FRS Generation for Safety Components of Reactor Assembly for KJRR

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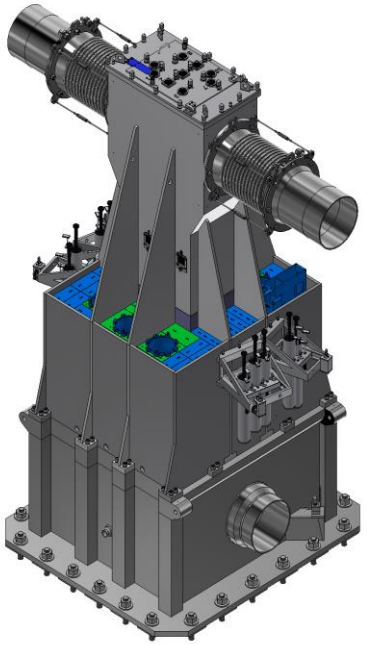

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1. Introduction

❑ Safety components and seismic inputs for Reactor Assembly for KJRR

- fuel assemblies, CAR/SSR Control and Shutdown mechanisms, Reflector Assemblies and Gamma Shielding, and Penetration Assembly attached to Grid Plate, Out-core reflector support plate, CAR/SSR Guide Tube and UGS Flanges
- 18 cases of 3 directions (NS, EW, VT), 3 soil properties (BE, UB, LB), and 2 building conditions (uncracked, and cracked) at the bottom of Reactor Assembly
  - ✓ 18 acceleration time histories provided by SSI analysis results
  - ✓ 3 enveloped Floor Response Spectra (FRS1)

❑ FRS calculations for seismic qualification with two ways.

- One is a simplified method to generate FRS2
  - ✓ The artificial time histories are generated compatible to the enveloped seismic input FRS1 at the bottom of the Reactor Assembly, which envelopes 18 cases of seismic inputs.
  - ✓ FRS2 is generated by the transient time history analysis.
- The other is full transient analyses for 6 sets of 18 cases, and then enveloping the FRS results.
  - ✓ The FRS3 is generated using the conservative time histories linearly amplified by 20% of the given time histories provided by SSI analysis results and broadening the calculated spectra by 15-20% to cover uncertainties in modeling and material properties.

2. Simplified Method [1/4]

❑ Seismic Analysis Procedure with 2 Ways [Fig.1]

- Path A : The FRS3 is generated using the conservative time histories linearly amplified by 10–20% of the given time histories provided by SSI analysis results and broadening the calculated spectra by 15–20% to cover uncertainties in modeling and material properties.
- Path B : FRS2 is generated by the transient time history analysis using Artificial TH compatible to the enveloped seismic input FRS1 at the bottom location of the Reactor Assembly, which envelopes 18 case of 3 directions (NS, EW, VT), 3 soil properties (BE, UB, LB), and 2 building conditions (uncracked, and cracked).

