Study on the Causes of Highway Pavement Cracks in Desert Environment

Quanxin Chang[1], Yongxiang Wu[2], Honggang Wang[3], Songshan Fan[4]
[1] Ningxia Invest Engineering Construction Managemengt Company, Yinchuan 750011, China
[2] Ningxia Highway Administration Center,Yinchuan 750011, China
[3] CCCC Second Highway Engineering Bureau Co., Ltd, Xi'an 710065, China
[4] Ningria Communications Construction Co., Ltd., Yinchuan 750002, China
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Abstract: According to relevant statistics, more than 90% of domestic high-grade asphalt pavement is semi-rigid base pavement, and semi-rigid base cracking is a congenital stubborn disease and common. In Tengger Desert section of Wuma expressway, the temperature difference is large, and the cracking of temperature shrinkage and dry shrinkage is difficult to avoid, resulting in the decline of pavement structure strength. Once the semi-rigid base is cracked, the asphalt pavement is equivalent to a flexible structure; the residual fatigue strength is greatly reduced; the long-term service performance of pavement structure can not be guaranteed; the durability is poor, the damage layer is deep; the repair is difficult and the cycle is long; maintenance costs are relatively high. This paper analyzes the causes of pavement cracks in the harsh environment in the hinterland of Tengger Desert, and studies its mechanism and treatment scheme.
***Keywords*:** desert pavement, cracks, strength

The construction of highway in desert area set off relatively late in our country, and the construction of desert highway has been explored continuously on the basis of normal section of highway. In recent years, with the continuous development of social economy, the desert highway has been frequently constructed, including many senior highway construction, and investigations of the desert highway are started. In desert highway pavement diseases among them, although we have had some research, there lacks enough analysis on the reasons of cracks of pavements in different desert environment, so it is difficult to meet the needs of actual engineering construction. Based on the survey of highway diseases near Shapotou in Tengger Desert, this paper will carry out the analysis of crack addiction of desert expressway pavement and put forward a reasonable design scheme[1].

1. Field investigation of pavement diseases

1.1 Road survey

In order to analyze the road surface disease in desert environment, analysis was made to find the relationship between desert road disease and terrain. The roads investigated are Line G338 , Line S218 , Dingwu Expressway (G20 fixed edge direction) in Zhongwei City and Line S218 in Inner Mongolia Autonomous Region.

The Line G338 in Ningxia starts from Hongjing, the boundary of Mengning Province, which passes through Yanchi, Hongsibao, Enhe, Zhongning and Zhongwei, and ends at Yingpanshui, the boundary of Ningan Province, with a total length of about 327 km. It is mainly composed of the original provincial highway of Line 304, Enhong Road, Line S201, and on the basis of the numbering adjustment, it is the main east-west highway transport channel in central Ningxia.

The Ningxia section of Dingwu Expressway (G2012) from Yanchi to Zhongning Expressway starts from the east of Yanchi County, Wuzhong City, and connects the completed G20 Qingdao - Yinchuan Expressway Wangwangliang (Ningshaan boundary) to Yinchuan section,which passes through Qingshan, Maizhuang, Hui-Anbao and Hongsibao, and ends at Enhe Town, Zhongning County, Zhongwei City, with a total length of 160.369 km.

The total length of Yingyan highway is 39.7 km, including 11 km in Ningxia, which is an important channel connecting Zhongwei City to Inner Mongolia in the north. It connects Zhongwei City with the photovoltaic industrial zone of Zhongwei City and the Arab League Tengger Industrial Park. It is the longest highway running through the desert in Zhongwei City, and also the tourism avenue leading to Tonghu Tourist area in Zhongwei.

S218 Wuzhong Highway is an important passage connecting Alxa Left Banner to Zhongwei City, which plays an important role in promoting the rapid economic development of Alxa League. The total length of the desert highway is 220 km.

1.2 Analysis of survey results

S218 road diseases are mainly vertical cracks, and cracks are mostly located in the middle of the road.Rutting and transverse cracks are common in K1708~ K1722 section of G338 road. From the actual terrain, S218 is in the desert and G338 is on the edge of the desert. S218 is closer to the heart of the desert.

In the survey section of G338 road, the transverse crack disease accounted for 33%, the longitudinal crack disease accounted for 23.8%, the other road diseases accounted for 4.8%, and the rutting disease accounted for 38.1%. S218 road survey section transverse crack accounted for 25%, longitudinal crack accounted for 41.7%, groove disease accounted for 25%, rut disease accounted for 8.7%, other accounted for 8.7%.

(1) Rutting disease. The results of disease investigation show that the disease phenomenon of asphalt pavement in desert area is serious and universal, among which the instability rut and structural rut are the main types of asphalt pavement rut in desert area.In some areas, abrasive ruts also account for a certain proportion.

