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Research Article

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Research on Common Asphalt Pavement Diseases

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Abstract In order to extend the service life of highways and improve the safety and comfort of driving, this paper introduces the common diseases of asphalt roads, including rutting diseases, cracks, water damage, congestion packs, peeling and subsidence, analyses the factors causing the diseases and puts forward reasonable solutions. In the maintenance of highway asphalt pavements, the concept of prevention-oriented and combined prevention and control should be established.

Keywords Asphalt pavement diseases; Rutting; cracks; Water damage

1. Introduction

With the rapid development of road traffic, highway construction projects are gradually shifting from big cities to small cities, promoting the development of China's economy and society. Compared with cement concrete, asphalt mixes are widely used in China's highway pavement projects due to their low cost, good durability, and ease of construction. However, the increase in traffic volume and vehicle loads, especially the influencing factors of traffic overload, have caused frequent damage to asphalt pavements in early use, which has become a constraint to the development of road traffic in China [1,2]. Various factors such as construction quality and methods, material properties, and external environment can lead to early damage of asphalt pavements.

2. Rutting damage

Rutting is an indentation formed when the pavement is repeatedly deformed in the longitudinal direction by the repeated action of the traffic load, and this deformation is then continuously superimposed and accumulated, mainly manifested by the formation of depressions in the wheel tracks, while the raised bumps are produced on both sides of the wheel tracks.

At the beginning of the pavement, the rutting depth is almost zero and the ride comfort is good; however, as the number of trips increases, the rutting depth increases and the impact on the ride becomes greater and the ride comfort decreases significantly; when the rutting depth reaches a certain value, it can even affect the safety of travelers to a certain extent.

2.1 Factors affecting the rutting resistance of asphalt pavements and measures to address them

2.1.1 Temperature

Temperature is one of the main factors affecting the high-temperature rutting resistance of asphalt pavements. Temperature changes in asphalt pavements not only cause expansion or contraction of the material but also change the viscoelastic characteristics of the asphalt mixture, which in turn leads to pavement deformation [3]. Pomeranian et al. analyzed the effect of temperature on the rutting performance of SMA and revealed that the stress sensitivity of the rutting performance of SMA asphalt mixtures decreased with increasing test temperature and that temperature had a significant effect on the flow number of SMA mixtures [4]. It was shown that the deformation observed in the asphalt mix structure was significantly influenced by the thermal deformation and thermal sensitivity of the viscoelastic material, both individually and in combination [5].

2.1.2 Aggregate grading type

The rutting resistance of asphalt mixtures depends to a large extent on the type of aggregate grading chosen. Katz has shown that even mixtures produced with the best materials may exhibit poor rutting resistance if a suitable aggregate grading is not available [6]. the effect of aggregate grading on the rutting resistance of asphalt mixtures was evaluated by Elliott et al. The physical properties of the minerals directly affect the properties of the mix and hence the performance of the pavement. The physical properties of aggregates that control the performance of asphalt mixtures are mainly gradation, particle shape, and absorption [7]. Pomeranian et al. analyzed the effect of coarse aggregate shape characteristics on the compaction performance of asphalt mixtures and showed that the compaction slope of asphalt mixtures decreases as the roundness and regularity of coarse aggregates increase [8]. In addition, coarse aggregates play an important role in achieving the high-temperature stability of asphalt mixtures. The interlocking between the coarse aggregates that make up the SMA mix skeleton is an important factor in the rutting resistance of asphalt mixes [9].

The weight and volume of minerals used in asphalt mixtures are 90-95% of the mix weight and 75-85% of the mix volume respectively. The physical and mineralogical properties of the mineral aggregates on which the pavement load-bearing capacity depends directly influence the characteristics of the mix, the compatibility of the new mix, and the performance of the pavement. The easier the asphalt mix is to work with, the easier it is to compact. Studies have shown that asphalt mixes that are easy to compact are prone to rutting under traffic conditions. Conversely, mixes with low compaction are less prone to rutting under the same conditions.

2.1.3 Amount of asphalt

Asphalt improves the shear resistance of the mix and affects the bonding and internal friction resistance of the asphalt mix. The viscosity of the asphalt, the amount of asphalt, and the compatibility of the asphalt with the mineral mixture are the main factors affecting the bonding of asphalt mixtures. The higher the viscosity of the asphalt, the greater the bonding force and the greater the resistance to shear. Therefore, the requirements for asphalt vary according to the geographical area of construction.

