Performance Evaluation of Geosynthetics Pocket filled with Expansive Material by Field Test

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ABSTRACT

This study conducted field test to evaluate the applicability of the road cavity-filling method to prevent subsidence due to cavity under the road. Ice was used to simulate the cavity occurring under the road, and the surface layer was paved with asphalt. GPR investigation was performed before and after filling the cavity, so as to identify the cavitation and ground behavior, and the effect of filling material was verified through partial excavation. Cavity-filling was completed by filling it with sand and compaction, and the geosynthetics pocket contained within the sand was filled with expansive material. After applying the filling material, monitoring by endoscope showed that the geosynthetics pocket filled with expansive material began swelling, making the sand layer dense. When filling with sand according to the traditional method, soil compaction was impossible, and the filling performance was unsatisfactory, but the geosynthetics pocket filled with expansive material proved to have enhanced compaction effects. The excavation survey of the road cavity filled with sand and expansive material confirmed that the backfill method using the geosynthetic pocket filled with expansive material is effective for road cavity restoration.

INTRODUCTION

Recently, accidents involving pedestrians falling into sinkholes that occur on roads are on the rise. The major cause of the road sinkhole includes erosion due to deteriorated sewer, poor compaction after backfilling, and excavation for tunnelling and underground structure work. When the land downtown sinks, as in the gigantic hole in downtown Fukuoka, southern Japan, which first appeared on November 8, 2016 (see https://www.abc.net.au/news/2016-11-16/japanese-road-reopens-one-week-after-giant-sinkhole-appears/8028756), restoration is challenging because of the complex underground utilities and traffic control, and thus an emergency restoration method that will minimize the needs of traffic control is necessary. In Seoul, the city government investigates such cavities, and applies a land subsidence risk category for effective restoration. To restore the cavities under the road surface, measures to fill the cavities using a non-open cut method and fluidized filling material are adopted. In particular, the cavity-filling method using quick-hardening filler requires no compaction, but early strength is achievable for fast application. The method that is most commonly used is soil-backfilling; and in some sites, fluidized filling material is used as backfill. However such methods reportedly have their own problems (Han et al., 2017). It takes time for plant installation at the site and road traffic control; moreover, loss of filling material due to groundwater leak is inevitable. Thus emergency restoration techniques that lead to the reduction of application time and material loss are most important. In this study, the field test of a cavity restoration method using new ground pocket together with expansive material was conducted. Cavitation was simulated using ice, and the performance of the expansive filling material was examined. Furthermore, the cavity-filling with sand and expansive filling material was verified through GPR exploration. According to the field test result, the effect of tamping the sand layer by expansion of filling material was successfully proven. While it is impossible to tamp when using sand, and cavity-filling was unsatisfactory, expansive filling material can enhance the tamping effect.

1. FIELD TEST

1.1 Test site

Part of the test site at the Korea Institute of Civil Engineering and Building Technology (KICT) SOC test center at Yeoncheon, Gyeonggi-do was designated as the test bed for the test of road cavities. To simulate the cavitations under the road surface, the method using ice that was used for the field test by Lee et al. (2015) was adopted. After excavation, laying the aggregate on the drainage layer and base layer at the test site, 25 mm aggregate was used for the drainage layer, and rubble for the base layer. After tamping the base layer, ice (T-1) sized 0.5 m width × 1 m length × 0.25 m height and ice (T-2) sized 0.25 m width × 0.5 m length × 0.25 m height were embedded, respectively (see Fig. 1). The depth was 0.7 m from the pavement surface, including 20 cm surface layer. After placing the ice, backfilling, and tamping, an asphalt layer was installed. The asphalt surface layer was installed using asphalt material, and tamping was carried out by roller (Lee et al., 2018).

a) Drainage layer and base layer

b) Ice for simulating the cavity

c) Asphalt surface layer

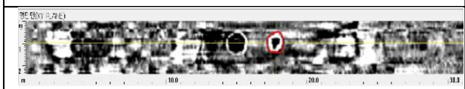
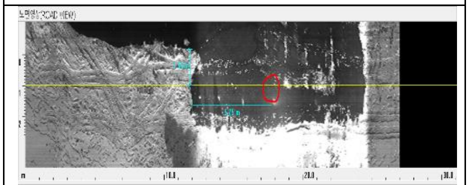
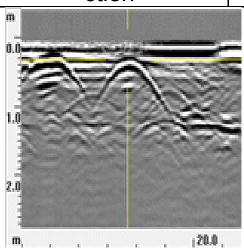
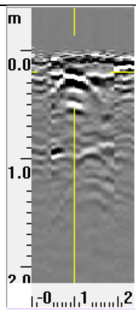
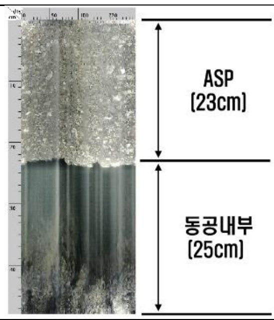
d) Surface layer tamping

Figure 1. Cavity simulation site

2.2 Identification of the cavity through GPR exploration

GPR exploration is a form of geophysical prospecting that is designed to emit an electromagnetic wave from a transmission antenna, and generate the image of ground structure or underground utilities using the time–distance of the electromagnetic wave reflected by the medium under the ground, or detected by antenna after penetration, so as to deduce the location of underground utilities or structure. The principle of GPR was first proposed in Germany in 1911, and has been widely developed and used since the 1970s (Daniels, 2004). A vehicle-type multi-channel GPR and hand-type single GPR equipment were used to investigate the cavities formed by ice and ground relaxation conditions (see Table 5). GRP exploration was conducted to check whether the cavities (T-1, T-2) were formed by ice melting. As part of the GPR exploration, a multi-GPR exploration of Lines (1, 2, and 3) (40.0 m) and Line 4 (30.0 m), total 150.0 m, were performed, and the GPR waveform for simulated cavities was analyzed. In addition, hand-type GPR exploration was carried out, and as a result, the size and location of simulated cavities were identified (see Fig. 3).

