A STUDY OF PENETRATION RESISTANCE VALUE AT LOOSE AREA UNDER THE CAVITY: EXPANSION PROCESS OF SUB-SURFACE CAVITY

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1. INTRODUCTION

A collaboration among Fujisawa city, IIS Univ. of Tokyo and GEO SEARCH address the countermeasure against road cave-in through various approaches in Fujisawa city since April 2017. Road cave-in causes traffic accidents / disturbances, especially in emergency situations. The purpose of this collaborative study is to investigate the mechanism of cavity formation and expansion. Thus, the study is important in maintaining road function safety. The study includes the monitoring surveys of sub-surface cavity using GPR (Ground Penetrating Radar) every 6 months, the detailed investigation of subsurface cavity, and regional evaluation based on the result of the surveys. As a part of the study, some of surveyed cavities were observed in detail by open-cut method. This paper describes the expansion process of sub-surface cavities.

2. PURPOSE AND METHODS OF PENETRATION RESISTANCE TEST OF GROUND BELOW THE CAVITY

Because there are various mechanisms of cave-in formation, an identification of the cause of the sub-surface cavity is essential for reliable repair. In this study, the factors of cavity formation and the ground conditions were investigated in detail at ten cavity-locations.

Figure1: Portable cone penetration test

After removing the pavement, digging up to the top of the cavity and measuring the size of cavity, the value of penetration resistance of the ground below the cavity was measured by a portable cone penetrometer (Fig. 1). The ground condition below the cavity is one of valuable information that shows the expansion process of the cavity. And the reason for using a portable cone penetrometer is that it is easy to understand the ground conditions accurately. Next, based on the result of the penetration test, the ground was further dug down to the point where the cavity originally generated. During the digging, the condition of the ground was carefully observed. After the causes of cavity were identified, repair works were carried out. In this study, all of ten cavities that investigated in detail were located in a sand layer by washing out due to damaged sewage pipes - cracked or broken (Fig.2). However there were differences in ground conditions such as the presence of groundwater.

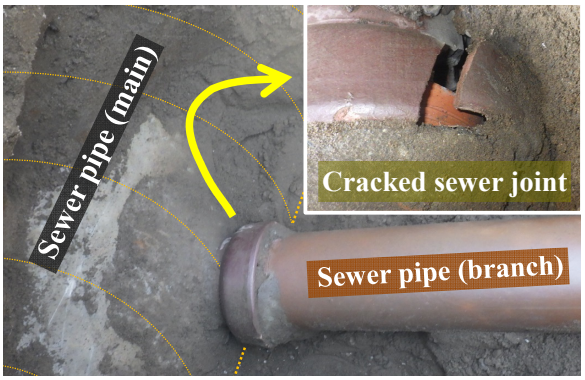


Figure 2: Damaged sewer joint

3. RESULTS AND DISCUSSION

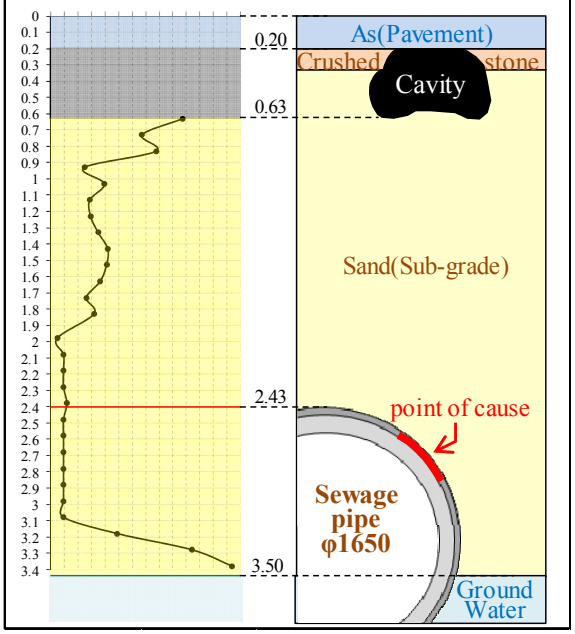
The relevance between the value of looseness below the cavity and the occurrence of cavity is considered according to the ground condition.

Case-A is a typical cavity that caused by washing out and expanded in a short period in a sand layer. The washing out of the sand occurred from small damaged joint of sewage pipe. As shown in Table 1, the result of penetration test, the soil below the cavity was uniform and very loose between the bottom of cavity (GL-0.63m)

and the ground water level (GL-3.5m). The similar conditions were observed at other three sites in this study.

Table 1: Outline of Case-A

CASE	A
LooseArea	Exist
Cause	Corrupted Sewage pipe (GL-2.45m)
Ground	Sandy soil
G.Water	Deep(GL-3.5m)
Penetration value and Around cavity (m)	



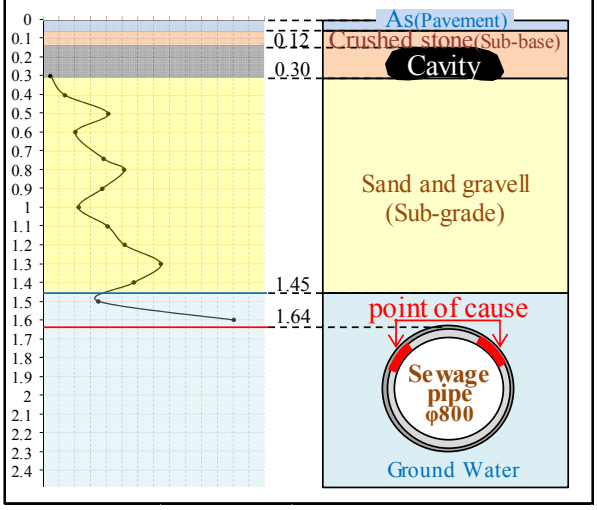
Case-B is another typical cavity that expanded slowly in sand and gravel layer with high groundwater level (Fig. 3). As shown in Table 2, the ground water level was GL-1.45m. It appeared between the bottom of cavity (GL-0.30m) and the damaged point of sewage as the factor of the cavity (GL-1.64m). The penetration resistance value of below the cavity was not uniform. Although it went up and down, the overall trend becomes larger with the depth. The similar type of cavities and loosening were observed at other two sites in this study.

Figure 3: Sewer pipe and ground water (CASE-B)

Previous researches by laboratory model tests[1] reported two key factors for the expansion of cavity, which are the fluctuation of water level and type of ground. A cavity in highly permeable model ground expands with the fluctuation of water level. In actual ground, it corresponds to the fluctuation of groundwater in a sand layer. The process is that a cavity expands upward while repeating the collapse of upper sand with the fluctuation of water level. It may be suggested that the non-uniform penetration resistance is the sign of repeated sand collapse, although it should be noted that the non-uniform cone penetration resistance can be caused by the presence of gravels.

Table 2: Outline of Case-B

CASE	B
LooseArea	Exist
Cause	Corrupted Sewage pipe (GL-1.64m)
Ground	Sandy soil
G.Water	Shallow(GL-1.45m)
Penetration value and Around cavity (m)	



4. CONCLUSION

The finding of this study based on the detailed investigation in actual ground is that the penetration resistance value may reveal a process of cavity expansion.

It is difficult to investigate the cause of cavity under road maintenance work in short time in usual way. Consequently, this consideration based on actual cases seems to be a lead to great breakthroughs in research into the causes and mechanisms of cavity.

If the process of expansion of cavity is estimated by simple method, it helps to solve the issue to maintain roads in optimum approaches.

REFERENCE

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