Research and Analysis of Disease Characteristics of Road Inspection Wells in Soft Soil Areas

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Abstract. Inspection well diseases are relatively common in soft soil areas. In response to the problem of road inspection well diseases in soft soil areas, a disease index system was established through systematic research, and the characteristics of road inspection well diseases in soft soil areas were analyzed based on the index system. The diseases of road inspection wells in soft soil areas were elaborated, and it was pointed out that the main types of well cover diseases were caused by poor road frame and cover frame. Based on factors such as materials, design, construction, and usage, this study systematically reveals the mechanisms of defects such as the strength of manhole cover materials, the connection between rigid structure inspection wells and flexible road surfaces, and the vertical pressure and horizontal shear forces that the road surface around the well must withstand during use. Targeted suggestions are proposed to ensure the quality of manhole covers and seats, strengthen construction quality control, and ensure the compactness of backfill soil around the well. The relevant research conclusions have reference value and guidance for the prevention and control of road inspection well diseases in soft soil areas.

Keywords: Soft soil areas; Road inspection well; Disease characteristics; Indicator system.

1 Introduction

Inspection well diseases are relatively common in major cities across the country, especially in soft soil areas. Wu (2018) conducted a survey on typical road inspection wells in Wuhan, and found that the most prominent damage was around the well, followed by subsidence greater than 20mm [1]. Zhao (2021) analyzed and studied the disease characteristics of inspection wells under vehicle loads by establishing numerical simulation models of mechanical response of inspection wells and road surfaces [2]. Wang (2007) established a finite element model analysis of inspection wells for typical road sections, calculated the stress on the mortar cushion layer below the well seat, and analyzed the reasons for the settlement of inspection wells [3]. Chen et al. (2016) established a numerical analysis model using finite element software and simulated that the combination of self-adjusting manhole covers and anti-settlement cover plate had

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the best anti settlement effect among the four combinations [4]. Bao (2013) proposed that the diseases of inspection wells are largely due to the insufficient compactness of the backfill material around the well [5]. The above has played a positive role in the diagnosis and treatment of road inspection well diseases. However, Research about inspection well diseases in soft soil areas are rarely seen [6-9], especial the disease index system is neglected in previous works. With the refinement of urban road operation and maintenance management, it is necessary to conduct more in-depth research on the characteristics of road inspection well diseases in soft soil areas to promote the safe operation and maintenance of urban roads and improve long-term service performance. Therefore, it is necessary to conduct research and analysis on the characteristics of road inspection well diseases in soft soil areas, which is aimed to propose a disease index system and enhance the disease control. And this work also has important practical value and practical significance.

2 Indicator Construction

2.1 Mythology

The research method for inspecting manhole cover diseases is a comprehensive process that involves multiple aspects, including observation of disease phenomena, analysis of causes, data collection, experimental verification, and formulation of prevention and control measures. Due to the extensive accumulation of relevant data in the early stage of the studied city, this project mainly focuses on research, interviews, and data collection.

2.2 Types of Diseases

(a) Road frame difference

(b) Cover frame difference

(c) Damage around the well

(d) Defects in the well cover

Fig. 1. Common inspection well covers diseases

According to national, industry, and local regulations, it can be found that the existing road inspection well cover diseases are mainly manifested on the well covers. After analysis, the road inspection well cover diseases could be mainly classified into four types: first, the difference between the road frame, which is the height difference between the road surface and the well frame; second, the difference between the cover frame, which is the height difference between the well frame and the well cover; third, the damage to the road surface around the well, which is cracks, subsidence, pits, bulges, fractures, looseness, etc. within a range of 1 meter outward from the edge of the well cover; fourth, the defect of the well cover, which is the lack, rupture, gap, etc. of the inspection well cover. The typical road inspection well cover diseases are indicated in Fig.1.

2.3 Evaluation Indexes

In order to accurately evaluate the impact of road inspection well cover diseases on road surface quality and safe passage, road inspection well diseases are classified into four levels: minor diseases, ordinary diseases, serious diseases, and dangerous diseases, as shown in Table 1.

