

Primary causes and treatment countermeasures of damages of pavement in Wuhan: A field investigation

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Abstract: At present, pavement in Wuhan is experiencing higher than anticipated rates of damages. Inspection of appearance evaluation, drilling core, deflection, flatness, rutting and tectonic depth is investigated to find the primary causes and treatment countermeasures of damages of asphalt pavement in Wuhan. It is found that vehicle overloading, maintenance period, insufficient compaction, increase of traffic load and differences in material properties of manhole cause the damages of asphalt pavement in Wuhan. The countermeasures include continuous reinforced pavement, double-surface layer and the use of black steel fiber.

1. Introduction

In order to understand the major urban road problems in Wuhan, analyze the outstanding problems existing in the current road and summarize existing experiences, this article mainly investigates three aspects of road cracking, intersections and road inspection wells. Based on this research, we fully understand the current situation, comprehensively evaluate the quality, analyze the main reasons and give recommendations for treatment of urban roads in Wuhan. The section of the survey is "Three Rings and 13 Shots" and 8 main urban roads in Wuhan. The "Three Rings" includes the first ring, the second ring and the third ring, all of which are expressways. The "Thirteen shots" are 13 rapid radiations, all out of the direction of the city. The 8 main roads are located in the central area of Wuhan, the development around the road is mature, and most of the roads along the route are important business districts and residential areas.

2. Research plan and test results

In order to understand the major urban road problems, analyze the outstanding problems existing in the current road use process and summarize existing experiences, this paper conducts a comprehensive survey of road conditions through the investigation of appearance inspection, core drilling, deflection, flatness, rutting and structural depth.

In this paper, the quality of roads in Hankou, Wuchang, and Hanyang districts was investigated. Combined with the road test report of the road reconstruction project, the average estimated road surface breakage rate was approximately 4.10%.

The comprehensive evaluation index (PQI) of the road surface includes: road surface driving quality index (RQI) and road surface condition index (PCI).



According to the results of quality inspection on the road surface of city roads in 2017, there are many road surface diseases, which are generally manifested as: line cracks, network cracks, ruts, repair damage and inspection well subsidence.

The extreme diseases mainly include deep sinking of inspection wells and deep rutting, as shown in Figure 1 and Figure 2.



Figure 1. Inspection well subsidence



Figure 2. Intersection Rutting

Table 1~3 lists the drilling and coring data statistics, deflection data statistics, flatness status and assessment.

Table 1. drilling and coring data statistics

average thickness of asphalt(cm)	average thickness of concrete(cm)	average thickness of cement stability(cm)	damage rate(%)
20.21	23.76	17.94	16.32

Table 2. deflection data statistics

average deflection value(cm)	average cell structure depth(cm)	average represents the rut(cm)
20.21	23.76	17.94

Table 3. flatness status and assessment

Represent of IRI(m/km)	average RQI	average PCI	Overview
5.64	3.42	83.88	poor flatness

3. Cause Analysis

3.1. Causes of pavement cracking

- Heavy cargo road overload is serious. After axle loading tests on several typical heavy-duty traffic roads in Wuhan, it was found that the proportion of over-limit trucks reached 52%, and the overload of the vehicle reached the maximum of 460% of the approved load [1]. According to the axle load conversion formula of the road design specification, the cumulative equivalent standard axle load of a road for one day will reach the standard of 20 years of heavy traffic load rating.
- Most urban roads enter the cycle of major repairs. Since the reform of blackening in Wuhan in 2003, asphalt pavements have gradually entered the period of major repairs, and road surface performance has led to an increase in road surface damage.

- Maintenance management needs further improvement. The first one is that maintenance is not timely, according to the results of the investigation, the early diseases such as cracks and looseness appear on the road surface. Because the road surface was not repaired in time, the rain and water infiltrated the base layer and roadbed, causing serious damage such as subsidence, pits, cracks and severe concrete cracking. The second is that the maintenance quality management is still insufficient. For example, the inadequate repair quality of some roads, such as Wuhan Avenue and Gongzheng Road, causes insufficient smoothness and secondary damage.
- Key project construction accelerates damage to roads around the site. In recent years, Wuhan's urban viaducts, subways and other key projects require tunnel occupation, the temporary pioneer roads overloaded with major urban traffic flow. As a result, the road around the site was damaged.

3.2. Cause of intersection rut

Rut is a common disease of asphalt pavement. The rut is a groove-shaped permanent deformation caused by the repeated action of the vehicle load under certain environmental conditions, especially in the hot season [2].

Wuhan is hot and rainy in the summer and lasts for a long period of time. This is a period of high incidence of rutting and pit problems. The study found that the intersections in Wuhan are mainly mobile vehicles due to the influence of high temperatures in summer. Under high temperature conditions, the wheel rolling acts repeatedly, as a result, the load stress exceeds the stability limit of the asphalt mixture and the flow deformation accumulates to form a rut. On the one hand, this type of rut is recessed, on the other hand, the sides of the lane where the wheels are less active raise up. In addition, there is a noticeable outward push at the bend, and the lane line or stop line may therefore be a deformed curve. Once the rut depth exceeds 15mm, it will not only lead to pavement water, structure thinning, cracking, directly affecting driving comfort and safety, but also affect the durability of the pavement structure.

