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Evaluation of earthquake amplification characteristic and seismogenic layer by in-situ deep underground rock properties

Yoshihiko Ishikawa[1*], NISHIZAKA, Naoki[1], SHIMOGUCHI, Yuichiro[1], OHNO, Yuki[1], KANBARA, Daisuke[2], TAMURA, Eiji[2], ANDO, Kenichi[3], NAGAI, chiaki[3], KIMURA, Kazunari[4]

[1]Shikoku Electric Power Co. Inc, [2]Yonden Consultants Co. Inc, [3]Obayashi Co. Inc, [4]Naiba Co. Inc

1. Introduction

We drilled boreholes to the maximum depth of 2,000 m and measured underground rock properties continuously from ground surface to 2,000 m deep by various geophysical logging in near the root of the Sadamisaki peninsula in western Shikoku where very hard crystallite schist of the Sanbagawa belt is distributed over ground surface. We report results of examination about earthquake amplification characteristic and the depth of seismogenic layer.

2. Outline of survey

(1) Deep drilling of boreholes

2,000 m and 500 m deep (for seismic observation)

(2) Geophysical logging

P and S wave velocity logging (downhole method, sonic logging), density logging, geothermal logging

3. Results and Discussion

(1) Earthquake amplification characteristic

In drilling site, reclaimed layers and weathered rocks are distributed from ground surface to 50 m-deep and from 50 m to 2,000 m deep fresh and hard crystalline schist continue. In addition, there was no loss of drilling fluids.

S wave velocity is 2.2-2.6 km/s (50-620 m), 3.0 km/s (620-1,280 m), 3.3 km/s (1,280-2,000 m) by S wave velocity logging (downhole method) and it is the almost same by sonic logging. The depth of 2,000 m is equivalent to seismic bedrock.

Density is 2.7-3.0 g/cm^3 (50-2,000 m) by density logging. Although density changes according to lithology, there is no tendency to increase or decrease globally to the depth direction.

As a result of examining the earthquake amplification characteristic using the ground structural model set up from in-situ velocity and density structure, the transfer function from seismic bedrock (depth of 2,000 m) to the rock near ground surface is around 1, and seismic waves are hardly amplified.

In the future, we are going to improve the accuracy of evaluation about the earthquake amplification characteristic further by seismic observation with vertical array.

(2) Seismogenic layer

P wave velocity is 4.6-5.0 km/s (50-620 m), 5.2 km/s (620-1,280 m), 5.5 km/s (1,280-2,000 m) by P wave velocity logging (downhole method) and it is the almost same by sonic logging. It is supposed that the upper surface of seismogenic layer correspond to the layer which P wave velocity indicate about 6 km/s (for example, Irikura and Miyake, 2001; Yoshii and Ito, 2001; Hirose and Ito, 2006) and it is presumed that the upper surface of seismogenic layer in this study site is deeper than 2 km deep.

Geothermal gradient from 300 m to 2,000 m deep where we can disregard the influence of the seasonal variation of temperature is 2.81 ^{o}C/100m and geothermal in 2,000 m deep is 73.2 ^{o}C by geothermal logging. Heat flow calculated from thermal conductivity of boring cores is 74 mW/m^2, and it is presumed that the depth of D90% equivalent to the undersurface of seismogenic layer is about 15 km deep according to Tanaka (2004).

According to the catalog of the Japan Meteorological Agency, the generating depth of crustal earthquakes around this study site is about from 2 km to 12 km. Moreover, the under surface of seismogenic layer around this study site is about 15 km deep according to the Earthquake Research Committee (2011). These knowledge is adjusted with evaluation by in-situ deep underground rock properties in this study.

From these examination, it is estimated that the upper surface of seismogenic layer in this study site is deeper than 2 km deep, and the undersurface is about 15 km deep.

Keywords: earthquake amplification characteristic, seismogenic layer, deep underground rock properties, seismic velocity structure, heat flow