

## Seismic Analysis Conditions of APR1000

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### 1. Introduction

The advanced Nuclear Power Plants (NPP) are being designed with 0.3g as safe shutdown earthquake to adopt the standard design in recent, which the geological and seismological characteristics of the expected construction site are enveloped. In case that safe shutdown earthquake is increased from 0.2g to 0.3g, the total construction cost is increased about 1 %. However, the construction period is reduced and the efficiency is improved due to the standard design and the repetitive construction.

APR1000 is being developed on a basis of the OPR1000 for the foreign export. APR1000 has several advanced design features as compared with OPR1000 and one of them is seismic design with 0.3g and the site envelope characteristics. The seismic analysis conditions of APR1000 are presented in this paper.

### 2. Design Response Spectrum

OPR1000 as the reference plant of APR1000, requires for the seismic design that safe shutdown earthquake (SSE) is 0.2g and operating basis earthquake (OBE) is 0.1g with fixed base condition. Also, OPR1000 adopts the design response spectrum of Regulatory Guide 1.60 as shown in Fig. 1.

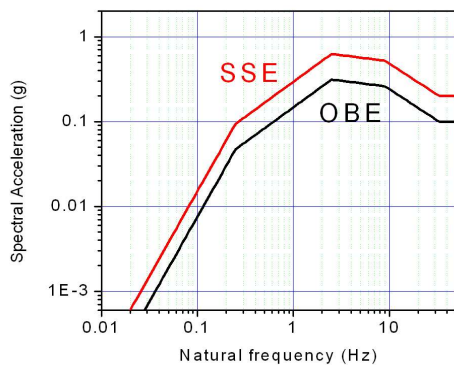


Fig. 1. Design response spectrum of OPR1000

The design response spectrum of AP1000 which Westinghouse electric company develops, is based on Regulatory Guide 1.60 but the spectral acceleration is increased 30 % at 25 Hz to enhance the high frequency contents and safe shutdown earthquake is 0.3g and the cutoff frequency is 33 Hz as shown in Fig. 2.

The design response spectrum of US APWR which Mitsubishi heavy industry develops, is based on Regulatory Guide 1.60 but one of the control points is

changed from 9 Hz to 12 Hz and the design response spectrum slope down from 12 Hz to 50 Hz to enhance the high frequency contents and safe shutdown earthquake is 0.3g as shown in Fig. 3.

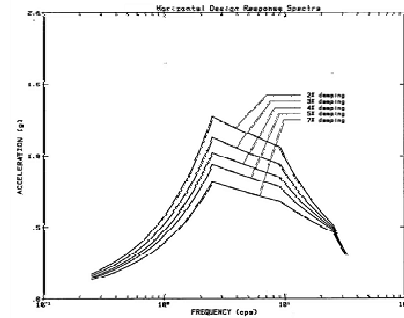


Fig. 2. Design response spectrum of AP1000

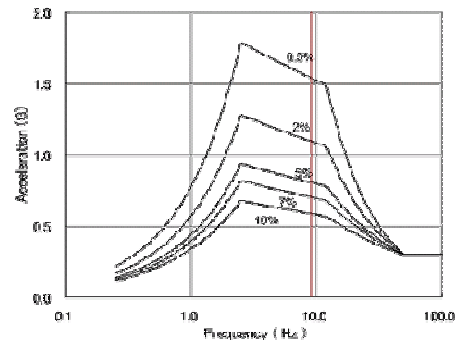


Fig. 3. Design response spectrum of US APWR

The design response spectrum of APR1000 is based on Regulatory Guide 1.60 but the spectral acceleration is increased 30 % at 25 Hz and the design response spectrum slope down from 25 Hz to 50 Hz to enhance the high frequency contents as shown in Fig. 4. The safe shutdown earthquake is 0.3g like AP1000 and US APWR.