3.3. Causes of road inspection well damage

The survey statistics of typical roads in Wuhan can be seen in Table 6. The analysis finds that the problem of inspection well subsidence is a major problem in inspection wells in various industries of motor vehicle lanes and non-motor vehicle lanes. Among them, the damage caused by subsidence problems is the most prominent. The problems of damage and subsidence in wells do not occur separately, but interact and concomitantly occur. In the vast majority of cases, the occurrence of well damage is caused by the sinking problems of the inspection well itself [3-4]. At present, most of the problems of the inspection well damage are insufficient strength of the brick wellhead, insufficient backfill compaction at the inspection well, poor bearing capacity of the foundation, increased traffic load and traffic flow, unreasonable position of the inspection well, etc.

In addition, there are great differences in the materials and types of manhole covers selected by the inspection wells in the pipeline industry, and the well cover identification industry is not uniform, so it is not good for beauty and management.

Table 4. Statistics of damage types of inspection wells in various industries on motor vehicle lanes (Units: Percentage)

Industry	Total	Missing	Subsidence (>20mm)	Inspection well damage	oblique	Unmatched wells and covers	Cover damage	Intact
Water supply	69	—	16/(23.2%)	45/(65.2%)	1/(1.4%)	1/(1.4%)	1/(1.4%)	22/(31.9%)
Drain	311	—	67/(21.5%)	277/(89.1%)	2/(0.6%)	4/(1.2%)	6/(1.8%)	23/(7.4%)
Electricit y	1	—	—	1/(100%)	—	—	—	—

Telecom municati ons	7	—	2/(28.6%)	5/(71.4%)	—	—	—	2/(28.6%)
Gas	17	1/(5.9%)	6/(35.3%)	13/(76.5%)	—	—	—	3/(17.6%)
Traffic managem ent	10	—	2/(20.0%)	7/(70.0%)	—	—	—	1/(10.0%)
Total	415	1/(0.2%)	93/(22.4%)	348/(83.9%)	3/(0.7%)	5/(1.2%)	7/(1.6%)	51/(12.2%)

Note: "-" indicates that the inspection well of this industry has not occurred in this form of damage

4. Treatment measures

4.1. Road cracking treatment measures

Continuously-reinforced pavement or double-reinforced concrete pavement should be installed on heavy-duty traffic sections[5-6]. The structure of continuous reinforcing pavement is in the form of the shattered petrochemical present road plus plain concrete plus asphalt concrete insulation plus continuous reinforcement concrete surface, the program offers high ride comfort and maintains flatness even after partial concrete cracks. Double-layer reinforced concrete pavement structure scheme: shattered petrochemical present road plus cement stabilized gravel leveling layer plus thin slurry sealing layer plus double-layer reinforced concrete surface layer. This kind of pavement has strong adaptability to the development of long-term traffic, and it also has high ride comfort.

4.2. Intersection rut treatment measures

The existing asphalt pavement in Wuhan is mainly the new road and the original concrete pavement plus asphalt surface layer structure, some serious problems such as ruts, crowding, cracking, etc. occur on the road surface of some road intersections. Aiming at the quality problems of asphalt pavement intersections in Wuhan, two-layer modified pavement-based treatment measures are proposed:

Considering that the maximum shear stress on asphalt pavement generally occurs at 4~10cm below the road surface, it is recommended to use double-layer modified asphalt anti-rutting pavement structure on the road surface and middle surface layer, it could improve the anti-rutting performance of the road surface. For existing roads, when the intersection rut depth is greater than or equal to 25mm, it should firstly mill the upper and middle surface of the original pavement, and then add anti-rutting pavement structure, the grass-roots level and soil base are processed separately according to actual conditions. Prior to the implementation of the road reconstruction project, the road condition investigation and core drilling sampling shall be performed on the rutting road section in order to analyze the cause of rutting disease and delineate the scope of the intersection [7].

For newly-built roads, the pavement structure in a certain area of the intersection should be raised to meet a higher standard than the ordinary road section, and two-layer modified asphalt anti-rutting pavement structure should be adopted on road surface and middle surface layer.

4.3. Road inspection well damage treatment measures

- Well covers should be selected to meet the requirements for load carrying capacity and deformation. Cast iron inspection wells are superior to other materials in terms of bearing capacity and deformation resistance, so cast iron inspection cover is recommended [8-9].
- The inspection cover should be fixed on the prefabricated well beam to prevent the cover from sliding and sinking.
- Black fiber-reinforced concrete could be used as a filling material around the well to balance strength and color.

5. Summary

- By investigating the pavement quality of several trunk roads in Wuhan, it was concluded that the main diseases were cracking, intersection rutting, and destruction of inspection wells..
- The reasons for cracking's formation include heavy traffic, roads entering major repair cycles, poor maintenance and management, and key projects speeding up the damage of surrounding roads. For newly built roads and renovation projects with heavy traffic, overloaded road sections and poor road conditions, continuous reinforcement pavement or double-reinforced concrete pavement can be installed to prevent pavement cracks.
- The main reason leading to the rutting is that the high temperature stability of asphalt pavement materials is insufficient. Aimed at Wuhan urban road asphalt pavement, it was proposed to apply two-layer modified pavement-based treatment measures.
- Aimed at inspection well subsidence damage, the first solution is to use qualified manhole covers that meet the requirements for carrying capacity and deformation. The other is to fix inspection manhole covers on prefabricated well beams to prevent sliding and sinking of manhole covers. Third, it is recommended that black steel fiber concrete be used as the filling material around the well.

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