REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**252-8299**
SRP Section:	**03.07.02 – Seismic System Analysis**
Application Section:	**3.7.2**
Date of RAI Issue:	**10/19/2015**

Question No. 03.07.02-9

10 CFR 50 Appendix S requires that the safety functions of structures, systems, and components (SSCs) must be assured during and after the vibratory ground motion associated with the safe shutdown earthquake (SSE) ground motion through design, testing, or qualification methods. In accordance with 10 CFR 50 Appendix S, the staff reviews the adequacy of the seismic analysis methods used to demonstrate that SSCs can withstand seismic loads and remain functional.

DCD Figures 3.7A-24 and 3.7A-25 show the ISRS in the E-W and N-S Directions respectively at EL 191'-0" for the PSW. The staff notes that the N-S ISRS in Figure 3.7A-25 corresponds to the out-of plane direction for the PSW, and shows a large difference in the amplitude of the response (e.g. at the ZPA and PSA) compared to the E-W ISRS in Figure 3.7A-24, which is the in-plane direction. The staff also observes a similar response in Figures 3.7A-42 and 3.7A-43 which show the ISRS in the E-W and N-S Directions respectively at EL 191'-0" for the SSW. To assist the staff in reviewing the adequacy of the analysis methods used for seismic Category I structures and the use of the respective analysis results, the applicant is requested to expand the presentation of the ISRS to include the individual soil profiles (including the fixed-base condition) and both concrete stiffness cases, that contribute to determination of the envelope ISRS., In presenting the expanded results, only 5% damping curves need to be provided, and the ISRS corresponding to cracked and uncracked concrete cases should be provided in separate figures to facilitate readability.

This information is requested for the E-W, N-S, and Vertical Directions at representative nodal points for the following locations:

- PSW, El. 191'-0"
- SSW, El. 191'-0"
- Top and Foundation level of CS

- Top and Foundation level of IS
- Top and Foundation level of AB
- Top and Foundation level of EDGB
- Top and Foundation level of DFOT

Response – (Rev. 1)

The comparisons of the 5% damped ISRS for individual soil profiles and both concrete stiffness cases are shown in Figures 1 through 72, below. The locations of the ISRS are at El. 191'-0" for PSW and SSW and top and foundation levels of the CS, the IS, the AB, the EDGB and the DFOT. Since the primary shield wall (PSW) and secondary shield wall (SSW) are included in the internal structure (IS), the locations of the foundation level of the IS is at EL. 66'-0" for the PSW and at EL. 78'-0" for the SSW. The top levels of the IS are the same for the PSW and SSW, EL. 191'-0".

Figures 49 through 72 show the ISRS for the EDGB and the DFOT. In these figures, the ISRS for the S05 soil profile case is not enveloped. Since the ISRS of the S05 soil profile are abnormal, the ISRS of the S05 soil profile are intentionally not incorporated in the enveloped ISRS. Three options are considered to the remove abnormal response for the S05 soil profile. The first option is inclusion of the ISRS of the S05 soil profile in the ISRS envelope for the EDGB/DFOT. Because the check results of sliding stability for structures do not satisfy the design requirements, this option is excluded. The second option is relocation of these structures away from the NI backfill portion. The relocation of structures leads to an increased potential aircraft impact; these analyses were already completed. Therefore, the second option is also excluded. The third option is chosen to minimize effects on other design processes. This option is a change of properties for backfill elements from structural fill granular to lean concrete property which are located between the EDGB and the DFOT, between the NI and the EDGB/DFOT, and backfill elements below the EDGB basemat as shown in Figure 73. This modification is applied to the SSI analysis model for only the rock type soil profile at ground surface such as the S05, S08 and S09 soil profiles. For sand type soil profile at the ground surface, structural fill granular is still maintained as a property of backfill elements. This option has an advantage that the similar backfill properties with in-situ soil properties can be used to minimize different settlements of the EDGB. Thus, the SSI analyses were performed using lean concrete properties for the S05, S08, and S09 soil profiles. The ISRS comparison results for the EDGB and DFOT are shown in Figures 74 through 97. As shown in the figures, the ISRS for the modified SSI analysis model slightly exceed the existing enveloped ISRS in the DCD at the top level of the EDGB/DFOT. Therefore, the ISRS in the DCD will be revised to envelop results of SSI analysis which is described above. The related results will also be revised.

The seismic response of the EDGB/DFOT are revised due to modification of the SSI analysis model for the S05, S08, and S09 soil profilse. DCD Tables 3.7-23 through 3.7-25 and Figures 3.7A-78 through 3.7A-93 will be revised.

Impact on DCD

DCD Tables 3.7-23 through 3.7-25 and Figures 3.7A-78 through 3.7A-93 will be revised, as indicated on the attachment with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on the Technical/Topical/Environmental Reports.

