 ℃, to 25 ℃, the maintenance time shall be no less than 4 hours. If the ambient temperature is less than 15 ℃, increase the maintenance time appropriately to make sure that the emulsified asphalt has been completely cured. For slurry seal coat: After completion of paving construction traffic should be closed. Keep it at room temperature for 1-2 days. Traffic can be opened while the surface of slurry mixture is dry. In the event of rain during the maintenance stage, cover it with a waterproof cloth as soon as possible to avoid rainwater washing away the compound. Post-construction of the maintenance, construction personnel should check carefully whether seal has problems such as peeling surface is oily if it is timely repair.

3.3 Overlay Technology

The basic principle of overlay technology is to spread a high-durability and flat-layered asphalt mixture overlay on the surface layer of existing crack diseases. This not only completely prevents the extension of the original cracks but also repairs various diseases such as rutting to wear on the

pavement surface, and improves the load-bearing capacity of the pavement. The technology is applicable to road sections with large-scale distribution of asphalt pavement cracks, heavy traffic and high-quality requirements for pavement. It has the effect of prolonging the overall service life of asphalt pavement, reducing subsequent maintenance costs [5]. Depending on the differences of overlay thickness, material characteristics and construction purposes, the overlay technology can be divided into ultra-thin overlay technology, medium thick overlay technology and thick layer overlay technology. There are slight differences in details of the process for these overlay technologies, and the core processes of construction can be divided as follows:

Detection of the Strength & Pavement Pre-treatment: Detection of the original base layer strength through a pavement detection scheme Should excavate to Bottom of Base in areas where the Deflection value exceeds that which is acceptable for design and treat those areas as desired. Mill the top layer of the original pavement surface using a milling machine. Ultra-thin overlay: 12 mm for milling depth; medium thick overlays: about 35mm, and thick overlay: About 70mm. Confirm that nothing is loose on the milled pavement, that it is flat and without height differences between strips (blunt or step-like). Press out broken stones, dust etc. when milling at high pressure(High-pressure blower)+ marble stone floor grinder If the asphalt has an oil stain, wipe it with asphalt cleaner and use a hot air gun at low temperature to dry the asphalt surface, from which 3% of the moisture inside can be sucked out.

Spraying Tack Coat: During construction, use a fast-breaking modified emulsified asphalt and spray it evenly with intelligent equipment. After the emulsified asphalt breaks and the surface turns black, the overlay layer can be paved.

Overlay Layer Paving: Use a high precision paver to pave the ultra-thin overlay while ensuring good fluidity of the mixture. Never stop the paver during the entire paving process. If due to condition special stopping is needed, Mortars construction joints at spot construction can be used here.To do vertical cuts milling the only at calculation joints, tack coat and repaving. Paving a large-size paver with contact balance beam requires use; regulates entresement during the layer paving under the thickness of two layers and thick. In the case of thick overlays, adopt a laying-over layering process and control the paving interval between the upper layer and lower layer scientifically to avoid bonding defects caused by cooling of the hot mixing material in different layers.

Rolling compaction: Rolling is the key link for ensuring compactness of overlay layer. Use close following, slow rolling, high frequency, and low amplitude during rolling construction. The first rolling stage is two rollings using a steel wheel roller at 1.5-2 km/h. The purpose of this initial stage is to stabilize the mixture, avoiding its movement [6]. The purpose of the re-rolling stage (5 rolling, rubber-tired roller, 2-3km/h speed) and final rollingstage (2 rolling, smooth-wheel roller,3.5km/h speed) is to remove rolling marks and improve pavement flatness.

Maintenance and Opening: From the completion of rolling construction, erect warning signs and close traffic. In general maintenance time for ultrathin overlay at room temperature about 7h, medium thick and thick overlays should be more than 12 h. Do not let the people walk on it while you make your maintenance. In case of rain, cover with a waterproof sheet.

3.4 Reinforcement Technology

Reinforcement technology is a breakthrough technology for bearing cracks due to insufficient strength of base layer. Its principle function being to significantly prevent cracking from travelling further through either stabiliser injection or structure repair. Mainly used for old road refurbishment, reducing "the only cracks in the repair of heavy-load road sections" repeated diseases and other diseases treatment, effectively solve this problem. The main types of this technology are the following:Grouting Reinforcement [7] (with high construction efficiency, small traffic interference, and low construction cost) Pump high-pressure cement-based or chemical injection grouts into loose zones. In the process of construction, different diseases should be accurately detected and grouting pressure should be controlled reasonably by construction personnel. For very loose areas, the upper limit of the pressure should be taken, for example 2.5 MPa for cementing material and a

lower limit of 1.5 MPa for slightly loose areas to prevent excessive pressure on the base layer at which it cracks.

Fiberglass Reinforcement: Lay glass fiber grids in the base layer and under the surface, with longitude tensile strength of not less than 80 kN/m and transverse tensile strength of not less than 60 kN/m, bending and breaking elongation of no more than 3%. When spraying the tack coat, wait until 20 minutes after breaking of the emulsified asphalt before laying the reinforcing material and carry out to ensure flat and wrinkle-free laying.

Reinforcement Layer Paving When the looseness of the bottom layer is more than 100 mm, this technology should be used to fundamentally repair these cracks. Concrete preservation is not possible without mill the upper layer of the original asphalt structure For your concrete after repairing In milling old building use high precision milling technology Combined with engineering management to control standard flatness top surface of milled base layer accurately, Also ancient structures uneven thickness failure After resurfacing because of poor flat position in a simple way. During subgrade treatment, if the subgrade after milling is found to be loose (the natural moisture content and density of soil are not enough), excavate it until the intact layer, backfill solid graded crushed stone in a layered manner, and control the compaction degree at about 97%, Subgrade resilient modulus is required to remain no less than 30 MPa.

4. Conclusion

Under the background of modern society, the rapid development of science and technology and the continuous improvement of the economic level, the construction technology of asphalt pavements in municipal road and bridge engineering has been highly valued by all walks of life. The relevant departments and construction personnel should reasonably use the corresponding construction treatment technology for asphalt pavement cracks according to the related characteristics of municipal road and bridge engineering, control the construction quality from different links, fundamentally improve the quality of municipal road and bridge engineering.

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