

## The analysis and prevention on water damage of asphalt pavement

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### Abstract

At present, with the enterprise vigorous development of road frastructure , all kinds of disease prevention and control work in highway construction are increasingly brought to the attention of the engineering and technical personnel. The asphalt surface water damage problem is a very notable one. Water damage is one of the early damage of asphalt pavement, not only caused a great economic waste, also seriously affected the safety of driving. Due to the reason of pavement structure, the construction level, and of the problems, this paper talked about water damage unlikely to occur. Water damage is one of early damage of asphalt pavement, in our country most of the road surface layer consisted of asphalt concrete , semi-rigid materials as a base, effects of rain and water on road surface water damage on a wide variety of diseases. This article analyzes the moisture damage to asphalt pavement type, characteristics, formation mechanism, on base of the causes of water damage from external and internal aspects and giving prevention measures covering different aspects.

### Keywords

Water damage, asphalt pavement, external and internal aspects, prevention measures.

### 1. Introduction

At present, with the enterprise vigorous development of road frastructure , all kinds of disease prevention and control work in highway construction are increasingly brought to the attention of the engineering and technical personnel. The asphalt surface water damage problem is a very notable one. Asphalt surface water damage refers to the asphalt pavement under the condition of moisture or freeze-thaw cycle, due to the traffic dynamic load and temperature humidity swell-shrink repeatedly, getting into the road surface in the pore water constantly flowing pressure or vacuum negative pressure suction of the cycle, water gradually into the asphalt and aggregate interface, and the asphalt emulsification, leading to the decrease of the strength of asphalt mixture. [1] At the same time under the influence of hydrodynamic, bitumen membrane detachment from aggregate surface between the aggregate loss, and form the asphalt surface pit slot and push the deformation damage phenomenons.

### 2. Water damage of asphalt pavement types

The general signs of water damage occurred and sequence is: the spring melting + continuous rainfall + coming last summer high temperature, rain or some tiny crack propagation along the fissures to crack, peeling off part makes the asphalt from aggregate surface, local mixture lossing of bond, creating loose after the vehicle under the action of craters. Water damage location is local, more severe in permeable and poor drainage and parts, main characteristics are: (1) the road hole.(2) local surface net cracks and deformation.(3) pumping slurry.(4) loose flake.

### 3. The characteristics of water damage of asphalt pavement

#### 3.1 Water damage from top to bottom surface

The early water damage of road surface are mostly from top to bottom, often limited to loose and potholes in surface layer. The surface pit slot whose forming condition is that water is able to penetrate into surface, but it is difficult to continue infiltration, at the same time with big pore surface. [2]

#### 3.2 Water damage from bottom to top

It often occurred in asphalt pavement of semi-rigid base which is thin. Early, usually with a small crack, pumping slurry, then under repeated load at high speed suction, asphalt layer and the base interface conditions deteriorating, asphalt layer bottom cracking due to tensile stress that exceeds the limitation, at the same time, under the asphalt pavement layer aggregate appear spalling, gradually formed the pit slot.



Fig.1 Water damage representative form of pit slot

### 4. Water damage mechanism analysis

Water damage is related with two processes of softening and peeling off. First of all, the water is able to enter into the asphalt asphalt, which making cohesive force miniishing, so as to reduce the strength of the mixture; Then, water can enter between aggregate and asphalt membrane, abate even blocking of asphalt and aggregate bond to each other. Because of water adsorption ratio of asphalt aggregate surface adsorption force strong, the contact surface of asphalt and aggregate surface is reduced, making the asphalt off from aggregate surface spalling.

Now it is learned that water damage mechanism usually has two kinds: loss of adhesion strength and cohesive force. The force loss caused by both internal factors and external factors. The internal cause includes: pavement material and pavement structure design, etc. while the external cause includes:

water temperature conditions, traffic load and construction, etc. The focus is on solving mixture Void ratio too large, road surface water seepage and unperfectly rainage facilities , the insufficient ompaction degree , shortage ability to resist damage of water asphalt mixture , thin thickness,etc, and dedicated to solve these problemes from the pavement structure form.

Surface free energy: work to separate solid or liquid to create a new section in a vacuum.

Surface free energy of liquid:  $\gamma_l = \gamma_l^d + \gamma_l^p$  .

Surface free energy of solid:  $\gamma_s = \gamma_s^d + \gamma_s^p$  .

Cohesive work: the energy needed to create two new section in the same phase .Adhesion work: the energy needed to create two new interface done from the contact of two different phase in a vacuum.

Cohesive energy: homogeneous material separation into two parts, create two new interface, to the outside world to do the work, also can be used to characterize the size of the asphalt adhesiveness.

Cohesive energy formula:  $\Delta G=2\gamma$ .

Existing studies have shown that high speed driving conditions, the dynamic water pressure and is proportional to the square of the driving speed, the highest part is about 1.55 times that of the tire pressure, the road surface under the action of vehicle load, internal in less than 0.1 seconds to create a cycle of around 300 kpa dynamic water pressure differential, road surface water for larger gap of dynamic water flushing action is the important cause leading to the pavement early damage [3].Research on SMA - 10, SMA - 13, AC - 13 three mixture grading according to its types, pore types are calculated by the coefficient of permeability of asphalt mixture, as shown in figure 3.

