STATUS AND FUTURE PLANS OF HANARO RESEARCH REACTOR

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ABSTRACT

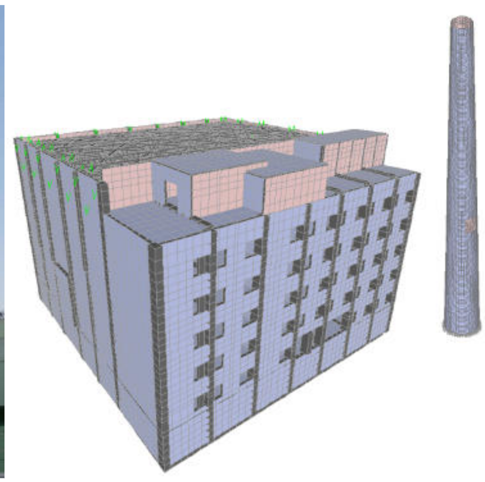
HANARO, 30MWth Multipurpose Research Reactor, is under construction to reinforce the reactor building for the earthquakes. The seismic margin evaluation was ordered by the regulatory body after the Fukushima accident. A special method using hybrid truss is applied to avoid ground works for the strengthening of the structures. The reactor has been stopped over two years since mid of 2014. After the safety inspections by the regulatory body, Hanaro will restart early of 2017. This paper describes the construction details, research activities done during shutdown period, and future plans of HANARO RR.

1. Introduction

Seismic reinforcement was performed with 3 steps. First the seismic performance of the building was evaluated to know what are limits and weak points of SSCs (systems, structures, and components) for the earthquake beyond the design basis intensity. Some structures were identified needed to be reinforced to withstand for the target seismic intensity, 0.3g for HANARO. Comprehensive design was followed to strengthen the structures. Finally construction works have been made. It took more than 3years to do actions need to complete the seismic reinforcement [1].

2. Seismic performance evaluation

Seismic performance evaluation was conducted for structural elements of reactor building using EPRI-NP-6041-SL (A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)), one of the assessment methods officially approved by the NRC (Nuclear Regulatory Commission in the USA). When HANARO was built, the design requirements were applied on the basis of a magnitude 6.5 on the Richter scale (0.2g in ground acceleration). In accordance with the seismic margin assessment, the seismic performance of the RCI (Reactor Concrete Island), the concrete structure containing the main systems and surrounding the reactor and water tank, was sufficiently safe with a magnitude 7.7 on the Richter scale (1.71g in ground acceleration). However, it was identified that some sections on the external wall of the reactor building did not meet the requirements. The results were reported to the Nuclear Safety and Security Commission on Dec. 19, 2014. In response, the Nuclear Safety and Security Commission ordered a reinforcement of reactor building on those sections that did not meet the seismic performance standards on March 19, 2015[2].

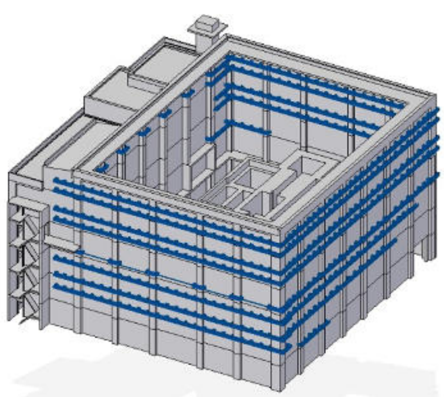


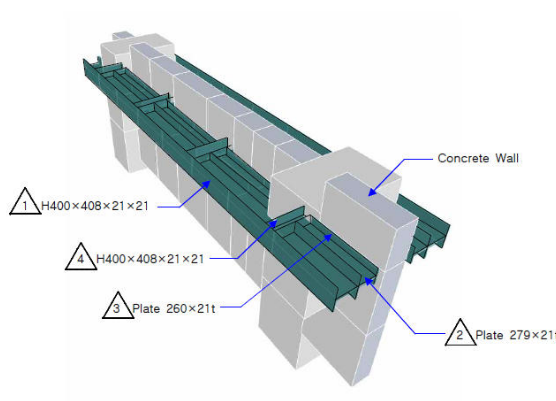
3. Design of seismic reinforcement

The seismic reinforcement of the external wall of the reactor building was implemented by integrating the steel H-beam with high stiffness to the internal and external sides of the existing reactor building. During the concept design stage, nine reinforcing methods were reviewed to select appropriate method because there were some important constraints in addition to the basic requirements (seismic, confinement, radiation and nuclear safety) as follows;

- Underground pipes, beam guides, and structures
- Adjacent buildings
- Radiation controlled area
- Construction period
- Costs

The steel H-beam method among reviewed ones is selected to share seismic force to be sustained by the external wall of the reactor building in case of earthquakes. It was confirmed that the concept of the reinforcement was effective through modelling and simulation. The results of the seismic reinforcement design for HANARO Reactor Building was satisfied with original design seismic performance for the horizontal PGA of 0.2g in SSE. The results of seismic analysis were obtained using the response spectra at the site. The seismic analysis has been performed using the SAP2000 Ver. 15. By the case-study, exterior walls shall be reinforced by installing structural steel assembly, named Hybrid Truss, into both side of the wall to reduce bending moments which was produced due to out-of-plane behavior of the wall. In a less bending moments and in-plane tension region of the wall due to seismic load, PS steel bar shall be applied to control induced tensile stress. The dynamic analysis of the existing structure has been performed. The dynamic analysis has been re-performed by reinforced structure and reevaluated the structural safety to identify effect of the reinforcement. According to the result, it is represented that induced maximum bending moments after reinforcing are decreased minimum under 47% compared with the maximum moments before reinforcing and that the proposed seismic retrofit technique is effective. Seismic reinforcement using the concept above will ensure safety even against an earthquake beyond the design basis earthquake (0.3g).