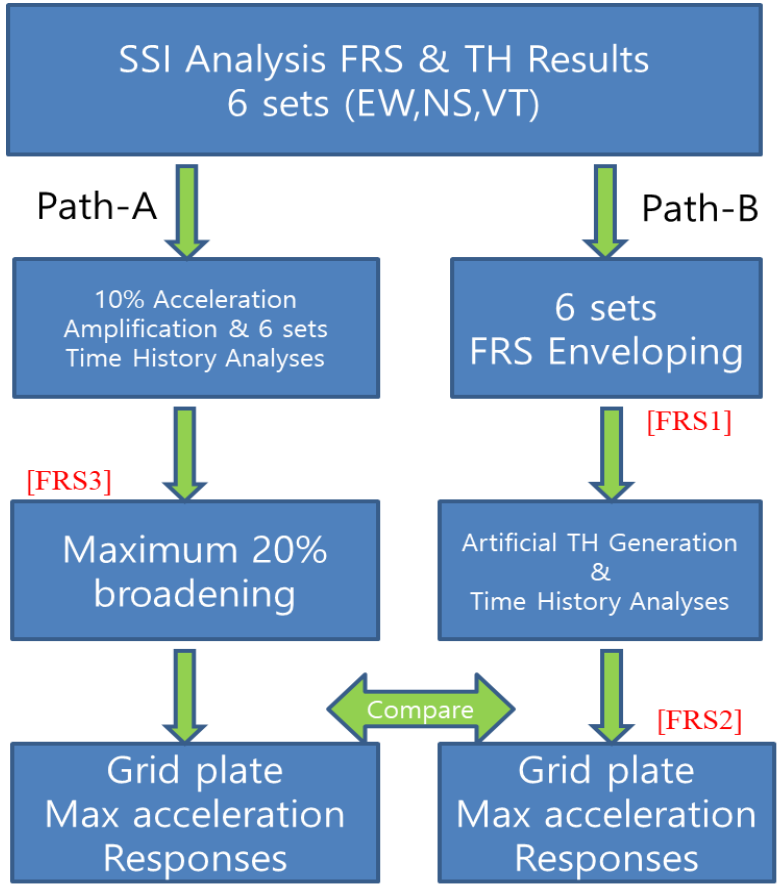
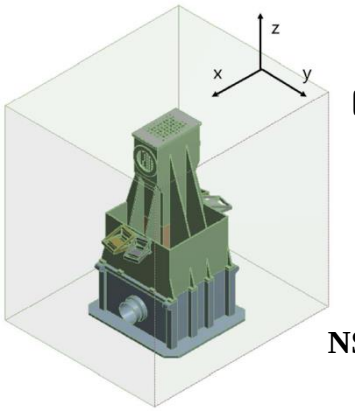


Fig 1 Seismic Analysis Procedure with 2 Ways

2. Simplified Method [2/4]

❑ Seismic Input [FRS1]

- The enveloped seismic input FRS1 at the bottom location of the Reactor Assembly which envelopes 18 case of 3 directions (NS, EW, VT), 3 soil properties (BE, UB, LB), and 2 building conditions (uncracked, and cracked) are shown in Fig.2.
- The 3 directional artificial time histories shown in Fig. 3.
  - EW direction only is generated using
  - P-CARES [2] compatible to the FRS1.



(H4.33 m x W2.155 m x D2.422 m)

Fig 4 Reactor Assembly, EW x- direction- Nozzle, NS y- perpendicular to Nozzle, VT z-direction