SMA - 10, the SMA - 13 dense water performance is superior to AC - 13, porosity more accord with the design requirements. SMA mixture due to its good water smaller voids, secrete, rough surface, can play a good supporting role, and can satisfy the functional requirements of skid resistance and noise.

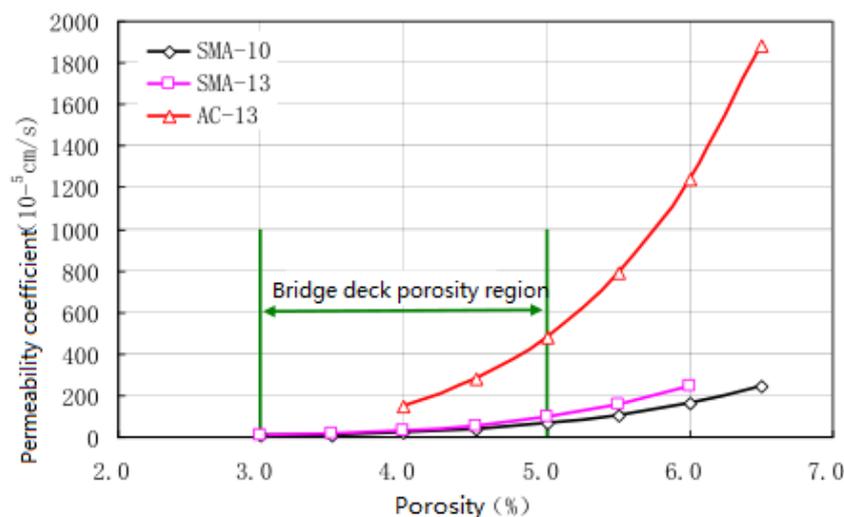


Fig. 2 SMA-10, SMA13, AC-5 coefficient of permeability of mixture

#### 4.1 Adhesion theory

Adhesion and peeling of asphalt and aggregate is a very complex physical and chemical process .Through to calculation of he adhesion strength of thermodynamics , from which we can see that smaller values of the aggregate and asphalt adhesion thermal is vulnerable to be replaced by higher heating adhesion values between aggregate and water; Once water intrusion arrival on asphalt aggregate interface, as a result, instead of the asphalt making it stripping.

#### 4.2 Sintering theory

In compacted asphalt mixture, the cohesive force of asphalt mixture can often still maintain its integrity under vehicle load or stress. Generally, through the stability test, modulus of resilience test or tensile strength test, we can test the mixture of cohesive force. Cohesive force is influenced by these factors such as the thickness of asphalt film, types of asphalt, aggregate, and the degree of interaction between the physical and chemical factors. Water decreases it by invading bitumen membrane or the expansion of the pore. [3]

#### 4.3 Water damage cause analysis

The internal cause to water damage

- (1) The aggregate properties: hydrophilic material adsorption capacity for water higher than asphalt, and to the contrary hydrophobic material is not. In addition, the aggregate surface chemical properties, surface area, pore size and so on all have influence on stability of asphalt mixture.
- (2) Asphalt properties: the viscosity of asphalt to resist the replacement of smaller than viscous asphalt, this is because the more polar substances exist in the viscosity of asphalt, and has good wettability. Polymer modified asphalt usually have good water resistance.
- (3) Design: the main index of asphalt mixture water resistance is its design of porosity and the actual porosity. Due to the mineral aggregate gradation design of mixture is unreasonable, porosity is too big, the dense water up poor, the stability of the mixture.
- (4) Construction: serious segregation of asphalt pavement, the uneven thickness of aggregate and asphalt content of mixture, the deviation from the design gradation and asphalt content, coarse aggregate concentrated part of the porosity is too large, increased the water damage; Due to the pursuit of flatness and worry about the adverse impact of the depth of the structure and cause construction compaction is insufficient, can't let go of RCC, the asphalt surface dense water, open the traffic after rolling can cause mixture pressure deformation is formed by abnormal rut, more serious is the hidden danger of water into the pore become damaged.

The external cause of water damage

There is no doubt that the traffic load and environment both external cause is not to be ignored. Low temperature, high humidity and paving of asphalt mixture pavement when there is rainfall, the water stability is bad, because this kind of circumstance and paving of asphalt mixture material of middlings was not easy to form a perfect bond between.

### 5. The road surface water damage prevention and control

The root cause of the water damage of asphalt pavement is due to water intrusion into the interface between asphalt and aggregate, water beforehand instead of asphalt makes asphalt membrane stripping from the aggregate surface, causing the loose aggregate missing strength loss. Therefore, to prevent water damage has two ways: one is to prevent or reduce moisture to enter, to cut off the water damage of external conditions; The second is to improve the bond between aggregate and asphalt and aggregate adhesive, prevent water from the internal factors caused by the damage.[3]

#### 5.1 Controlling the porosity

Every layer of asphalt surface with void ratio is not more than 5% of the dense asphalt concrete. Now generally below layer design for the void fraction larger II type asphalt concrete, the middle layer is I more dense type asphalt concrete, or only a layer of asphalt sand surface design, this is used to prevent moisture intrusion is not enough.

