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Experimental Evaluations for Failure Behavior of PCCV Wall-Base Juncture

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1. Introduction

Hyundai Institute of Construction Technology Development (HICTD) has been conducting the project on the research and development of prestressed concrete containment vessel (PCCV) that would be sponsored and funded by Korea Atomic Energy Research Institute (KAERI). As a part of this research, quasi-static Structural Failure Mode Test (SFMT) will be carried out on a 1:16 scale PCCV model of existing Korea Standard Nuclear Power Plant (KSNP). Many types of global and local analyses on a 1:16 PCCV test model were performed to establish a test methodology in our research program.

The PCCVs are required to withstand various extreme accidental and external loads, such as internal pressure and thermal loading, seismic events, external explosions and aircraft impacts. Among these loads, this study is aimed at observing its failure mechanisms, especially in case of seismic events. Quasi-static SFMT will be accomplished to inspect PCCV wall-base juncture behavior in the event of seismic events. To provide some insights into the mechanisms leading to the structural failure, in addition to summarizing comparisons between measured behavior and predicted behavior of concrete, rebars, and tendons, a variety of failure modes and locations will be investigated.

2. PCCV Test Model

In this section the design, construction and instrumentation of PCCV test model are described.

2.1 Design

The PCCV test model is a uniform 1:16 scale model of actual PCCVs used in Korea (KSNP). This simple test model includes only a prestressed concrete cylinder wall and basemat with rebars and vertical post-tensioned unbonded tendons. There are no dome, buttress, hoop tendons, and various kinds of openings in this model. Both the rebar ratios and the wall thickness are the same as those of general cylinder walls for reinforcement. The reinforcement consists of one layer of vertical rebar and one layer of hoop rebar. The test model has been prestressed with 19 vertical steel tendons that are anchored at the basemat. The level of prestressing force in each of the vertical tendons is approximately a tenth of 1:16 scaled that. Also, there is no internal pressure to which the test model is subjected. The cylindrical portion of the model is long from basemat up to the center of mass of PCCV test model with hemispherical dome, to fulfill the test effectively in case of seismic events.

2.2 Construction

Test model construction was made at the Structural Testing Laboratory in HICTD. Cylinder wall of the test model was fabricated into two segments for the convenience of concrete placement, because the thickness of the cylinder wall is 7.5cm thin. The configuration and structure outline of the test model is shown in Figure 1.

2.3 Instrumentation

HICTD instrumented the model with nearly 40 transducers to measure strain, displacement and forces in the model through testing. To monitor plastic strain, the plastic stain-gauges were installed at the test model. These transducers will be monitored by a data acquisition system while providing real time display of any sensor channel.

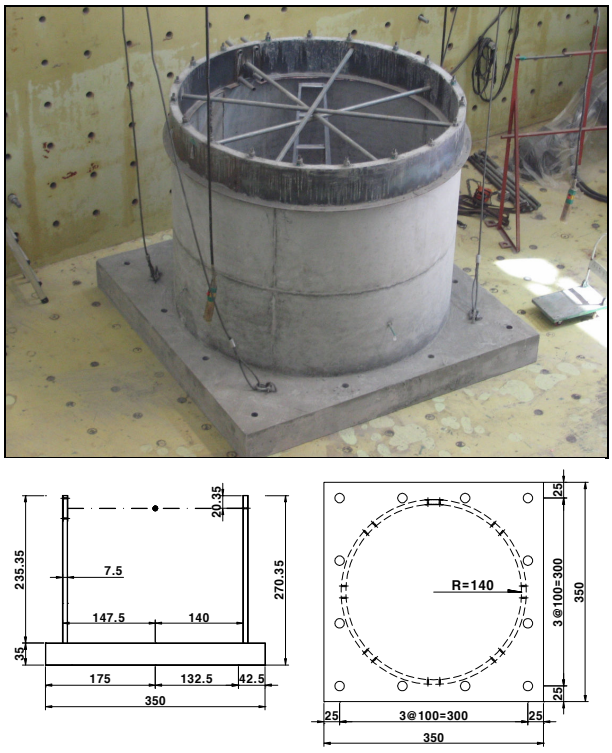


Figure 1. Configuration and outline of PCCV test model (unit : cm).

3. Structural Failure Mode Test (SFMT)

Quasi-static testing of the model consists of a series of static monotonic load of increasing magnitude. This test, which is named System Functionality Test (SFT), will be conducted to confirm the operation of all test and data acquisition system, verify that the model is able to be stably tested and calibrate the measurement system.

In the predictions of local wall-base juncture behavior, the SFMT will provide additional insight as to how the structural failure is likely to be developed. Maybe, there will be a shear or combined shear/flexural failure at the wall-base juncture. With the triggering event of a massive wall rupture, mechanism may have caused shear demand to exceed capacity. Creating large rotations in the vicinity of the base of the wall would crush the outer concrete of the flexural section and thereby reduce the capacity. There is a virtual view for SFMT of PCCV test model as shown in Figure 2.