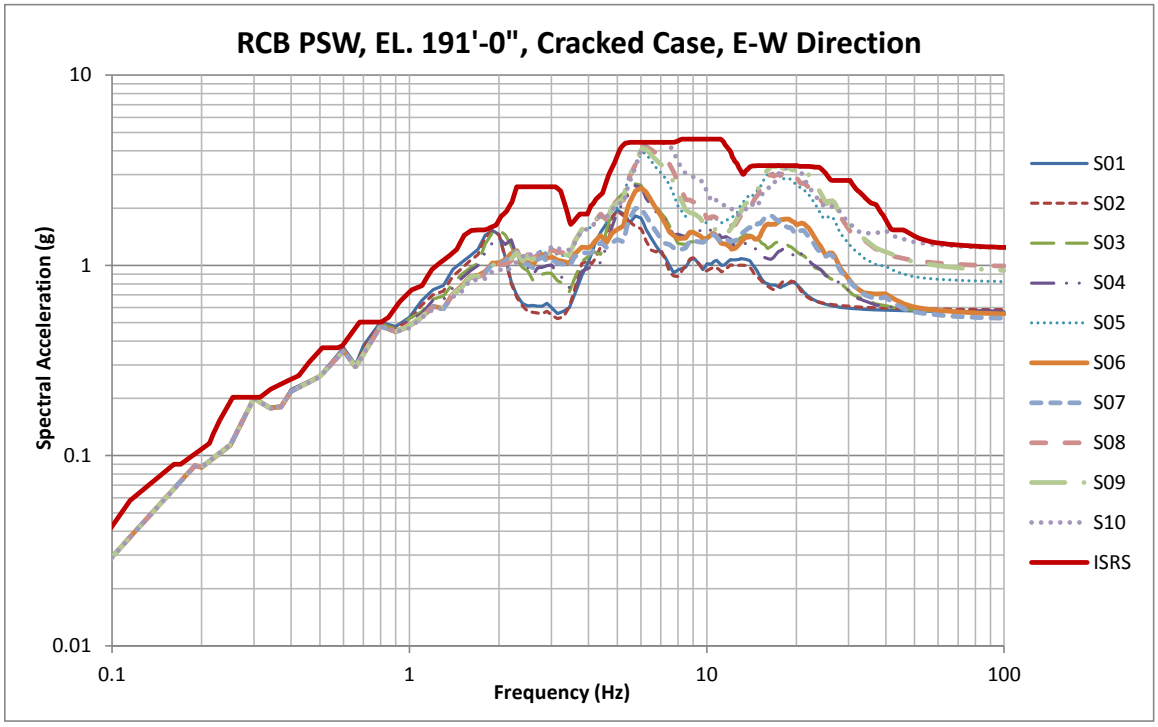


Figure 1 ISRS for RCB PSW, El. 191'-0", Cracked Case, E-W Direction

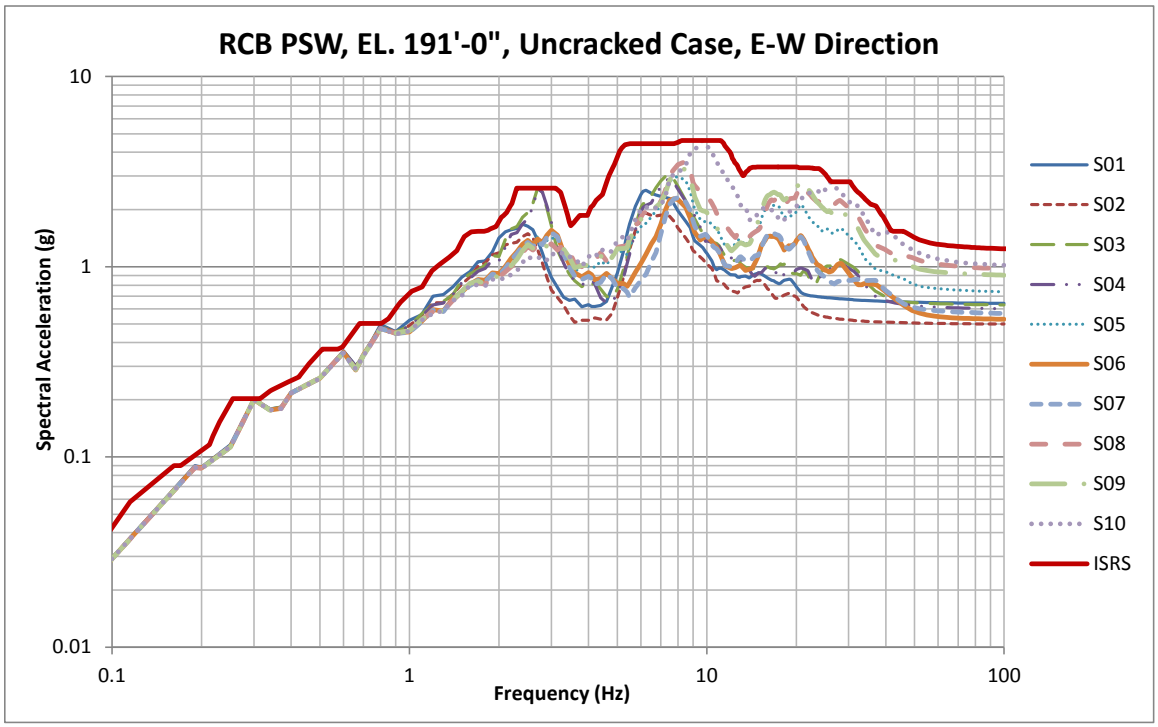


Figure 2 ISRS for RCB PSW, El. 191'-0", Uncracked Case, E-W Direction

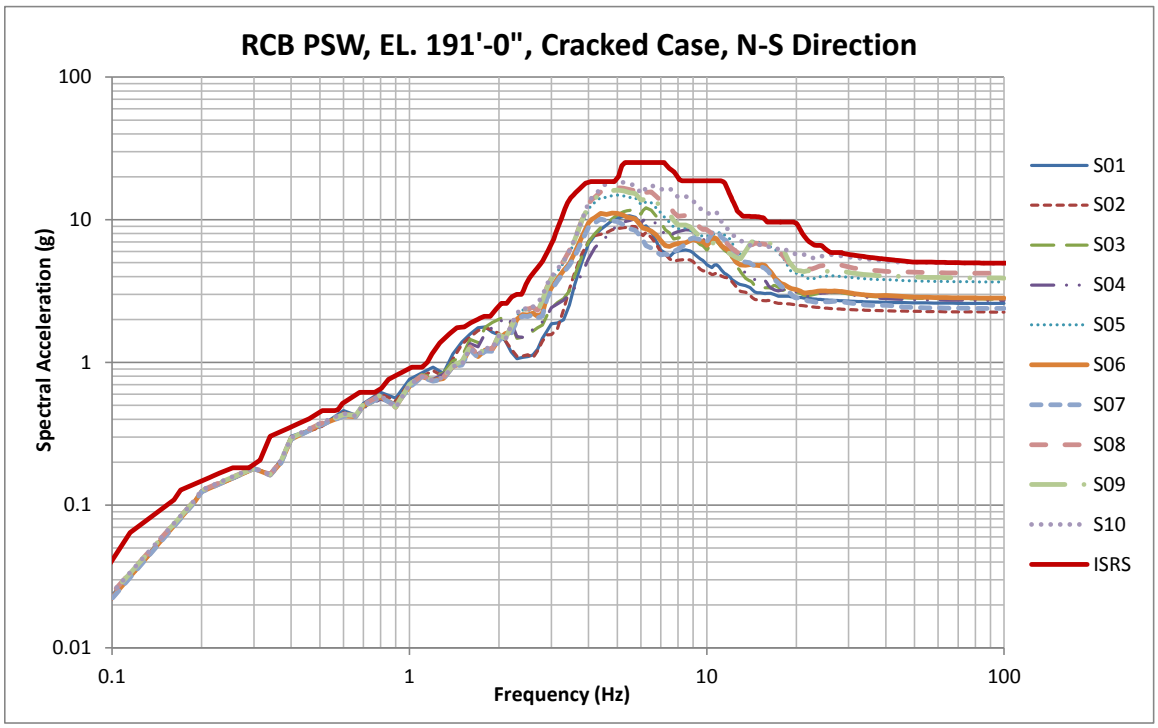


Figure 3 ISRS for RCB PSW, El. 191'-0", Cracked Case, N-S Direction

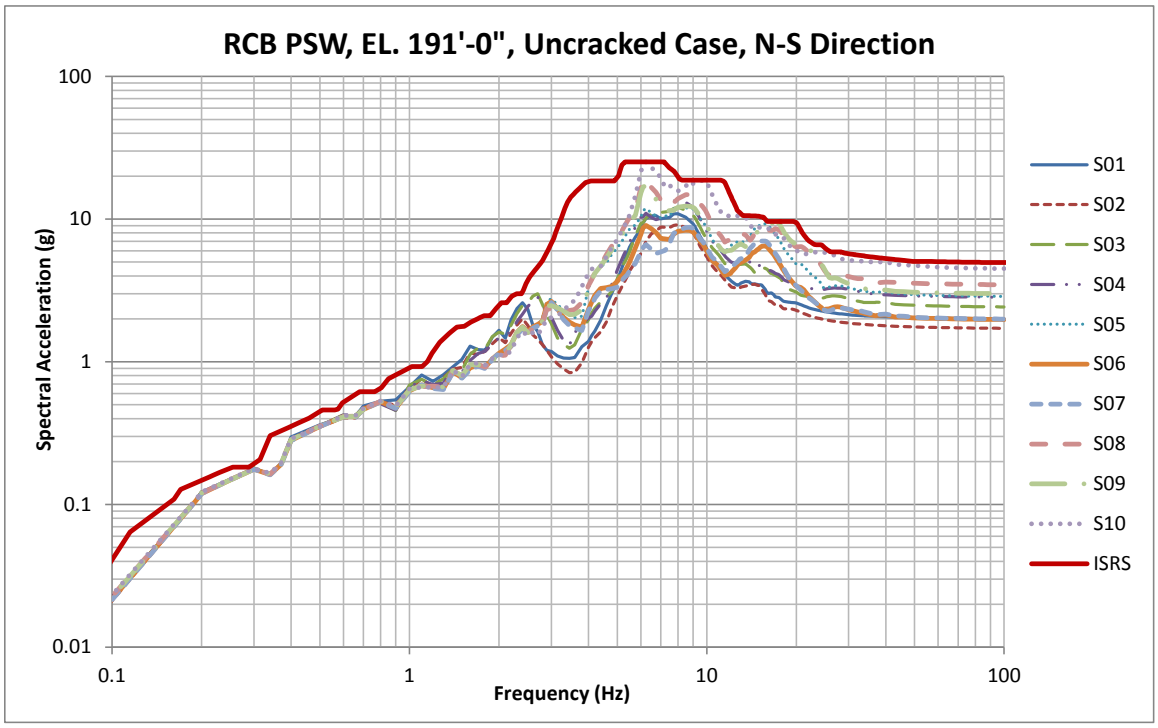


Figure 4 ISRS for RCB PSW, El. 191'-0", Uncracked Case, N-S Direction

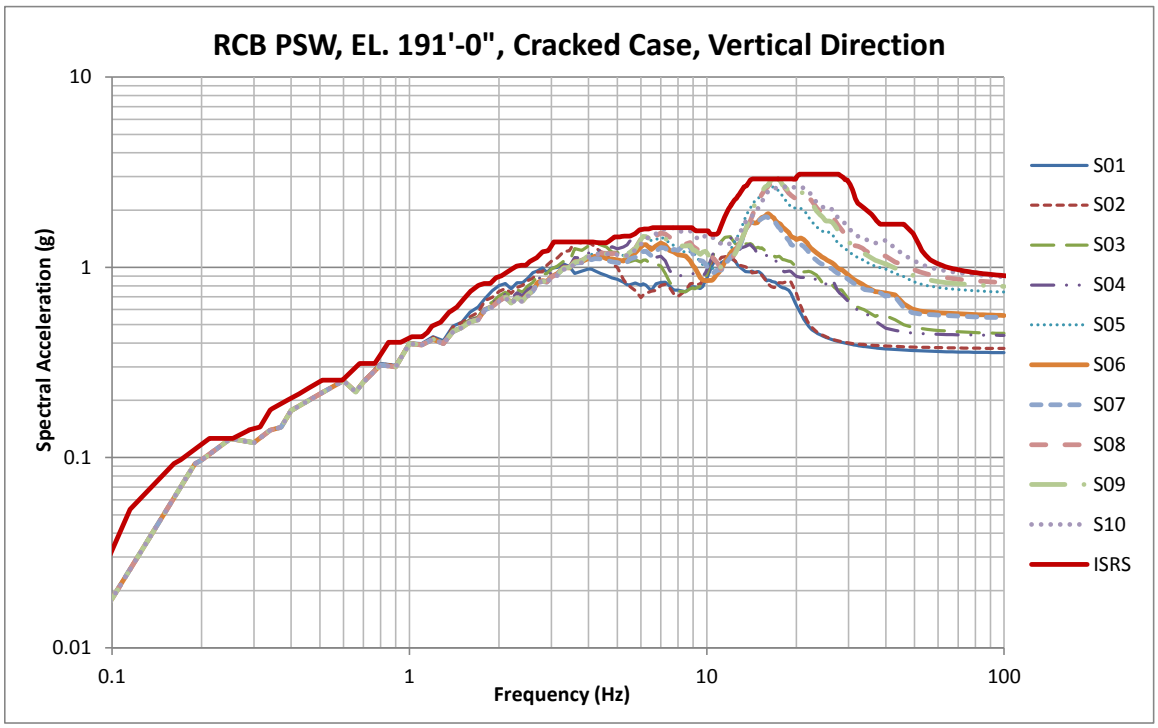


Figure 5 ISRS for RCB PSW, El. 191’-0”, Cracked Case, Vertical Direction

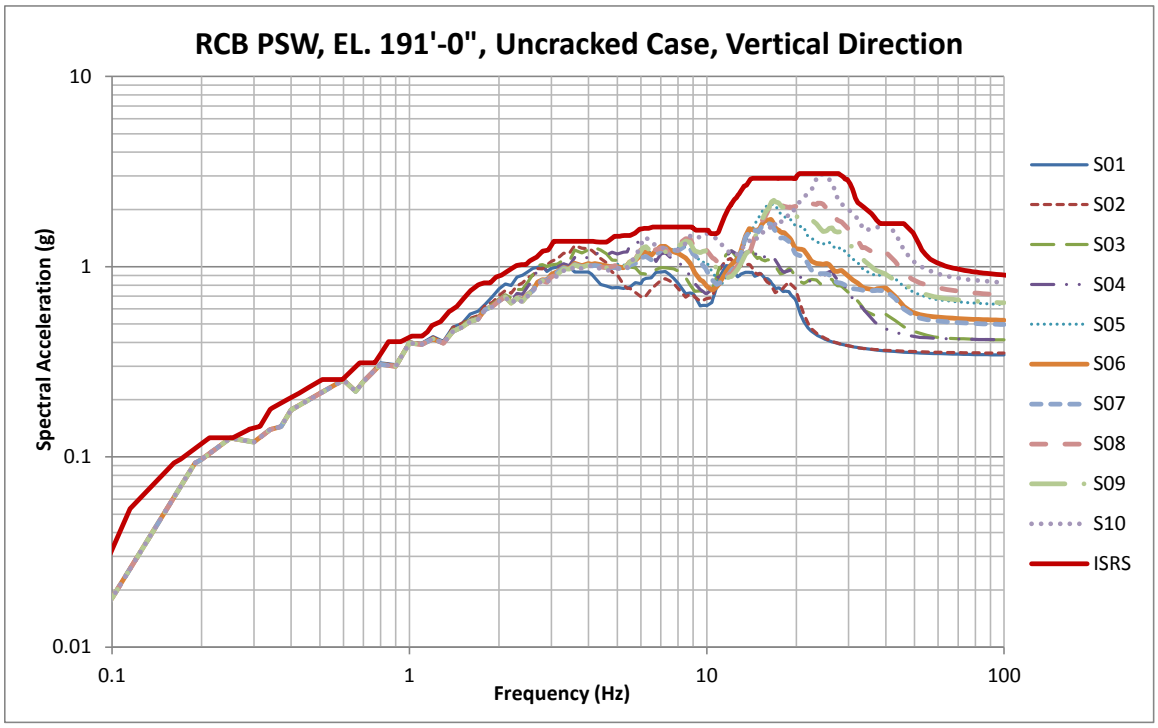


Figure 6 ISRS for RCB PSW, El. 191’-0”, Uncracked Case, Vertical Direction

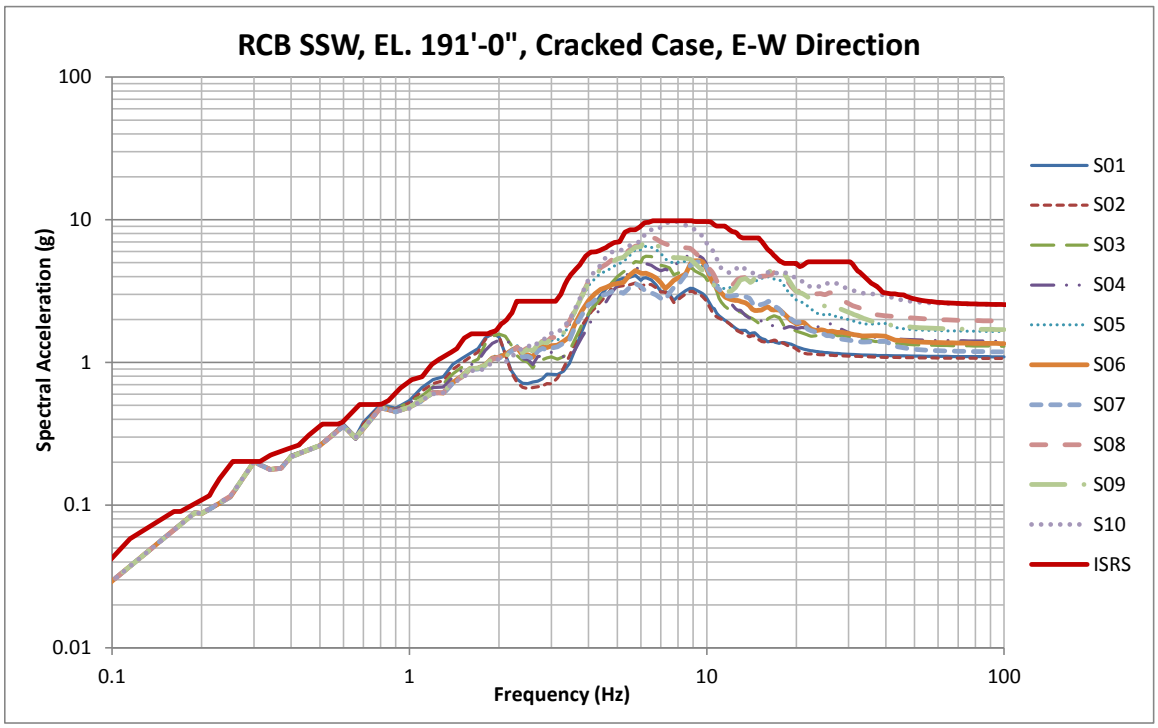


Figure 7 ISRS for RCB SSW, El. 191’-0”, Cracked Case, E-W Direction

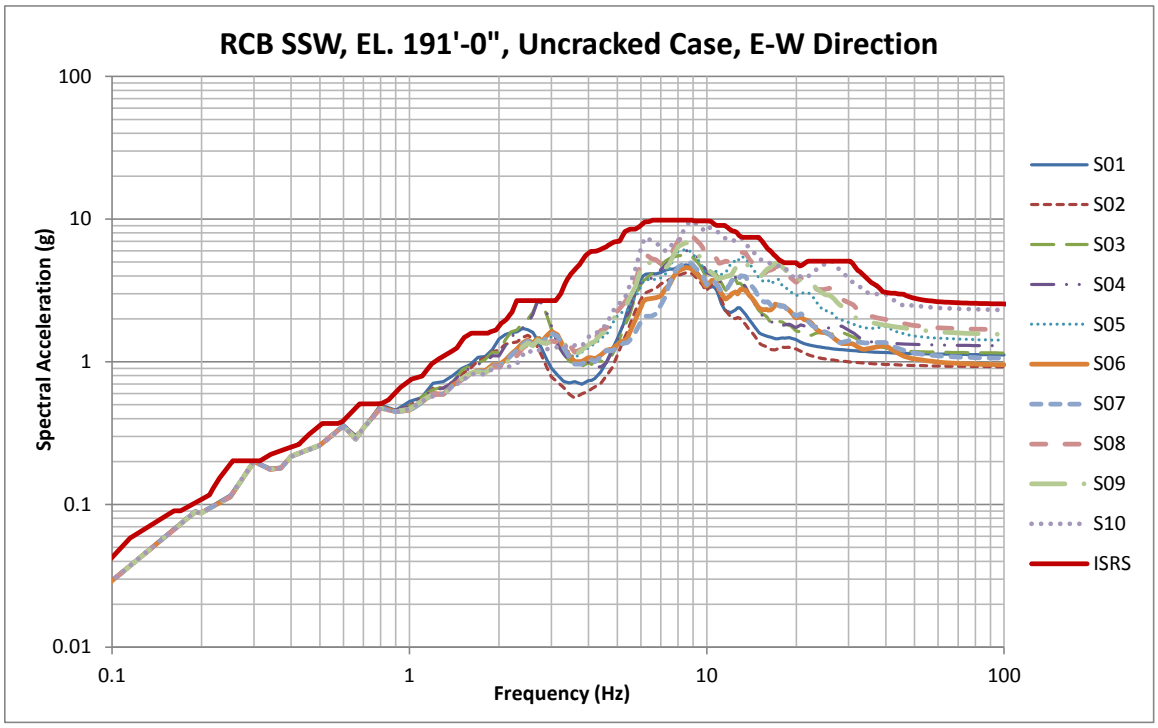


Figure 8 ISRS for RCB SSW, El. 191’-0”, Uncracked Case, E-W Direction

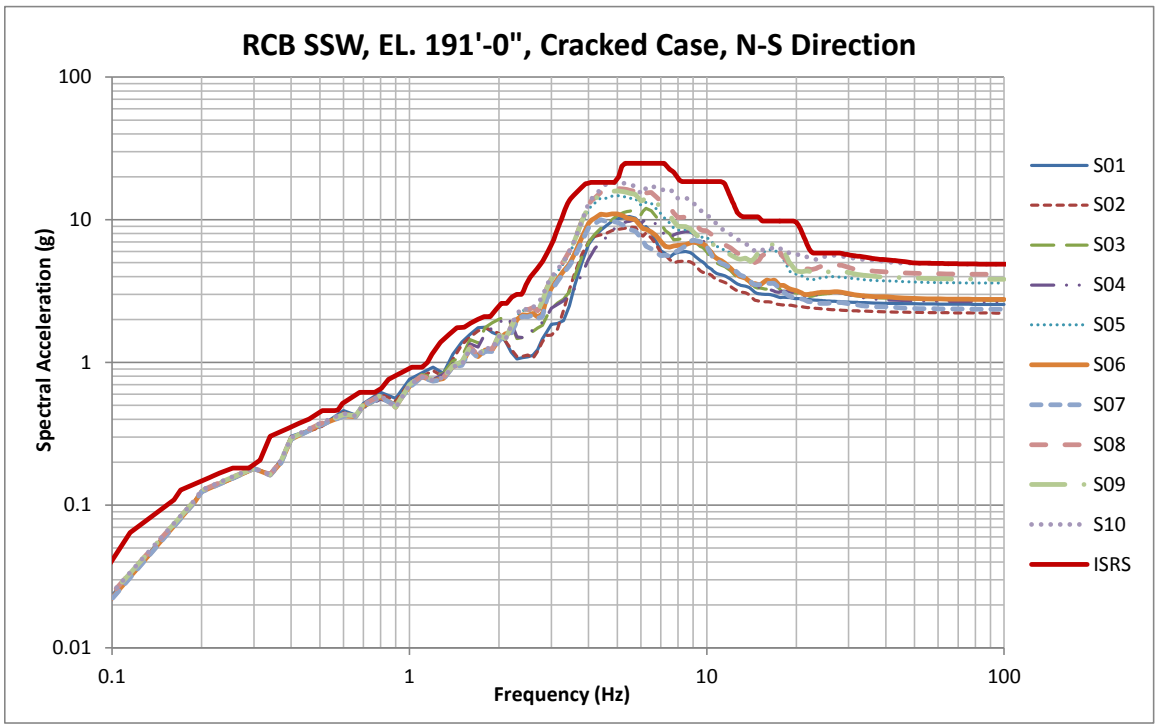


Figure 9 ISRS for RCB SSW, El. 191’-0”, Cracked Case, N-S Direction

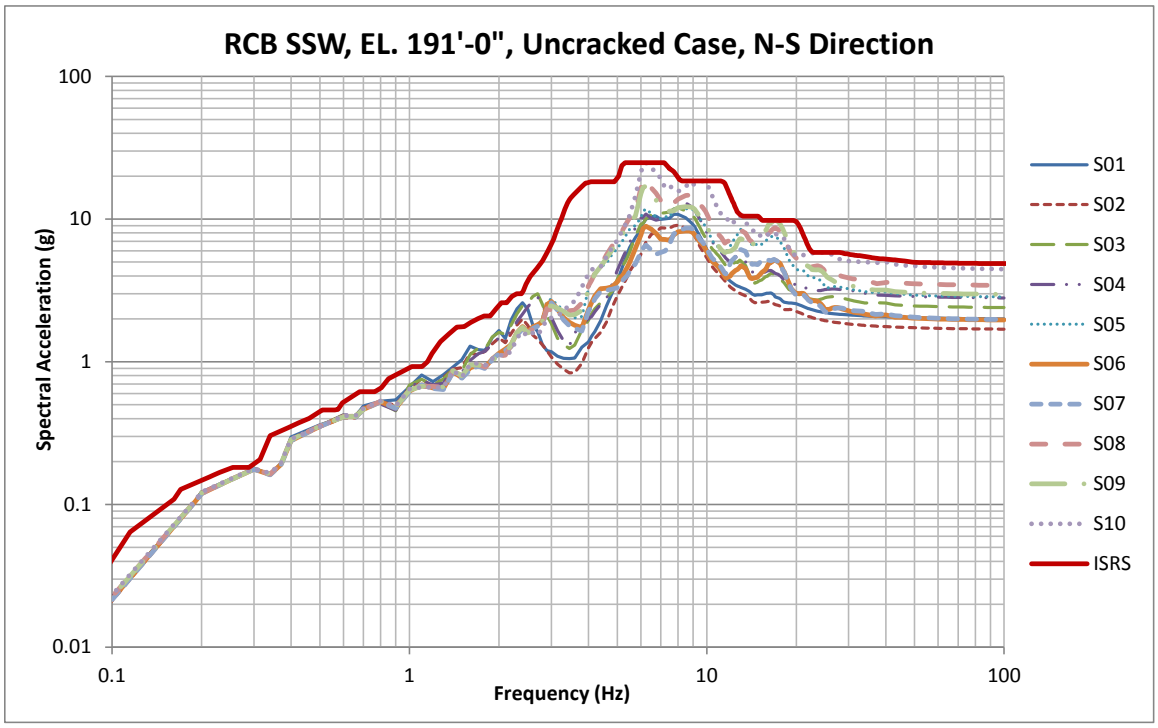


Figure 10 ISRS for RCB SSW, El. 191’-0”, Uncracked Case, N-S Direction

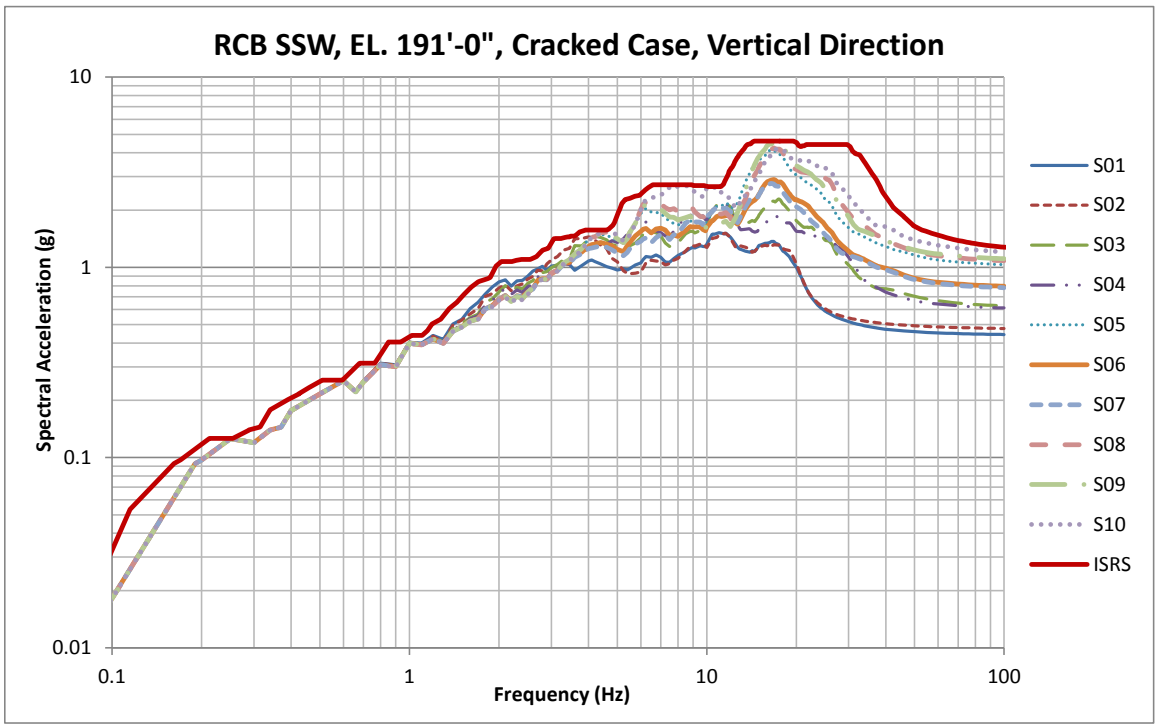


Figure 11 ISRS for RCB SSW, El. 191’-0”, Cracked Case, Vertical Direction

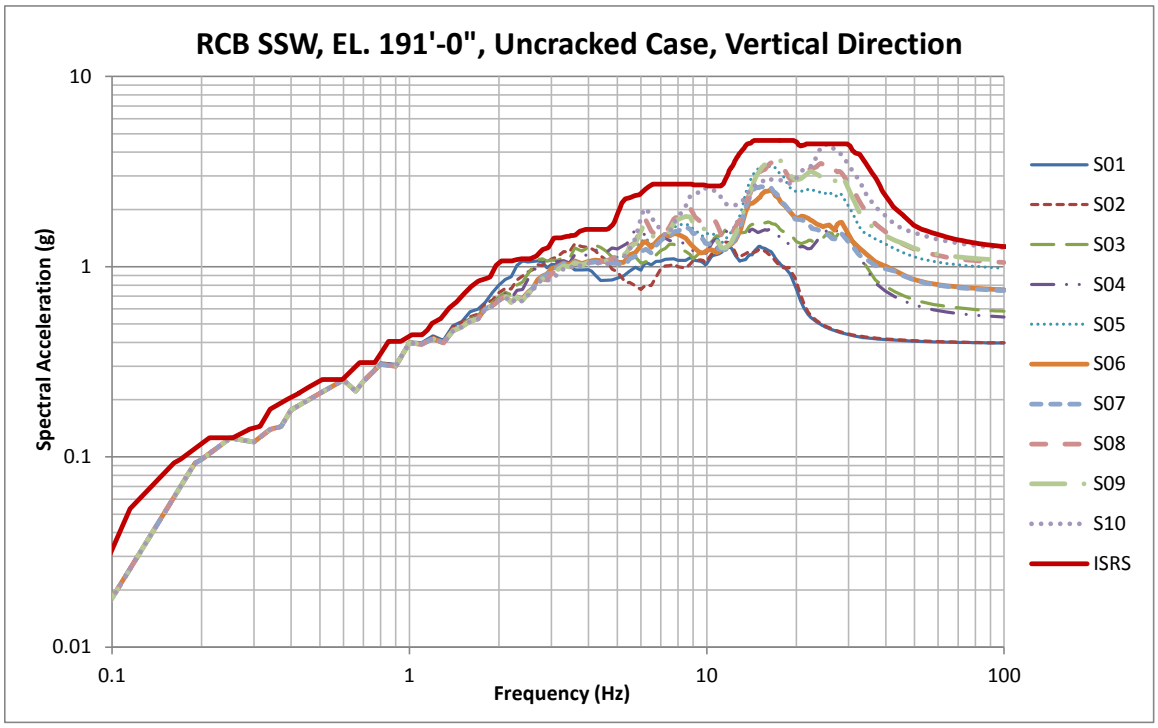


Figure 12 ISRS for RCB SSW, El. 191’-0”, Uncracked Case, Vertical Direction

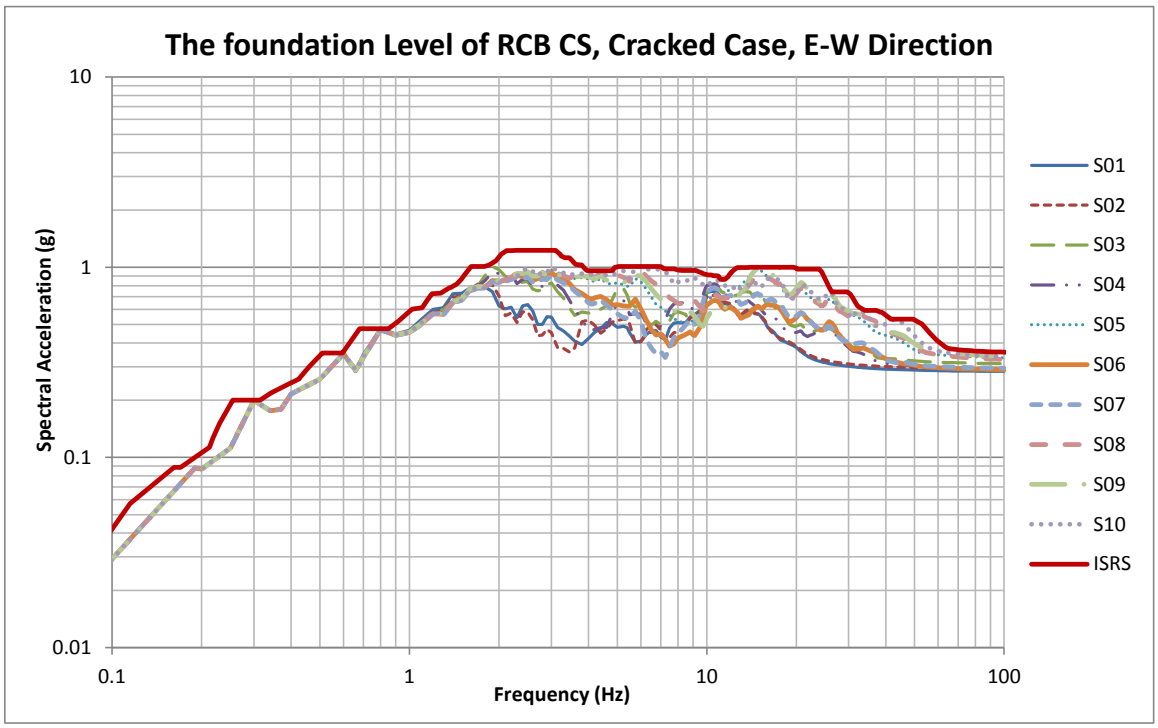


Figure 13 ISRS for foundation level of RCB CS, Cracked Case, E-W Direction