#### 5.2 Improving the adhesion of asphalt and aggregate

Adhesive is refers to the asphalt adhesion on the surface of aggregate performance. So you must improve the adhesion of asphalt and aggregate and stripping resistance. This can be added in the asphalt antistripping agent to improve the adhesive power.

### 5.3 Improving the compaction standard, increasing the rate of in situ gap index

The compaction degree of asphalt concrete of the physical and mechanical properties of asphalt concrete has a vital influence. Pavement compaction degree is insufficient cause big void fraction, permeability increase, if internal drainage not free, extremely easy to accumulate a large number of water after rain, leading to water damage. Therefore, should try to improve the compaction degree of asphalt road surface.

### 5.4 Improving pavement construction process, control the pavement compaction

Some one-sided pursuit of smoothness of asphalt pavement, tend to relax the requirement of compaction, especially in the construction process for fear of the vibration road roller can affect the flatness and structural depth, therefore tend to use pneumatic tyre roller, but small pneumatic tyre roller tonnage, resulting in asphalt roadbed compaction degree is insufficient.

### 5.5 Setting drainage layer or the waterproof layer of pavement structure

Internal drainage asphalt pavement structure, the main is accomplished by setting the drainage system at the grass-roots level, it is directly set up under the surface drainage drainage at the grass-roots level, in its vertical edge set gully and drain, and lateral outlet pipe, etc., of drainage drainage system at the grass-roots level.

Water has great influence on the strength of the soil along with the strength of cement stabilized soil. But too much cement dosage. Although gain strength increase, but not necessarily reasonable economically, in effect is not significant and easy to crack. Experiment and research shows that the cement dosage is 4% 8% more reasonable. Moisture content had a great influence for the strength of cement stabilized soil. When insufficient water content, cement can't completely hydrated and hydrolysis in the mixture, exert no effect on the stability of soil cement, influence the formation of bow to change ,less moisture content at the same time.

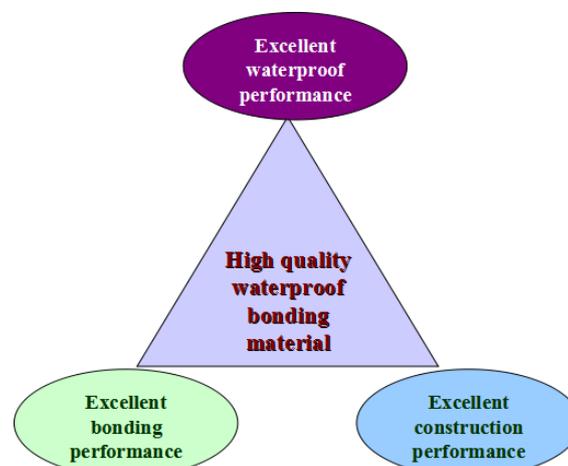


Fig. 3 The necessary elements of high quality waterproof bonding material

## 6. Conclusion

Water damage is one of the early damage of asphalt pavement, not only caused a great economic waste, also seriously affected the safety of driving. Due to the reason of pavement structure, the construction level, and of the problems, this paper talked about water damage unlikely to occur. In fact, all kinds of factors interact together, like water damage usually have heavy traffic, more rain and snow water, waterproof and drainage facilities is not good, material defects, water stability of asphalt mixture itself is insufficient, construction segregation, insufficient compaction and a series of problems exist in different degrees. Therefore, local water damage need to find the reason, from the local common problems to find reasons from the commonness.

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## References

- [1] Jinan Shen, Fupu Li, Jing Chen: The analysis of early damage of asphalt pavement in Expressway and countermeasures. Beijing: China communications press, Vol.9(2004)No.1, p35-38.
- [2] Tie Wang: Cause analysis and prevention of water damage of asphalt pavement Traffic world (built. machinery), Vol.26(2011)No.10, p132-138.
- [3] Hongyou Zhang: Discussion on reasons and preventive measures for water damage of Expressway pavement. Heilongjiang science and technology information., Vol.18 (2011) No.14, p65-72.
- [4] Yan Wang: Common diseases of asphalt pavement of high grade Highway and its control method. Highway and motor carriers. Vol.5(2011)No.1, p99-103.
- [5] Junyi Ma, Herui Hao, YIjun He: Application of Old Bitumen Pavement Material Stabilized by Concrete in Base-course[J]. Xian: Pavement Engineering & Transportation, 2005, 141 (2) : 52-54
- [6] Famao, Shi Wu, Zhongda Chen: The Research of Cold Recycling Asphalt Pavement Materials Stabilized by Cement of Semi-Rigid Base[D]. Changan: Changan University, 2012, 1 (2) : 25-28.