2.1.4 Other factors

The design, construction, and traffic conditions of asphalt pavements are also important factors influencing the development of rutting distress. Periodic temperature changes lead to repeated contraction and expansion, which generate tensile stresses in the pavement [10]. The repeated passage of vehicles and the leverage effect generated by the stresses caused by temperature changes trigger fatigue processes that eventually lead to the appearance and expansion of cracks in the wear layer [1].

3. Asphalt Pavement Cracking Diseases

The pavement structure is a whole, which is attached to the soil base, consisting of an asphalt surface layer, base layer, bedding layer several parts, any one structural level there are defects or improper linkage between the layers may make the pavement cracks. When moisture enters the subgrade, the road base softens and the load-bearing capacity of the pavement decreases, resulting in kipping, stepping, and net cracking, accelerating the destruction of the pavement.

3.1 Temperature cracks

Temperature cracks occur when asphalt pavements are not designed to meet the temperature requirements. As the temperature changes, the load on the surface layer of the asphalt pavement changes with the alternation of temperature differences between the seasons and between day and night. In low-temperature environments, the strength of the asphalt mixture is high, the pavement has better strength and stiffness, but the resistance to deformation is poor, the temperature decreases the asphalt surface layer will shrink, due to the constraints of the base layer will produce transverse spacing cracks.

3.2 Horizontal and vertical cracks

Longitudinal cracks are caused by uneven settlement of the roadbed or improper handling of construction joints during construction, the direction of which is parallel to the direction of traffic, and Kagoshima Road itself generally does not produce longitudinal cracks. Transverse cracks are perpendicular to the center line of the road, with a regular distribution of crack widths, and the temperature and crack resistance of the asphalt pavement affect the spacing between each crack.

3.3 Handling measures

(1) Select the correct type of aggregate. The design and construction of asphalt pavement have an important impact on the service life of the road, and the scientific proportioning in highway construction has a very important impact on the performance of the asphalt mixture. To improve the quality of construction (pavement strength and other road performance), deal with the road base and grass-roots level to meet the quality requirements of the project.

(2) Select good anti-cracking asphalt, and mixes, improve construction quality; use a good anti-cracking base layer

(3) Deal with the longitudinal joints when paving.

(4) Strengthen maintenance, road maintenance personnel need to regularly check the road, strengthen the regular maintenance of the road, eliminate potential disease problems, and crack disease, repair in a timely manner, prevent the role of vehicle loads, rainwater seepage, increase the cracks.

4. Water damage to asphalt pavements

Water damage to leach asphalt pavement is due to the inappropriate design of asphalt pavement void ratio, asphalt-aggregate adhesion is not high, and through the action of dynamic water pressure, resulting in asphalt mixture spalling, asphalt migration in the pavement, the strength of the asphalt mixture is reduced. Not only does the service life of the asphalt pavement deteriorate considerably, but it also has a significant impact on drivers traveling on the road.

Water damage to asphalt pavements generally occurs during the rainy season in sections with poor drainage capacity.

4.1 Structural water damage to road surfaces

The most obvious feature of structural damage to asphalt pavement is kipping (bubbling slurry). When a large amount of water is retained on the asphalt pavement and cannot be discharged in time, the water that flows into the surface layer of the asphalt pavement will continue to flow to the base layer, forming stagnant water between the base layer and the surface layer [12]. When the vehicle drives away, the asphalt pavement has a certain elasticity and the pavement will spring back. Then under the constant reciprocating movement, the water and powder immersed are brought out.

4.2 Mix water damage

Pavement structure water damage is due to the poor drainage capacity of the pavement, at first, the water will flow into the surface layer of the asphalt pavement, can not be discharged in time, and will affect the bonding force of the asphalt mixture, in the long run, coupled with the role of long-term vehicle loading, the surface layer of the aggregate began to flake off, in the bubble slurry out, under the action of the traffic load, due to the damage of water, reducing the bonding properties between the asphalt and mineral, so that the mineral stripped from the mixture, carried out by the wheels, and finally formed potholes [13].