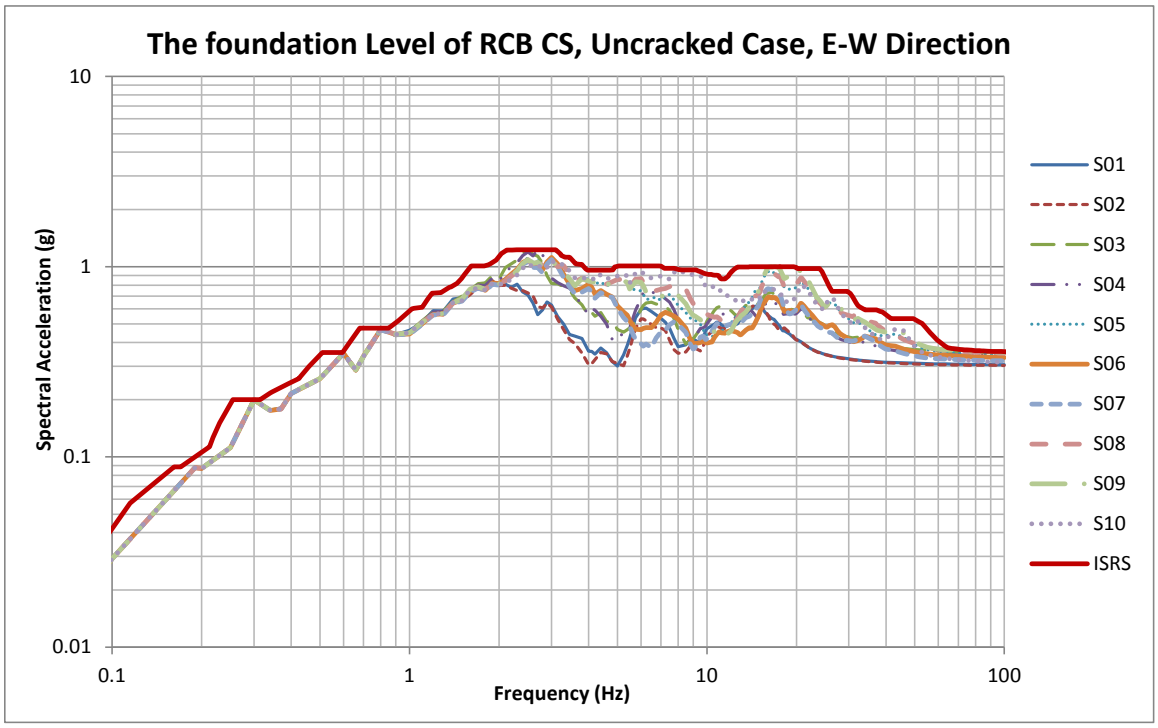


Figure 14 ISRS for foundation level of RCB CS, Uncracked Case, E-W Direction

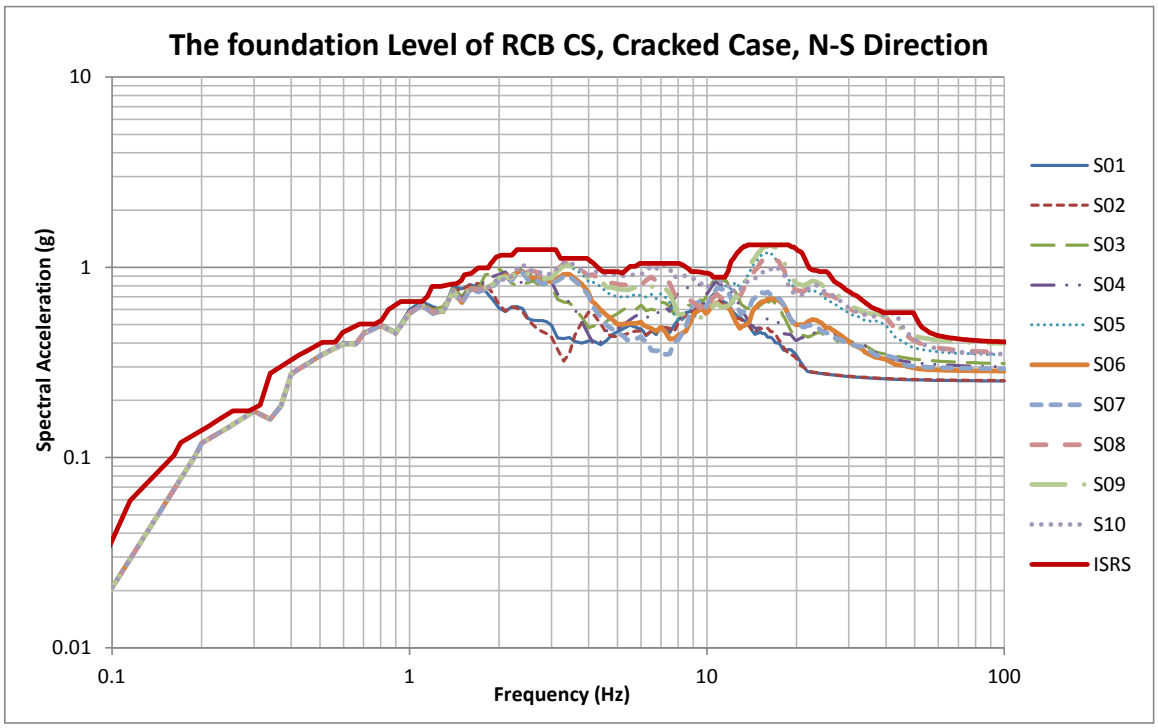


Figure 15 ISRS for foundation level of RCB CS, Cracked Case, N-S Direction

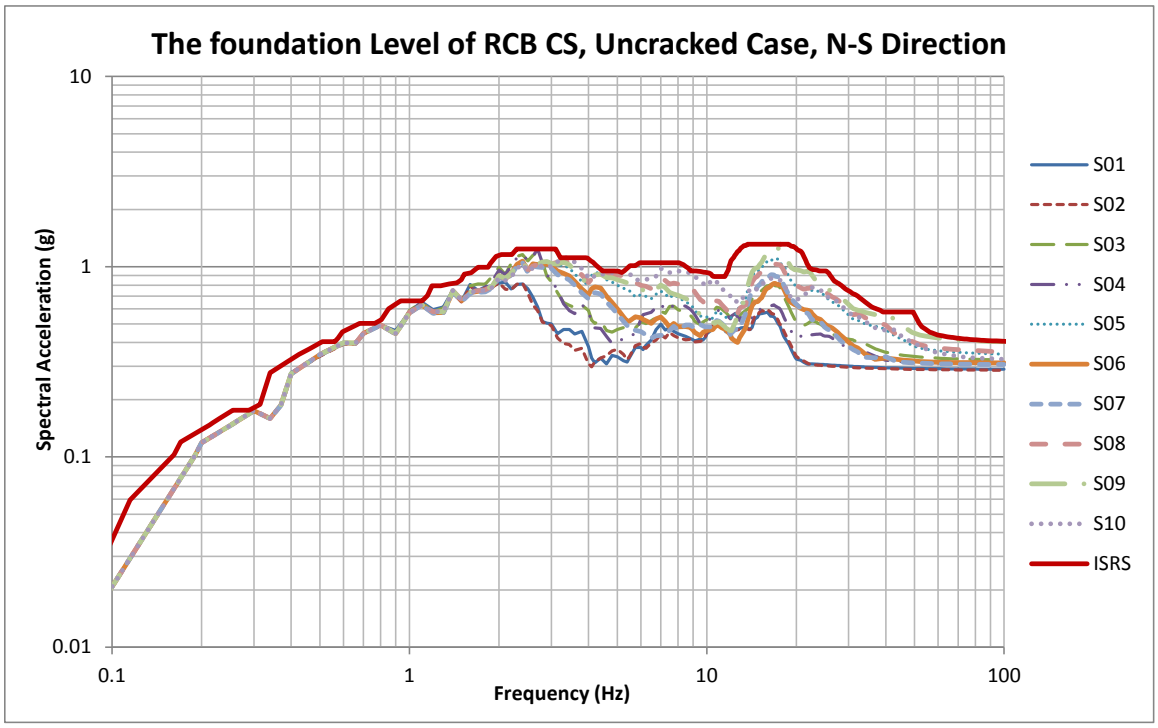


Figure 16 ISRS for foundation level of RCB CS, Uncracked Case, N-S Direction

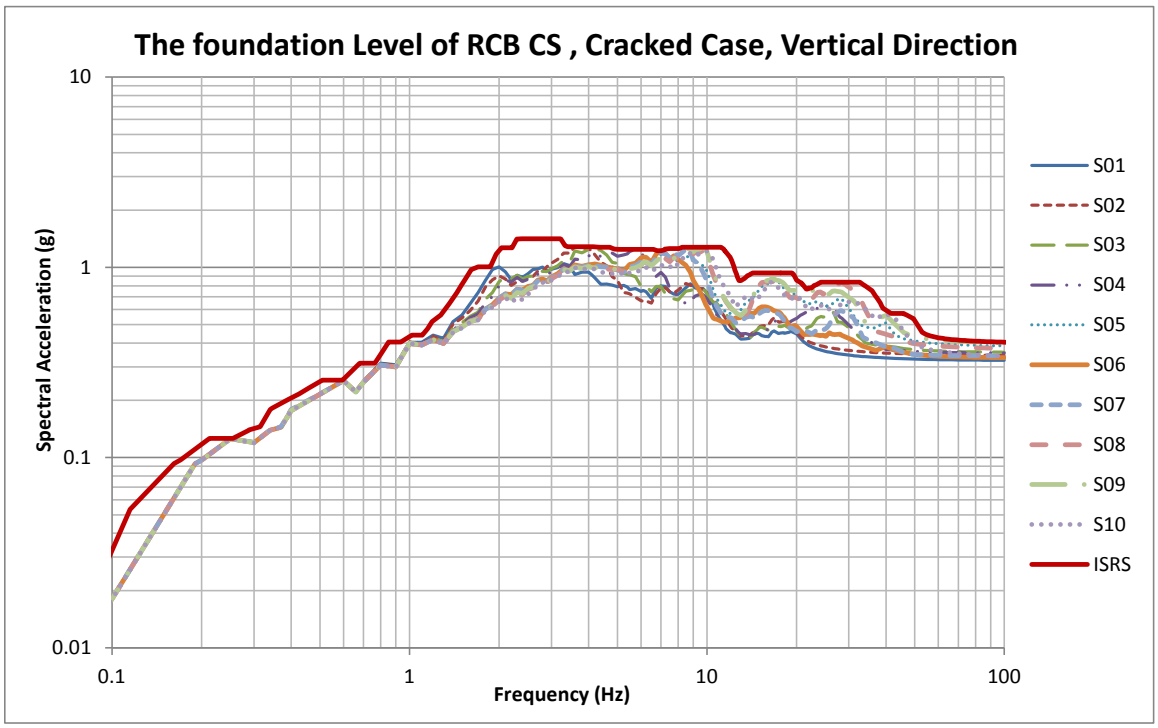


Figure 17 ISRS for foundation level of RCB CS, Cracked Case, Vertical Direction

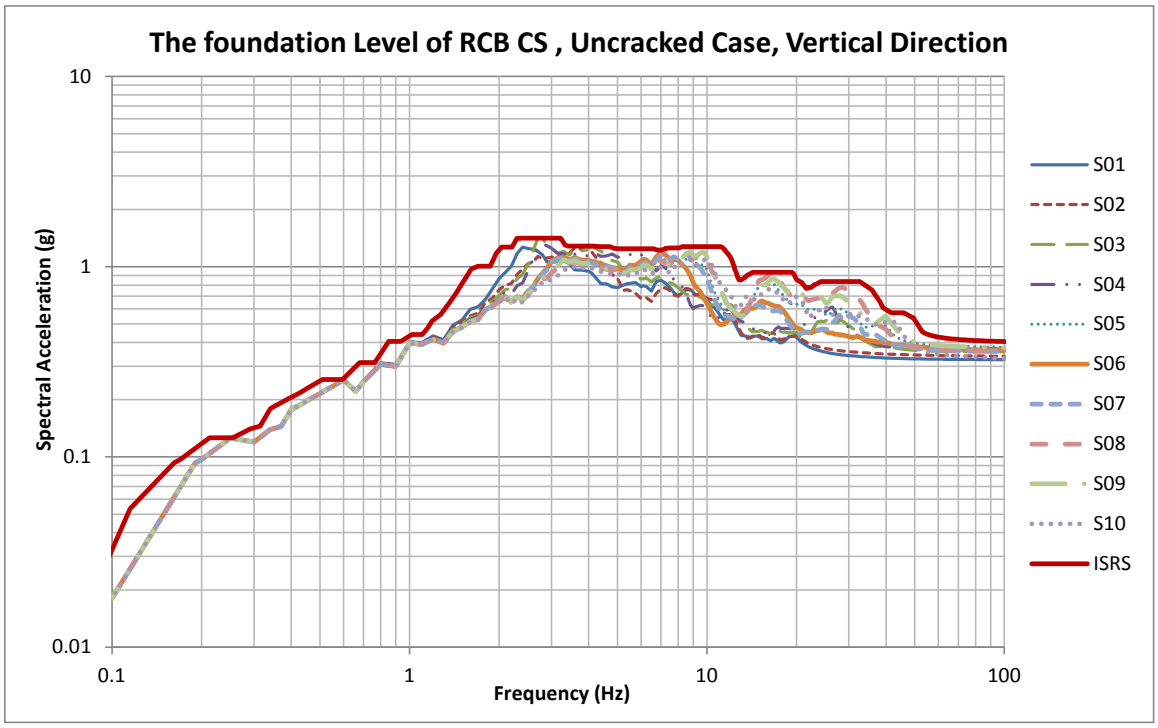


Figure 18 ISRS for foundation level of RCB CS, Uncracked Case, Vertical Direction

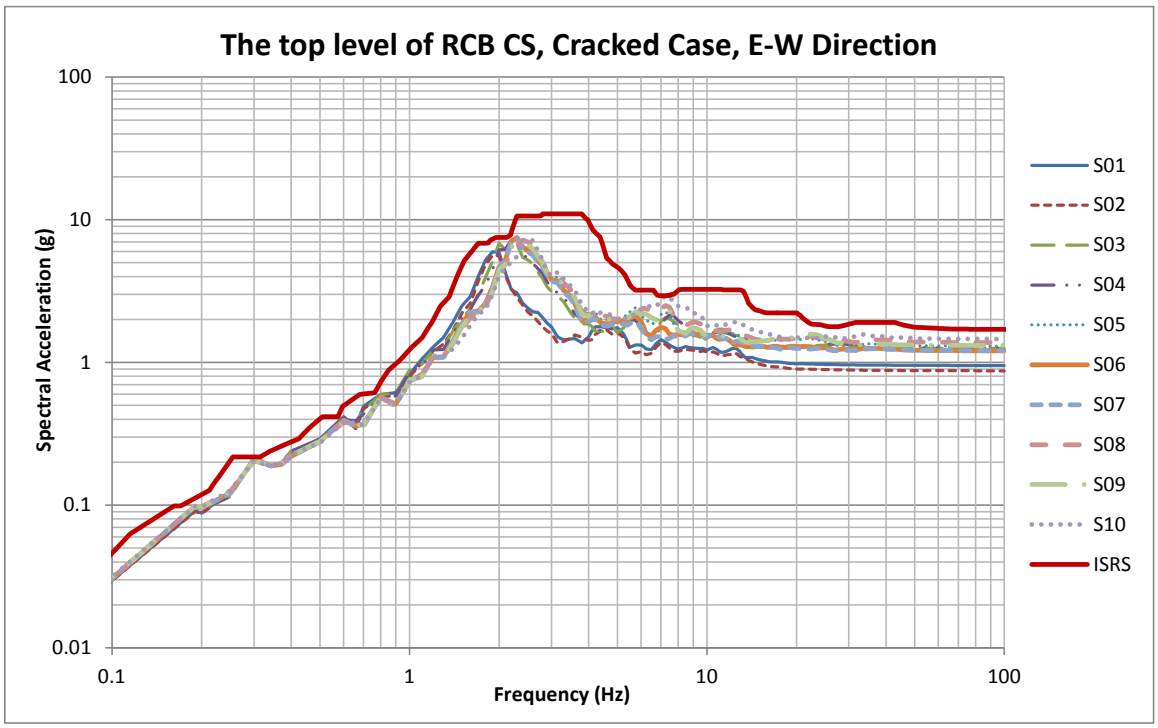


Figure 19 ISRS for top level of RCB CS, Cracked Case, E-W Direction

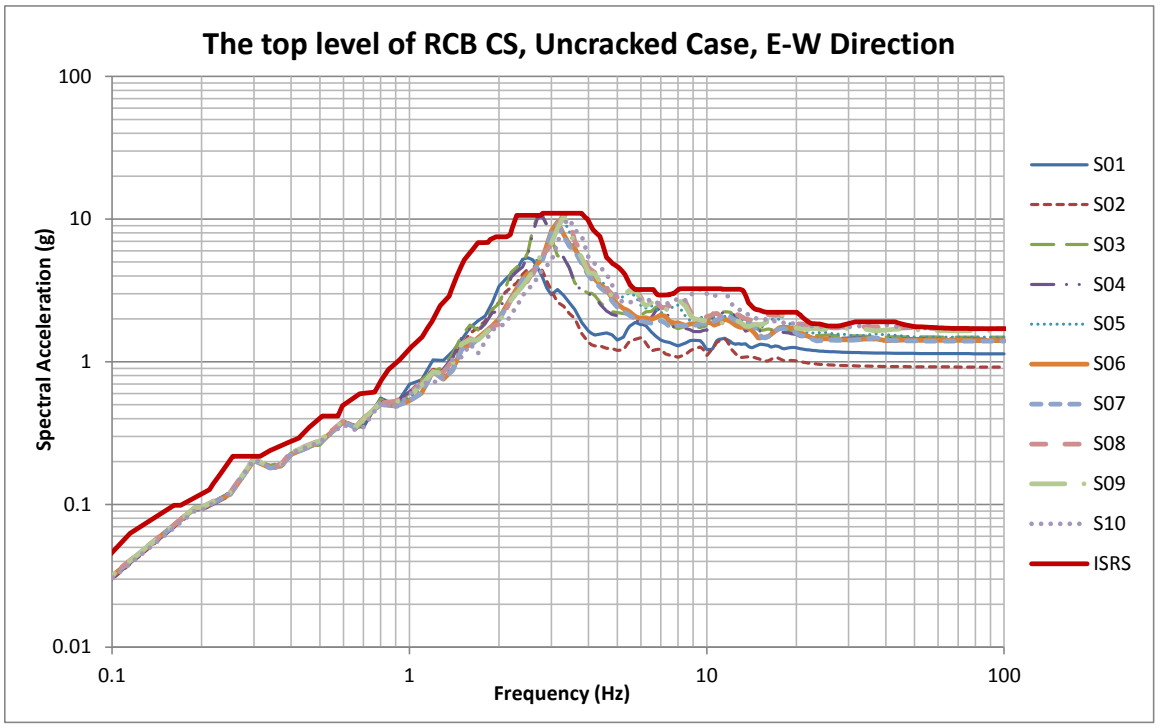


Figure 20 ISRS for top level of RCB CS, Uncracked Case, E-W Direction

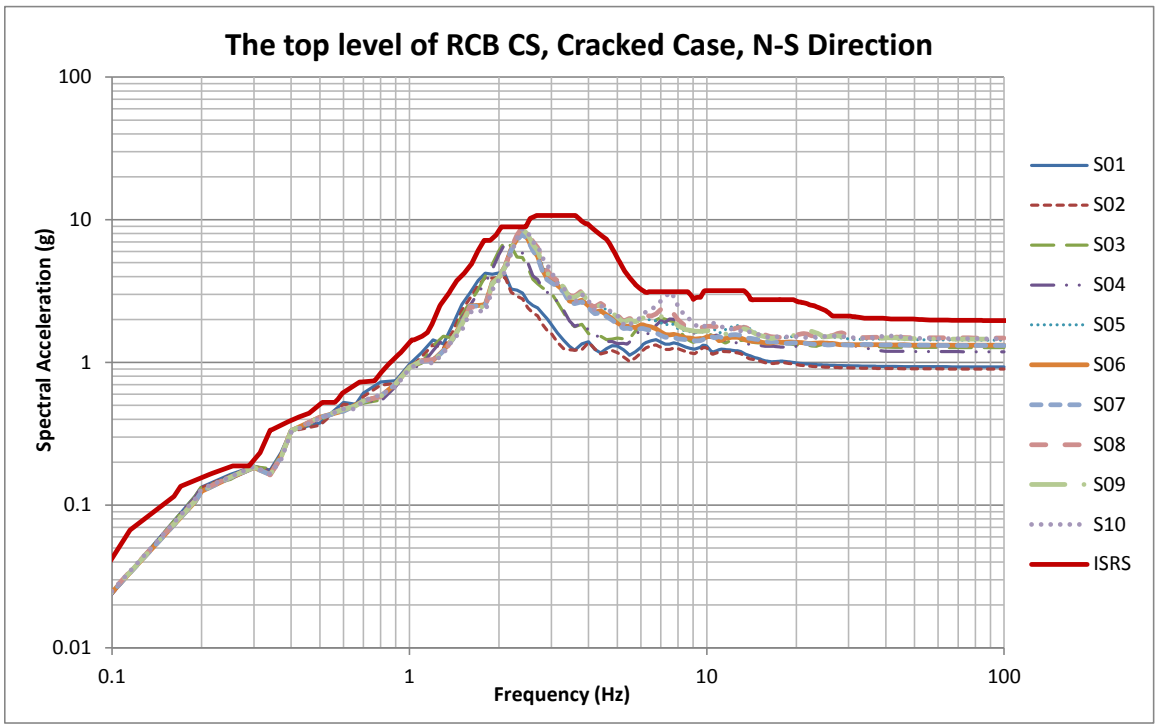


Figure 21 ISRS for top level of RCB CS, Cracked Case, N-S Direction

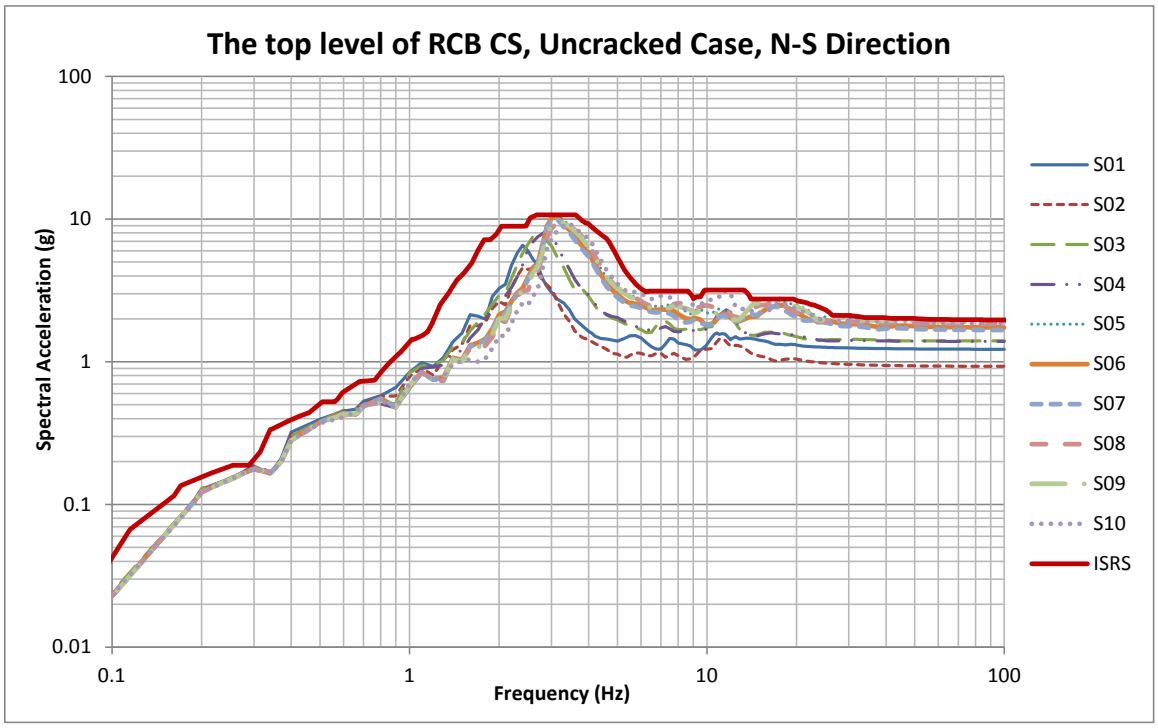


Figure 22 ISRS for top level of RCB CS, Uncracked Case, N-S Direction

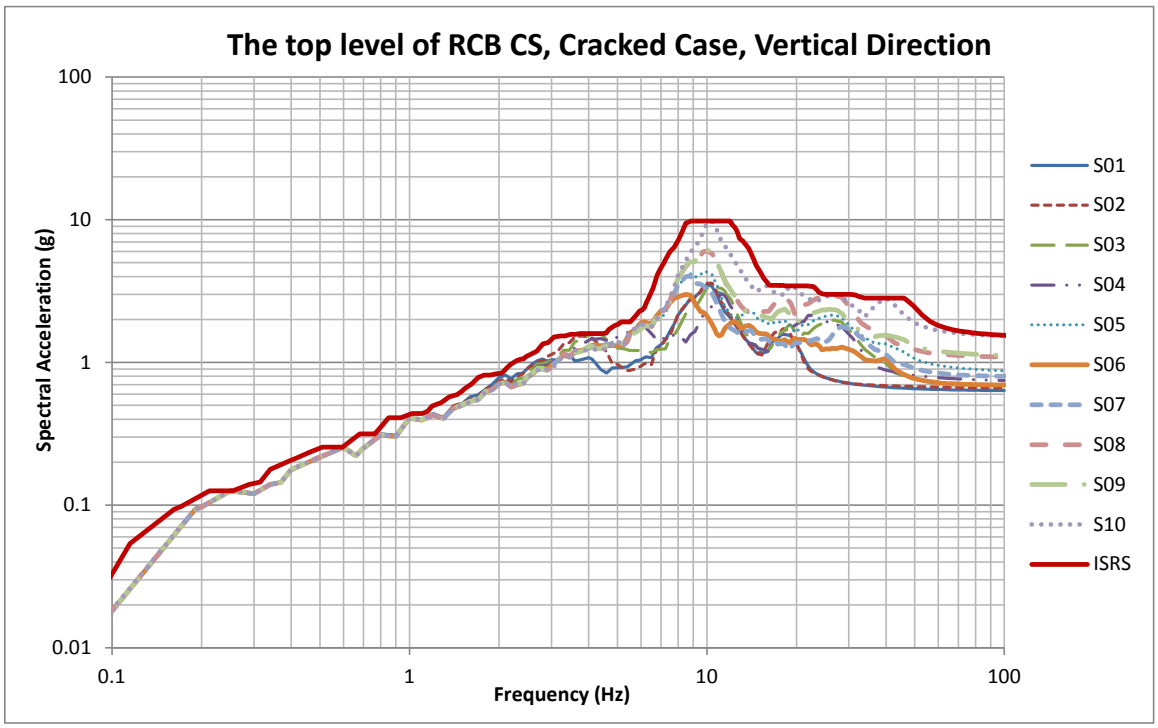


Figure 23 ISRS for top level of RCB CS, Cracked Case, Vertical Direction

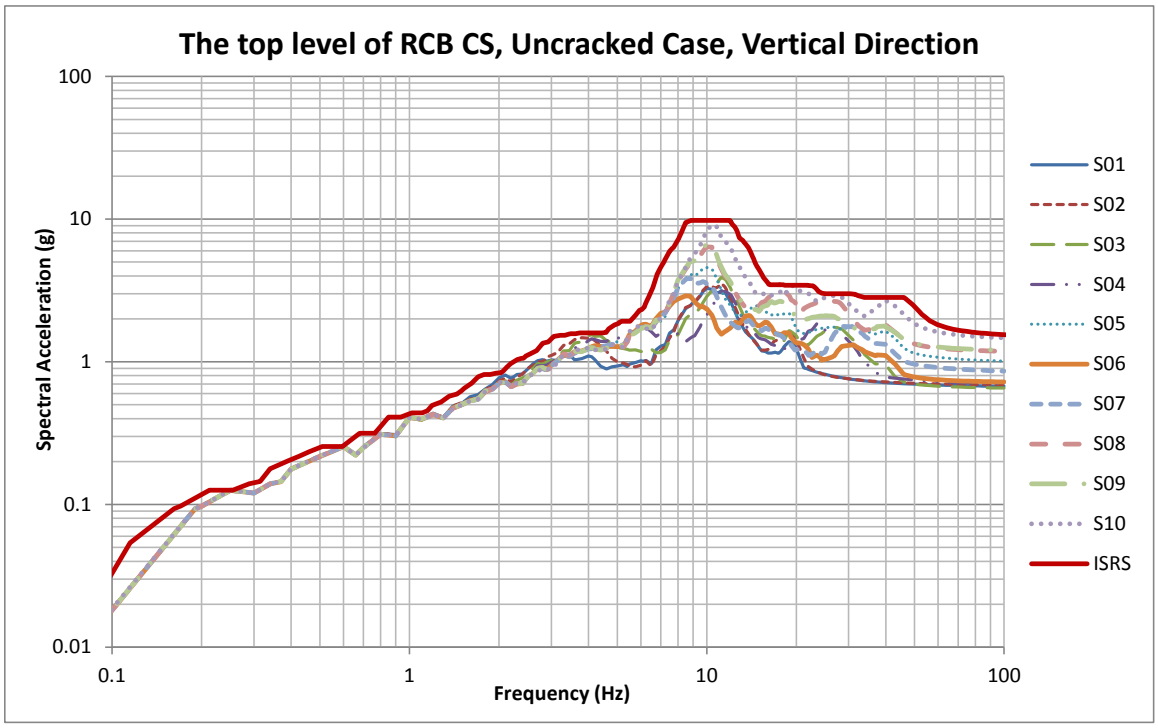


Figure 24 ISRS for top level of RCB CS, Uncracked Case, Vertical Direction

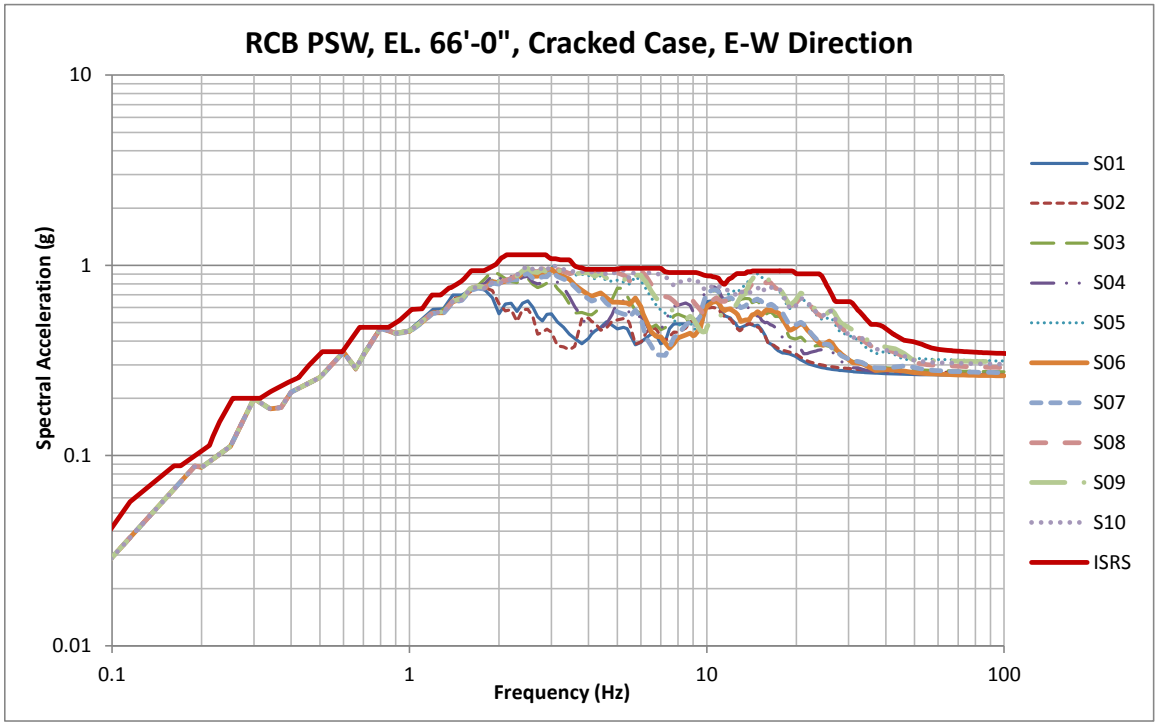


Figure 25 ISRS for foundation level of RCB IS, El. 66’-0”, Cracked Case, E-W Direction

