

Analysis of early rutting disease at urban road intersection

Xiubo Kuang¹, Fei Yang^{2, *}, Jiancun Fu², Fangtao Liu²

¹ Jiaozhou Transportation Bureau, Qingdao, China

² Shandong Transportation Institute, Jinan, China

*Corresponding Author Email: yangfei@sdjtky.cn

Abstract. Because of the special stress characteristics and location of Urban Road intersection, the proportion of early rutting disease is larger than that of ordinary road section. In order to solve the early rutting problem of intersection, this paper analyzes the causes of rutting road conditions based on the actual project, through the verification of raw materials and mix proportion.

Keywords: Intersection; Rutting; Early disease; Urban Rd.

1. Introduction

With the rapid development of transportation, the channelization of vehicle traffic and the increase of axle load, the rutting deformation is more and more serious, especially near the urban road intersection, due to the frequent vehicle braking (starting), the rutting, bag holding and other damage phenomenon is more serious.

The formation of rutting and other diseases at intersections will not only lead to the reduction of road surface water and local pavement thickness, but also lead to the generation and aggravation of other forms of pavement damage. At the same time, it will directly affect the comfort and safety of driving. The test shows that when the rut deformation of road surface exceeds 6 mm, the water drift phenomenon will occur when driving in rainy days, which seriously affects the driving safety. According to the investigation of road conditions, the rutting of asphalt pavement at urban road intersections is mainly instability rutting, that is, the plastic shear flow caused by the shear failure of asphalt concrete surface. Based on the actual project, this paper investigates the early rutting disease of Urban Road intersection, and analyzes the causes through experiments.

2. Investigation and sample analysis

One year after a project was put into normal operation, different degrees of rutting and other diseases appeared at the intersection of two sections. The rutting depth of section A is about 6cm, and the rutting section is about 100m; The rutting depth of section B is about 2cm, and the rutting section is about 60m long. No rutting is found in the normal driving section. The research group drilled core samples from the bottom, uplift and normal parts of the rutting groove near the rutting disease parts. The comparison of the samples of the same section is shown in Figure 1.

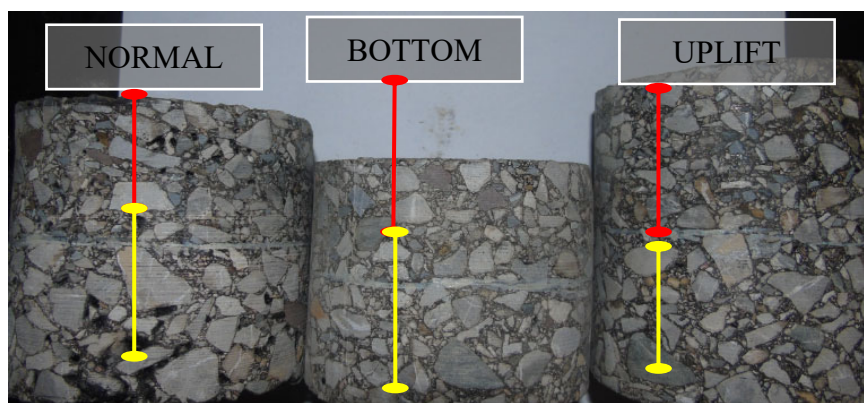


Figure 1. Comparison of samples of the same section

It can be seen from the figure that the thickness difference between the bottom of rutting position and the bulge is very obvious. After the core samples of two sections are measured layer by layer, the thickness of each layer of mixture is summarized in Table 1.

Table 1. Comparison of samples in the same section

	position	Normal position	Rutting bottom	Rutting uplift
Section A	Thickness of SMA-13 (mm)	35	36	37
	Thickness of AC-10 (mm)	30	24	/
	Thickness of AC-20 (mm)	42	40	/
Section B	Thickness of AC-13 (mm)	40	33	55
	Thickness of AC-20 (mm)	55	44	63

It can be seen from the table that except SMA-13 mixture, all structural layers have different degrees of deformation. The deformation of core sample drilled in section A mainly occurs in AC-10 structural layer, and the uplift has been dispersed.

3. Mix proportion and mixture performance evaluation

3.1 Investigation of raw materials

Table 2. raw material test parameters

Type of mixture	Aggregate			asphalt		
	lithology	Crushing value	Needle sheet content	type	softening point	Penetration
AC-13	limestone	17.4%	10.5%	70#	47.0	70
AC-20	limestone	17.4%	10.5%	70#	47.0	70
SMA-13	limestone	17.4%	10.5%	SBS	61.5	50
reference value	/	≤26	≤15	/	47/68°C	70/52

Note: the "reference value" in the table is based on the average test results of Shuanglong asphalt in South Korea in recent two years.

Through consulting the self inspection data of the client, the data show that all aggregates and asphalt used can meet the technical specification for asphalt pavement construction (JTG F30-2004) and design requirements. The softening point of some SBS asphalt is only 61.5 °C, which is close to the lower limit of the specification and lower than the reference value (68 °C).

3.2 Review of mix proportion design

Through consulting the self inspection data of the client, the data shows that the designed mix proportion gradation meets the requirements of specification scope and design scope in technical specification for asphalt pavement construction (JTG F40-2004).

However, the design value of 2.36mm to 13.2mm mesh passing rate of AC-20 mixture exceeds the lower limit of Engineering gradation, and the 0.075mm mesh passing rate is 5.9%, which is close to the upper limit of Engineering gradation. There is a certain degree of difference between the design and the typical gradation in the region, and the high powder binder ratio leads to a certain decline in the high temperature rutting resistance of the mixture. The 0.075mm mesh passing rate of SMA-13 asphalt mixture is close to the lower limit of the specification, which is lower than 10% of the conventional design value. It is not conducive to the formation of asphalt mastic and has a certain impact on the durability of the mixture.