Table 1. GPR exploration result

Exploration plane (top) and road surface (bottom)	Exploration image		Cavity depth measured by en doscope
	road longitudinal se ction	road cross sec tion	
 			

After confirming the cavitation through GPR exploration, cavities were checked using a drilling machine. After drilling using a 50 mm diameter core drill, the depth of pavement and cavities was measured using endoscope camera. According to the investigation, the asphalt thickness of cavity T-1 was 18 cm, and the depth of the cavity was 22 cm; and for cavity T-2, they were 23 cm and 25 cm, respectively.

2.3 Cavity-filling using ground pocket

Using the new pocket manufactured after performance verification through lab test, cavity-filling was carried out. Based on preliminary cavity-filling test using the sand and ground pocket, sand was poured into the cavity, and then the pocket was put into the cavity, so as to estimate the sand compaction effect by swelling pressure. The pocket used in this study was manufactured by mixing the main material and hardener in the ratio 1: 2, which was obtained from the lab test as the optimal mixing ratio, and the mixture was put into the polygonal silicon rubber pocket. The mixture of main material and hardener injected into the pocket began expanding due to the reaction force, creating the compaction effect. The volume of pocket used for the test was determined in consideration of the swelling pressure obtained from the lab test. Viewing the field test procedure in Fig. 6, after drilling the cavity identified by GPR exploration to 50 mm diameter, the cavity was filled with sand. After the cavity was uniformly filled with sand, a cavity wall was formed, and the pocket was put into the cavity. After the sand layer was densely stabilized for a certain time, the cavity hole was closed with asphalt concrete. After filling the cavity, GPR exploration was carried out to check for abnormal signal, as well as to compare the ground conditions

a)Sand filling

b) cavity wall in sand layer

c) Injection of expansive material

d) GPR exploration

Figure 2. Cavity-filling using new material pocket

3. Resultss amd Discussion

After cavity-filling using the pocket, endoscope exploration after drilling the cavity was conducted to identify the cavity-filling effect. Through GPR exploration, drilling was made at 3 different points and sand-filling was monitored. The sand filled in the cavity is as Fig 5 which was confirmed by endoscope camera. The sand was expanded in the cavity by swelling material and the sand-filling effect of the pocket was verified. According to GPR exploration after sand-filling, no cavity signal was detected, indicating the cavity-filling was satisfactory. Though no cavity signal was not detected, weak abnormal signal was detected which is considered attributable to ground disturbance by expansive material.

Filling material application mechanism and method used for the indoor model test proved to be applicable through the field test. Viewing the study above, thanks to compaction effect by the expansive material with swelling effect on sand layer, the strength similar to foundation ground is expected. Further investigation of the cavities through open cut method would be necessary to identify the compaction effect and cavity-filling efficiency.

a) Drilling the cavity

b) Sand filler in cavity

c) Endoscope photographing

d) Sand filled in cavity photographed by endoscope

Figure 3. Investigation of cavity-filling

4. CONCLUSIONS

Field test was conducted in this study to prove the effect of cavity-filling using new pocket expansive material and the conclusion obtained from the study is outlined as follows. As a result of GPR exploration to identify the abnormal signal before and after applying the expansive material, no signal indicating a cavity was detected, but considering the weak signal, ground disturbance by the expansive material might have occurred. As a result of partial excavation investigation of the cavities filled with sand and pocket, the cavity was found to have been filled densely with the sand. Such result indicates the compaction effect by swelling effect of the expansive material. Using the sand and expansive material to fill the cavities under the road surface would make possible the non-open cut application, which would reduce both the time and cost.

ACKNOWLEDGEMENT

This research was supported by the Korea Agency for Infrastructure Technology Advancement under the Mini stry of Land, Infrastructure and Transport of the Korean government. (Project Number: 19CTAP-C152164-01)”

REFERENCES

Han, J. G., Ryu, Y. S., Kim, D. W., Park, J. J and Hong, G. W.(2017). A Study on Expansion and Strength Characteristics of Material for Emergency Restoration in Ground Cavity, , *Journal of the Geosynthetics Society*, Vol.

16. No. 2, pp.131-138.

Ganiels, D. J. (2004). Ground Penetrating Radar, 2nd ed., The Institution of Electrical Engineers, London, United Kingdom.

Lee, D. Y., Kim, D. M., Yoo. Y. S., and Han, J. G.(2015). Development and application of backfill material for reducing ground subsidence, *Journal of the Geosynthetics Society*, Vol. 14. No. 4, pp.147-158.

Lee, D. Y., Kim, K.C., Kim, D. W., and Ryu, Y. S.(2018). A study on construction method of geosynthetics pocket with expansive material using field test, *2018 Spring Geosynthetics Conference*, pp.39-40.