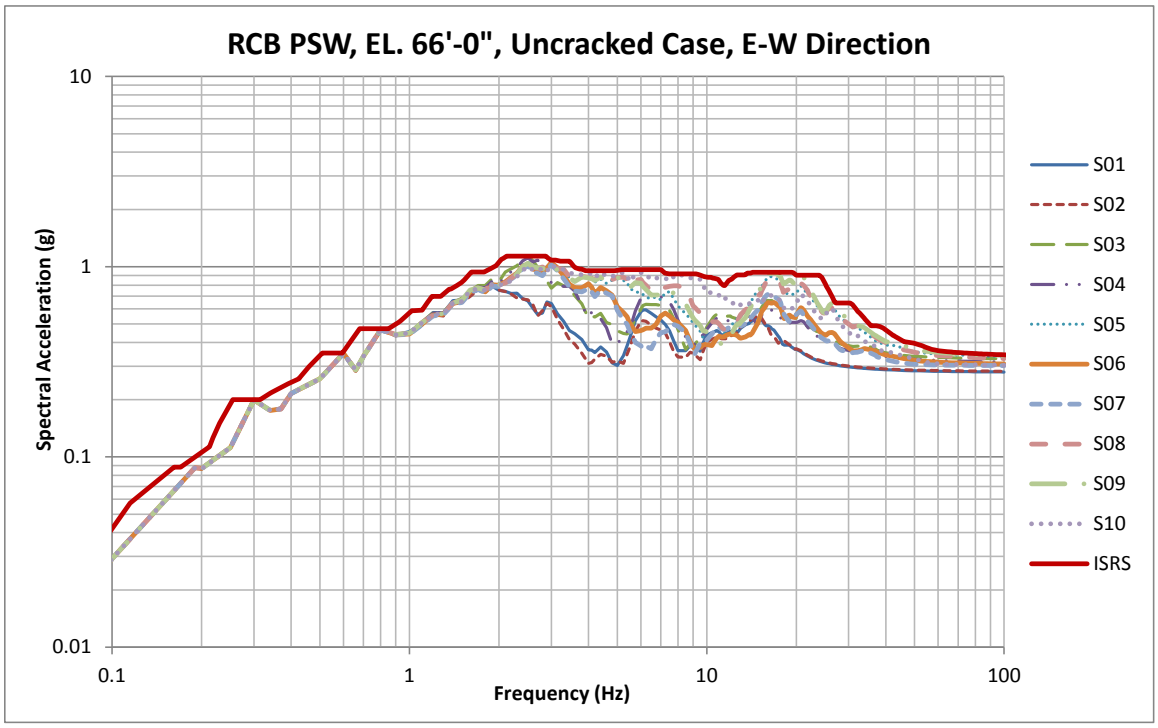


Figure 26 ISRS for foundation level of RCB IS, El. 66’-0”, Uncracked Case, E-W Direction

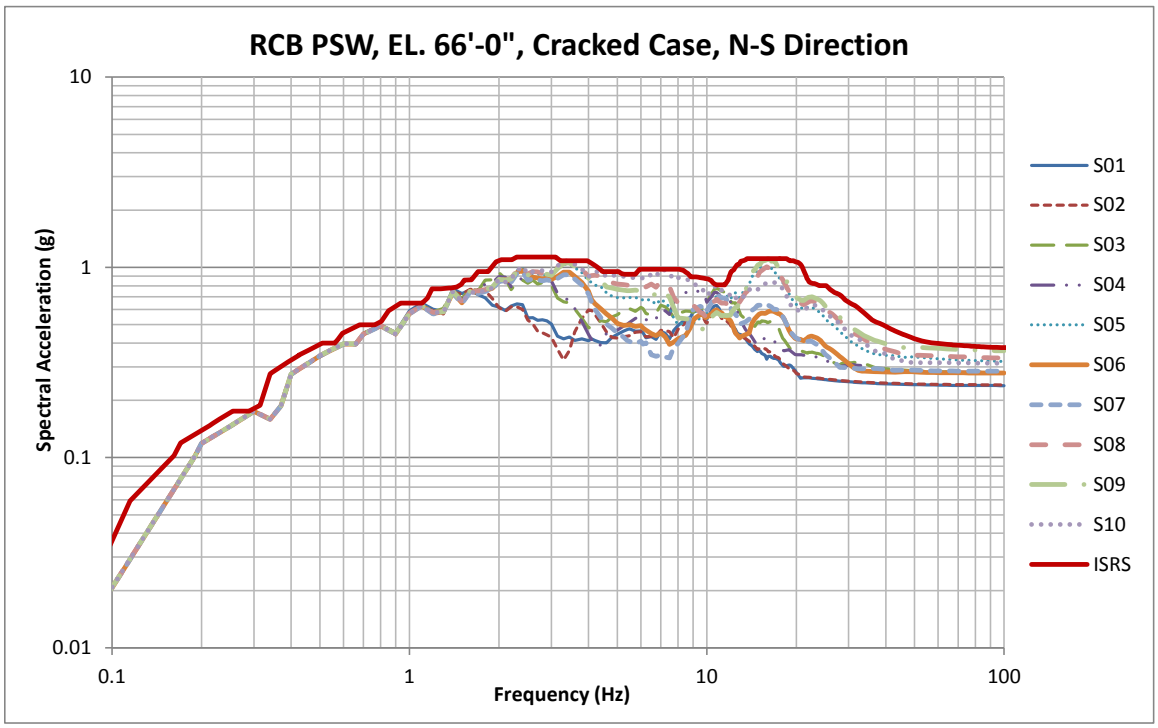


Figure 27 ISRS for foundation level of RCB IS, El. 66'-0", Cracked Case, N-S Direction

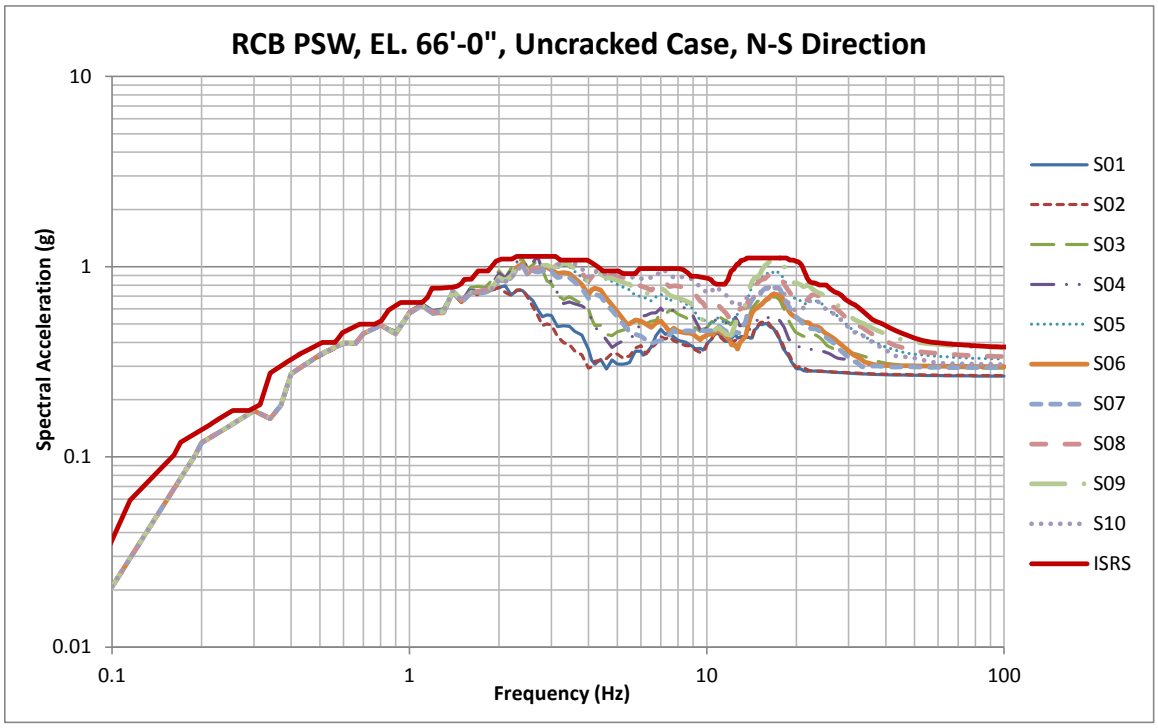


Figure 28 ISRS for foundation level of RCB IS, El. 66'-0", Uncracked Case, N-S Direction

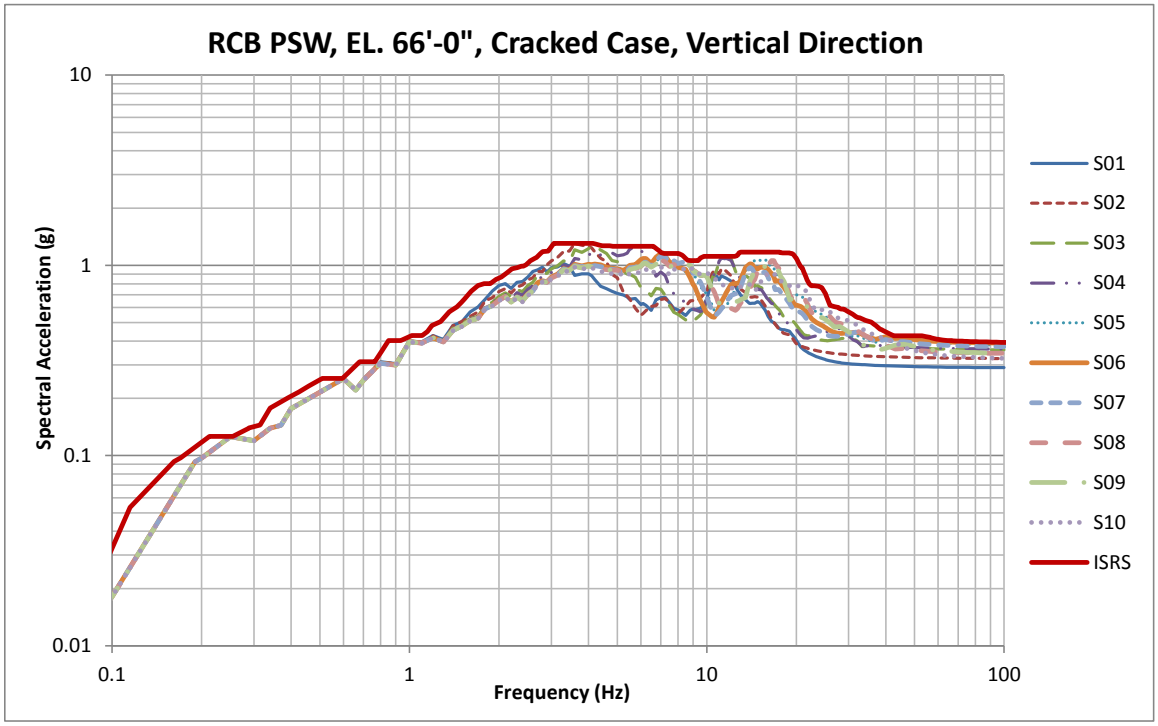


Figure 29 ISRS for foundation level of RCB IS, El. 66’-0”, Cracked Case, Vertical Direction

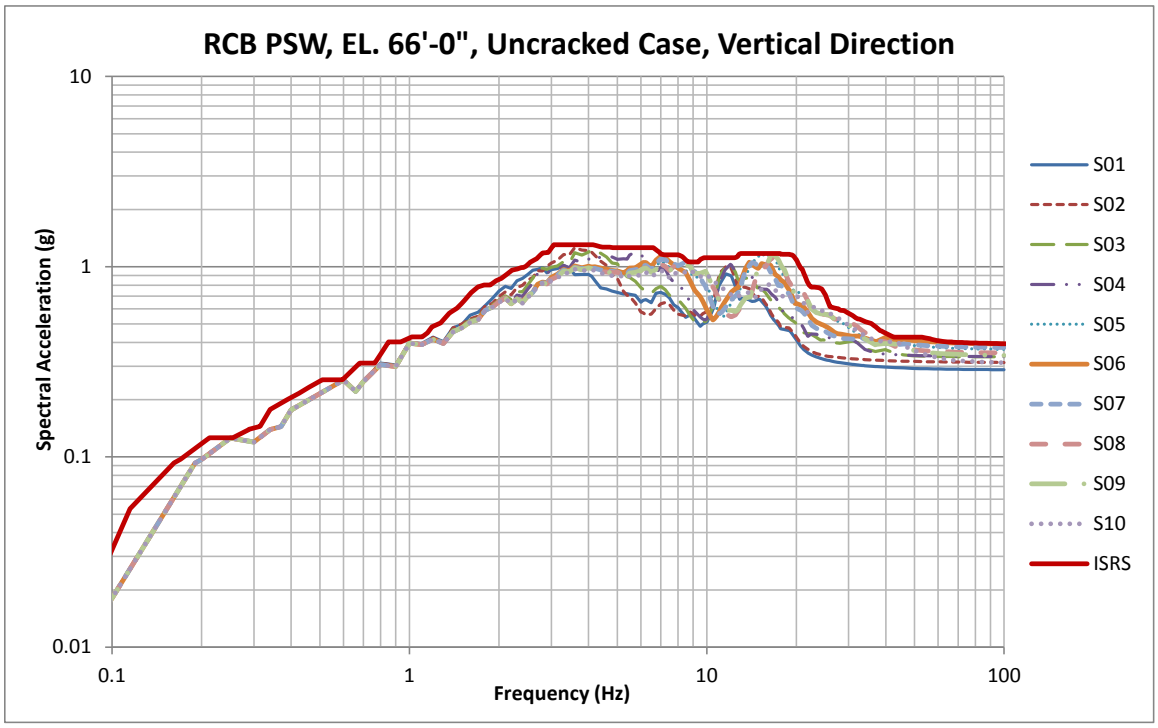


Figure 30 ISRS for foundation level of RCB IS, El. 66’-0”, Uncracked Case, Vertical Direction

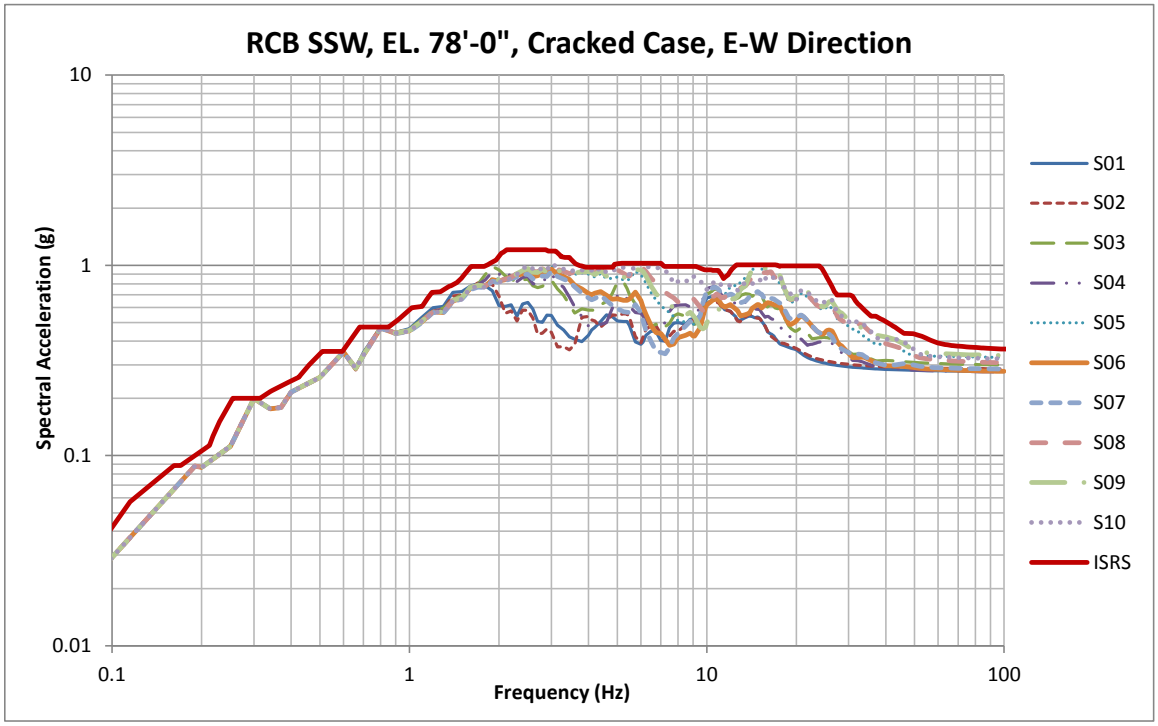


Figure 31 ISRS for foundation level of RCB IS, El. 78’-0”, Cracked Case, E-W Direction

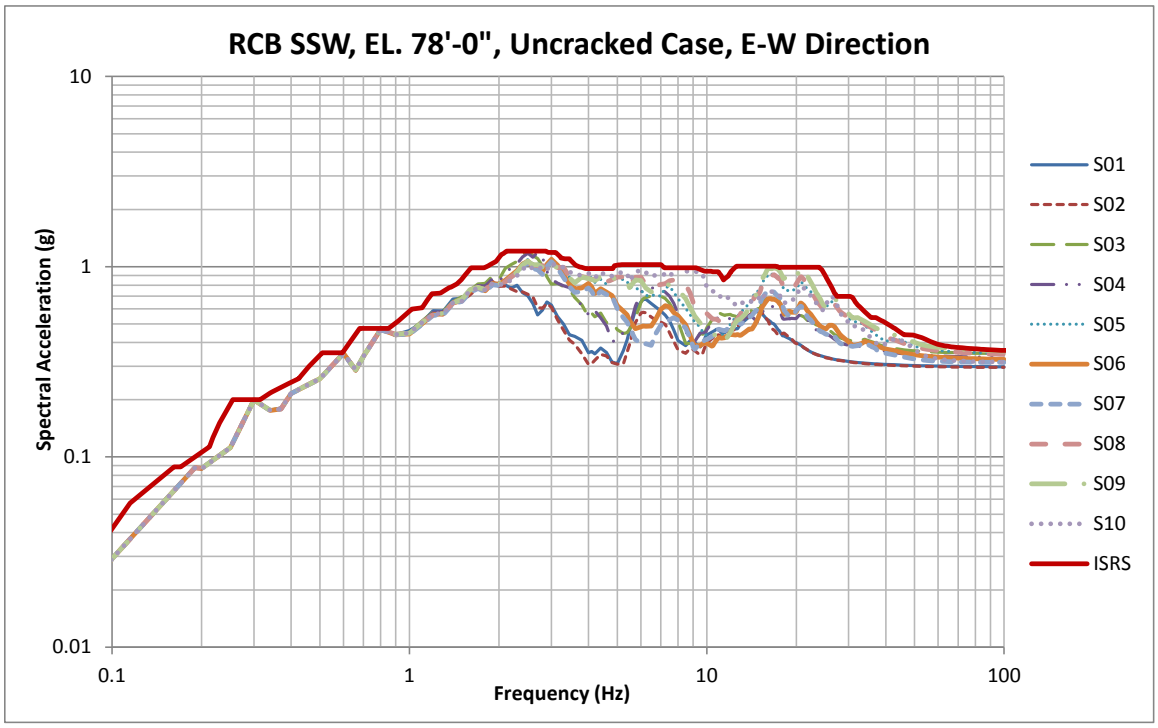


Figure 32 ISRS for foundation level of RCB IS, El. 78’-0”, Uncracked Case, E-W Direction

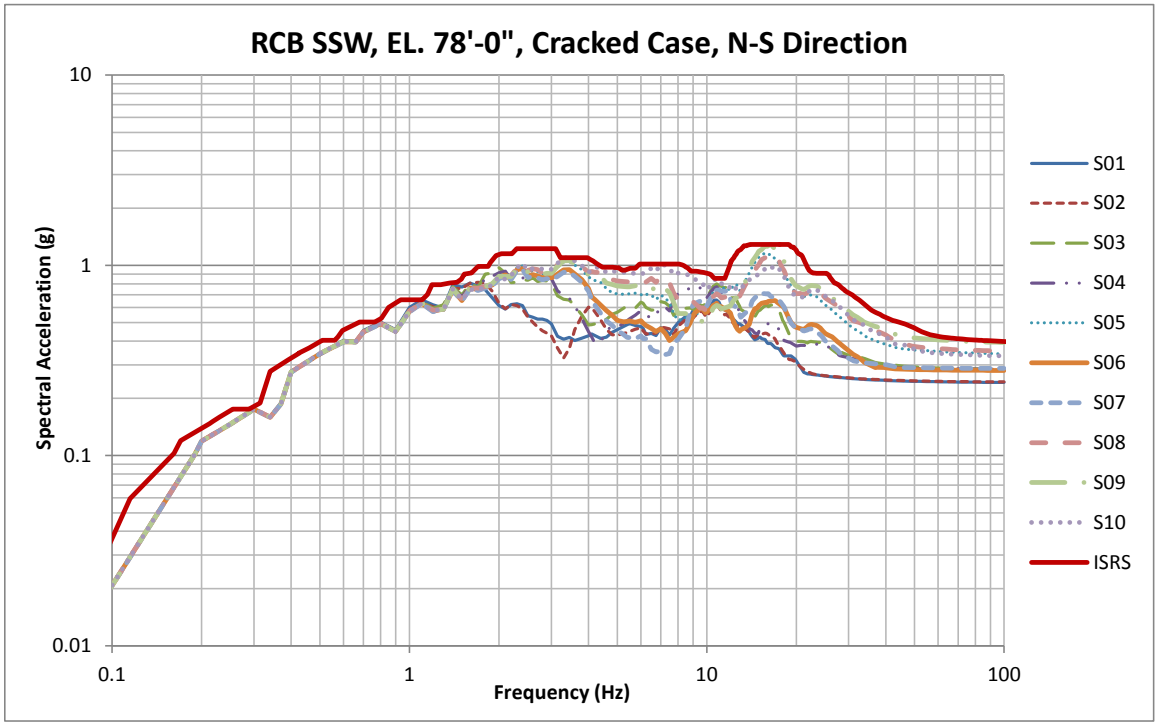


Figure 33 ISRS for foundation level of RCB IS, El. 78’-0”, Cracked Case, N-S Direction

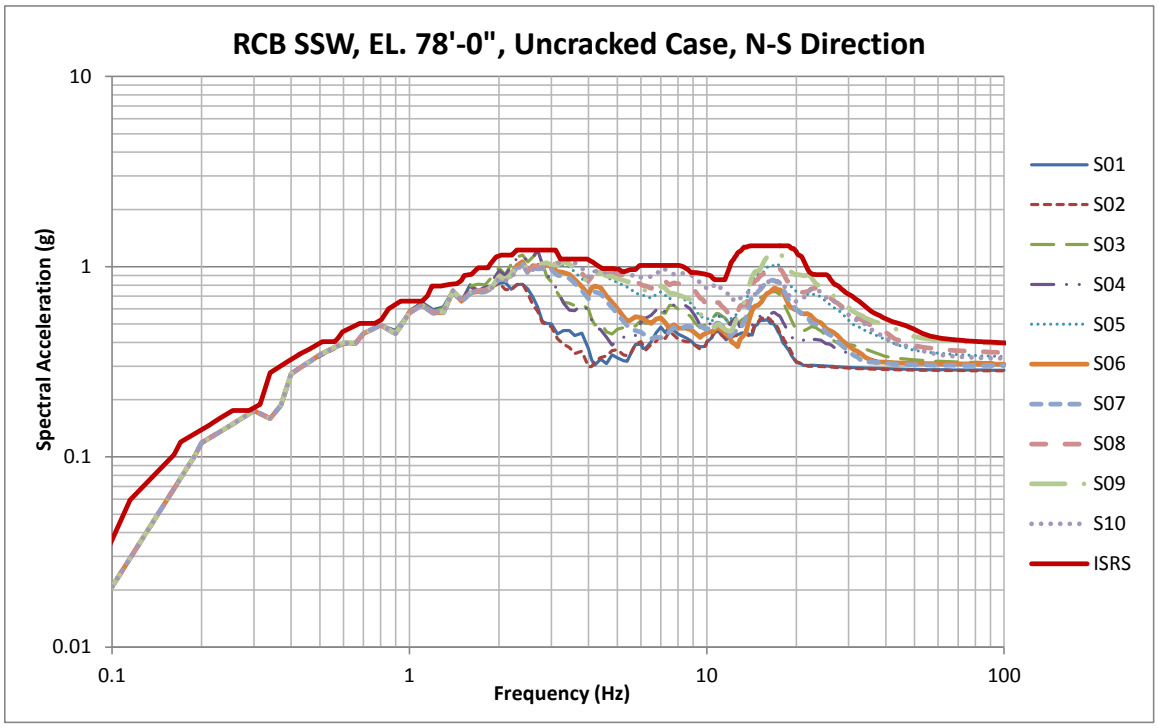


Figure 34 ISRS for foundation level of RCB IS, El. 78’-0”, Uncracked Case, N-S Direction

