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High Performance Computation and Walkthrough Visualization for Assessing Seismic Safety of Nuclear Power Plants

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SUMMARY

In such countries as Japan where earthquake occurs frequently, reliable and sufficient seismic proof design plays a key role in operating nuclear power plants (NPPs) safely and stably. Especially, recent strong earthquakes attacking some Japanese NPPs such as Niigataken-Chuetsu-Oki (NCO) earthquake with 6.8 Mw occurred on July 16, 2007 and Off the Pacific Coast of Tohoku Earthquake / Tsunami with 9.0 Mw occurred on March 11, 2011 recalled its practical importance seriously.

In conventional seismic design of NPPs, a variety of safety margins are embedded in various ways in order to consider uncertainty in design and operation processes such as a magnitude of earthquake, material strength and operating conditions. However, it is still unknown how strong earthquake the existing NPPs can stand in reality.

Under the above-mentioned background, we have been developing a multi-scale and multi-physics based numerical simulator for quantitatively predicting actual quake-proof capability of ageing NPPs under operation or just after plant trip subjected to strong earthquake. Here we divide the whole phenomena into three sub-phenomena, and develop simulation codes and numerical models for the sub-phenomena. As for a main sub-phenomenon, we construct full scale and precise 3D finite element models of building, pressure vessels with internal structures with nearly billion degrees of freedom, and perform dynamic nonlinear response analyses with considering fluid-structure interaction between pressure vessel, internal structures and coolant by iterative partitioned coupling algorithms. We also develop a parallelized walkthrough visualization technique to effectively deal with a huge amount of data coming from large scale simulations. Those simulation codes are tuned for Japanese peta-flops computer “K” with sub-millions cores. In this talk, we describe key algorithms of the simulation methods and some preliminary results.