A Study on seismic stability safety evaluation of the cap rock for geological CO\textsubscript{2} storage using non-linear dynamic response analysis

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Authors studied non-linear dynamic response analysis at the geological CO\textsubscript{2} storage site, and tried the seismic stability evaluation of the cap rock and the reservoir. The test site is the Nagaoka CCS site. The input earthquake motion used the wave of the ‘Mid Niigata Prefecture Earthquake in 2004’ recorded by the surface-type seismograph installed in this site. The engineering characteristic values of the foundation used for analysis inputted the numerical value acquired at this site.

In advance of dynamic response analysis, the earthquake motion recorded on the earth surface assumed the horizontally layer model, and set up the input wave from a basement layer (We assumed Shiiya Formation distributed from the depth of 1,370m) by SHAKE (= One-Dimensional Seismic Response Analysis). This wave was inputted into the analysis model and the equation of motion was solved using the direct integral calculus by Newmark Beta Method. In Seismic Response Analysis, authors have used Multiple Yield Model (=MYM, Two-Dimensional Finite-Element Method), which can respond also to complicated geological structure.

The intensity deformation property of the foundation added the offloading characteristic to the composition rule of Duncan-Chang model in consideration of confining stress dependency, and used for and carried out the non-linear repetition model. The deformation characteristic which made it depend on confining stress with the cyclic loadings and un-loadings, and combined Mohr-Coulomb's law as a strength characteristic. Analysis ranges are about 1.2km * 1.4km focusing on an injection well.

The maximum dynamic shearing strain of the cap rock was generated about 1.1E-04 after the end of an earthquake. Although the dynamic safety factor was 1.925 on the beginning, after the end of an earthquake fell 0.05 point. This result is equivalent to having fallen about 2.5% from the beginning, the influence on safety is slight.

As a result of CO\textsubscript{2} migration monitoring by the seismic cross-hole tomography, CO\textsubscript{2} has stopped in the reservoir through two earthquakes till the present after injection, and the leak is not accepted till the present. By the result of non-linear dynamic response analysis, we obtained a result in support of them. That is, it turned out that the stability of the foundation is not spoiled after the earthquake. By carrying out performance simulation using this non-linear dynamic response analysis by MYM, the prediction of the safety assessment in rock masses at the deep depth accompanying the occurrence of a massive earthquake is possible also at geological CO\textsubscript{2} storage site planned from now on.

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