A rut is a longitudinal ribbon groove with a depth greater than 10mm at the wheel or rail.The causes of rutting on desert highway are complicated. Oil flash directly reduces the friction between wheels and road surface and the skid resistance of road surface.Rutting and oil spill are usually directly related to the quality, performance and material structure of highway pavement asphalt mixture. Therefore, the occurrence of rutting and oil spill disease is the result of multiple comprehensive factors. According to the different depth of rutting deformation, rutting can be divided into two types: light rutting and heavy rutting. Mild rutting is mainly characterized by shallow deformation, the depth is not more than 25mm; severe rutting is mainly characterized by deep deformation, the depth is greater than 25mm.

Figure 1. Road rutting disease field diagram

Most ruts are caused by instability, depression and lateral displacement of pavement materials under shear stress induced by traffic load. The appearance of such ruts is characterized by the unstable lateral creep displacement of the mixture along both sides of the ruts to form a flange. Usually occurs in the wheel-rail area of a vehicle. When the strength of roller pavement material is not enough to resist the stress imposed by traffic load, especially when heavy vehicles pass at high frequency and the road surface is repeatedly subjected to high frequency heavy load, it is easy to produce such ruts.

The rutting disease of G338 road is obvious, and the rutting disease of K1708~K1722 section is more. And the disease mainly concentrated in the road inside. Heavy trucks drive mainly on the inside of roads.

(2) Crack disease. The special climate conditions in desert area make asphalt pavement need to bear the influence of high temperature, low temperature and large temperature difference.The road grade also has a certain effect on road diseases. G338 National Road is an important traffic artery in central Ningxia, and there are many heavy trucks on the road.

According to G338 statistics, the proportion of the truck and the car in the opposite direction is about 3:1, and the proportion of the truck is larger. The appearance of transverse cracks and vehicle load has a great relationship, so transverse cracks, rutting disease more. S218 road can be seen outside the stone grain, sand grain, etc. The sand and gravel on both sides of the road invade into the outside of the road under the action of the wind. When the car runs on it, it may bring traffic danger due to the change of friction coefficient.

2. Cause analysis of field investigation of Uma high-speed cracks

The cracks generated at the site of Uma expressway show that there are fewer cracks on the 8 standard road surface of Uma Expressway, and more cracks on the 9 standard road surface, and the most serious cracks on the 10 standard road surface. Pavement cracks mostly run through the upper base and the lower layer, and local cracks run through the upper and lower base and the lower layer. The fracture forms are mainly transverse cracks, and the longitudinal cracks, cracks and mesh cracks are rarely seen or not found. The structural damage caused by rolling of transport vehicles can be excluded.

The found cracks basically run through the upper and lower levels, and most of them occur in the desert section 9 and

10. They are temperature shrinkage cracks at the base level caused by the large temperature difference between day and night in the desert. The cracks are reflected from the base to the asphalt surface and produce transverse cracks. In addition, the semi-rigid base of cement-stabilized gravel itself will also produce cracks and reflect to the asphalt surface due to dry shrinkage. Therefore, when considering the structure of desert highway asphalt pavement, it is necessary to consider the structure of blocking or slowing down the reflection cracks of the semi-rigid base.section.

Figure 2. Crack running up to down

3. Study on the treatment measures of Uma high-speed cracks

The following measures are put forward to prevent the crack of asphalt pavement in desert expressway:

(1) By controlling the three indicators of asphalt, selecting asphalt with excellent performance and good low temperature sensitivity based on reasonable grading and advanced construction technology, the low temperature crack resistance of pavement can be improved.

(2) When the dry shrinkage crack of semi-rigid base of cement-stabilized macgravel is nearly complete, laying asphalt surface layer can reduce the reflection crack caused by dry shrinkage.

(3) The asphalt mixture design is scientific and reasonable, and the skeleton dense asphalt mixture is used as far as possible to strictly control the construction quality, mainly controlling the compactness and rolling temperature of the mixture.

(4) A structure is set between the semi-rigid base and the surface layer to block or slow down the reflection crack of the semi-rigid base.

4. Asphalt pavement structure design

According to the climate of Tenger desert, local stone materials and the field investigation of Uma Highway, the primary objective of solving the reflection cracks of dry rigid base of desert asphalt pavement is to put forward the pavement structure of the matter as shown in Table 1.

Table 1. Research scheme of pavement structure combination

Design scheme	Large crushed stone asphalt mixture flexible base pavement
Pavement structure	4cmAC-13C 6cmAC-20C 10cm macadam asphalt mixture -- 25 flexible base 36cm cement stabilized macadam base 16cm cement stabilized macadam base
The total thickness(cm)	72

5. Conclusion

After field research, under the influence of temperature difference and stress change, pavement crack is mainly temperature crack and stress reflection crack. The use of larger aggregate can reduce the occurrence of cracks, and the modified design scheme has played an effective role in improving the occurrence of cracks.

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