Some examples of application of the method to estimate subsurface structure using joint inversion of gravity and microtremor data

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Characteristics of strong motion are affected by 3-D subsurface structure. Thus, it is important to estimate the subsurface structure, in order to consider the earthquake disaster and its mitigation, the geophysical survey technique such as seismic refraction and reflection, microtremor and gravity surveys can be useful to estimate the subsurface structure. The seismic refraction and reflection survey can provide good information about the ground structure, while this type of survey requires much cost and labor for the observation. Simple observation systems can be used for the microtremor and gravity surveys and the data of microtremor and gravity can be obtained anytime and anywhere. The microtremor and gravity surveys, however, cannot provide a unique solution for the ground structure because there are so local minimum solutions in the process to find the ground structure by means of the inversion technique. Furthermore, we often face the problem that a model of the ground structure, obtained through one physical value does not satisfy the other physical value. To avoid these problems and to obtain more precise model of ground structure, we propose a joint inversion method using microtremor and gravity data.

It is known that microtremor and gravity data depend strongly on the velocity structure and density structure, respectively. Thus, the estimated ground structures from the microtremor and gravity data show good resolution for the velocity and density, respectively. We employ advantages of microtremor and gravity data for the proposed method.

The procedure of the method is follows: (1) two-layered (sediment and basement) model is estimated from the inversion of Bouguer anomaly, which is computed from gravity data. On this step, the thickness of the sedimentary layer is unknown. (2) n-layered model is estimated from the inversion of the phase velocities which are obtained through the array observation of microtremors. On this step, the thickness and S-wave velocities of each layer are unknown. (3) n-layered model is estimated from the inversion of Bouguer anomaly. On this step, density is unknown. (4) The values of the density at step (2) and (3) are compared. In a case where the differences between these two values are enough small, we finish the calculation. In the other case, the procedure goes back to the step (2). We may find the base model of the ground structure through the iteration of step (2) to step (4).

To evaluate the appropriateness of the proposed method, numerical simulation is conducted. First, we examine joint inversion of phase velocity and Bouguer anomaly. Let us consider a ground structure with four layers. The phase velocities and Bouguer anomaly, which are calculated analytically from the considering ground structure, are given as the observation data. Applying the proposed method to the data set from the pseudo observation, we estimate the ground structure. The finally obtained structure coincides with the given one.

As we verify the validity of the method, we apply the method to real data, finally. Gravity and microtremors are observed at the Tottori, Japan. The procedure is applied to the data set of Tottori. The structures obtained through the inversion almost agree with the structures obtained by reflection survey of the site.

Through the results of inversion obtained from the numerical and real data, we confirmed that the proposed method could provide the reasonable model of the ground structure.