4. Reinforcement work

The construction for reinforcement was started in Feb. 2016 and is undergoing. Construction works were variety in fields and activities as follows;

- Installation of scaffolds and safety measures
- Removing interference fixtures
- Scanning of rears in the walls
- Drilling of the walls
- Installation of thru-bolt and grouting
- Attaching H beam structures
- Reinstallation of detached fixtures
- Dismantling of scaffolds and safety measures

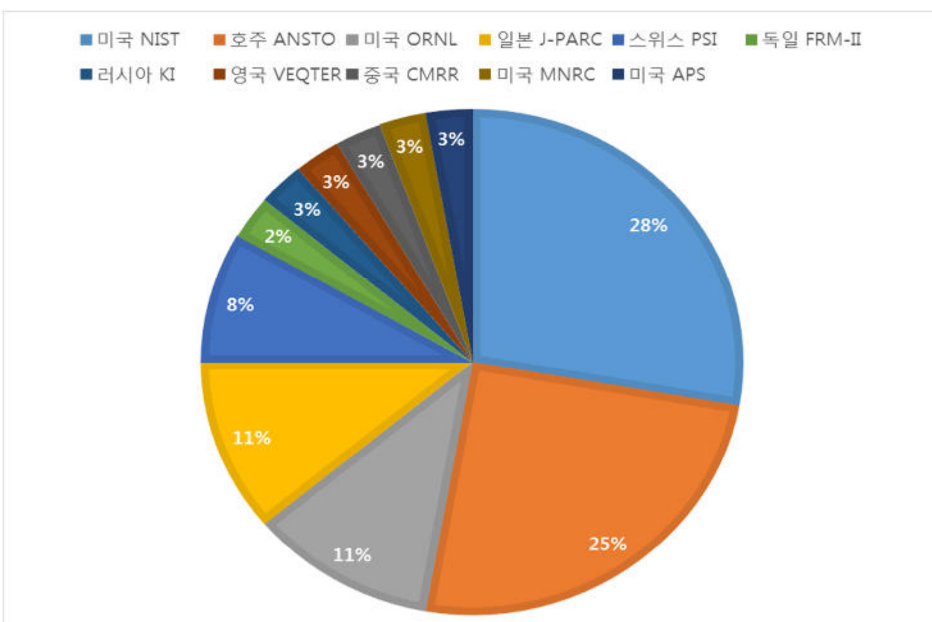
Major concerns are capability to keep the safety barriers, structural integrity and confinement. The performance of the building structure has been verified by simulation using the approved codes and confinement performance shall be verified by the air leak rate test.

5. Activities during the shutdown period

HANARO has been not operating due to the reinforcement construction of the reactor external walls since July 2014. The project aims to continue neutron science research during the shutdown and analyze foreign neutron science facilities.

Nineteen (19) instrument scientists in neutron science division have been dispatched totally 37 times to USA, Australia, Japan, Switzerland, Germany, Russia, and China for the neutron research and the investigation of the foreign neutron science facilities. Neutron small angle scattering, neutron reflectivity, neutron powder diffraction, neutron residual stress, and etc. were being utilized to study steel, polymer, thin films, and single crystal materials. In addition, facilities on/off-line accessibility, safety regulation, and neutron instruments was studied.

Behavior analysis of polymer in liquid, residual stress analysis of welding alloys, magnetic structural profiling of condensed matter thin films, non-destructive analysis of hidden relics have been conducted by using neutron scattering and imaging instruments. Dispatched scientists experienced easy access to/from the neutron facilities, strict safety procedures and regulations, and user support program [4].



6. Future plan

The reactor will start operation again after inspection by the regulatory authority. Before restart, it should be taken all necessary actions to secure the safety of the reactor by conducting safety checks on all the SSCs because the reactor has been shut downed during the construction work. HANARO need to restore the user community and to gain public acceptance lowered due to political and environmental issues in a short period as possible.

7. References

[1] I.C. Lim and et al., “Safety Reassessment of HANARO and Status of Safety Improvement Measures”, RRFM 2016, Berlin, Germany, 13-17 March 2016.

[2] “Seismic Performance Evaluation Report”, Korea Maintenance Ltd. & KAERI, 2014

[3] “HANARO Reactor Building Exterior Wall Reinforcement calculation” Jace Korea Inc. & KAERI, 2016

[4] “Neutron Scattering Research and Analysis on Foreign Neutron Science facilities”, Technical Report, KAERI, 2017