Through the analysis and test of core gradation and asphalt aggregate ratio, the results show that AC-13, AC-20 and SMA-13 gradations are within the specification range. However, the passing rate of 9.5mm and 2.36mm key sieve of AC-20 mixture is close to the engineering allowable deviation requirements, and there is a certain degree of fluctuation in the mixture production process. The

measured passing rate of AC-20 mixture at 0.075mm is 6%, which is slightly higher than the design value, and it is the upper limit of Engineering gradation, which is not conducive to the improvement of high temperature performance.

4. Cause analysis of rutting

4.1 Significant influence of driving speed on pavement structure stress

Through the dynamic modulus test, it is found that the load frequency increases linearly with the increase of driving speed, and the load frequency at the depth of 2.5cm is about 2.5 times that of 20km / h for vehicles running at 60km / h; The measured dynamic modulus increases gradually with the increase of driving speed. The measured dynamic modulus of vehicles running at 60 km / h is about 1.4 times of that of vehicles running at 20 km / h.

The measured dynamic modulus increases with the increase of vehicle speed, resulting in the decrease of road surface deflection and tensile strain at the bottom of asphalt layer; Under the same conditions, when the driving speed increases from 10km / h to 120km / h, the surface deflection and tensile strain of asphalt layer decrease by 22% and 32% respectively in summer, and 11% and 31% respectively in winter. That is to say, under the same temperature environment and vehicle load conditions, the speed of heavy vehicles on the uphill section is generally 10 ~ 20km / h. compared with the design running speed (60km / h), the deflection of road surface and the tensile strain of asphalt layer bottom increase by 24% and 37% respectively.

4.2 Influence of material design parameters on structural layer function

(1) The asphalt surface of section a of the project is the traditional dense graded AC-13 asphalt concrete. Its dense structure has the characteristics of impermeability and good durability, but its suspension dense structure reduces the thermal stability. At the same time, the binder used in the asphalt mixture of the two sections is No. 70 base asphalt. In summer and daytime, the pavement temperature is easy to reach the asphalt softening point (about 46.5 °C), which leads to the softening of the structural layer. Under the action of traffic load, the bearing layer is easy to produce rutting.

(2) When the passing rate of 0.075mm is about 7%, the mixture with high powder binder ratio is easy to produce rutting under the continuous rolling of vehicles.

(3) Unreasonable selection and design of surface layer stone and asphalt will affect the bearing capacity of structural layer. Through indoor tests, it is found that the order of high temperature resistance of different stone and asphalt combination is basalt + SBS > limestone + SBS > basalt + 70 # > limestone + 70 #.

4.3 The influence of the functional transformation of the upper layer of the old pavement on the stress of the pavement structure

The overlay scheme of medium repair in test section B is to pave 4cm SMA-13 structure layer directly on the old pavement, at this time, the upper layer of the old pavement changes from the original wearing layer with insignificant shear stress to the bearing layer with large shear stress. However, the fine-grained asphalt mixture is used in the upper layer of the old road, which has lower shear strength than the coarse-grained asphalt mixture designed in the conventional medium layer, and the probability of early shear failure increases under the action of heavy load and overload vehicles.

5. Conclusion

Through the investigation and analysis, it is found that there are ruts only at the intersection of this section. Combined with the above analysis, the conclusions are as follows:

(1) The driving speed will increase the stress state of the road, the vehicle at the intersection will be stationary for a long time, and the effect of vehicle load on the road is greater than that of the normal driving section. Therefore, the intersection is more prone to rutting than the normal position.

In similar projects, it is found that rut disease occurs when conventional design schemes are adopted at level crossing. The rutting disease of level crossing is a common problem in the same area of the country. The design scheme of conventional old road overlay or medium surface course with matrix asphalt has little effect on solving the rutting disease of intersection.

(2) The type of asphalt mixture and the type of raw materials have a certain influence on the pavement deformation, that is, the high strength rock, modified asphalt and the dense skeleton asphalt mixture are beneficial to bear the vehicle load. The crushing value of limestone used in AC-13 and AC-20 coarse aggregate of section A in this project is higher than that of basalt, And the asphalt binder of section A and section B are matrix asphalt, this material and structure is not conducive to improve the occurrence of rutting disease at level crossing.

(3) In this project, section B is simply overlaid. The upper layer of the old road is used as the bearing layer, which has lower shear strength than the coarse-grained asphalt mixture designed by the conventional medium layer, and the probability of rutting disease will be further increased.

References

- [1] Song Liwei, LV Shaofang. Causes of early damage of urban roads and preventive maintenance measures [J]. Urban and rural construction, 2008 (05): 66-67.
- [2] Wang Baolin. Field investigation and numerical simulation of rutting deformation of urban asphalt pavement [D]. Zhejiang University of technology.
- [3] Analysis of urban road rutting causes and prevention measures [J]. Building materials development orientation (Part 1), 2019, 17 (9).
- [4] Xu Wei, Zhang Xiaoning, Han Dajian. Analysis of early rutting disease investigation and treatment test of Expressway [J]. Highway, 2004, 000 (003): 113-117.
- [5] Lu Weiwei. Cause analysis and treatment suggestions of early rutting disease on an expressway [J]. Highway and automobile transportation, 2014, 000 (004): 145-147.