# Dynamic Impact Force Behavior of Spent Fuel Pool using Seismic Table under DBE and BDBE Conditions

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## 1. Introduction

In order to evaluate the structural integrity of the spent fuel pool (SFP) and fuel storage rack, a seismic simulation test using two axis shaking table was carried out. Since the size of the seismic table is small, it is not possible to perform the real size seismic simulation test. Therefore, the 1/8th scale model SFP was manufactured and tested under the safe shutdown earthquake (SSE, DBE) and the beyond design basis earthquake condition (BDBE). Impact forces acting on the wall of the SFP were measured through seven underwater force sensors. Impact force measurements were used to select vulnerable fuel storage racks, which provided input data for evaluating the structural integrity of the SFP and storage racks due to seismic loads.

## 2. Seismic Simulation Test

### *2.1 1/8th scale SFP*

The 1/8th scale model dimension was designed based on the hydraulic actuator and excitation capacity according to similarity rule for Korean Standard Nuclear Power plants (KSNP, OPR-1000), which was shown in Fig. 1.

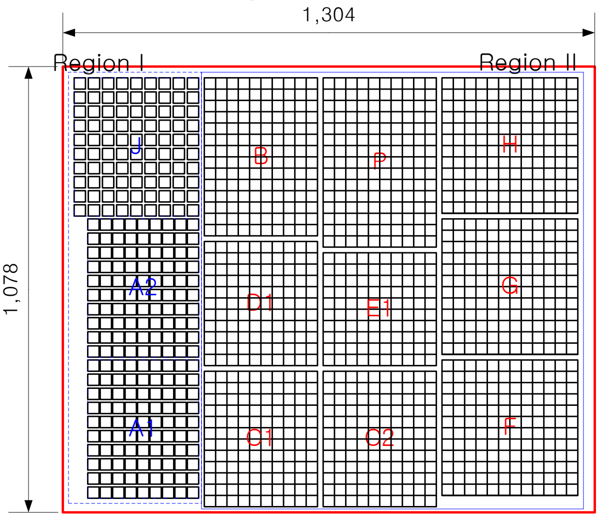



Figure 1. Schematic drawing of SFP for KSNP.

### *2.2 Test condition*

Standard seismic inputs were produced by applying the lowest ground attenuation ratio model of 1 g in compliance with NRC Reg. Guide 1.6.

Finally, the standard seismic input acceleration data were generated as shown in Fig. 2. Based on this, the seismic input from the SSE condition was produced by multiplying the standard seismic input by 0.2 and the seismic input from the BDBE by 0.3. In this case, a horizontal X represents the EW-directional acceleration, and the horizontal Y represents the NS-directional acceleration.

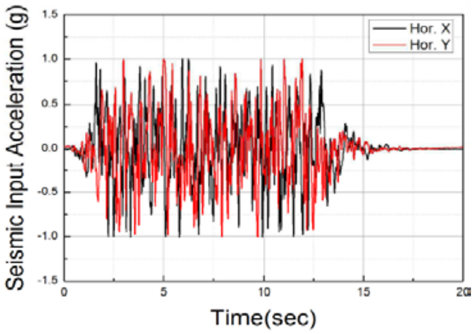
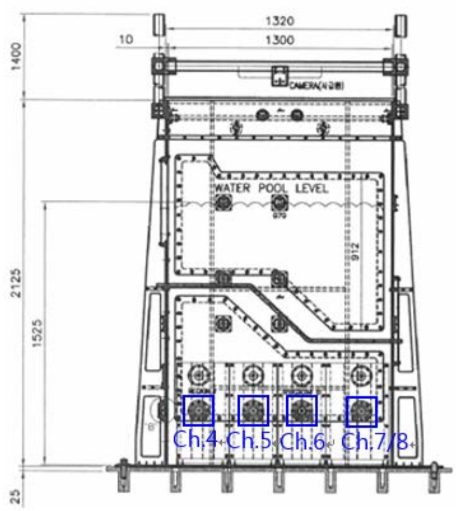


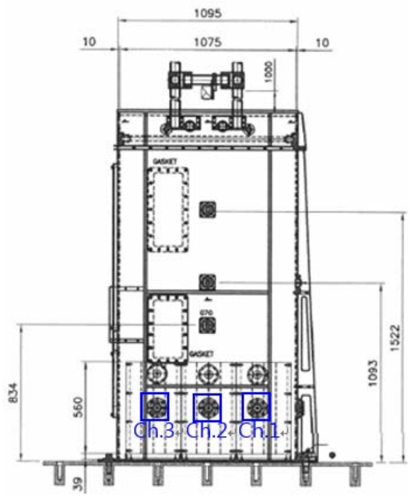

Figure 2. Standard seismic input acceleration time history.

### *2.3 Test setup*

The 7(seven, Fig. 3 square) force sensors were installed on the side and back panels of the SFP to measure the dynamic force applied to the wall by impact between the SFP wall and fuel storage rack. The force sensors were positioned one-half the height and width of each fuel storage rack in the west and north panels.




