

# Disease Characteristics and Maintenance Technology of Highway Subgrade and Pavement

Yuan Yin\*

China Merchants Chongqing Communications Technology Research & Design Institute Co., LTD., Chongqing 400067, China

\*Corresponding author: Yuan Yin, 392682416@qq.com

**Copyright:** © 2022 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** In recent years, the subgrade and pavement diseases account for the vast majority of the expressway maintenance diseases, which puzzles many expressway maintenance departments and units. To sustain the continuous development of the expressway, the service level of the expressway is need to be improved, by ensuring the safety of the people, and by providing more convenient services for the people during travel. The technical measures for scientific maintenance of expressway subgrade and pavement diseases were discussed in this paper. Further, this paper discusses the main subgrade and pavement diseases types, and proposed the targeted maintenance methods, which can be as a reference for the expressway maintenance departments.

**Keywords:** Expressway; Subgrade and pavement; Disease characteristics; Maintenance technology

**Online publication:** May 31, 2022

## 1. Introduction

For the same pavement condition, implementing different preventive maintenance measures will give different outcome, for example, micro surfacing treatment can increase the friction of pavement, improve the anti-sliding ability of the pavement, and improve the rutting, in contrast, using fog sealing treatment has little effect on the anti-sliding ability of the pavement <sup>[1-6]</sup>, therefore, different maintenance measures need to be taken for different types of diseases.

## 2. The main disease types and the cause of expressway subgrade and pavement

### 2.1. The main disease types of expressway subgrade and pavement

At present, there are many classification methods was used to classified the asphalt pavement diseases, including damage, transverse cracks, longitudinal crack and subsidence. Meanwhile, according to the damage mechanism, asphalt pavement can be further subdivided into damage under water, damage under heavy load, damage caused by soil foundation, and damage caused by construction.

Damage due to the vehicle load, and harsh natural environment, will cause asphalt pavement to have various damage conditions, further, the damage will gradually become severe over time, subsequently, will affect the vehicle running speed, duration of the journey, driving safety, and the maintenance cost <sup>[2]</sup>, therefore, to reduce the impact of pavement diseases on highway quality, it is essential to take suitable measures based on disease types.

## **2.2. The main cause of diseases in the expressway subgrade and pavement**

### **2.2.1. The impact of external environment and climate change**

The rainwater has strong acidity, and strong surface tension, therefore, rainwater can react on the asphalt surface, by infiltrating into the asphalt layer, through the action of vehicle load, and water pores, forming asphalt water pressure, subsequently, damaging the adhesion of asphalt film. Further, the binding force between each layer of the aggregate will be damaged, leading to series of disease development such as cracks, pits and damage. Following disease development, the asphalt surface will have a different structure, where the gap become large, and the tension and cohesion between the aggregates will also change, with the change in the temperature, further, the damage degree of asphalt pavement will be different in time <sup>[1]</sup>.

### **2.2.2. Impact of asphalt materials and daily maintenance**

To improve the quality of asphalt pavement, some constructors forcibly increase the proportion of some materials during the construction work, which affects the service life span of the asphalt structure, limited to a certain duration, further increase the damage speed. In addition, the impact of overloaded vehicles on asphalt pavement, further, accelerates the damage to a certain extent. The poor maintenance of the expressway, and untreated small cracks and diseases on the asphalt pavement, can seriously affect the asphalt pavement, due to continuous action of the impact.

### **2.2.3. Impact on construction quality**

The construction quality has a great impact on the highway asphalt pavement. For example, improper mixing of the asphalt materials during the construction process, and usage of stir frying can, further, can lead to uneven mixing, eventually, will affect the asphalt, and reduce the performance of the structure in use <sup>[2]</sup>.