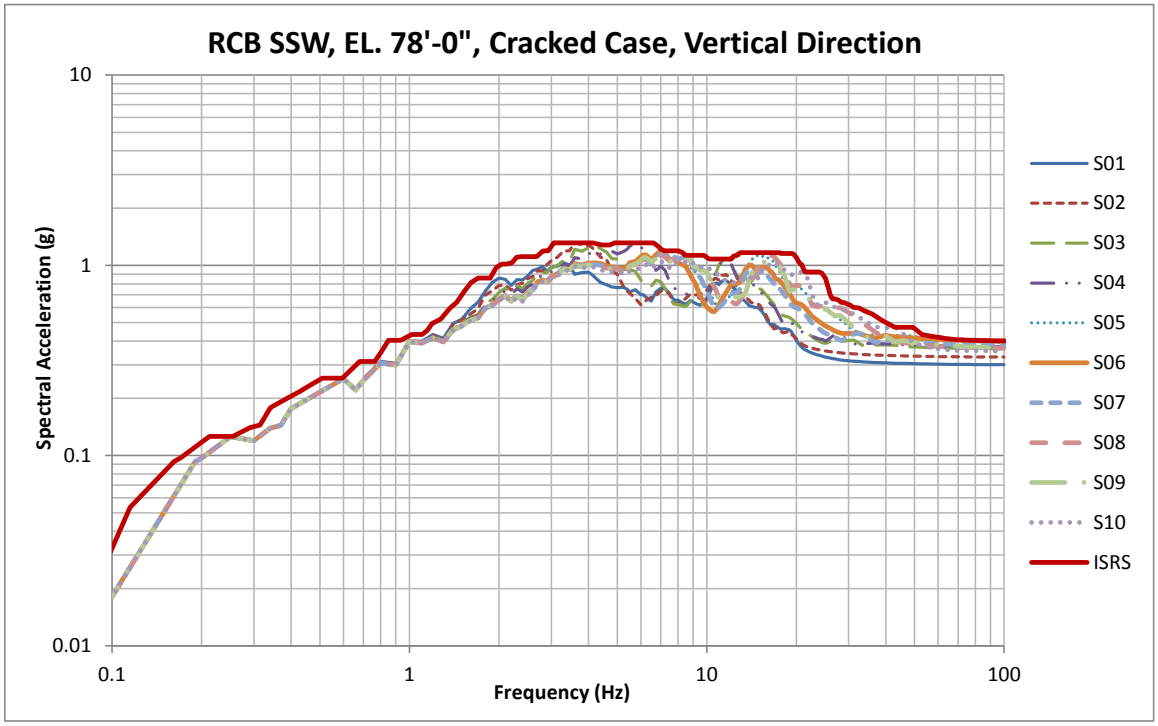


Figure 35 ISRS for foundation level of RCB IS, El. 78’-0”, Cracked Case, Vertical Direction

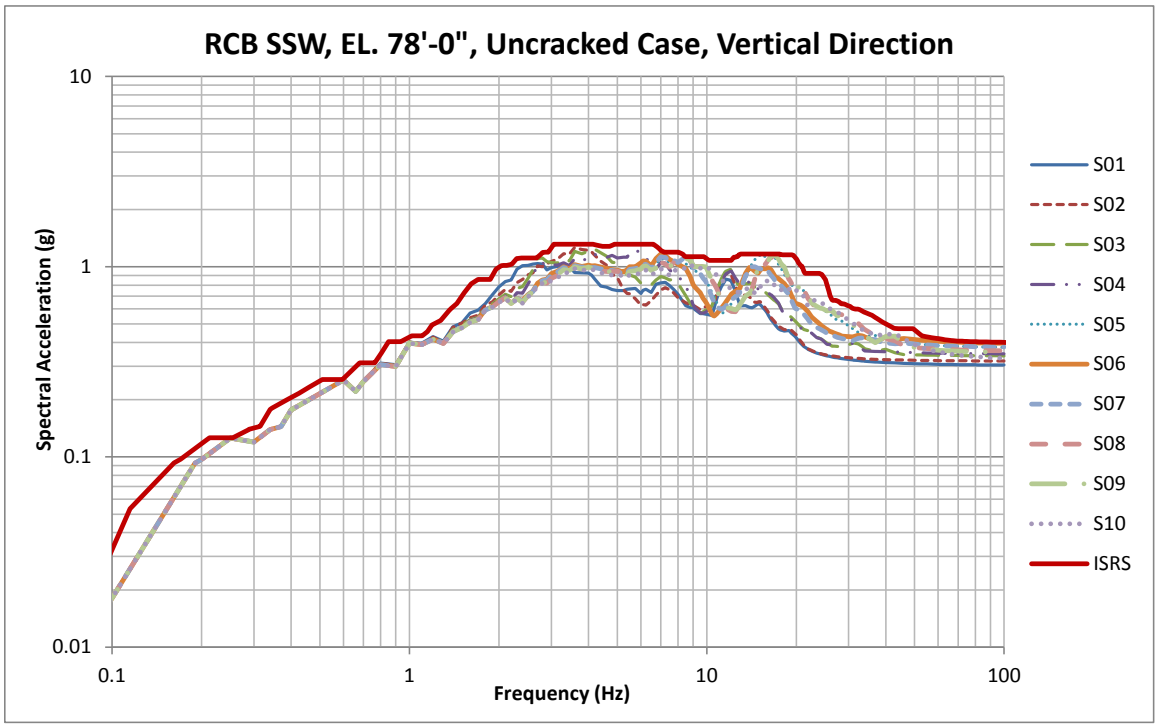


Figure 36 ISRS for foundation level of RCB IS, El. 78’-0”, Uncracked Case, Vertical Direction