4.3 Prevention and control measures of asphalt water damage

(1) Good set design and good supervision during construction are very important, if the set design is not reasonable, or problems in construction, result in an area of coarse and fine aggregate distribution is not uniform, the coarse aggregate concentration of parts, the void rate is large, less asphalt content, easy to occur water damage; the void rate is an important reason affecting the asphalt pavement water damage, the mix of the dense degree of size directly affects the asphalt pavement The strength of the mixture directly affects the strength of the asphalt pavement, and research shows that water damage is most likely to occur when the void ratio is between 8% and 15%.

(2) Strengthen the drainage, and strengthen the drainage capacity of the pavement, when the rainfall is relatively large, the water will be lost in time and will not remain on the road, after the laying of the water-stable base layer, laying the waterproof layer. For both the middle surface layer and the sub-base layer, a dense graded mix should be used.

(3) Strictly control the quality of construction, improve the standard of compaction, ensure the quality of the mix, and adopt a reasonable thickness of the structural layer.

5. Other diseases

5.1 Congestion

Congestion packs are born in the direction of travel on the road, at stopping points or intersections, where vehicles need to brake and start.

The causes of congestion packs are generally the following.

(1) set design is not reasonable and is easy to cause the pavement an important reason for congestion pack, when the set design if the choice of fine aggregate is more, it will cause the asphalt mixture of high-temperature shear resistance is reduced. Applied to the road surface, the repeated action of external forces will be easy to deformation and produce a congestion package.

(2) If the asphalt mixture is added to the asphalt, it will cause the softening point and viscosity of the mixture to be low, which will produce congestion under the repeated action of vehicles.

(3) Pavement grass-roots local water content is too large, moisture retention in the grass-roots level or too much grass-roots floating soil, or permeable layer of asphalt sprinkling does not meet the requirements and so on, affecting the combination between the surface and grass-roots level, in the role of the horizontal force of traffic, so that the pavement produced by pushing and lead to local irregular bulging deformation.

5.1.1 Solution measures

Congested bales that have stabilized under the action of vehicles over a long period of time should be promptly repaired, chipped by machine, and filled in with material to make the road surface level.

If the congestion is due to an unreasonable design of the aggregate, too much fine aggregate, or too much asphalt, but the base layer is not affected, the surface layer should be removed in its entirety, cleaned up, and resurfaced.

Between the grass-roots level and the surface layer, if the combination is not tight, local retention of a large amount of water, under the action of dynamic water pressure and vehicle pressure generated by the congestion pack, should be removed from the surface layer, the grass-roots level replaced with a good permeability of the material, air dry moisture, laying waterproof layer to redo the surface layer.

Due to the road base and surface layer of asphalt mixture of insufficient strength, water resistance caused by the poor performance of the pack, the surface layer, and the base layer should be completely reconstructed, select the appropriate materials and set design, the use of the correct construction methods, laying the last layer of waterproofing materials.

5.2 Peeling

The peeling phenomenon is mostly a problem in construction, when laying the surface layer, there is no good bonding measures, resulting in the bond between the base layer and the surface layer is not strong, and under the repeated action of vehicles, the surface layer of asphalt pavement is deformed and pushed. The peeling phenomenon was formed.

The reasons for peeling are generally twofold.

(1) Poor bonding of the asphalt surface layer and the upper seal layer due to poor initial maintenance.

(2) Poor bonding between the asphalt surface layer and the base layer.

5.2.1 Solution measures

Regularly check the structure of the pavement for damage, repair any damage found, redo the sealer and use a reasonable amount of asphalt, and set the design to prevent the damage from becoming more serious if it is not controlled in time.

5.3 Subsidence

Due to the deformation of the road's base and surface layers in the vertical direction, the structure of the road surface is deformed, resulting in the phenomenon of the sinking of the road surface.

5.3.1 Solution measures

(1) If the settlement is not obvious and is only a local uneven settlement, the subgrade does not appear to be a problem, the surface layer can be removed and the surface layer repaired.

(2) For settlement caused by localized damage to the road base, the surface layer should be laid after the soil base and subgrade have been repaired with sand and gravel, and other materials.

(3) Depending on the specific situation, slurry reinforcement can be used to repair the settlement.

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