### **2.2.4. Impact of drainage system**

The drainage system has a great impact on the highway asphalt pavement, especially in areas the with heavy rainfall. If the pavement is not drained in time, it will cause different degrees of water damage on the asphalt pavement. Due to the low investment, and other factors, the road construction in China in the past was imperfect, and the ponding in the rainy season was serious, where, the rainwater was not removed on time, and the traffic load was greatly affected, leading to the water damage of the asphalt pavement. Additionally, the drainage of the highway isolation belt, is often poorly designed, therefore, rainwater may seep into the asphalt structural layer from the isolation belt, resulting to serious asphalt diseases, subsequently, affect the normal highway traffic <sup>[3]</sup>.

## **3. The subgrade and pavement construction technology of expressway**

In the construction of expressway asphalt concrete pavement, the quality control of mixed material transportation, paving, and rolling construction technology is the important key factors in the construction. After the asphalt concrete is mixed, it needs to be transported to the construction site quickly. In the process of transportation, the heavy-duty dump truck with metal bottom plate, should be selected, further to prevent the mixed materials from being polluted, the bottom plate of the truck should be cleaned and coated with a layer of oil-water mixture. Another advantage of this cleaning method, is will effectively prevent the moderating materials from sticking to the bottom plate of the truck, which may lead to incomplete unloading. Further, it also plays the role of heat insulation and heat preservation <sup>[4]</sup>.

After the mixture is transported to the site, construction personnel should organize the paving work immediately. In recent years, the paving work has changed from manual to mechanical paving, due to the continuous development of the construction technology. In the paving process, professional pavers are

selected, or if there are multiple pavers operating together on one site, it is important to stagger the front and back for paving. The paving width of each paver, should be strictly controlled, to prevent the uneven paving width, further during paving process, the temperature should be strictly controlled. According to the construction requirements of fiber stabilizer, the paving temperature is strictly controlled within the range of 170°C to 180°C, and if the paving temperature decreases to 140°C during the process, the paving should be stopped immediately, and the materials should be scrapped out. For the selection of paving time, it is essential to avoid overcast, and rainy weather, preferably carry out the paving process on a sunny day in the afternoon, when the temperature is the highest on a day or exceeds 150°C. In case of sudden rainstorm during paving, the paving process should be stopped immediately, and the uncompacted materials should be cleaned, to avoid affecting the next day construction.

Next, the pavement rolling process should be performed immediately after the paving process is completed. Rolling process can be divided into three stages, which are initial rolling, re-rolling, and the final rolling, and different types of mechanical equipment are required for different stages of rolling. For example, during initial compaction and re-compaction, double drum vibratory roller can be used, to roll with low amplitude and high frequency techniques [5-10]. The initial rolling process is generally carried out for 1-2 times, with running speed of the roller is controlled at 1.5 to 2.0km/h, while re-compaction requires 4-5 times, with the driving speed is set to 2.5 to 3.5km/h, and the final rolling process should be not be less than 2 times, with the driving speed is controlled at 2.5 to 3.5km/h. The paving process should be uniform and slow, to ensure the stability, and continuity of the paving construction.

#### **4. Maintenance measures for the subgrade and pavement diseases of expressway**

##### **4.1. Curing of crack diseases**

In the process of highway pavement construction in the summer, due to the high external temperature, if there are small cracks in the asphalt pavement, special treatment is not necessary, because the cracks can be repaired automatically under the action of high temperature. However, the aging problem of the asphalt pavement will become more aggravated with the extension of service time, therefore, more scientific and effective technical processes should be used for the treatment.

###### **4.1.1. Infuse stitch**

The caulking method maintenance is generally used in the late autumn and late winter. Few steps are involved in this method, firstly, the highway pavement is cleaned thoroughly, followed by injection of the asphalt mortar into the crack, finally, the surface is thermally protected. Meanwhile, for the unstable crack area, the edge reinforcement treatment must be carried out in advance, to stop the continue expansion of the crack, followed by the deep treatment [6].

###### **4.1.2. Emulsified asphalt slurry seal**

The application of emulsified asphalt slurry seal, has a good effect on the treatment of highway pavement cracks, where the emulsified asphalt is injected into the cracks to allow quick evaporation of water from the cracks.