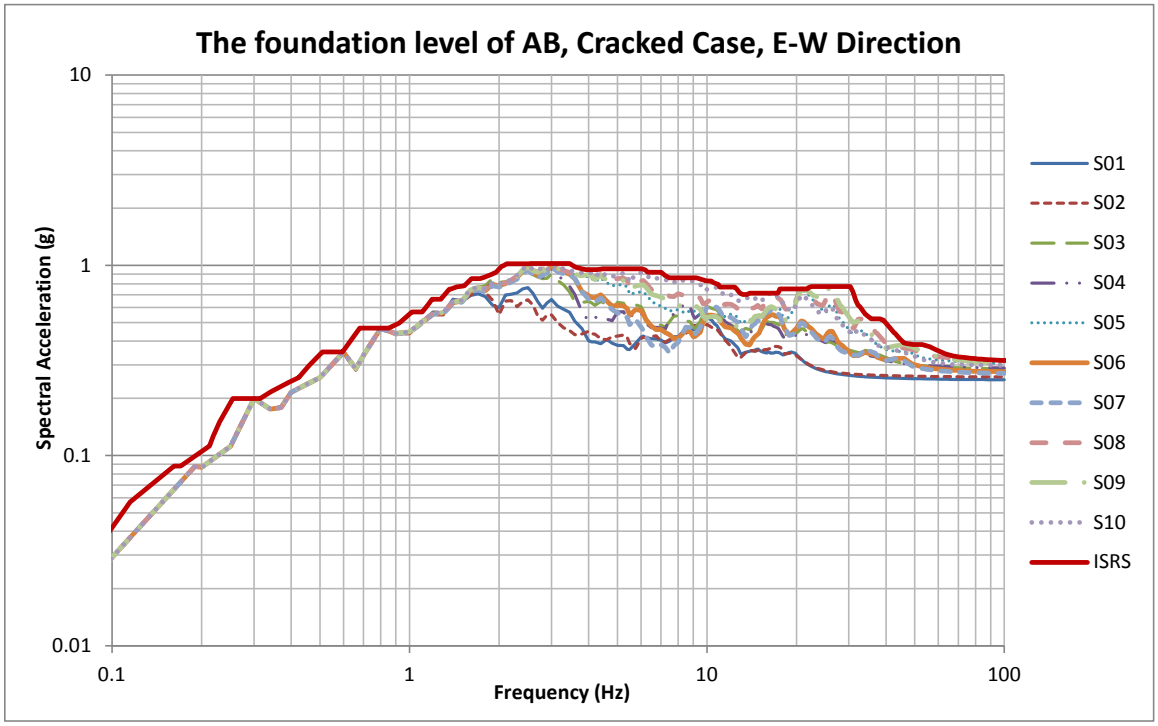


Figure 37 ISRS for foundation level of AB, Cracked Case, E-W Direction

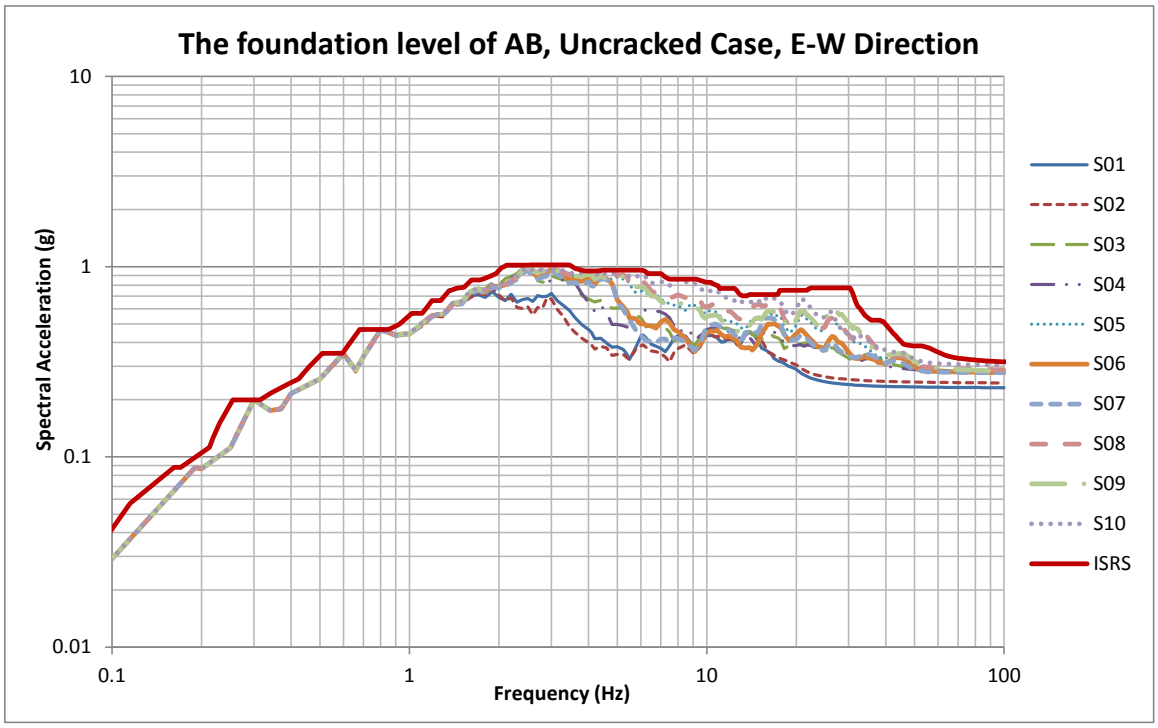


Figure 38 ISRS for foundation level of AB, Uncracked Case, E-W Direction

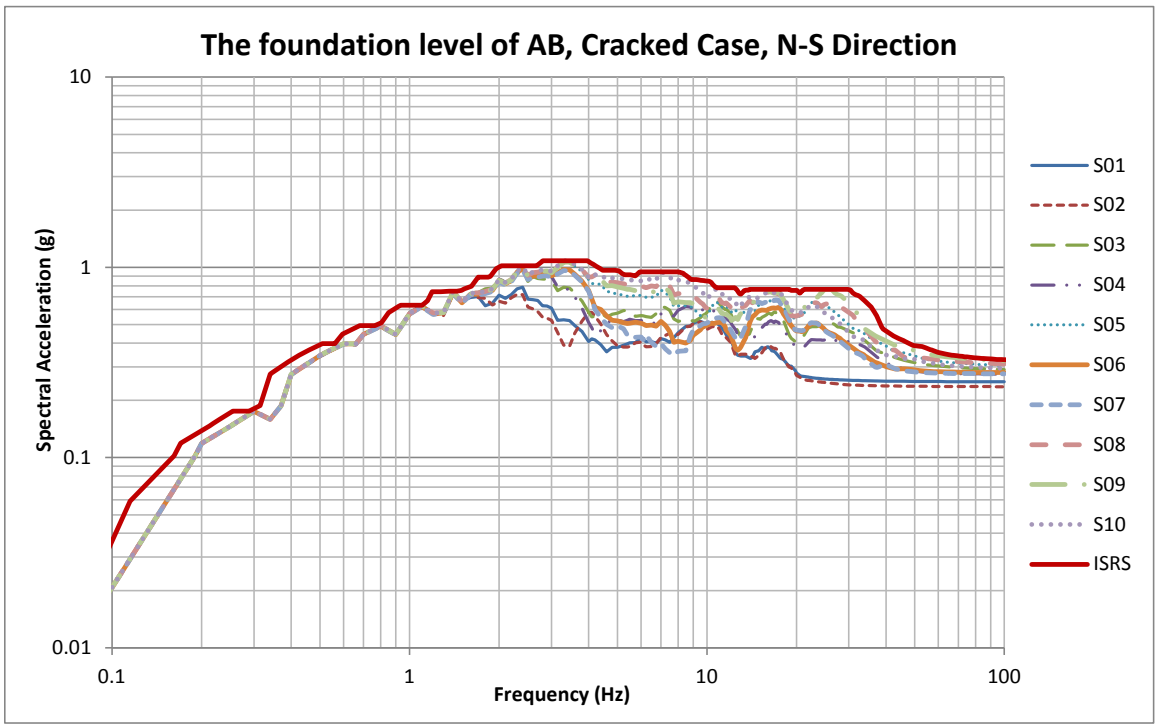


Figure 39 ISRS for foundation level of AB, Cracked Case, N-S Direction

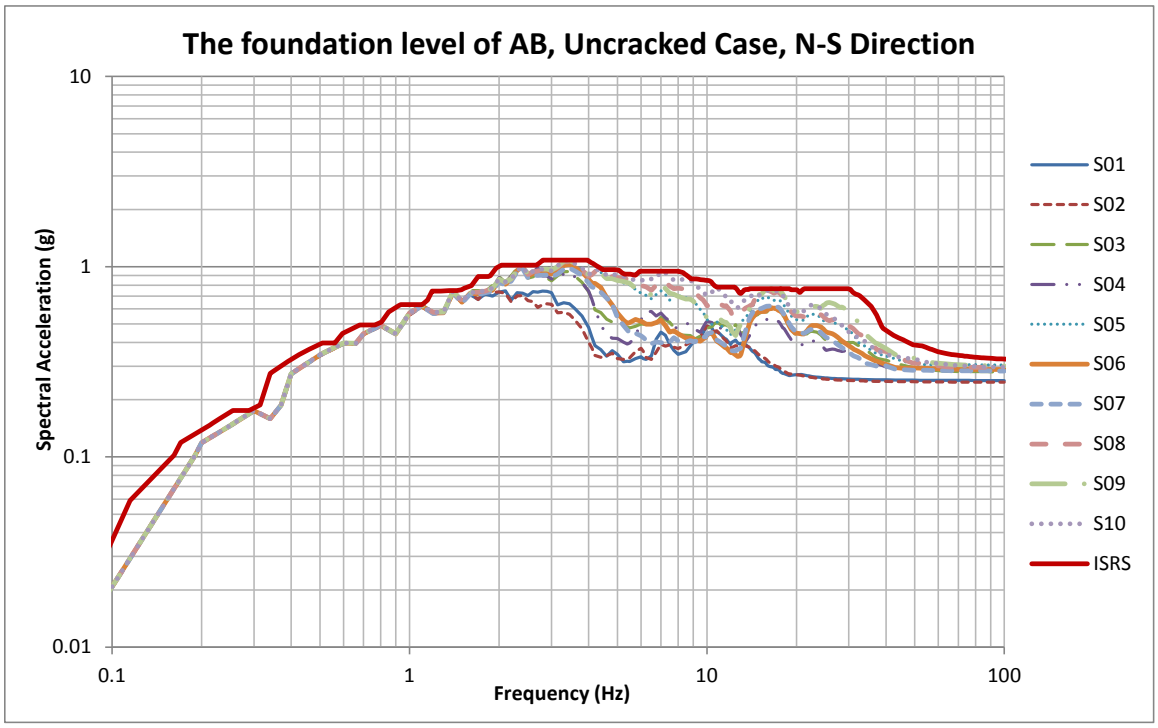


Figure 40 ISRS for foundation level of AB, Uncracked Case, N-S Direction

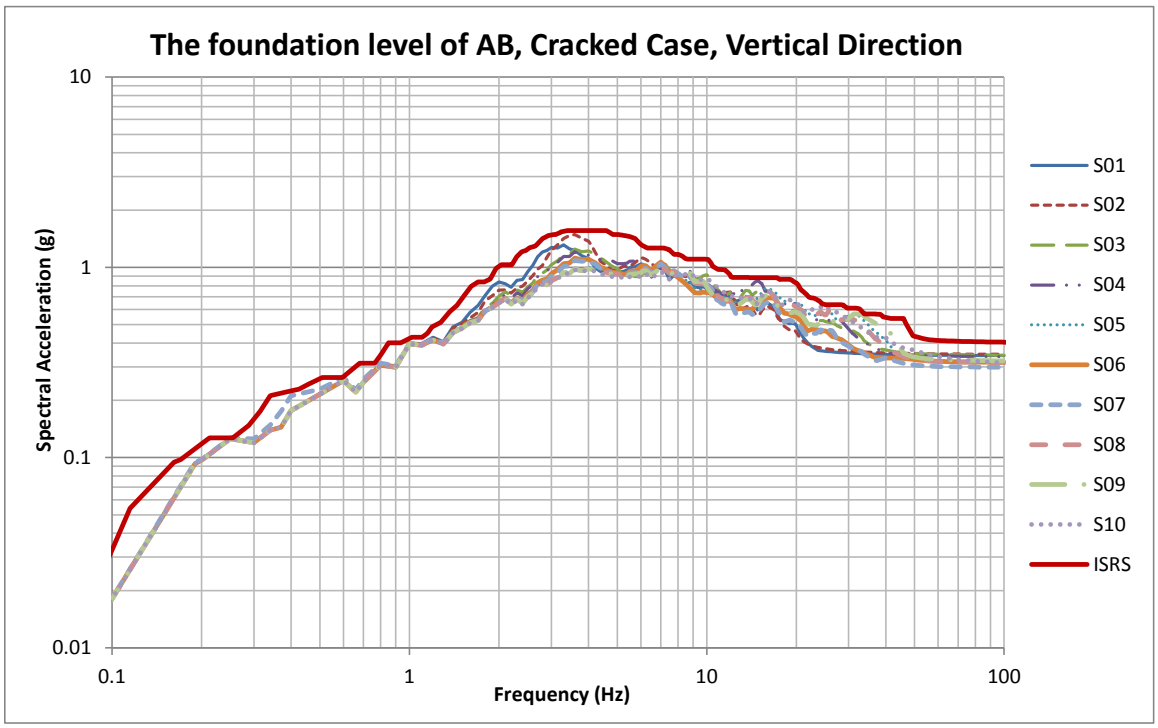


Figure 41 ISRS for foundation level of AB, Cracked Case, Vertical Direction

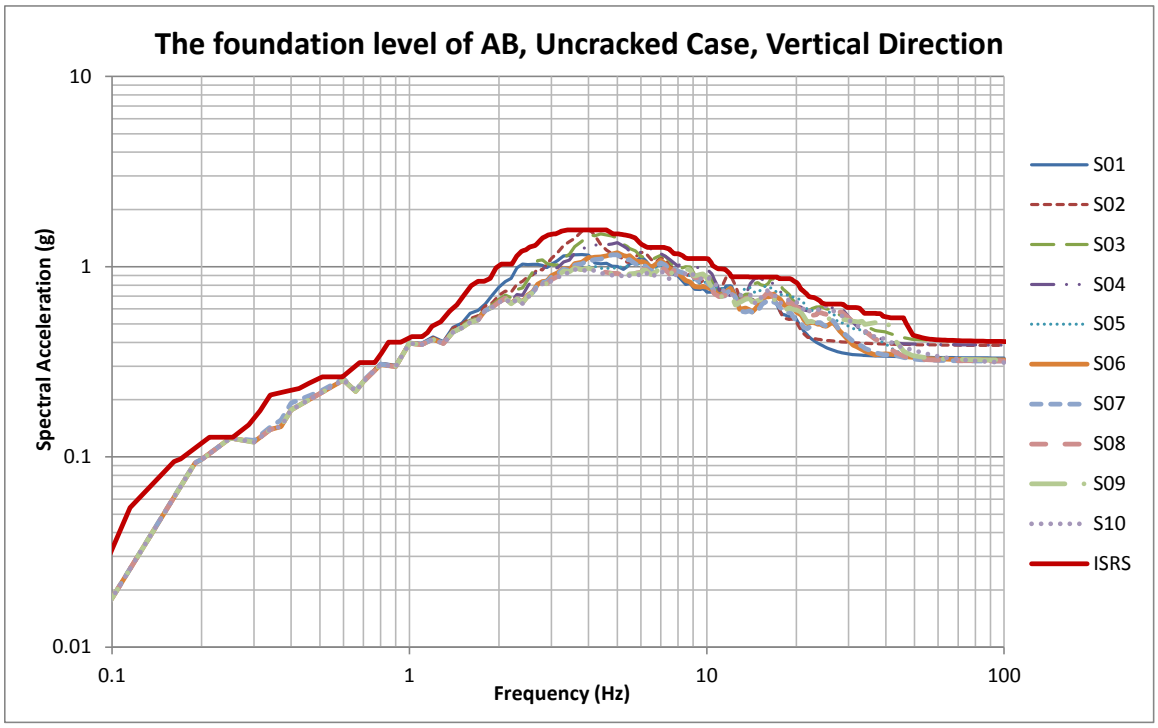


Figure 42 ISRS for foundation level of AB, Uncracked Case, Vertical Direction

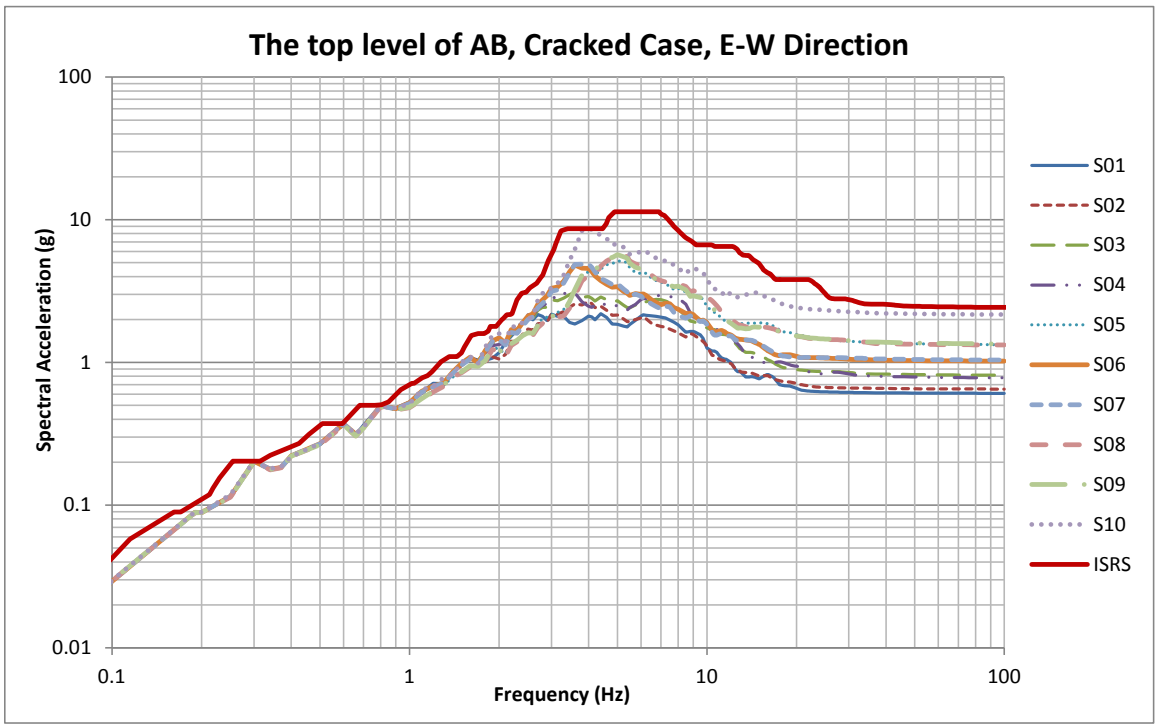


Figure 43 ISRS for top level of AB, Cracked Case, E-W Direction

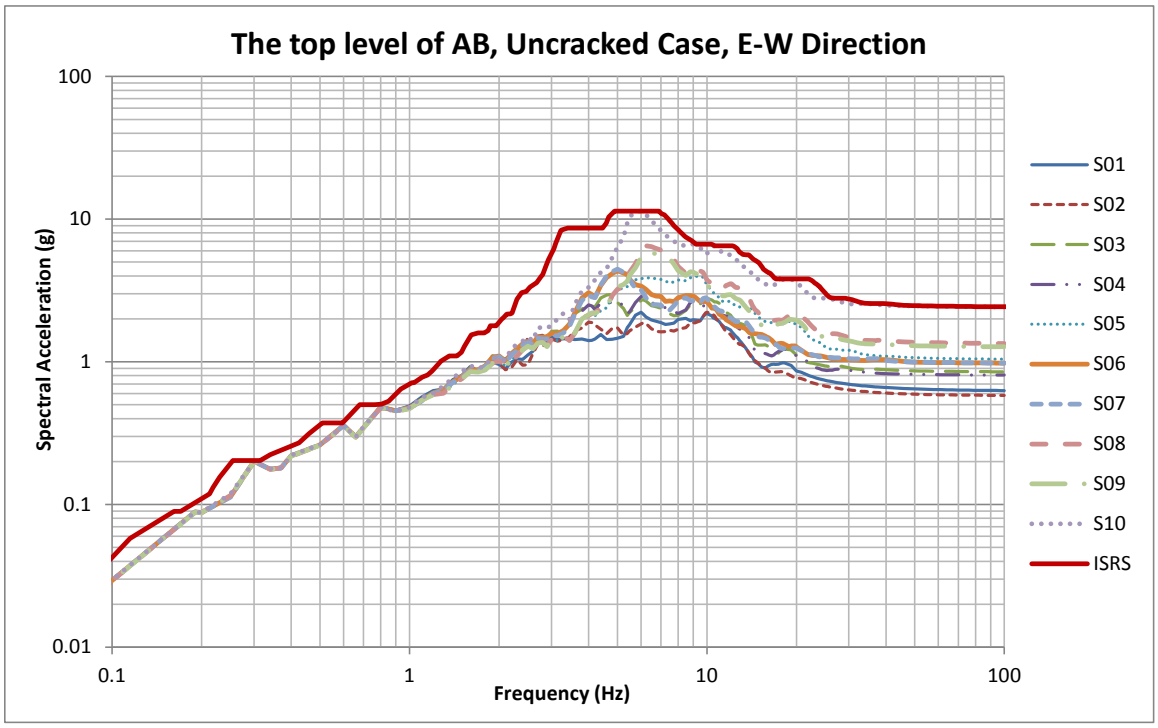


Figure 44 ISRS for top level of AB, Uncracked Case, E-W Direction

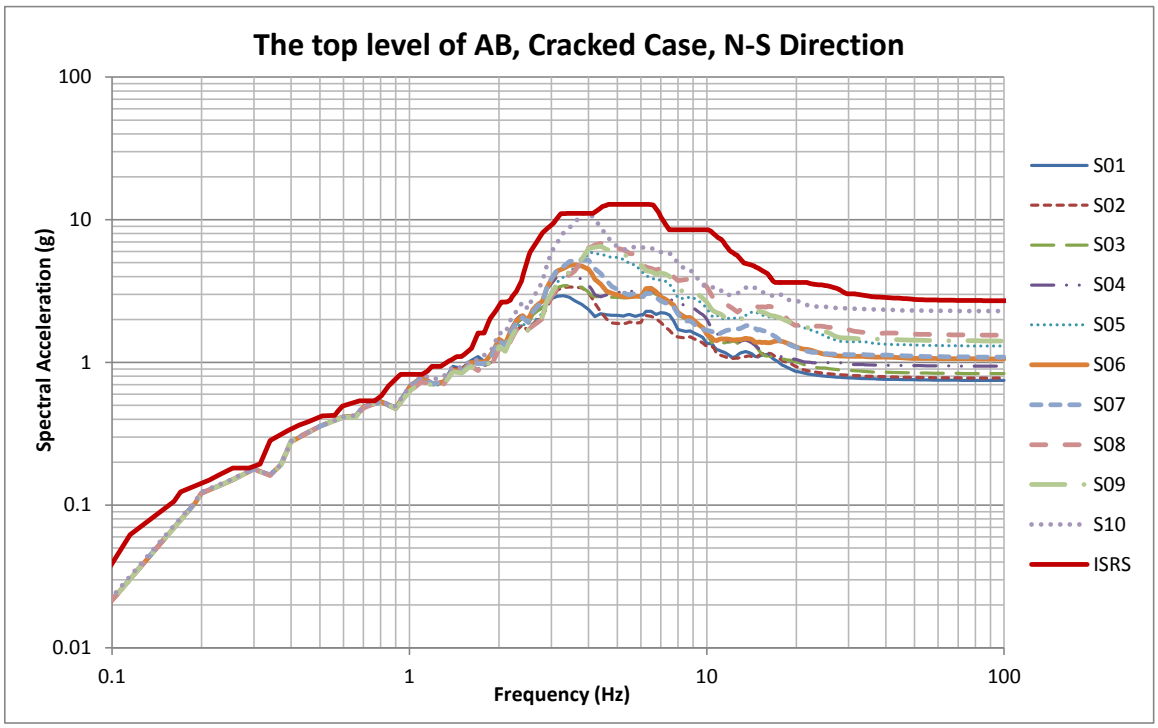


Figure 45 ISRS for top level of AB, Cracked Case, N-S Direction

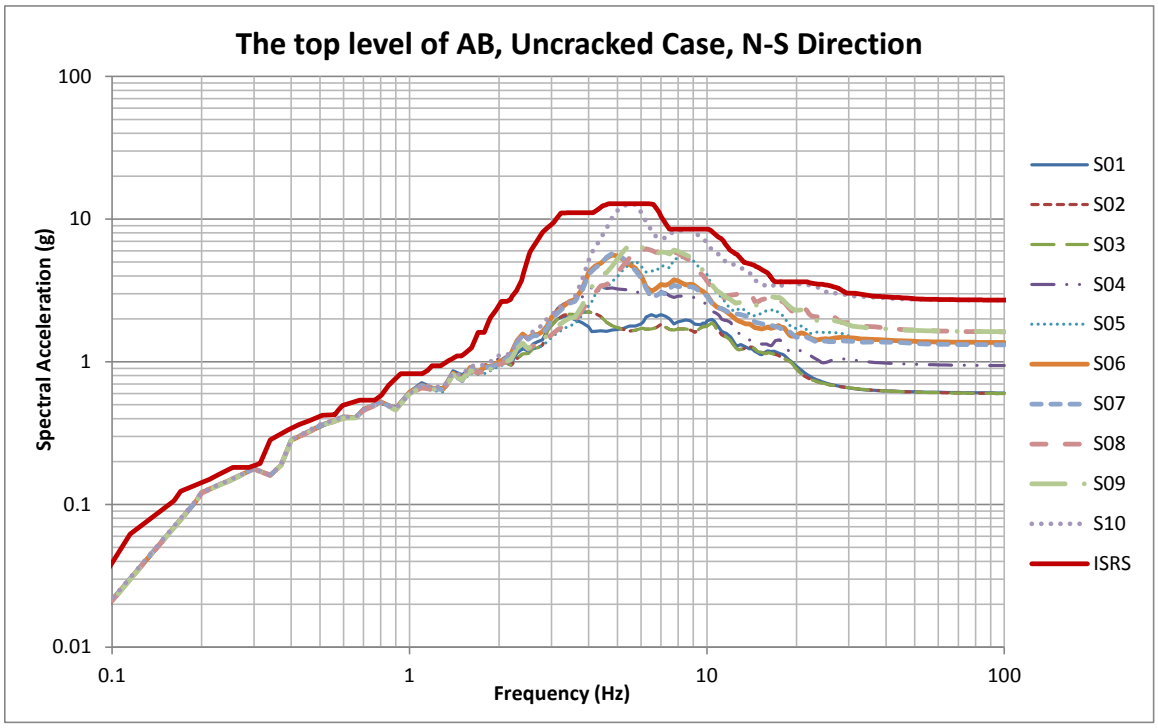


Figure 46 ISRS for top level of AB, Uncracked Case, N-S Direction

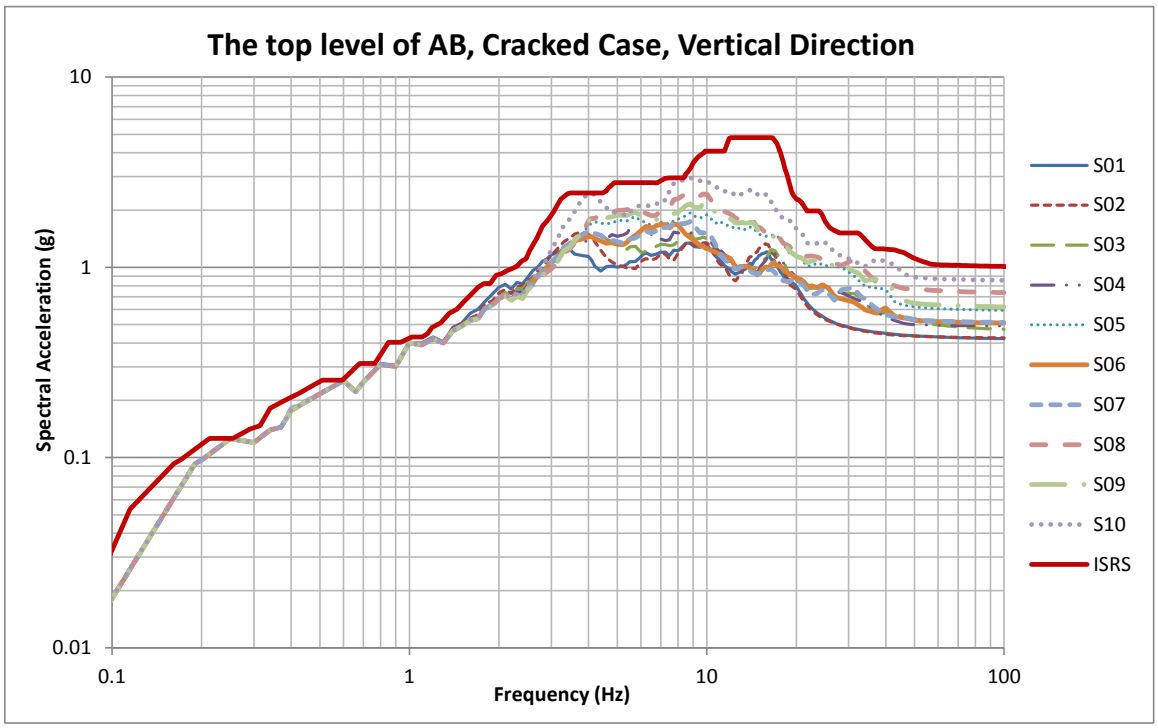


Figure 47 ISRS for top level of AB, Cracked Case, Vertical Direction

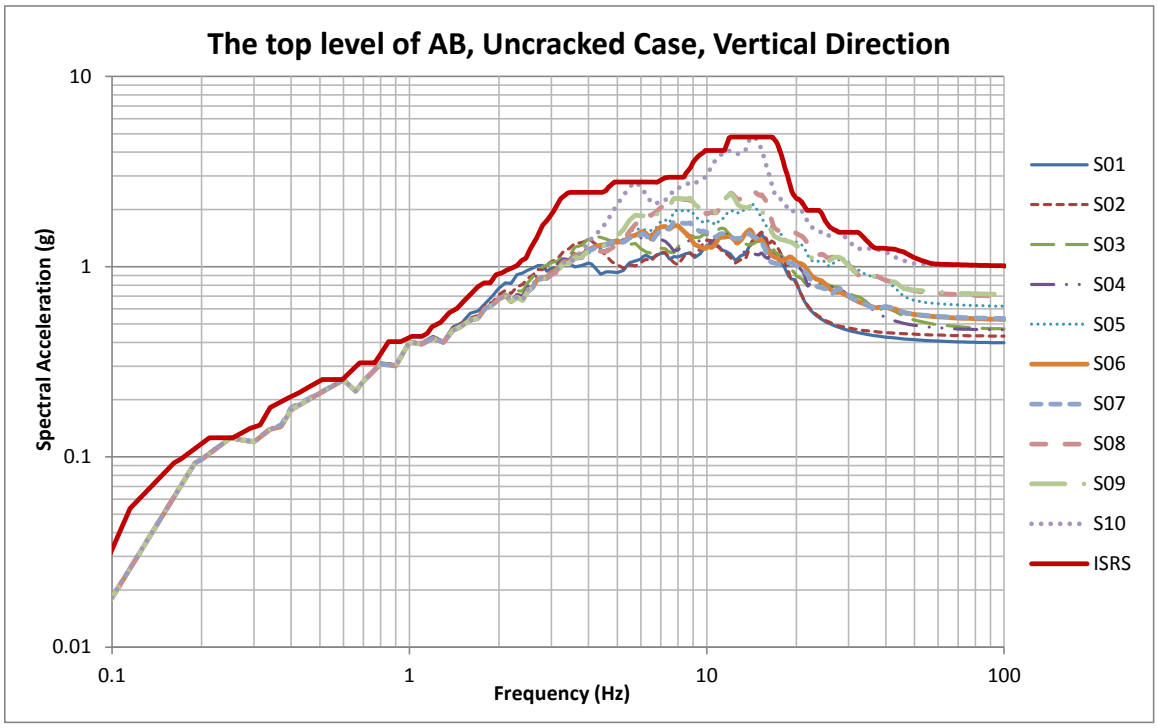