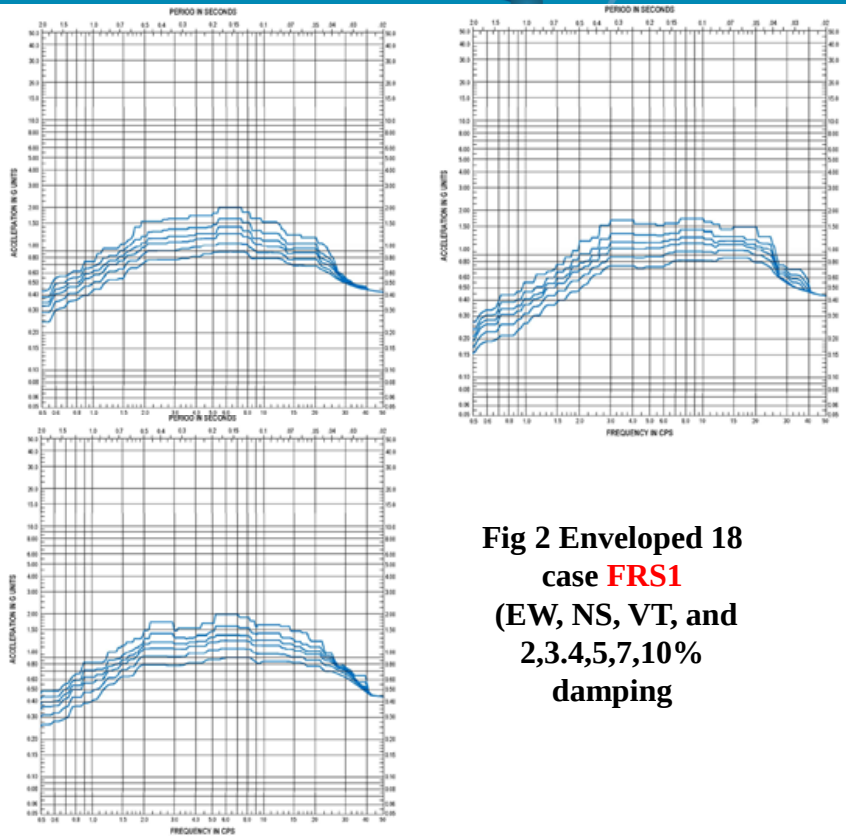


Fig 2 Enveloped 18 case FRS1 (EW, NS, VT, and 2,3.4,5,7,10% damping

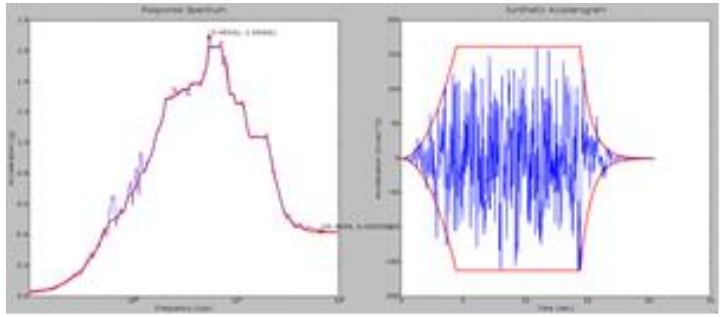
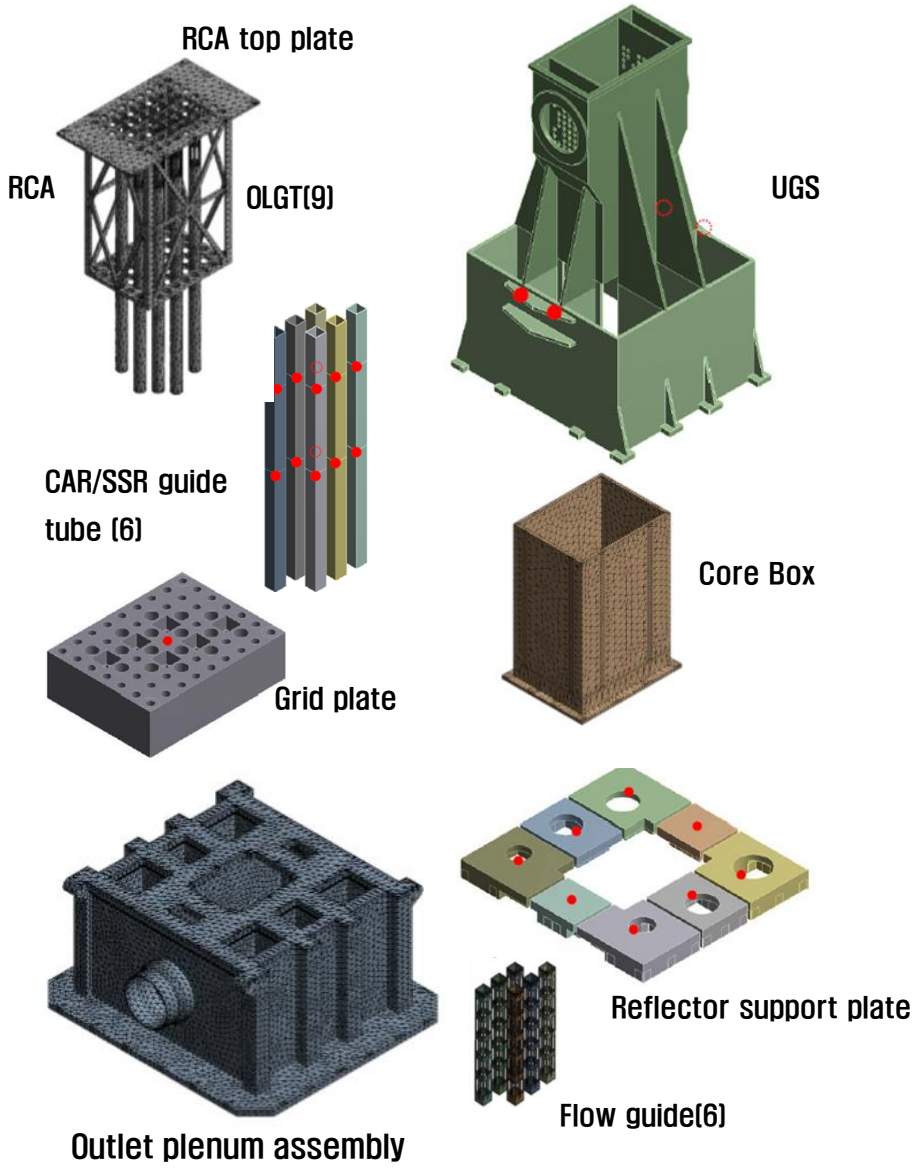