###### **4.1.3. On site regenerative maintenance method**

For the highway section with a small crack, the best maintenance method is on-site regeneration method, where, the principle of thermal regeneration is applied to carry out the on-site maintenance. If the pavement cracks are serious, and a simple thermal regeneration method could not complete the repair, the maintenance method should be scientifically selected by combination the damage degree of pavement with the base course, and it can be re paved if necessary. It should be noted that, in the maintenance, and

overshoot of highway pavement cracks, one should focus on the drainage system of the subgrade and pavement, to minimize the adverse impact of rainwater on the annual structure of the road.

## **4.2. Maintenance of water damage diseases**

Due to the complex factors that are affecting the damage of the asphalt pavement structure, the prevention of water damage diseases on expressway needs to be performed through the following ways.

### **4.2.1. Scientifically formulate pavement waterproof and drainage scheme**

At present, the common structural form in the construction of many domestic expressways is semi-rigid base structure. Although this structure has dense characteristics, the pavement groove will allow water flow into the pavement. If the water on the surface in the base continues to accumulate, it will further, endanger the safety of the pavement. Therefore, the best way to maintain water damage diseases is to strengthen the waterproof and the drainage system of the pavement.

### **4.2.2. Control the void ratio of asphalt mixture**

Reasonably controlling the void ratio of asphalt mixture, is the best and effective way to minimize the highway diseases of water damage, where it can greatly reduce the possibility of water entering into the asphalt pavement, thereby, avoiding the pavement pits problem,

### **4.2.3. Strengthen the bonding between asphalt and mineral aggregate**

With the continuous development of the asphalt raw material extraction, and bonding method, the incidence of asphalt peeling has decreased significantly. When extracting the asphalt mineral aggregate, it is important to select non hydrophilic alkaline materials with strong bonding performance in the combination with the principle of proximity <sup>[7]</sup>.

### **4.2.4. Strictly control the degree of compaction**

The degree of compaction of highway pavement will have a direct impact on the water seepage of the highway pavement to a great extent, therefore, the compaction process should be carried out strictly according to the national regulations, by establishing construction schemes, and strengthening the control of the construction process.

### **4.2.5. Control the uniformity of asphalt concrete**

When performing the mineral aggregate mixing operation, uneven mixing often occurs, resulting in the reduction of the pavement paving quality, therefore, the construction enterprise should strictly control the mixing uniformity of the asphalt concrete, further, reduce the interference of material and human factors in the mixing process.

### **4.2.6. Timely and reasonably control cracks**

Pavement crack, is a common disease problem of expressway. Once there is a crack in pavement structure, which may lead to the deformation, and uneven settlement of the subgrade structure under the action of rainwater erosion, and vehicle load, therefore, scientific and effective technical means should be taken to manage the problem.

In the practice of asphalt concrete pavement maintenance, the repair scheme should be scientifically selected by integrating the situation of the road disease, with various repair processes in accordance with the principle of 'square repair of round hole, and positive repair of inclined hole.' Few steps are involved in the maintenance process, firstly check the basic condition of the pavement base carefully, next remove

the surface sundries in time, further compact after the painting, and lastly fill the crack surrounding area after the compaction process. The problems of pavement pits and grooves are generally caused by the water on the road area, therefore, the pavement must be kept dry during the repairing process. After being treated with relevant drying equipment, asphalt concrete materials should be paved in time, combined with necessary maintenance measures.

It should be noted that, during the pavement excavation construction, the excavation methods should be adopted, to ensure that the joints of each layer are always maintained in the same section. Further, one should also pay attention to the adhesion control of asphalt pavement, and seal the edges after paving, to prevent the rainwater infiltration, and to reduce the risk of water damage.

For the treatment of the pavement with micro pitted surface disease, thin asphalt brushing, and compaction process can be adopted. If the pitted surface area is large, high consistency of asphalt spraying, and rolling forming process can be adopted [8-14].