Table 1. Evaluation indicators for road inspection well cover diseases

Type / Indexes	minor	common	serious	dangerous
The height difference between the road and frame(h_1)	$5 \le h_1 < 15$mm	$15 \le h_1 < 30$mm	$30 \le h_1 < 50$mm	$h_1 \ge 50$mm
The height difference between the cover and frame(h_2)	$5 \le h_2 < 15$mm	$15 \le h_2 < 30$mm	$30 \le h_2 < 50$mm	$h_2 \ge 50$mm
Defect around the well	/	/	/	damaged manhole cover
Damage to the road surface around the well	The crack width is less than 1.5mm.	The crack width is between 1.5mm and 3mm.	The main crack has a width greater than 10mm and a length greater than 5m.	The plate is divided into three or more pieces by cracks.

3 Analysis of Disease Characteristics

Based on key content such as disease type identification, cause analysis, and spatiotemporal distribution characteristics, through on-site investigation, conference discussions, and online questionnaires, the collected data was sorted, classified, and statistically analyzed. Finally, the partial well conditions of 498 roads in 9 districts including Xuhui District, Huangpu District, Jing'an District, Changning District, Yangpu District, Hongkou District, Baoshan District Pudong New Area, Baoshan District, and Minhang District in Shanghai were completed. About 4223 manhole cover diseases were found during inspection, and corresponding analysis was carried out.

3.1 Type Characteristics

Classification and statistics were conducted on 4223 manhole cover diseases, and the results showed that there were 2688 road frame differences, accounting for 63.7%; There are 809 differences in the cover frame, accounting for 19.1%; 629 damaged road surfaces around the well, accounting for 14.9%; 97 manhole covers were damaged, accounting for 2.3%, as shown in the distribution chart of the proportion of manhole cover diseases in Fig. 2.

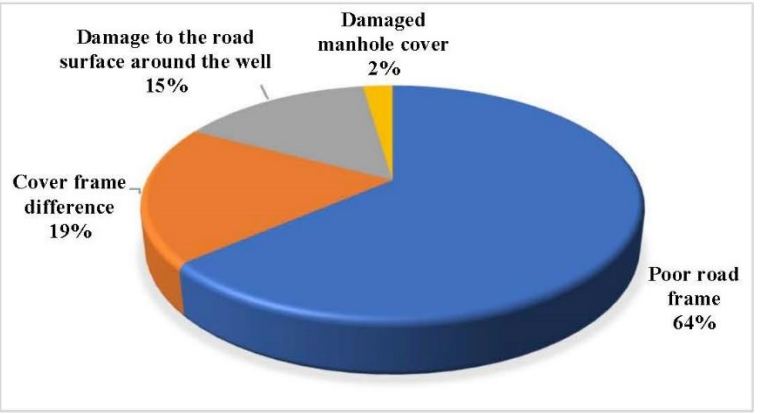

Fig. 2. Proportion distribution of various manhole cover diseases

As shown in Fig. 2, the proportion of road frame defects is as high as 63.7%, which is close to two-thirds of the total number of defects, and is the main component of manhole cover defects. The second is the difference in cover frame, accounting for 19.1% of the total number of diseases, and the sum of the two reaches 82.8%. In summary, the main types of manhole cover diseases are poor road frame and poor cover frame.

3.2 Characteristics of Road Frame Defects

According to the evaluation criteria in section 2.2, extract data on road frame defects and classify them, forming Table 2 as follows.

Table 2. Distribution of road frame defects and height difference

Height difference of road frame h_l (mm)	$5 \le h_l < 15$	$15 \le h_l < 30$	$30 \le h_l < 50$	$h_l \ge 50$
Disease severity	minor	common	serious	dangerous
Proportion of road frame defects	0.7%	68.7%	24.7%	5.9%
Proportion of total damage to manhole covers	0.44%	43.76%	15.73%	3.76%

As shown in Table 2, common diseases with a height difference between 15mm and 30mm account for the highest proportion of road frame defects, reaching 68.7%, which has a significant impact on road smoothness. At the same time, they also account for 43.76% of the total number of manhole cover defects, indicating that common diseases caused by road frame defects are quite common; Serious diseases with a height difference between 30mm and 50mm account for 24.7% of the road frame defects, which have a certain impact on driving safety.