Figure 48 ISRS for top level of AB, Uncracked Case, Vertical Direction

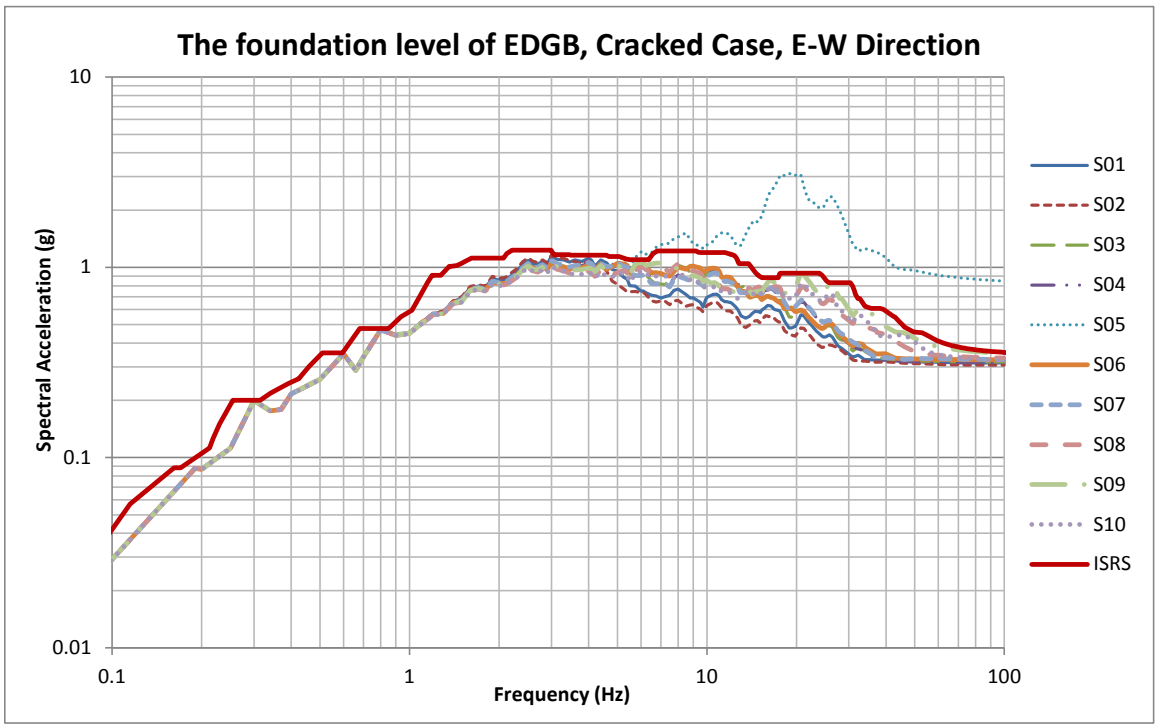


Figure 49 ISRS for foundation level of EDGB, Cracked Case, E-W Direction

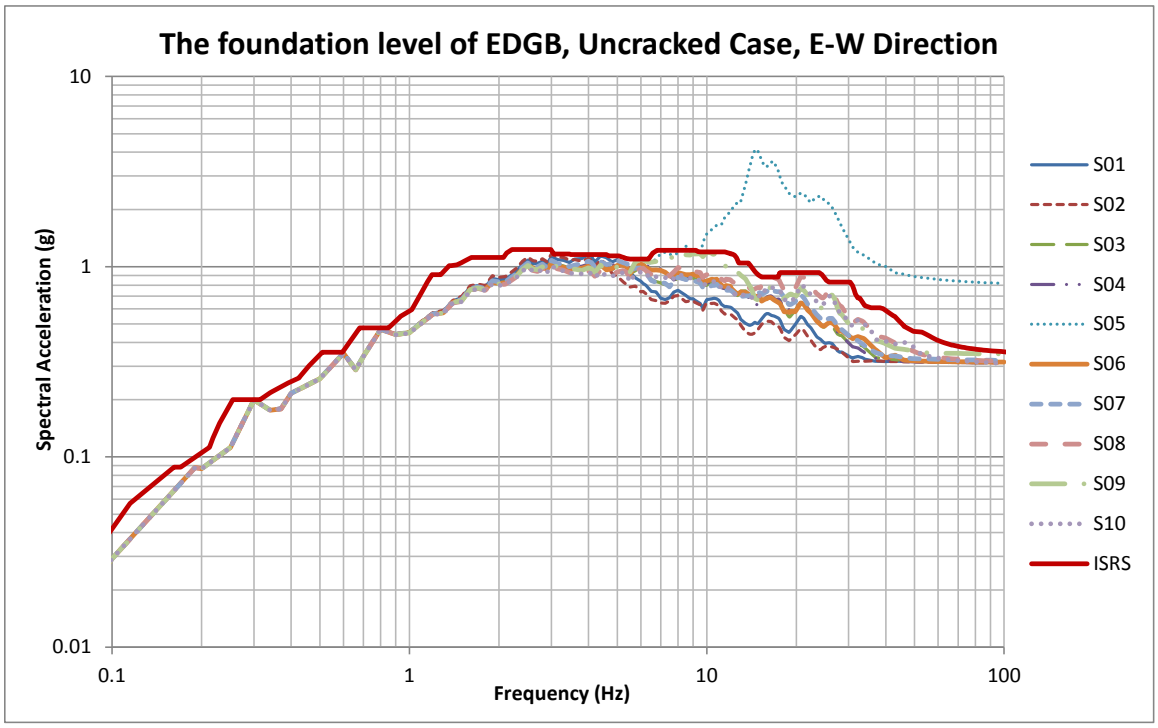


Figure 50 ISRS for foundation level of EDGB, Uncracked Case, E-W Direction

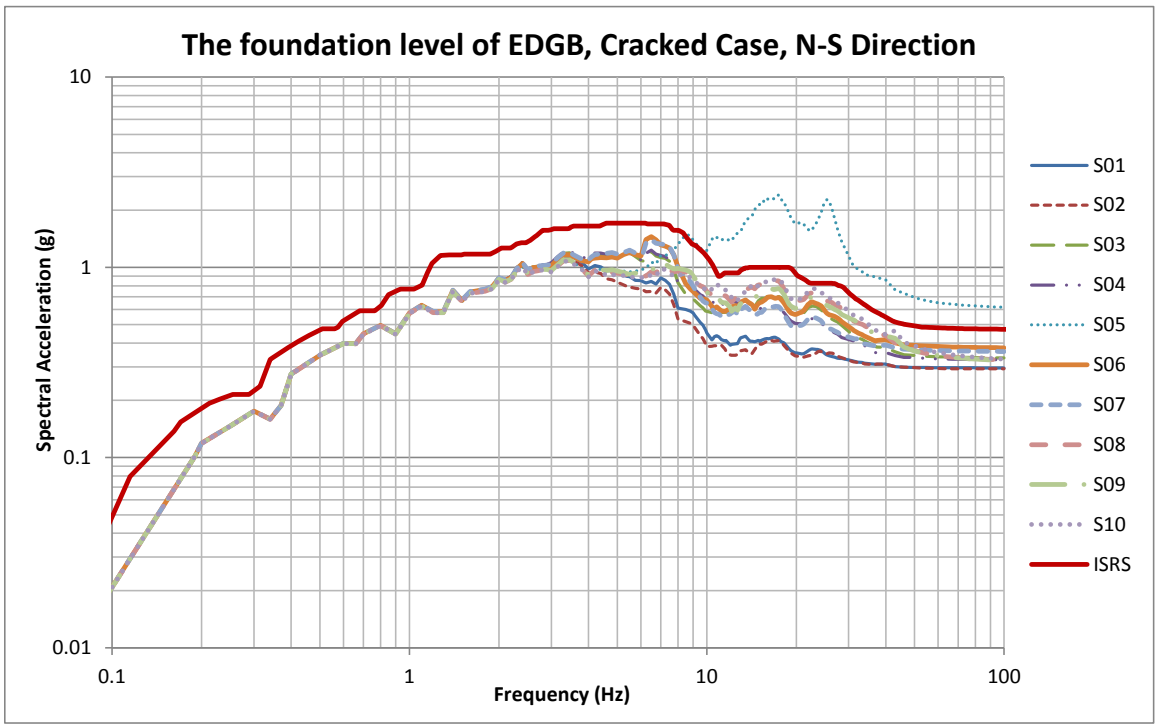


Figure 51 ISRS for foundation level of EDGB, Cracked Case, N-S Direction

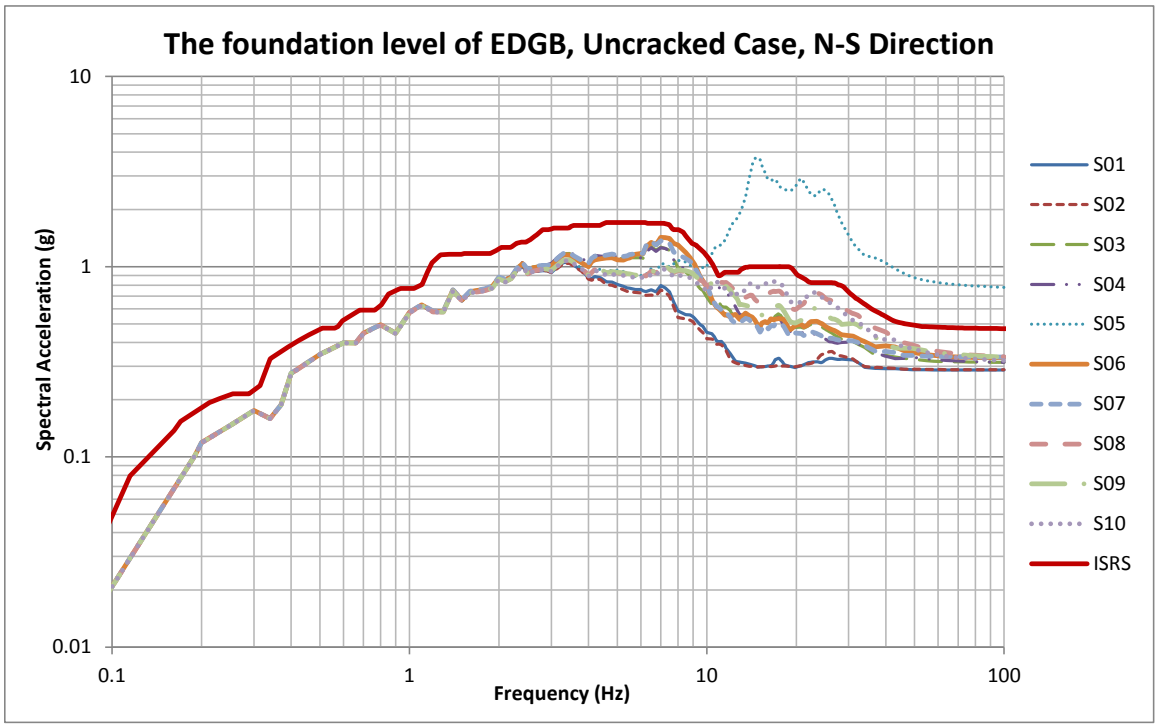


Figure 52 ISRS for foundation level of EDGB, Uncracked Case, N-S Direction

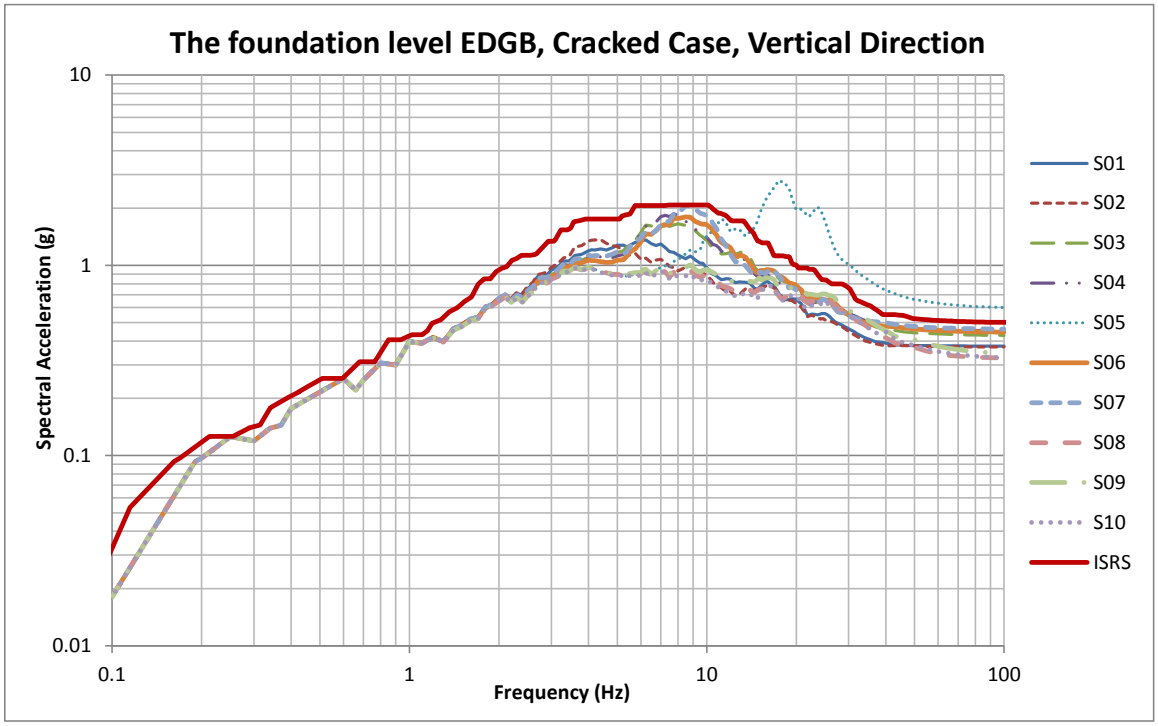


Figure 53 ISRS for foundation level of EDGB, Cracked Case, Vertical Direction

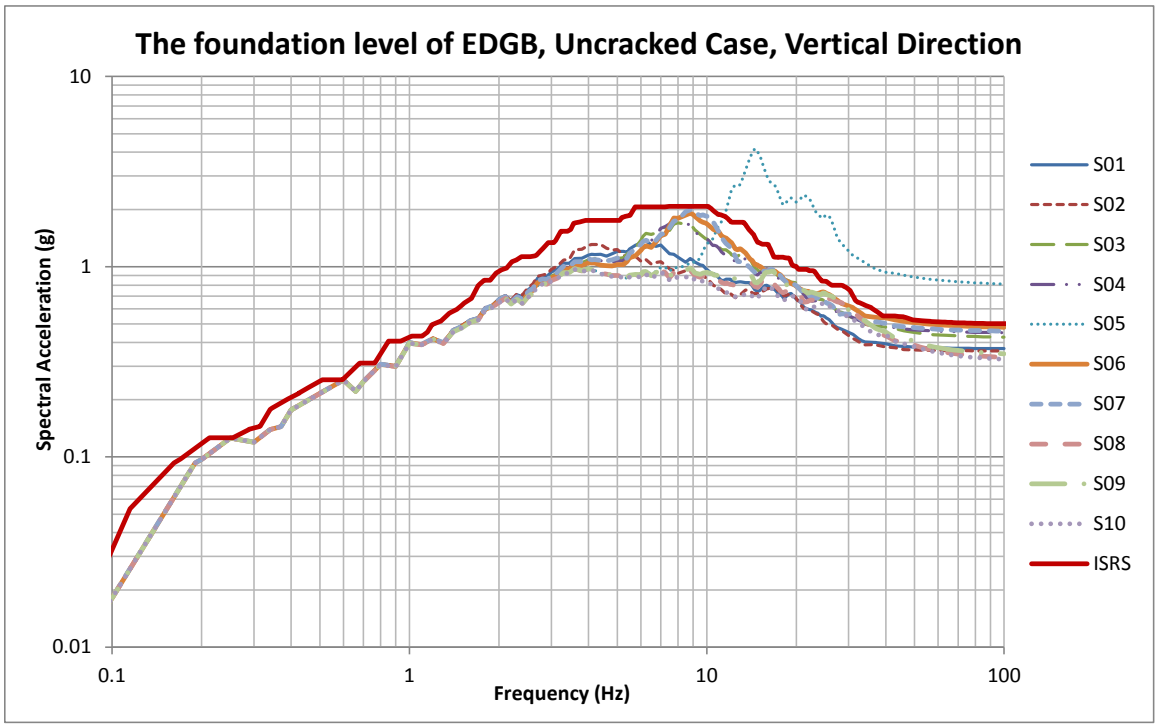


Figure 54 ISRS for foundation level of EDGB, Uncracked Case, Vertical Direction

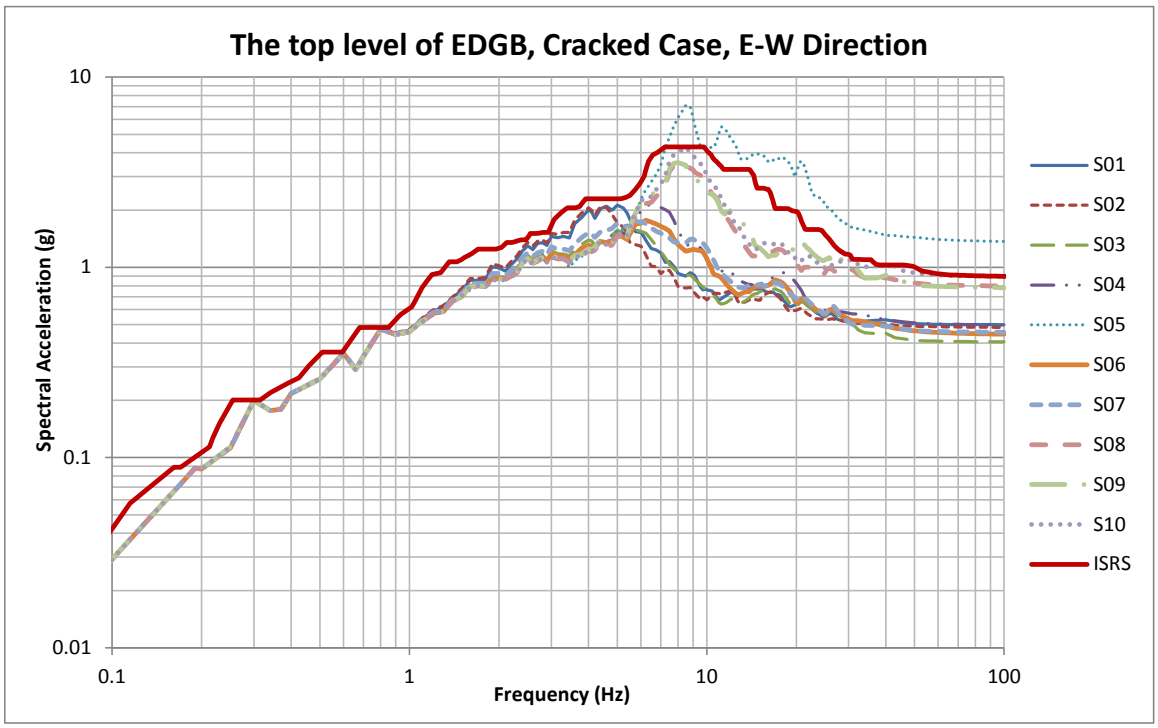


Figure 55 ISRS for top level of EDGB, Cracked Case, E-W Direction

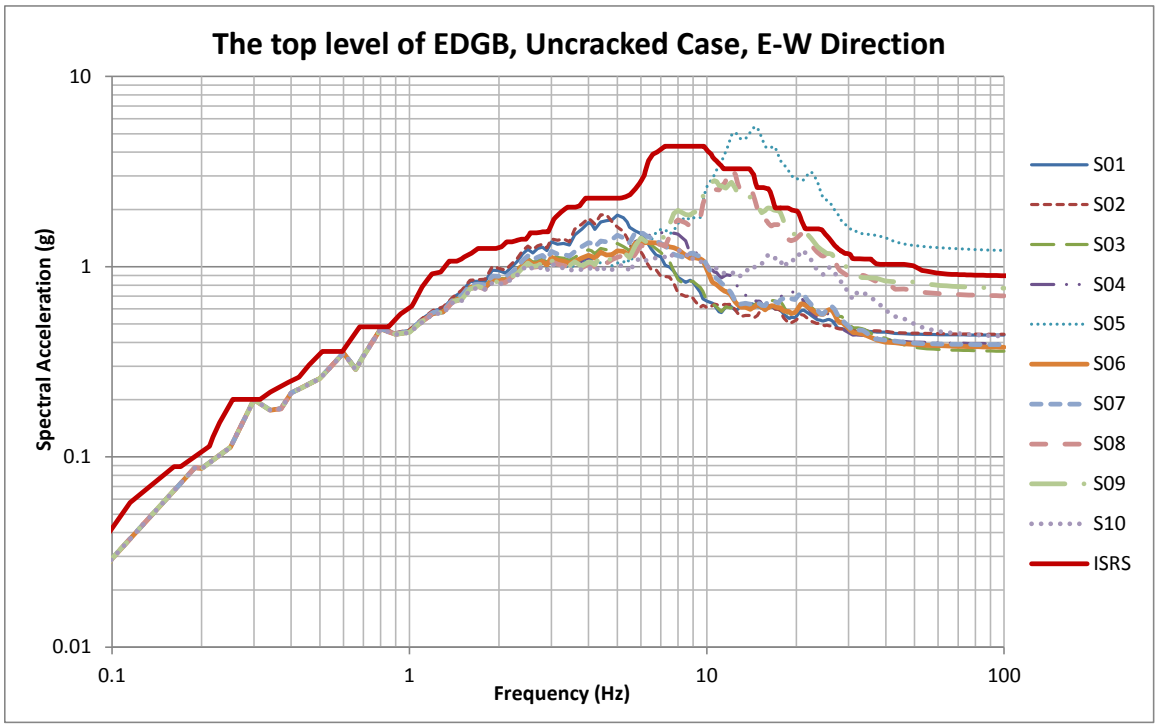


Figure 56 ISRS for top level of EDGB, Uncracked Case, E-W Direction

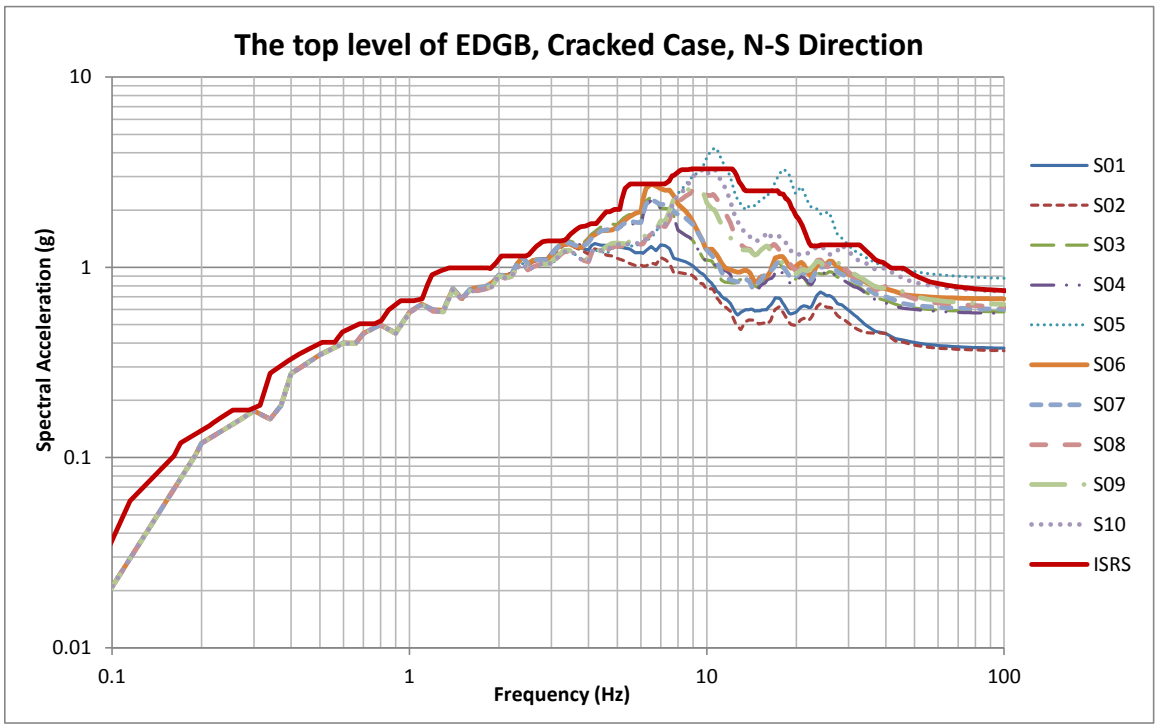


Figure 57 ISRS for top level of EDGB, Cracked Case, N-S Direction

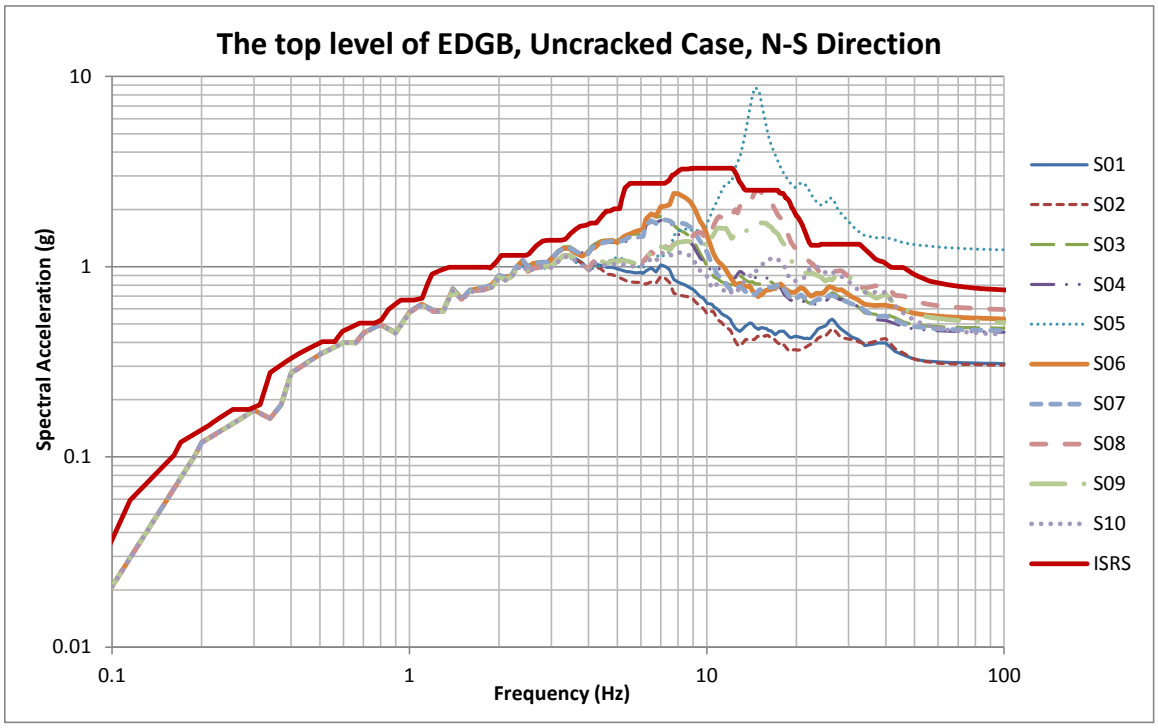


Figure 58 ISRS for top level of EDGB, Uncracked Case, N-S Direction

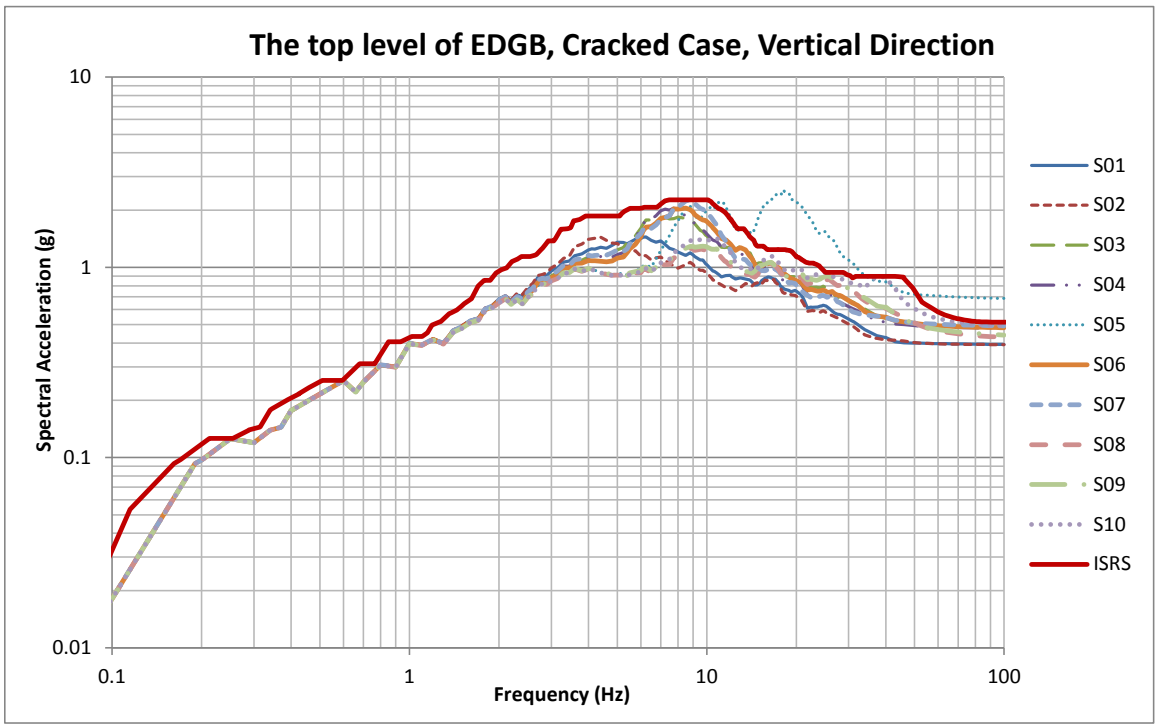


Figure 59 ISRS for top level of EDGB, Cracked Case, Vertical Direction