Fig 3 Comparison of calculated Spectra (3% damping) with given FRS1, its Artificial Time History in EW direction

2. Simplified Method [3/4]

❑ FE Modeling of Reactor Assembly

- Safety Class 3 and Seismic Category Ⅰ structure of KJRR,
  - ✓ Outlet Plenum Assembly,
  - ✓ Grid Plate,
  - ✓ Core Box,
  - ✓ Upper Guide Structure Assembly (UGS), Reactor Cover Assembly,
  - ✓ Control Absorber Rod/Second Shutdown Drive Mechanism (CAR/SSR) Guide tube,
  - ✓ Expansion Joint, and Neutron Detector Housing Assembly (NDHA).
- Not including the components located under the pool bottom such as penetration parts and drive mechanisms of CARs and SSRs.
- FE model using ANSYS.



2. Simplified Method [4/4]

❑ FE Modeling of Reactor Assembly

- External added masses as 7452Kg in x direction and 6791Kg in y direction.
- Internal fluid masses as 5693Kg in both x and y directions, which submerged in Reactor Pool.
- The safety components are fuel assemblies, CAR/SSR Control and Shutdown mechanisms, Reflector Assemblies and Gamma Shielding, and Penetration Assembly, and need to generate FRS (ie, either FRS2 or FRS3) at their support positions such as Grid Plate, Out-core reflector support plate, CAR/SSR Guide Tube and UGS Flanges.
- Typical material properties of safety components are shown in Table 1.

Table 1 Material properties of safety components of Reactor Assembly

번호	구성품	개수 [ea]	재료	밀도 [kg/m^3]	탄성계수 [GPa]	쁘아송비	총 질량 [kg]
1	Outlet plenum assembly	1	S30403 (SA240 304L)	7900	187.8	0.300	7883.3
2	Grid plate	1	S30403 (SA240 304L)	7900	187.8	0.300	534.5
3	Core box	1	R60804 (Zircaloy-4)	6550	87.46	0.365	586.2
4	UGS	1	A96061 (AL6061)	2713	64.8	0.330	1449.5
5	RCA	1	A96061 (AL6061)	2713	64.8	0.330	122.0
6	CAR/SSR guide tubes	6	A96061 (AL6061)	2713	64.8	0.330	44.8
7	NDHAs	4	A96061 (AL6061)	2713	64.8	0.330	78.6

3. Results [1/2]

❑ FRS1 Vs. FRS3 at the Reactor Bottom

- The FRS1 are compared with the FRS3 at the Reactor Bottom, as shown in Fig 5 resulting that

	FRS3 (3% damping)			FRS1 (3% damping)		
	EW	NS	VT	EW	NS	VT
PSA(g)	2.8	2.8	1.7	1.63	1.6	1.42
f[Hz]	[5–8]	[4.2–7.2]	[7.2–10]	[5.4–7.3]	[5.2 – 7]	[7.4–10]
ZPA(g)	0.58	0.61	0.5	0.42	0.43	0.424

- PSAs(peak spectral accelerations) of FRS3 are much larger than enveloped FRS1 at the Reactor Bottom
  - ✓ by 72–75% in horizontal direction,
  - ✓ by 20% in vertical direction.

