Prediction of Support Reaction Forces of ITA via Response Spectrum Analysis

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1. Introduction

The HTS (Hydraulic Transfer System), which is installed in KJRR (KI JANG Research Reactor), is a facility for producing radioisotope. The irradiation targets are transferred along pipes between TTS (Target Transfer Station) and ITA (Irradiation Tube Assembly) by hydraulic forces. The ITA corresponds to the vertical guide tube for irradiation targets inside a reactor, and it penetrates the reactor structure as shown in Fig. 1.

Because the ITA is classified into seismic category II, its structural integrity must be evaluated by the seismic analysis. To approach more realistic problem, the interaction between the ITA and the reactor structure must be considered. However, this paper is focused on the preliminary analysis, and it is simplified that only the response of the ITA caused by earthquake affects the reactor structure.

The response of the ITA is predicted by the spectrum response analysis based on the FDRS (Floor Design Response Spectra) of KJRR. Finally, the reaction forces corresponding to the load transfer into the reactor structure are estimated by using ANSYS.

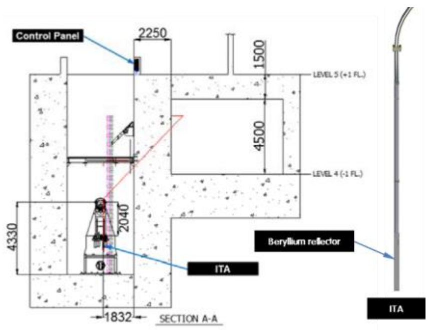


Fig. 1. HTS and ITA configuration

2. Analysis model

2.1 FE model

The FE model of the ITA is constructed by using both hexahedral and beam elements. For using the hexahedral elements, the geometry of the ITA is imported directly from the 3D CAD. For using beam element, the corresponding cross sectional geometry along the height is applied to the line body.

The ITA is submerged under demineralized water, the hydraulic mass is added because the inertia of the surrounding fluid on the vibration of the structure shall be considered. The added mass is given by ASME B&PV code[1]. For the FE model with hexahedral elements, the added mass can be distributed by SURF154 element in ANSYS. For the FE model with beam elements, density is modified to compensate the added mass. Total masses are presented in Fig 2.

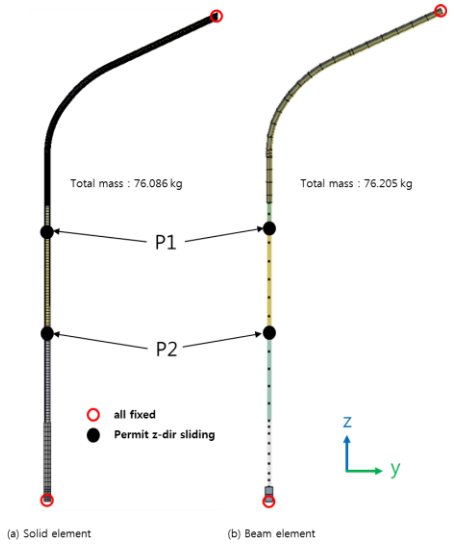


Fig. 2. FEM model

The ITA is constrained laterally in the P1 and P2 as shown in Fig. 2, and the load due to vibration of the ITA is transferred to the reactor structure through these points. In order to compute the reaction forces at these points, the degrees of freedom are fixed in the x and y directions. Meanwhile, the underbody of the ITA is inserted in the beryllium reflector so that the only vertical motion in the positive direction (z-dir) is permitted. Therefore, the contact condition between the ITA and the beryllium reflector must be involved. However, the response spectrum analysis can be applied to the linear problem. From the view point of the conservativeness on the design, all the degrees of freedom at the bottom of the ITA are fixed.

2.2 Frequency response spectrum

Because the KJRR is designed excluding Operating-Basis Earthquake(OBE), only the seismic analysis for Safe Shutdown Earthquake(SSE) is conducted.

The frequency response spectrum for ITA is generated from FDRS where the ITA is installed. The

FDRS are calculated followed by NUREG1.122 [2] and the critical damping ratio 4% for the welded and bolted steel structure is chosen according to NUREG1.61 [3]. After the enveloped spectra for two horizontal directions (east-west, north-south) is newly constructed, it is applied to the seismic loadings for the conservative design.

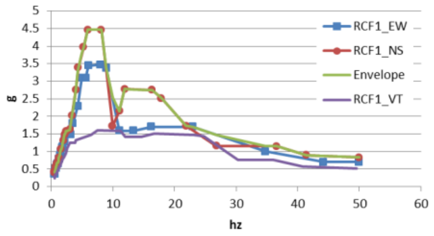
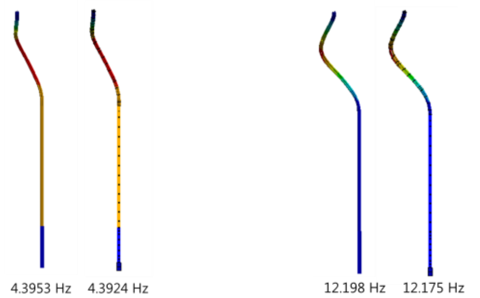


Fig. 3. Floor Design Response Spectra

3. Analysis results

3.1 Modal analysis

To capture the dynamic behavior of ITA in the high frequency range, 150 modes are extracted, and consequently more than 85% of effective mass for each direction is contained. Although more than 90% of mass participation rate is recommended, frequencies less than Zero Period Acceleration (ZPA) are all included and missing mass is compensated by considering acceleration at ZPA. The modal results are compared between the solid model and the beam model as shown in Fig. 4.



First mode (a) solid, (b) meal

Second mode (a) Solid, (b) beam

Fig. 4. Mode analysis results

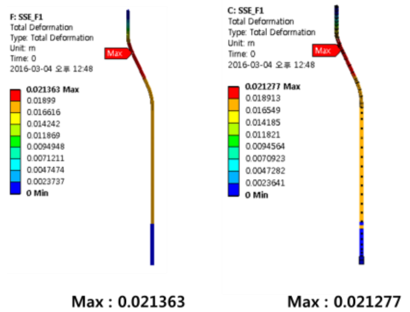
3.2 Response Spectrum Analysis

For the seismic analysis in the frequency domain, the response spectrum analysis is conducted. Three directional FDRS are applied to all the fixed boundary conditions at a time, and then results from each mode are combined by SRSS[4].

The reaction forces at the support points (P1, P2) are listed in Table I.

Table I: Support reaction forces

Location		Solid	Beam	Diff(%)
P1	Fx	266.56	265.75	0.3
	Fy	634.17	612.43	3.4
P2	Fx	82.890	73.636	11.2
	Fy	71.799	73.666	1.4



solid

beam

Fig. 5. Total deformation results

Except for Fx at P2, all values are within 5% differences. The main reason for this discrepancy results from the different way of imposing the added mass in the solid and beam FE models. Consequently, the inertia forces due to seismic input works differently on the response of the ITA in two FE models. Although the discrepancy exists, the difference is insignificant; therefore, it has no problems in predicting the reactor forces roughly.

4. Conclusions

In this study, the reaction forces due to the earthquake are estimated by the response spectrum analysis. For the saving computational time and resource required, the FE model with beam element is constructed, and it is confirmed that the accuracy of the solution is acceptable by comparing the results of the solid model. The reaction force in this paper will be used as the base input data on the design of the reactor structure.

5. Acknowledgement

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