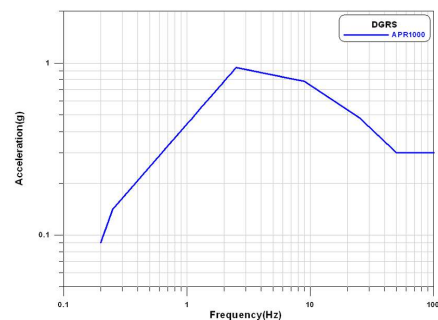


Fig. 4. Design response spectrum of APR1000

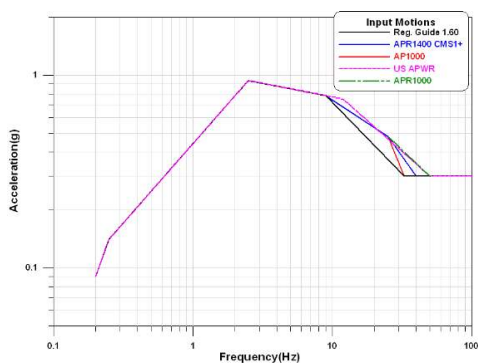


Fig. 5. Comparative results of each design response spectrum

### 3. Site Envelope Characteristics

AP1000 considers 5 soil profiles and a fixed base condition as site envelope characteristics and shear wave velocity, 8000 ft/s is considered as fixed base condition according to the SRP 3.7.2 as shown in Fig. 6. Also, the depth of base rock is 120 ft.

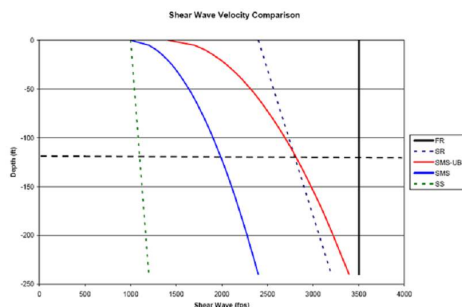


Fig. 6. Site envelope characteristics of AP1000

US APWR considers 3 soil profiles and a fixed base condition as site envelope characteristics and shear wave velocity, 8000 ft/s is considered as fixed base condition as shown in Fig. 7. Also, the depth of base rock is considered as the half infinite space.

- Soft soil site,  $V_s = 1,000$  ft/s,  $\gamma = 110$  pcf,  $\nu = 0.40$
- Rock site (Medium 1),  $V_s = 3,500$  ft/s,  $\gamma = 130$  pcf,  $\nu = 0.35$
- Rock site (Medium 2),  $V_s = 6,500$  ft/s,  $\gamma = 140$  pcf,  $\nu = 0.35$
- Hard rock site,  $V_s = 8,000$  ft/s,  $\gamma = 160$  pcf,  $\nu = 0.30$

Case No.	Soil Properties				Input Earthquake (SSE) Time Histories		
	Soft	Medium 1	Medium 2	Fixed Base	H1	H2	V
1	✓				✓	✓	✓
2		✓			✓	✓	✓
3			✓		✓	✓	✓
4				✓	✓	✓	✓

Fig. 7. Site envelope characteristics of US APWR

APR1000 considers 9 soil profiles and a fixed base condition as site envelope characteristics and shear wave velocity, 8000 ft/s is considered as fixed base condition as shown in Fig. 8. Also, the depth of base rock is 53 ft, 100 ft and 200 ft. APR1000 reflects the various soil profiles as compared with the other advanced NPPS

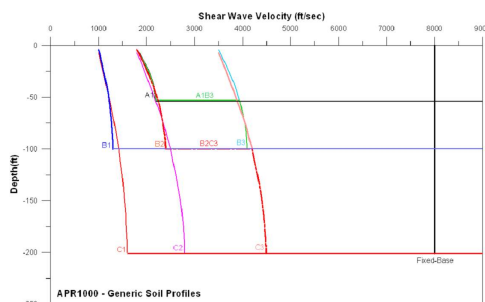


Fig. 8. Site envelope characteristics of APR1000

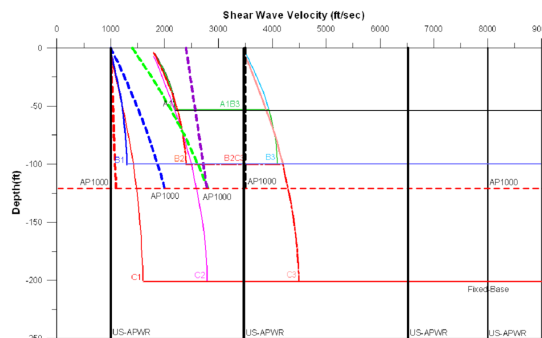


Fig. 9. Comparative results of each site envelope characteristic

### 4. Conclusions

The advanced NPPs which are being developed in recent, take account of 0.3g as safe shutdown earthquake and intensify the high frequency contents. Also, site envelope characteristics are being considered for the standard design. The safe shutdown earthquake of APR1000 is 0.3g and the spectral acceleration is increased 30 % at 25 Hz and the design response spectrum slope down from 25 Hz to 50 Hz to enhance the high frequency domain. In addition to design response spectrum, APR1000 considers 9 soil profiles and fixed base condition as site envelope characteristics. APR1000 has a considerable competitive power as compared with the other advanced NPPs from a seismic point of view.

### REFERENCES

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