A Study on seismic stability safety evaluation of the cap rock for geological CO_2 storage using non-linear dynamic response analysis

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Authors studied non-linear dynamic response analysis at the geological CO_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_2 migration monitoring by the seismic cross-hole tomography, CO_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_2 storage site planned from now on.
Acknowledgements : The 5th and 6th authors were funded by the Ministry of Economy, Trade and Industry (METI), Japan under the contract research of ''Development of Safety Assessment Technology for Carbon Dioxide Capture and Storage''.

Keywords: Carbon Dioxide Capture and Storage, non-linear dynamic response analysis, seismic stability evaluation