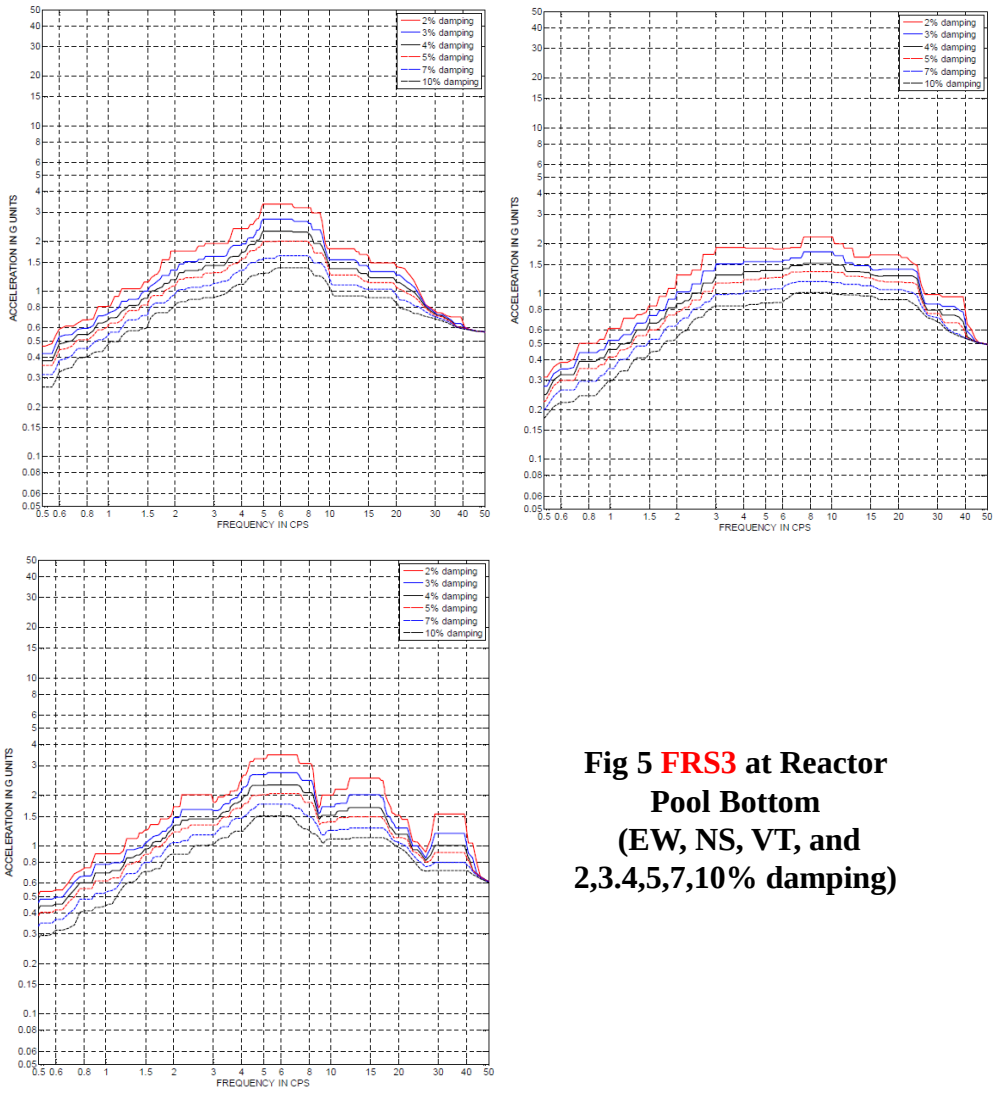


Fig 5 FRS3 at Reactor Pool Bottom (EW, NS, VT, and 2,3.4,5,7,10% damping)

3. Results [2/2]

- FRS2 (Simplified) Vs. FRS3 (Conservative) at the Grid Plate
  - Peak Spectral Accel (PSA) of FRS3 are compared with calculated FRS2,
  - For example, using one set of given time histories among six sets before 15–20% broadening spectral values at the Grid Plate of the Reactor Assembly as shown in Fig. 6 and Fig. 7.