### **4.3. Maintenance of the subsidence diseases**

Subsidence disease, is another major disease after highway crack and water damage disease. Meanwhile, settlement disease generally refers to the uneven decline of the subgrade in varying degrees, under the action of external load, resulting in pavement pits and grooves, which has a very bad impact on the driving safety and driving comfort. Therefore, scientific repair treatment should be performed in based on the degree of the pavement damage [8].

If the pavement subsidence and the disease loss are small, it is only necessary to use the spray viscous asphalt method on the settlement surface, followed implement scientific compaction. Whereas, if the road is seriously damaged, the trench repair method should be adopted, and the concrete materials shall be filled and compacted after the pit bottom becomes stable. Additionally, if the highway pavement has a serious subsidence disease, it needs to be completely excavated, followed by treatment with similar rutting disease treatment method. When, the subgrade belongs to the soft soil or cohesive soil, it can be pre-treated by replacing and grouting with highly permeable materials, to ensure that the overall quality of the whole section is not affected by the soft soil subgrade.

### **4.4. Shoulder maintenance**

The road shoulder of a highway often becomes soft, due to the water force, therefore, in the maintenance and repairing of the road shoulder, attention should be given to the treatment of water disasters, to further eliminate the threat of water on the road shoulder. Since the surface of the water is discharged from the road shoulder to the road surface, the cross slope of the road shoulder should be leveled as much as possible, to ensure that the water can be removed on time. During the winter, the road anti-skid materials, and some road maintenance materials should be placed at the designated position with reference to the road shoulder and terrain conditions. For some areas, where the road shoulder is often wet and soft, the best way is to excavate a blind ditch from the inner edge of the road shoulder, to ensure the water infiltrated into the subgrade can be removed on time. Once, the vehicle has an accident in the process of driving, it must immediately accept the inspection at the emergency stop, and repair the pavement on time. This is mainly because the accident vehicles will cause certain pits on the asphalt shoulder, and some vehicles will even leak diesel oil in this area, which will have a negative impact on the asphalt concrete pavement. Over time, the asphalt shoulder of the parking belt, will become more loose, further endangering the stability of the subgrade structure. In the long run, it brings serious negative impact on the safety of parking, therefore, after the subgrade maintenance, the traces left in the parking lot must be handled on time.

#### **4.5. Slope maintenance**

The maintenance of the slope is mainly composed of two aspects, which are cutting and embankment slope. The main purpose of doing this is to keep the highway subgrade stable, and to facilitate people's travelling. Premises which have a certain landscape, the factors affecting the slope include hydrology, geology, and weather, which will pose a threat to the safety of the slope. At present, in the vast majority of highway subgrade, the disasters caused by slope instability include rockfall, collapse, and others. Therefore, while maintaining the subgrade of high-grade highway, one should pay attention to the rock tension on the slope, as long as any conflict with the subgrade condition is found, measures should be taken immediately to solve the issue. In view of the slope collapse, it is necessary to grasp the key points in the process of maintenance. For the parts, where the collapse is not very serious, the method of soil sticking repair, can be used for the slope maintenance. In the case of bench filling, it is necessary to consolidate the soil.

#### **4.6. Define preventive maintenance costs**

The maintenance and the management are required in the process of road operation. The cost spent in the process of maintenance should be detailed about the type of preventive maintenance cost. Further, when calculating the benefits of a road can bring, the cost of maintenance expenditure is necessary to be a part of the total construction cost. When calculating the preventive maintenance cost, it can be controlled by a certain mathematical model. The preventive maintenance cost includes the estimation of the user's measurable cost, and the vehicle cost also includes in the estimation of the cost of tire loss. In the process of road maintenance, vehicles running on the road will cause certain wear and tear on the road, especially large vehicles and vehicles with sufficient power, which will exert heavy pressure on the road during driving. It will exert certain pressure on the road surface and foundation. Exceeding the bearing range of subgrade and pavement will lead to the collapse of road bridges. In the process of facing natural disasters, the road will also cause ground cracks, due to natural hazards such as earthquake. Therefore, it is necessary to clarify the use of road preventive maintenance costs, so as to ensure the improvement of the roads and bridge maintenance <sup>[15-18]</sup>.

