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Seismic excitation tests for 1/4 scale models of a PWR spent fuel storage cask

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1. Introduction

The spent fuels from a nuclear reactor are usually stored in storage casks or a facility in site or outside a reactor plant when the internal capacity of the spent fuel storage building is full. In Korea, a conceptual study for storing the spent fuels in a concrete storage cask was started recently [1, 2]. One concept is that the spent fuel assemblies of a PWR type are stored in a dry type concrete storage vessel system, which consists of a canister and a storage cask body. The canister accommodates 24 spent fuel assemblies of a PWR type. The storage cask is a steel cylindrical shell structure and contains the canister. This system is a free standing structure on a concrete installation pad. It should resist a seismic load and not be overturned, and be within a limited slip distance.

As listed in Table 1[3], the seismic excitation tests for two kind models are performed for several seismic loads. The data are also used to check the computer simulation methods and the seismic response for a prototype cask.

2. Description of test model

The test models of a concrete storage cask are represented in Figs. 1&2. The 1/4 scale models consist of a cask body of 1.43 tons, a canister of 0.6 tons, and an added mass of 5.34 tons. The total weight of the storage cask model 1 (named by CASK1/4-SB) is 2.118 tons. The model 2 (named by CASK1/4-SM) is 7.37 tons.

The model 1 is geometrically scaled by 1/4. The model 2 has a dynamic similarity with a prototype by keeping the weight ratio of 1/16 with an added mass to model 1. The concrete pad weighs 1.24 tons, and its dimension is 1.5m (D) x 1.5m (W) x 0.2m (H). The main body and canister are made of SA516 Gr.70 and SA240, respectively.

The seismic loads used in the tests are two kinds. One is an artificial time history (ATH) of 0.1g to 0.3g generated by using the seismic acceleration spectrum of the NRC Reg. Guide 1.60. The other is a soil response time history (SRTH) load given by KONES Inc. Several load levels from 0.1g to 0.8g are used in tests for the both horizontal and vertical directions.

To measure the seismic response of the models, 9 accelerometers and two displacement sensors for cask movements in the horizontal direction, and 4 laser sensors for the lift heights of the model bottom are used. The accelerometers are installed on top of the model body and the concrete pad with 3 axes.

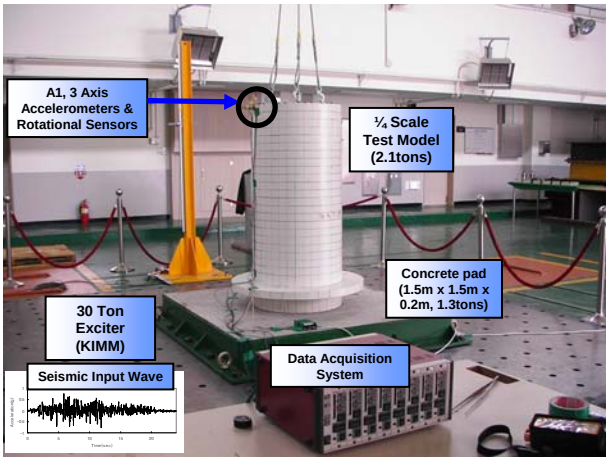

Fig. 1 Test model 1 of a concrete storage cask (CASK1/4-SB)

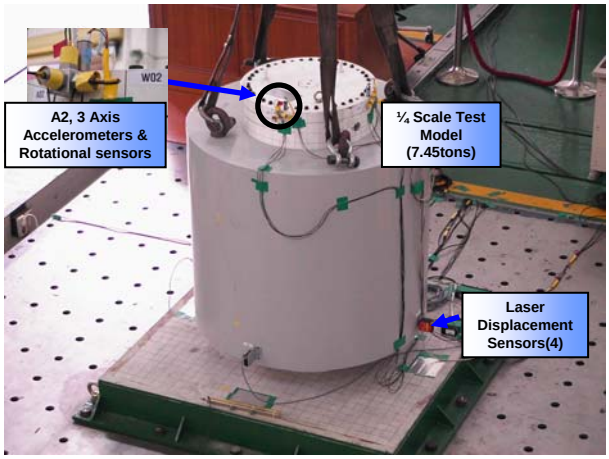

Fig. 2 Test model 2 of a concrete storage cask (CASK1/4-SM)

3. Test results

The 50 seismic tests were successfully performed with a full capacity of the table exciter with an 80mm stroke.

Both models were shaken with rocking motions of over 0.3g table excitations.

The rocking impact loads of the models could have some influence on the exciter's system frequency of near 30Hz. That would amplify the model acceleration responses. The seismic rocking responses in the x-direction are larger than the y-direction due to the concrete pad's irregularity as shown in Fig.3.

The maximum response displacement of the CASK1/4-SB model is 16.2mm in the horizontal

direction as shown in Fig.4, and the maximum acceleration is 5.7g at the top of the model as shown in Fig.5. The rocking angle is estimated to be about 1 degree.

The maximum displacement of the CASK1/4-SM model is 19mm in horizontal direction as shown in Fig.6, and the maximum acceleration is 6.55g at the top of the model as shown in Fig.7. The maximum lift height of the model 1 is about 12.4mm at the bottom of the added mass of an annular type as shown in Fig.8. The rocking angle is estimated to be about 1.3 degree.