(a) front panel




(b) side panel

Figure 3. Force sensor position (square) for impact force measuring.

*2.4 Test results*

1) SSE load case

The contact on the SFP wall caused by the movement of the fuel storage rack under the SSE seismic load and full water level conditions was negligible. Therefore, no contact force occurred between the SFP wall and the fuel storage racks under the SSE condition. Several times the same seismic loads were applied in consideration of aftershock, but no contact occurred between them.

Considering the loss of coolant by SSE, 60% water level condition, the impact force occurred in several fuel storage racks located north side wall regardless of the direction of the seismic input load, and the largest impact force was the maximum value under bi-axial seismic loading condition, which was shown in Fig. 4.

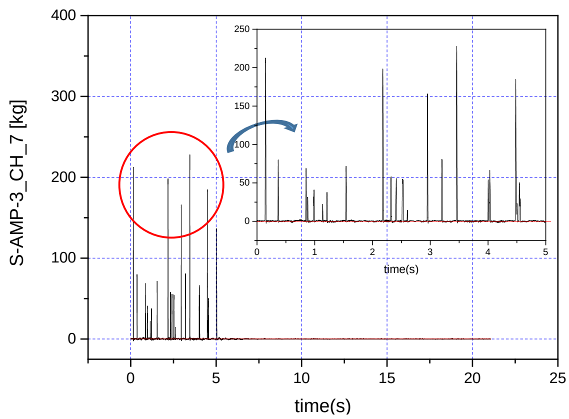



Figure 4. Impact force history of fuel storage rack "H" under SSE, 60% water level condition.

This seems to be due to the decrease in the level of the coolant, which results in greater inertia forces due to the sloshing of the coolant compared to the full water level. The magnitude of the maximum impact force with respect to the water level was compared to assess the effects of inertia on the same seismic loading condition, which was summarized in Table 1.

Table 1 Maximum impact force of each fuel storage rack under SSE condition

| Classification / loading condition | | Impact force ($kg_f$) | |
|---|---|---|---|
| | | Ch.6 | Ch.7 |
| 0.2g xy- | full | - | - |
| | 85% | 161.5 | 216.5 |
| | 60% | 122.1 | 233.5 |

2) BDBE load case

The design basis for seismic loads was also reinforced, imposing 0.3g, the seismic input for beyond design basis accidents. The results of the impact forces in the fuel storage racks under each seismic input load were summarized in Table 2. As expected, the impact forces of each fuel storage racks under BDBE input load case were larger than the results under the DBE input load case.

Table 2 Impact force of each channel under BDBE condition

| 0.3g / dir. | | Impact force ($kg_f$) | | | | |
|---|---|---|---|---|---|---|
| | | Ch.1 | Ch.3 | Ch.4 | Ch.6 | Ch.7 |
| full | x- | 206.8 | - | 125.4 | - | 270.0 |
| | y- | 153.3 | - | 70.0 | 74.3 | 261.0 |
| 85% | xy- | - | - | - | - | 306.4 |
| | y- | - | - | - | 231.4 | - |
| 60% | x- | 163.1 | - | - | - | 219.9 |
| | xy- | 247.3 | 116.4 | - | 150.4 | 301.9 |
| | y- | 139.4 | 254.0 | 272.3 | 262.8 | 343.0 |

The largest impact force was also occurred at the "H" rack position under the xy- seismic, and 60% water level condition, which was shown in Fig. 5.

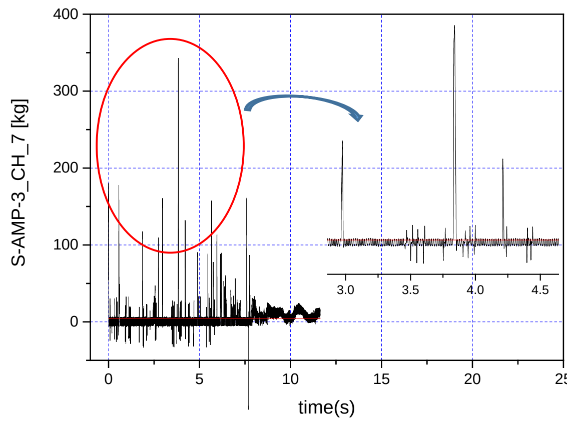



Figure 5. Impact force history of fuel storage rack "H" under BDBE, 60% water level condition.

## 3. Conclusion

A 1/8 scale model of the spent fuel pool was designed and manufactured to verify the integrity of the SFP for seismic simulation tests. Seismic loads were imposed onto the shaking table of DBE and BDBE condition, and a seismic simulation test was carried out by changing the water level from full to a 60% water level condition, taking into account the loss of coolant due to the seismic loads.

Fuel storage racks in the spent fuel pool exhibited sliding, rotation, and tip over phenomena due to seismic loads. Among these storage racks, the storage rack "H" in the northeast corner was not only heavier, but also had a relatively smaller gap with the SFP wall. Therefore, this fuel storage rack was easy to contact with the SFP wall, and had the largest impact force behavior compared to other racks.

## ACKNOWLEDGEMENTS

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