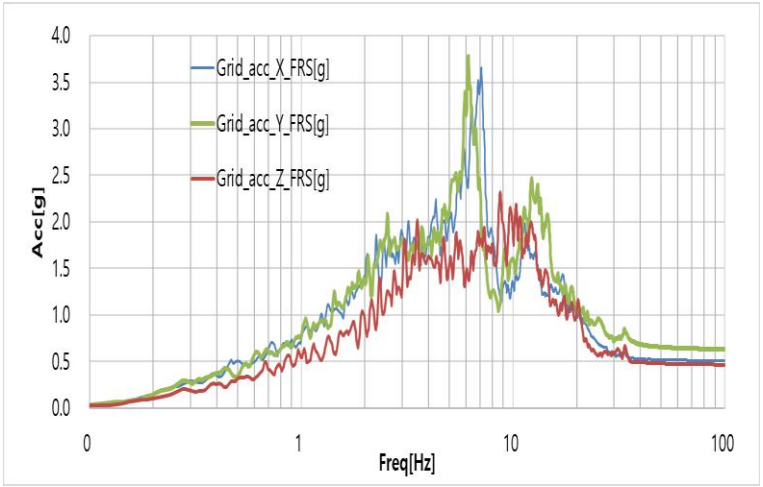


Fig. 6 FRS3 at Grid Plate of Reactor Assembly

	FRS3 (2% damping)			FRS2 (2% damping)		
	EW	NS	VT	EW	NS	VT
PSA (g)	3.65	3.78	2.19	2.13	2.22	1.99
ZPA (g)	0.517	0.649	0.476	0.47	0.478	0.442

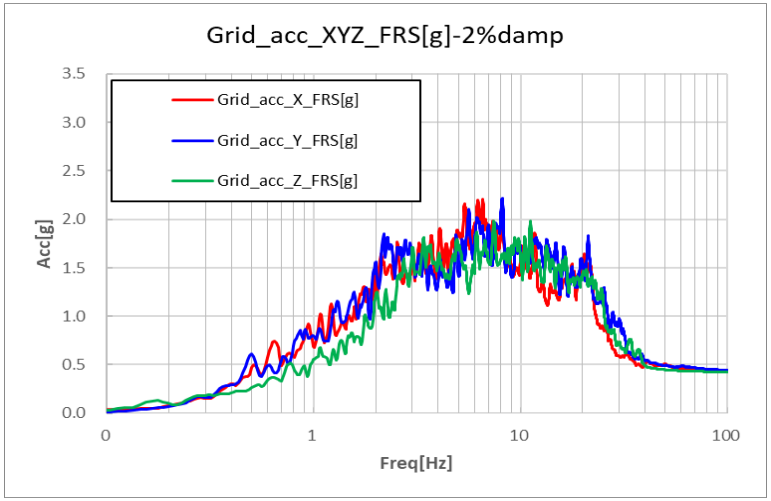


Fig. 7 FRS2 at Grid Plate of Reactor Assembly

8. Summary

- The simplified method is proposed to generate FRS2 to be used for the seismic qualification for the safety components attached to the Reactor Assembly.
- The artificial time histories generated at the Reactor Assembly Bottom are less conservative than the 20% amplified time histories.
- At the Reactor Assembly Bottom, Peak spectral accelerations of enveloped FRS1 are much smaller than those of FRS3 by 72–75% in horizontal directions, and by 20% in vertical direction.
- At the Grid Plate, Peak spectral accelerations of FRS2 are much less conservative than those of FRS3 generated from the linearly amplified time histories in most frequency ranges by 70% in horizontal directions, and less conservative by 10% in vertical direction.
- The simplified method proposed can reduce remarkably computing and post processing times, and provide with reasonable seismic responses for the seismic qualification for the safety components in the Reactor Assembly.