#### **5. Conclusion**

In summary, the main reasons for the formation of expressway subgrade and pavement diseases are caused by the external environment, climate change, pavement materials, construction quality, and the drainage system, which can lead in the pavement cracks, water damage diseases, subsidence, and other diseases. According to these disease types, targeted solutions are proposed, and advanced construction technology is further used to improve the maintenance level of expressway subgrade and pavement, and lastly, the cost of the preventive maintenance was also described, to achieve the purpose of scientific and reasonable maintenance.

#### **Disclosure statement**

The author declares no conflict of interest.

#### **References**

- [1] Li R, 2022, Analysis of Typical Diseases and Preventive Maintenance Technology of Expressway Asphalt Pavement. *Sichuan Building Materials*, 48(03): 136-137.
- [2] Liu J, 2022, Performance and Evaluation of Expressway Asphalt Pavement. *Heilongjiang Communications Technology*, 45(02): 26-28.

- [3] Jiang Y, 2022, Discussion on Pavement Diseases of An Expressway. *Anhui Architecture*, 29(01): 172-173.
- [4] Chen H, Shen R, 2022, Analysis on Causes and Maintenance Measures of Common Diseases on Expressway Pavement. *Scientific and Technological Innovation and Application*, 12(01): 123-125.
- [5] Chen X, 2021, Pavement Structure and Disease Prevention Measures at the Entrance and Exit of Expressway Tunnel. *Transportation World*, 2021(36): 16-18.
- [6] Cui K, 2021, Key Points of Research on the Development of Expressway Maintenance Management. *Sichuan Building Materials*, 47(12): 67-68 + 77.
- [7] Li C, 2021, Research on Disease Characteristics and Maintenance Technology of Expressway Subgrade and Pavement. *Transportation World*, 2021(34): 64-65 + 73.
- [8] Li W, 2021, Causes of Expressway Pavement Diseases and Maintenance Construction Technology. *Transportation World*, 2021(33): 89-90.
- [9] He M, 2021, Research on Highway Pavement Maintenance Technology and Management. *Heilongjiang Communications Technology*, 44(11): 153 + 156.
- [10] Peng F, 2021, Maintenance and Construction Management of Early Diseases of Expressway Asphalt Pavement. *Transportation World*, 2021(32): 79-80.
- [11] Shi D, 2021, Typical Diseases and Preventive Maintenance Technology of Expressway Asphalt Pavement. *Transportation World*, 2021(32): 83-84.
- [12] Wang J, 2021, Research on Common Diseases of Highway Pavement and Application of Maintenance Technology. *Home*, 2021(30): 169-170.
- [13] Liu A, 2021, Research on Common Diseases and Maintenance Measures of Expressway Pavement. *Transportation World*, 2021(29): 64-65.
- [14] Zhang J, 2021, Causes of Diseases and Maintenance Measures of Expressway Long Longitudinal Slope Asphalt Pavement. *Smart City*, 7(19): 93-94.
- [15] Song Z, 2021, Typical Diseases and Preventive Maintenance Technology of Expressway Asphalt Pavement. *Engineering Technology Research*, 6(16): 131-132.
- [16] Sun X, 2021, Discussion on Treatment Technology of Slurry Pumping Disease of Expressway Asphalt Pavement. *Northern Transportation*, 2021(08): 52-55.
- [17] Yang J, 2021, Study on Standardization of Expressway Maintenance Construction. *Sichuan Cement*, 2021(08): 260-261.
- [18] Zhang S, 2021, Research on Maintenance Construction of Expressway Pavement. *Smart City*, 7(14): 101-102.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.