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Geophysical Investigation for Delineating Subsurface Structures and Characteristics of Riverside Alluvium in Gwang-Ju, Korea.

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1. Introduction

Active farming has been commonly developed along the riverside alluvium. In these agricultural areas, pollutants derived from the usage of fertilizer directly flow into the rivers without purification. Hence, Ministry of Environment sets certain areas around the rivers as a riparian buffer zone which can improve water quality by delaying and purifying the influx of pollutants. For instance, along the watershed of the Han River, 191 km^2 were designated as the riparian buffer zone.

The Gyeongan River, a branch of the Han River, has large areas of riverside alluvium mainly used for agriculture. This area is also one of the candidates for the riparian buffer zone. In order to construct the riparian buffer zone, information for the subsurface environments including soil types, flow direction of groundwater and the thickness of aquifer is urgently required. In this study, we performed seismic and electrical resistivity surveys to obtain subsurface information in the riverside alluvium of the Gyeongan River.

2. Results and discussion

Seismic refraction survey has been carried out along the six survey lines (GS1 ~ GS6). The four survey lines, GS1 ~ GS3 and GS6, are approximately perpendicular to the direction of the river flow while other two survey lines (GS4 and GS5) are nearly parallel. A total of 2,116 m is covered in the present study. All the six profiles systematically reveal a four-layered structure (Table 1).

Table 1. The result of seismic refraction and vertical electrical sounding (VES)

Seismic refraction profiles			*VES profiles*		
Layer	Depth* (m)	Vp (m/s)	Layer	Depth* (m)	Resistivity (ohm-m)
Layer 1		360 ~ 520	Layer 1		13 ~ 516
	1 ~ 6.5			1 ~ 5.8	
Layer 2		1,600 ~ 1,900	Layer 2		12 ~ 67
	4.5 ~ 19.8			4.3 ~ 12	
Layer 3		2,100 ~ 3,300	Layer 3		109 ~ 175
	14 ~ 31			11 ~ 29	
Layer 4		3,600 ~ 4,110	Layer 4		8 ~ 53

* Boundary depth between layers

Keyword: Riverside alluvium, Seismic refraction, Vertical electrical sounding

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The uppermost layer shows the P-wave velocities of 360 ~ 520 m/s (average: 440 m/s). The Layer 2 is initiated at the depths between 1 m and 6.5 m. This layer shows the P-wave velocities of 1,600 ~ 1,900 m/s (average: 1,770 m/s). The velocities for the Layer 1 and the Layer 2 correspond to those of unsaturated fine ~ coarse sand-layer and saturated gravel-layer, respectively (Burger, 1992). The Layer 3 begins at the depths between 4.5 m and 19.8 m. The velocity of the Layer 3 varies from 2,100 m/s to 3,330 m/s (average: 3,006 m/s). These velocities can be attributed to the weathered bedrock, based on borehole data. It is worthy of note that the boundary between the Layer 2 and the Layer 3 is generally deeper toward the upstream (GS5 and GS6) compared to that in the downstream (GS1 ~ GS4). This result indicates that the upstream area has thick and saturated aquifer layer (Layer 2). The boundary between the Layer 3 and the Layer 4 is detected at 14 ~ 31 m beneath from the surface, based on significant increasing P-wave velocities (3,600 ~ 4,110 m/s, average: 3,966 m/s) in the Layer 4. The velocities of the Layer 4 are indicative of the fresh bedrock (Burger, 1992) composed of biotite banded gneiss. The depth of bedrock is generally deeper towards the riverside. As a result, the subsurface layers are gradually deeper towards the southeastern part of the study area (south: upstream, east: riverside).

After the seismic survey, a total 15 vertical electrical soundings (VESs) were performed on top of the seismic survey lines. The 15 VES profiles also detected a four-layered structure (Table 1). The apparent resistivities (ρ_a) of the Layer 1 are 13 ~ 516 ohm-m. Characteristically, the Layer 1 has increasing ρ_a towards the riverside. For example, the VES13 located far from the riverside has ρ_a of 56 ohm-m for the Layer 1, while the VES6 in the riverside has ρ_a of 516 ohm-m (Fig. 1). In general, the layer composed of unsaturated fine-sand has ρ_a of 50 ~ 100 ohm-m, whereas coarse

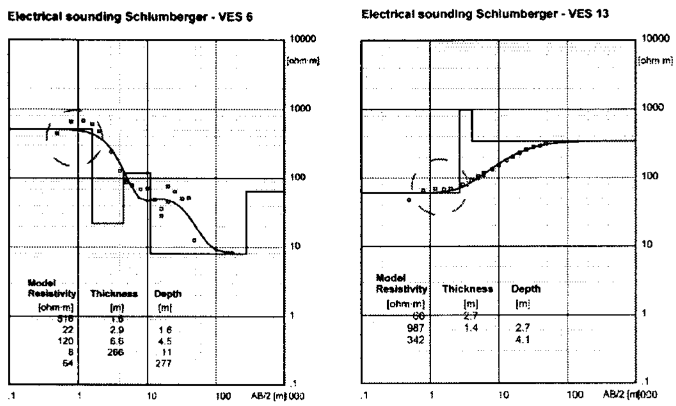

Fig. 1 The apparent resistivity variation in VES6 and VES13

sand-layer shows ρ_a of 100 ~ 600 ohm-m (Milsom, 2003). Therefore, increasing ρ_a of the Layer 1 towards the riverside is possibly attributed to the increasing grain-size. This interpretation is supported by the borehole data that shows higher content of coarse grains towards the riverside. The Layer 2 is initiated at 1 ~ 5.8 m beneath from the surface. This layer has ρ_a of 12 ~ 67 ohm-m. Low ρ_a values of the Layer 2 possibly reflect the influence of water. We also confirm the initiation of the aquifer at the depth of about 2 m by the borehole data. The boundary between the Layer 2 and the Layer 3 is detected at the depth between 4.3 m and 12 m, based on the increase ρ_a (109 ~ 175 ohm-m) in the Layer 3. This depth is similar to the result of seismic survey, which defined the Layer 3 as a weathered bedrock. Therefore, the Layer 3 appears to be a weathered bedrock. The Layer 4 begins at the depths between 11 m and 29 m. Although this depth is corresponding to the depth of weathered and/or fresh bedrock of seismic survey, values of ρ_a of the Layer 4 are abnormally low (8 ~ 53 ohm-m). Note that the fresh bedrock usually shows ρ_a of several hundreds ohm-m (Milsom, 2003). Therefore, the VES profiles in this study may indicate the presence of low resistivity layer at the lower part of the weathered bedrock. A possible explanation is related to the events which can decrease the resistivity of the weathered bedrock such as influx of water and increase of clay contents.

3. Conclusion

The seismic refraction method applied in this study provides a four-layered subsurface structure: unsaturated top soil, saturated gravel-layer, weathered bedrock and fresh bedrock. The VES also yields a four-layered structure and sensitively detects a depth of the water table and spatial distribution of soil types. In particular, VES can detect the grain size increase towards the riverside in the Layer 1 as well as the existence of low resistivity zone at the bottom of the Layer 3. Based on the spatial patterns of subsurface layers, we can interpret that the groundwater possibly flows towards the southeast, i.e., upstream and riverside directions.

4. Reference

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