Calculations of Elliptical Pressure Source Models by FEM

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Mogi-Yamakawa-model, which is based on the solution showed by Yamakawa (1955), has been often used as crustal deformation models at volcano region. Accurately Yamakawa""s solution can be used only under the restricted condition that small enough pressure sphere exists at deep enough position in half-infinite elastic body. Meanwhile, the condition which Yamakawa""s solution requires is not realized in many cases at the volcano region, because of the volcanic edifice which rises up on the earth""s surface, the shape of pressure source except sphere, heterogeneous crustal structure, and so on. One method by which we can simulate the crustal deformation in such various conditions is Finite Element Method (FEM).

The last aim of our FEM study is the calculating of actual volcano models which includes the real edifice and crustal structure of volcano region. As the first part of it, we have advanced the calculating of many simple-shaped three-dimension pressure source models by FEM. Recently we succeeded the modeling of elliptical pressure source models, which have been seldom discussed because of the difficulty of handling of them. So this time we present the results of calculation of them.

We used ANSYS Ver.7.0 supplied by ANSYS, Inc. for modeling and analysis. The surface and inner structure of the model were set up as plane and homogeneous, respectively. The size of the model and boundary conditions are important to obtain enough precision in FEM. We succeeded to obtain enough precision by setting large enough model both in horizontal and vertical directions.

Now we consider the cases that the depths of the elliptical pressure sources are deep enough. We define the radius of XY-direction of the ellipsoid as a and that of Z-direction as b. When a/b is larger than 1, the ratio of maximum of vertical displacement to that of horizontal displacement (k) is larger than that of Mogi-Yamakawa-model (2.598), and the maximum of horizontal displacement appears at a nearer distance than that of Mogi-Yamakawa-model. When a/b is smaller than 1, above relations are all reversed. Furthermore, when a/b becomes smaller than about 0.5, the maximum of vertical displacement appears at a point apart from the pressure source. The distance of the point at which vertical displacement is equal to horizontal displacement is nearly equivalent to the depth of the pressure source despite of the value of a/b. When we plot a/b in the horizontal axis and k in the vertical axis, the trend of the curve changes at about a/b = 0.5. There the value of k is about 1.6.

The relations similar to above is also seen in cases of columnar pressure source models (Sakai et al., 2002) and square pillar pressure source models.

We can determine a columnar or a square pillar model which indicates displacement almost similar to an elliptical model by using k as a index. For example, an elliptical model whose a/b is 0.5 indicates displacement almost similar to a columnar model whose ratio of radius to height is about 0.16. This result means that, at least in case of the depth of pressure source is deep enough, it is difficult to determine the shape of the pressure source from among above three shapes. However, if we assume one shape as the pressure source, we can determine the shape-parameters of it. For the purpose of it, it is necessary to evaluate not only horizontal displacement which is regarded as important in GPS observation but also vertical displacement simultaneously.