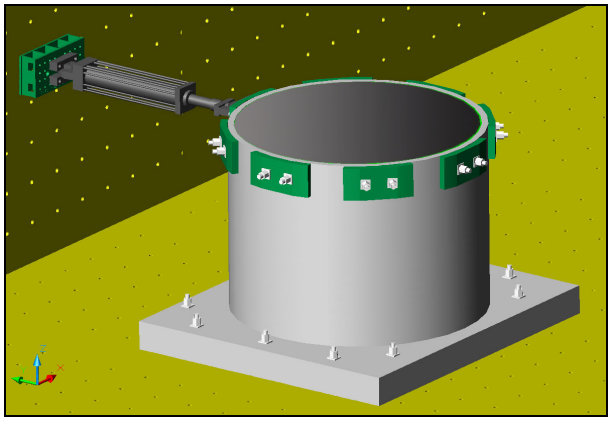


Figure 2. Virtual view for SFMT of PCCV test model

4. Pretest and Posttest Analyses

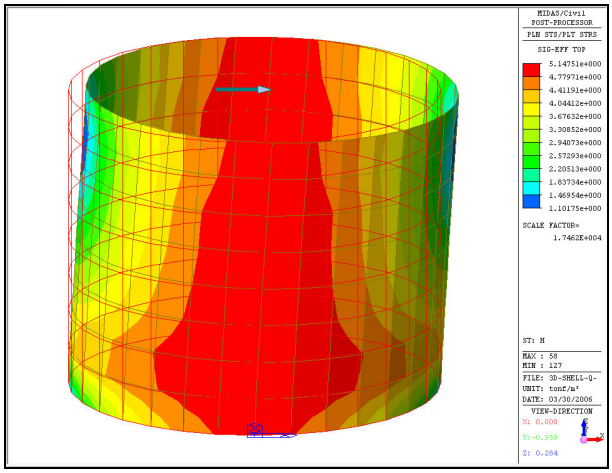
The objective of the global analyses is to evaluate the global non-linear behavior of the test model. For the purpose, the ABAQUS/Standard and MIDAS finite element program were used for the analyses. Tendons and their prestressing forces were modeled to replicate expected tendon stress-strain behavior and friction effects. Concrete was modeled as a non-linear material, which is implemented into ABAQUS/Standard, throughout the deformation range.

The possible structural failure region of the test model by the pretest analyses is shown in Figure 3. Figure 3 presents the deformation and stress contours obtained from the global analyses.

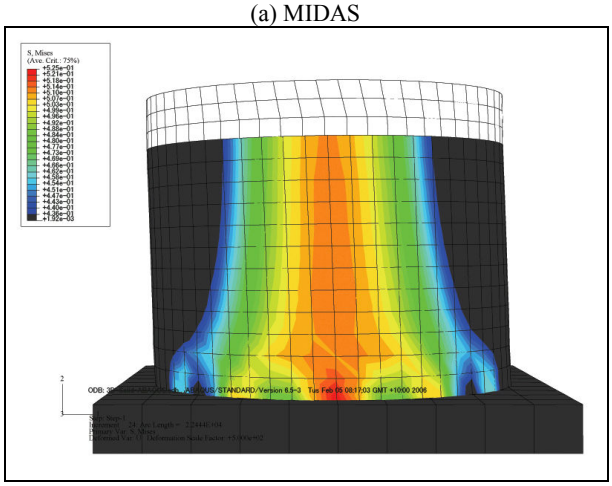
Posttest analysis will be performed in consideration of SFMT results.

5. Conclusion

This paper will present results of analysis of PCCV loading with seismic cases until total break of the structure. There will be comparisons of the pretest and posttest analyses with test results. The details of the experimental results will be published shortly from HICTD.



(a) MIDAS



(b) ABAQUS/Standard

Figure 3. Pretest analyses for SFMT of PCCV test model

Failure mode such as first concrete cracking, rebar yielding, and loss of bond between concrete and steel members and through thickness cracking of cylinder wall will be predicted in the future analysis.

This would further help in improved understanding of PCCV wall-base juncture behavior near the ultimate and the structural collapse states, in case of seismic accidents.

REFERENCES

[1] K. Yonezawa, K. Imoto, M. Ohba, T. Ikeuchi, M. Kozuma, Y. Murazumi, and K. Sato, Analytical Study on Structural Failure Mode of 1/4 PCCV Test Model, Proceedings of the 17th International Conference on Structural Mechanics in Reactor Technology (SMiRT 17), Aug.17-22, 2003, Prague, Czech Republic.

[2] ABAQUS/Standard User's Manual, Versions 6.5.

[3] MIDAS/Civil User's Manual, Versions 5.9.