4. Conclusions

The rocking motions for the 0.3g and 0.4g tests with the real time scale excitations represent the behaviors of the prototype cask. The measuring data of the 0.8g excitations of the SRTH seismic loads can be used for verifying a computer simulation for a storage cask.

ACKNOWLEDGEMENT

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REFERENCES

1. Seo, K.-S., et al., Structural, Thermal Analyses and Safety Test Evaluation for Dry Storage System(Final Report), KAERI/KHNP-NETEC, KAERI/CR-218/2005, 2005.
2. Lee, Jae-Han, et al., Seismic Response Analysis and Test of 1/8 scale model for a spent fuel storage cask, KAERI/TR-3032/2005, 2005.
3. Tests on Evaluation Earthquake Response Characteristics of the Spent Fuel Storage Cask Model, Report No. 2008000350, KIMM, 2008.7.

Table 1. Seismic excitation test kinds

	Seismic Load Type	Test Magnitude	Time compression
Model 1 (CASK1/4-SB)	ATH	0.1g - 0.3g	1 / 2
	SRTH	0.1g - 0.4g	1 / 2
Model 2 (CASK1/4-SM)	ATH	0.1g – 0.3g	1 / 1
	SRTH	0.1g – 0.4g	1 / 1
	SRTH	0.8g	1 / 2

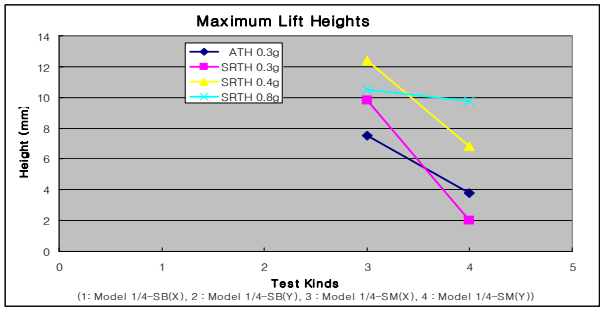

Fig.3 Lift heights of the rocking motions for the ATH and SRTH seismic excitations

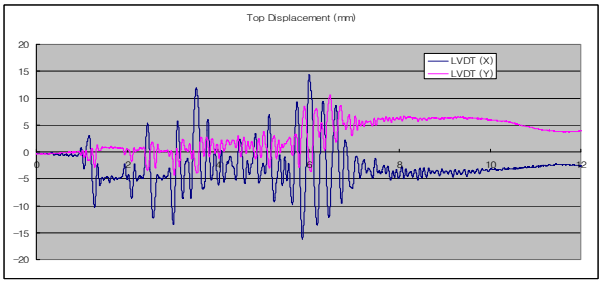

Fig.4 Displacement responses of model 1 for ZX-direction of SRTH 0.8g

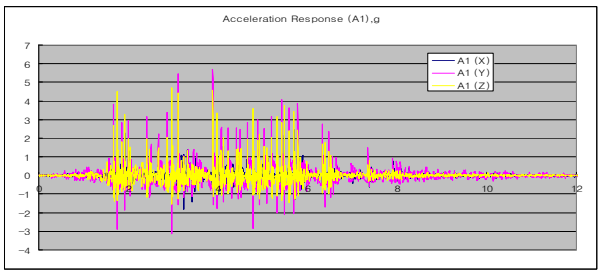

Fig.5 Acceleration responses of model 1 for ZY-directions of SRTH 0.8g

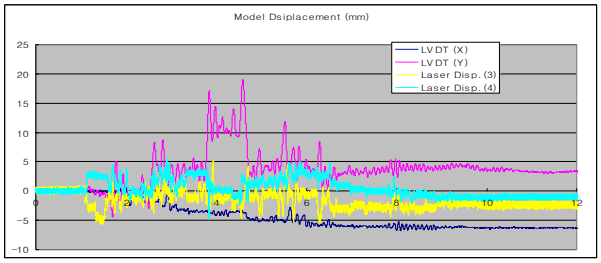

Fig.6 Displacement responses of model 2 for Y-directions of SRTH 0.8g

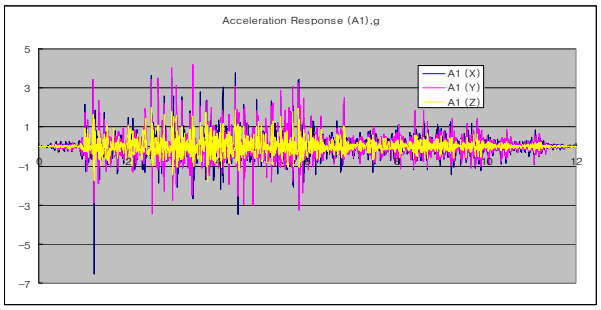

Fig.7 Acceleration responses of model 2 for ZX-directions of SRTH 0.8g

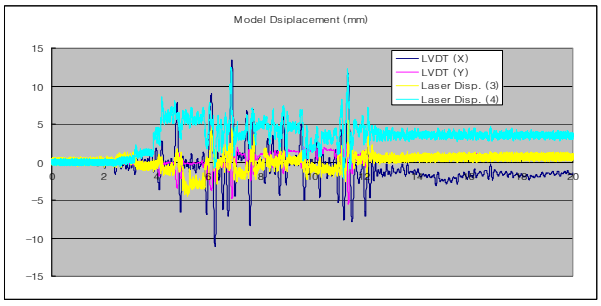

Fig.8 Lift heights of model 2 for ZX-directions of SRTH 0.4g