At the same time, the total proportion of manhole cover defects reached 15.73%, indicating that serious diseases caused by road frame defects also account for a relatively large proportion; The proportion of dangerous diseases with a height difference more than 50mm reached 5.9%, accounting for 3.76% of the total number of manhole cover diseases. This type of disease is particularly serious and has a significant impact on road traffic, posing serious safety hazards that require immediate attention and measures to be taken. From the above, it can be seen that in addition to minor diseases accounting for 0.7%, the actual proportion of common diseases, serious diseases, and dangerous diseases in the road frame difference is as high as 99.3%, indicating that road frame difference is the largest component of inspection well diseases and accounts for a large proportion, which is consistent with the overall characteristic analysis mentioned above.

3.3 Characteristics of Well Cover and Frame Defects

Similarly, using the evaluation index of 2.1, the data of cover frame defects were extracted and classified to obtain Table 3.

Table 3. Distribution of well cover frame defects

Height difference of well cover and frame h_2 (mm)	$5 \le h_2 < 15$	$15 \le h_2 < 30$	$30 \le h_2 < 50$	$h_2 \ge 50$
Disease severity	minor	common	serious	dangerous
Proportion of well cover and frame defects	2.9%	75.2%	17.9%	4.0%
Proportion of total damage to manhole covers	0.55%	14.36%	3.42%	0.76%

As shown in Table 3, only 2.9% of minor diseases with a height difference between 5mm and 15mm, and 97.1% of diseases with a height difference larger than 15mm. The proportion of diseases with a height difference between 15mm and 30mm is 75.2%, which affects the smooth flow of roads; Height difference between 30mm and 50mm is a relatively serious disease, accounting for 17.9%, which will have a certain impact on driving safety; The proportion of diseases with a height difference of $h \ge 50$mm reached 4.0%, accounting for 0.76% of the total number of manhole cover diseases, which is a particularly serious disease and poses a serious safety hazard to road traffic. It can be seen that ordinary diseases account for the highest proportion of cover frame defects, and the manhole cover defects caused by cover frame defects are second only

to road frame defects, which is consistent with the overall characteristic analysis mentioned above.

4 Mechanism of Diseases in Wells

Through the above analysis, it can be concluded that the basic manifestation of the height difference disease of manhole covers is the settlement of manhole covers, which is mainly caused by the common use of brick masonry or concrete prefabrication for inspection well walls, and the installation of manhole cover supports with cement mortar on the upper seat. Compared to the surrounding road surface, the inspection well has different stiffness and strength. At the same time, in road engineering construction, the connection between rigid structure inspection wells and flexible pavement is ignored, which can easily lead to settlement and tilting of inspection wells. Again, the insufficient compaction of backfill soil and road surface around the well, as well as the fact that the road surface around the well mainly bears vertical pressure and horizontal shear force when vehicles pass by, have all led to the occurrence of road inspection well diseases.

5 Suggestions of Diseases Control

1) Ensure the quality of the manhole cover. In actual road engineering construction, emphasis should be placed on strengthening the quality control of manhole covers and seats, and manhole cover products should be strictly selected according to design and specification requirements.

2) Strengthen construction quality control. Before masonry, check the integrity and strength of the bottom cushion layer pouring, and increase the maintenance and upkeep of the well on a daily basis.

3) Ensure the compactness of backfill soil around the well. Firstly, it is necessary to control the quality of the selected gravel, and secondly, it cannot be constructed to the top elevation at once to ensure the uniformity and compaction degree of the overall compaction.

6 Conclusion

A disease index system was proposed after the systematic investigation was conducted. To overcome the road inspection well diseases in soft soil areas, this index system serves as landmark for the guide to disease prevention. The following main conclusions were drawn:

1) The common diseases mainly include poor road frame, poor cover frame, damaged road surface around the well, and damaged manhole cover. Among them, poor road frame and cover frame diseases are the main types of manhole cover diseases.

2) By combining materials, design, construction, and usage, the mechanism of manhole cover diseases such as the strength of manhole cover materials, the connection

between rigid structure inspection wells and flexible pavement, and the vertical pressure and horizontal shear force that the pavement around the well must withstand during use have been systematically revealed.

3) Based on research and analysis, reasonable suggestions have been proposed to ensure the quality of manhole covers and seats, strengthen construction quality control, and ensure the compactness of backfill soil around the well.

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