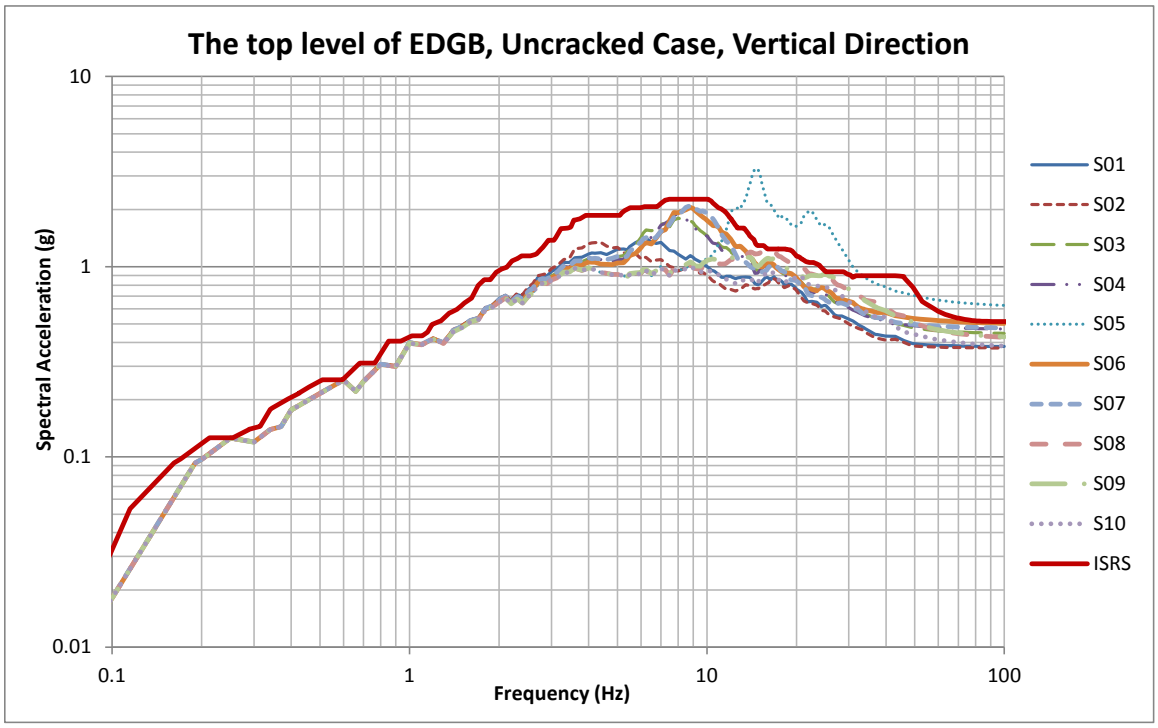


Figure 60 ISRS for top level of EDGB, Uncracked Case, Vertical Direction

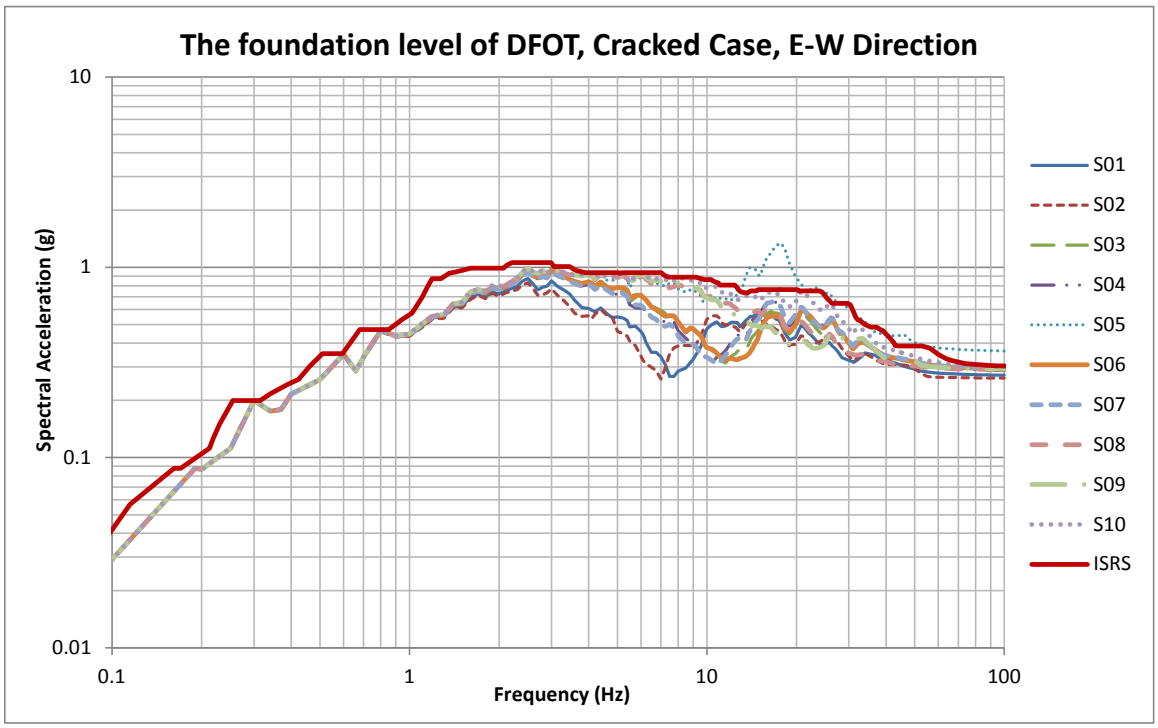


Figure 61 ISRS for foundation level of DFOT, Cracked Case, E-W Direction

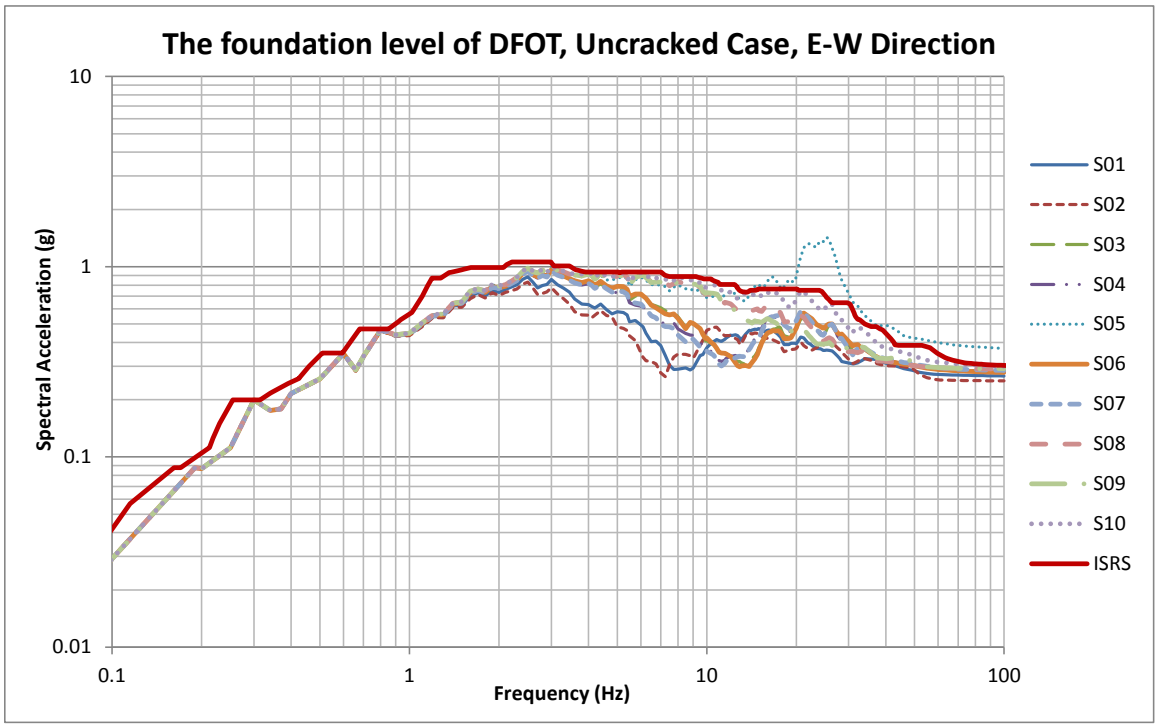


Figure 62 ISRS for foundation level of DFOT, Uncracked Case, E-W Direction

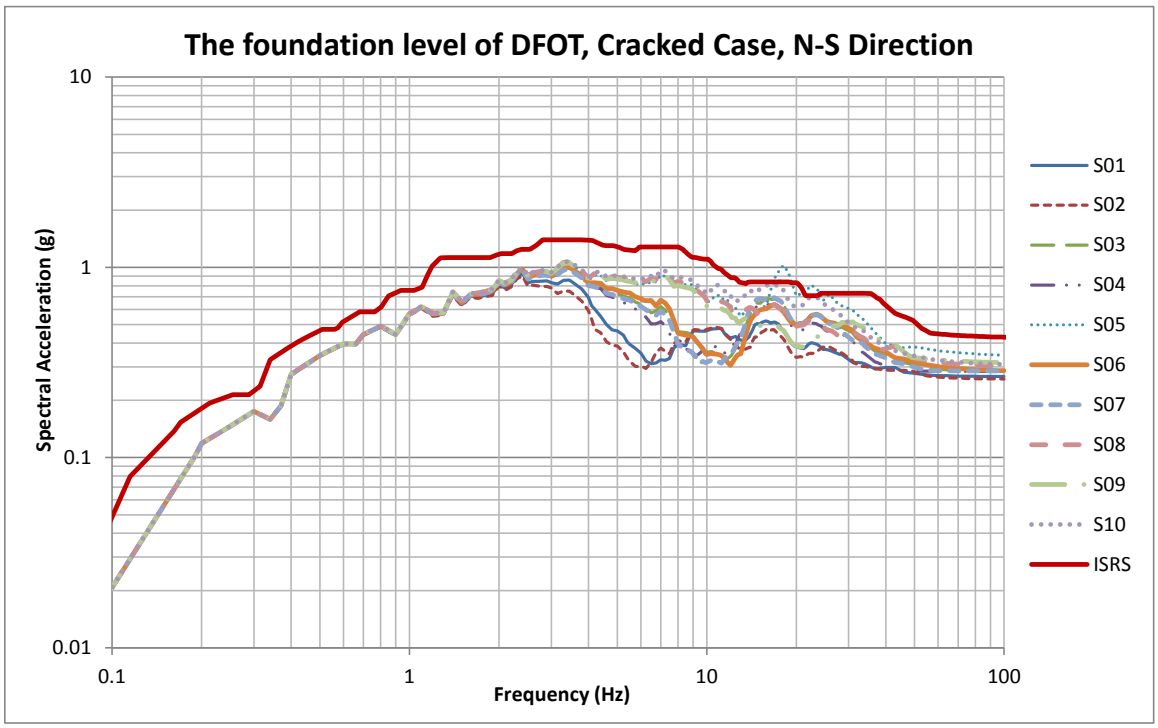


Figure 63 ISRS for foundation level of DFOT, Cracked Case, N-S Direction

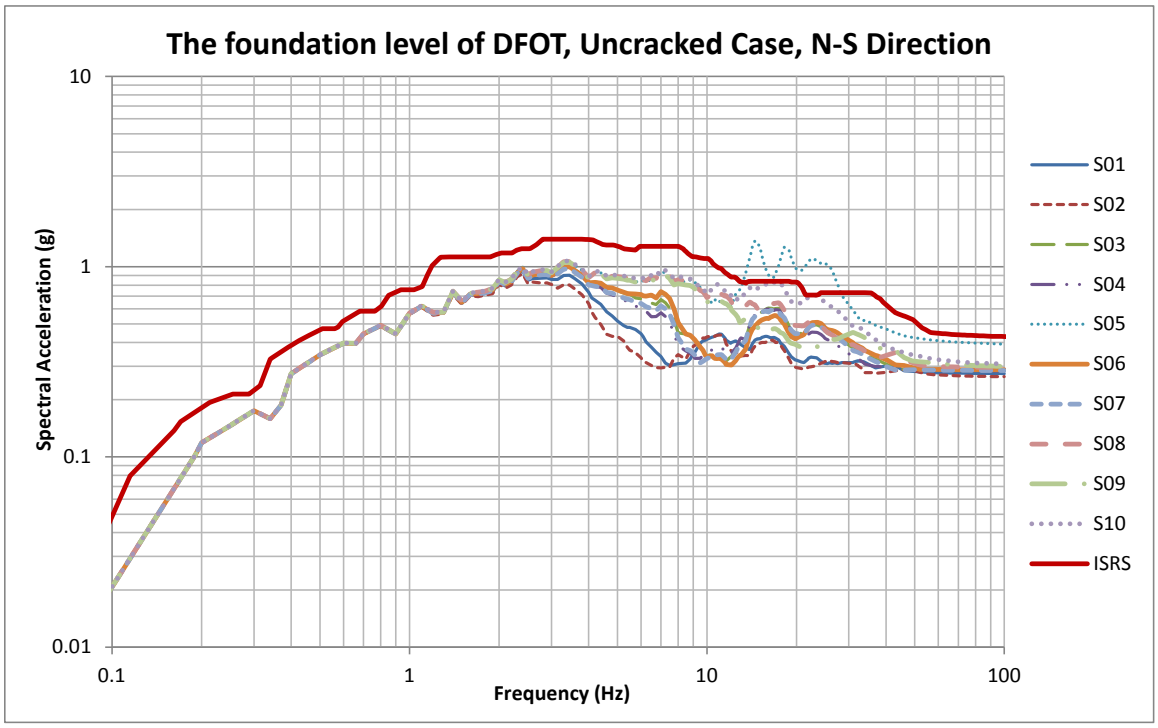


Figure 64 ISRS for foundation level of DFOT, Uncracked Case, N-S Direction

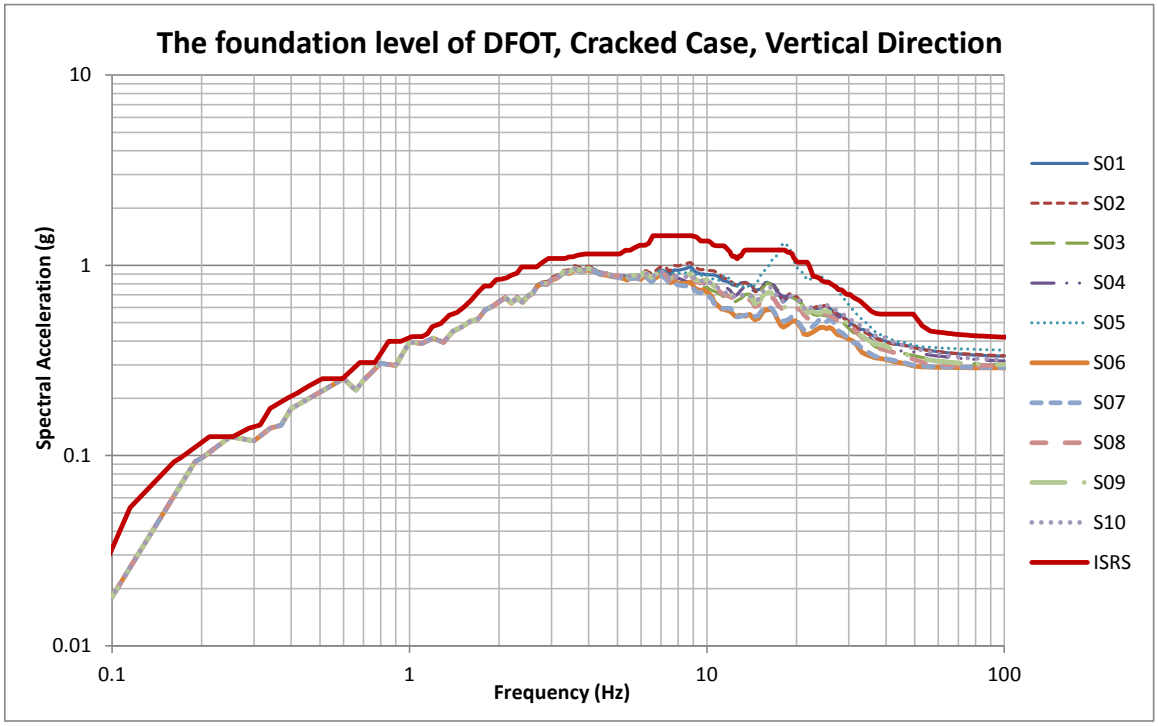


Figure 65 ISRS for foundation level of DFOT, Cracked Case, Vertical Direction

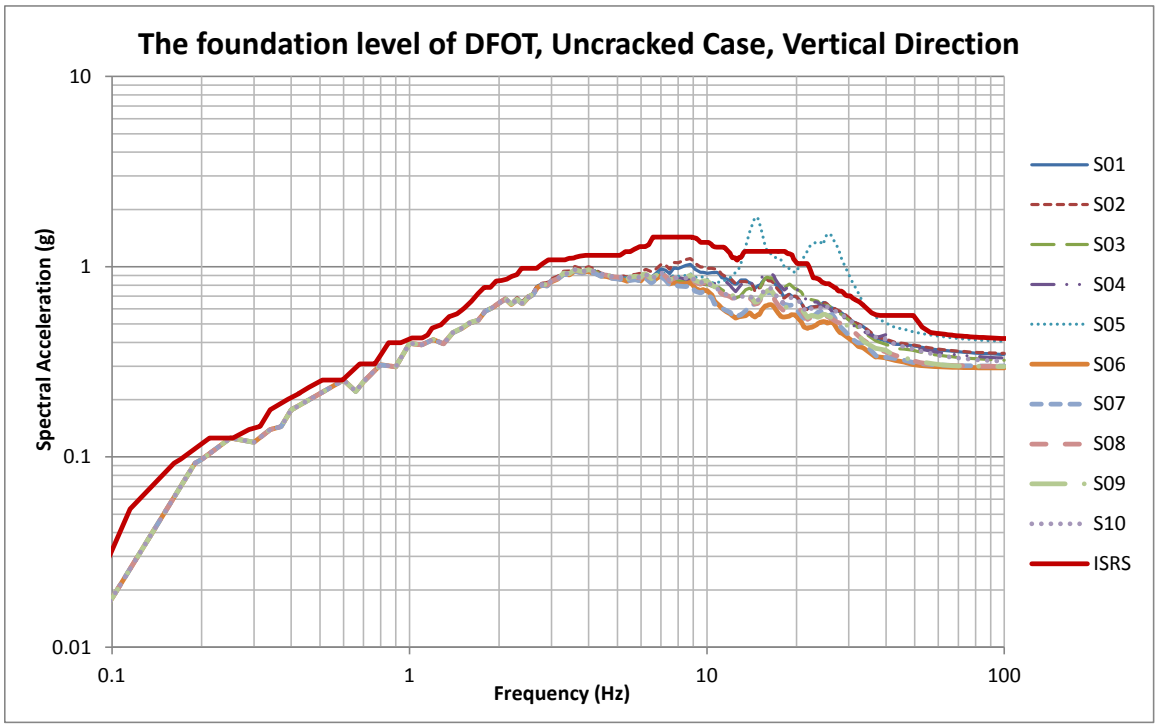


Figure 66 ISRS for foundation level of DFOT, Uncracked Case, Vertical Direction

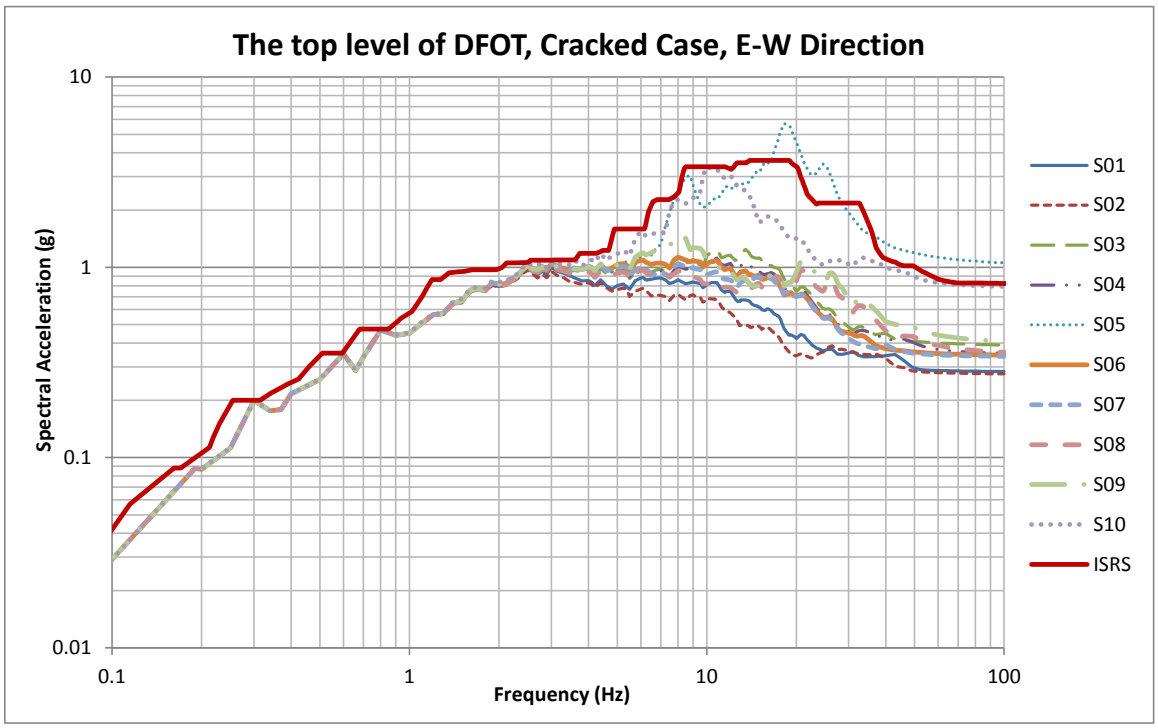


Figure 67 ISRS for top level of DFOT, Cracked Case, E-W Direction

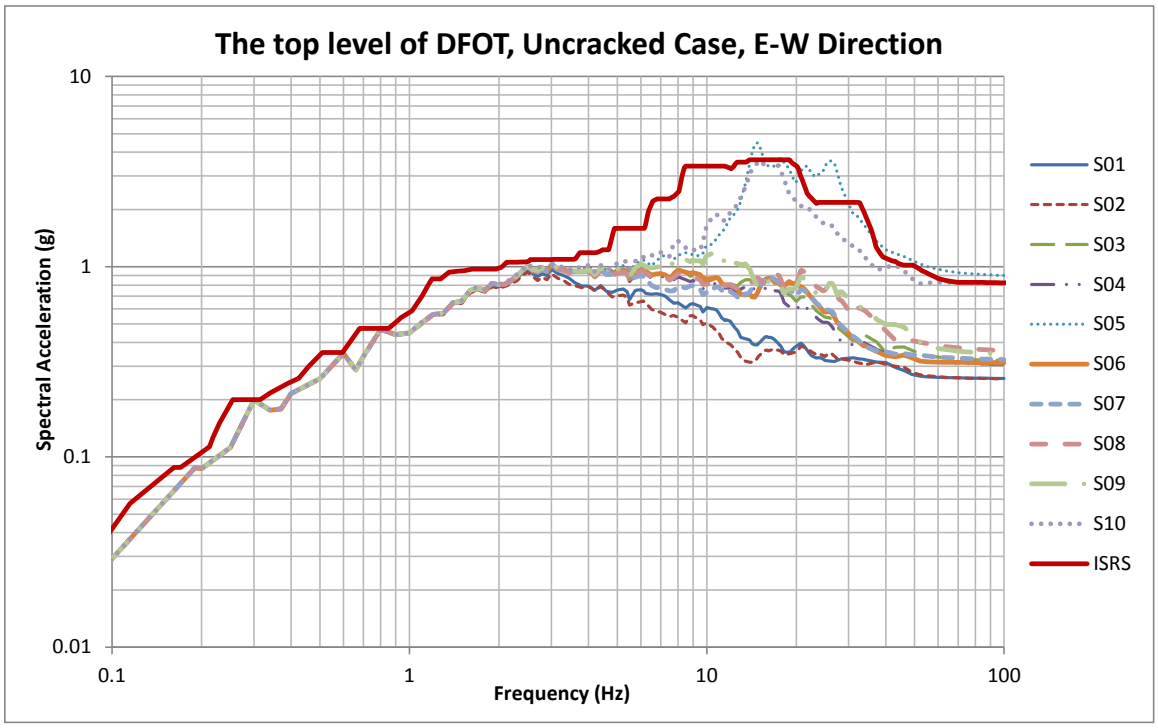


Figure 68 ISRS for top level of DFOT, Uncracked Case, E-W Direction

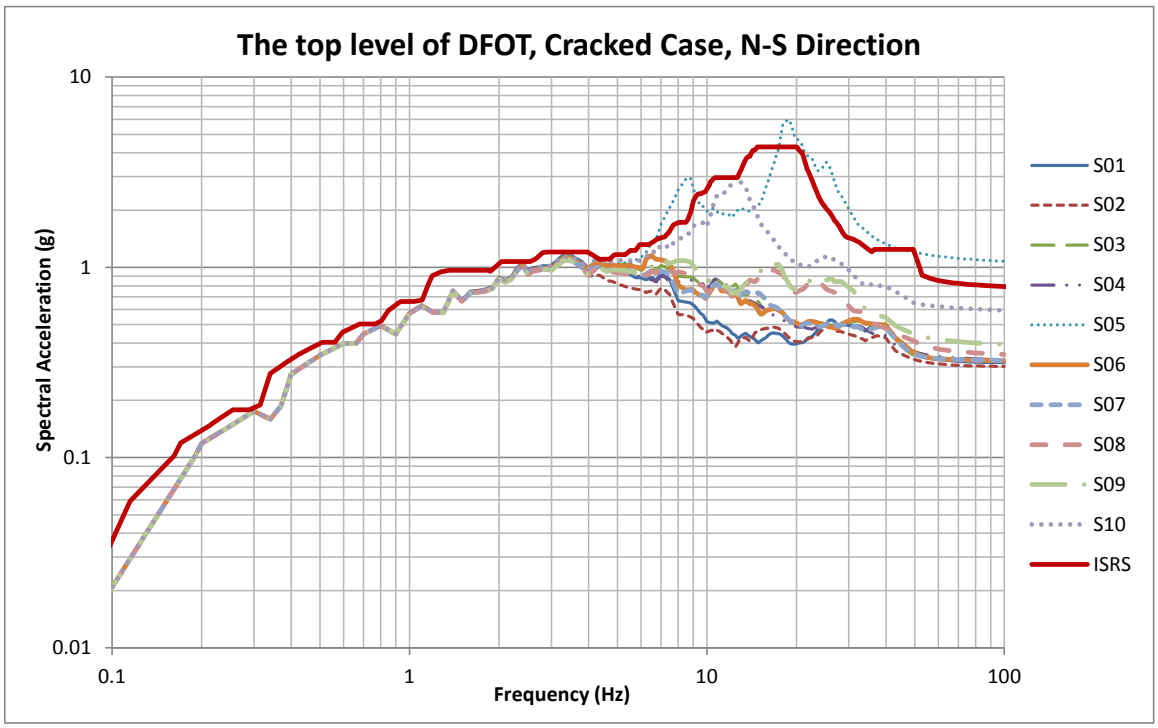


Figure 69 ISRS for top level of DFOT, Cracked Case, N-S Direction

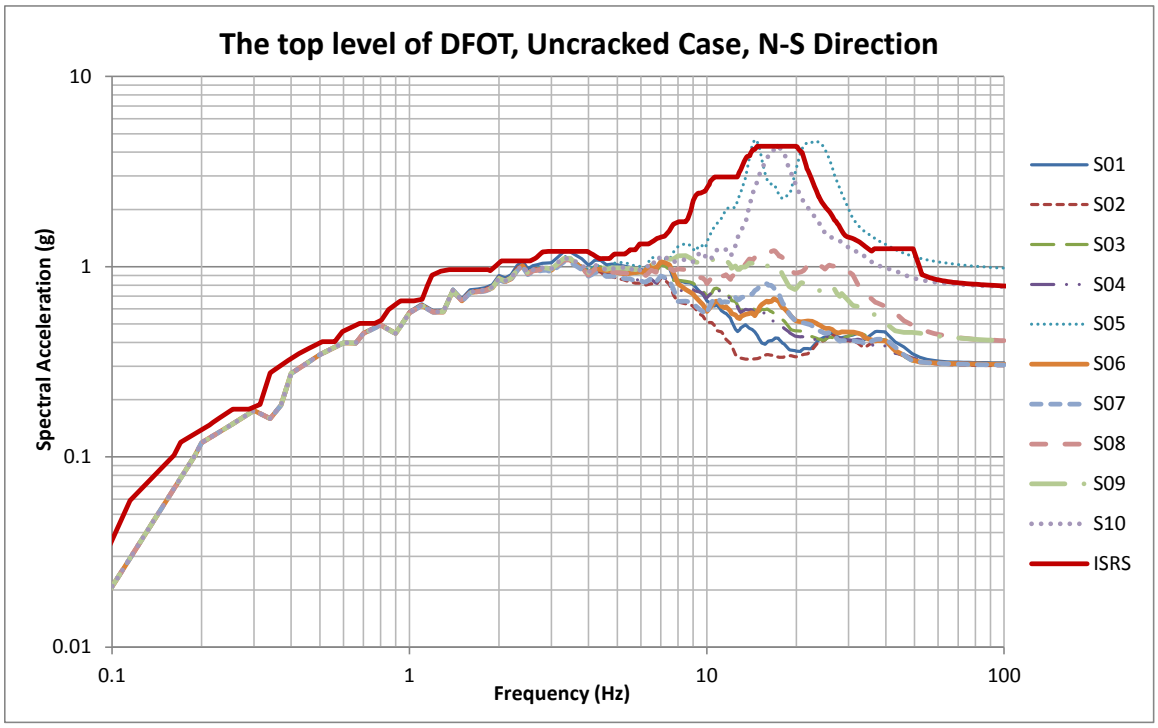


Figure 70 ISRS for top level of DFOT, Uncracked Case, N-S Direction

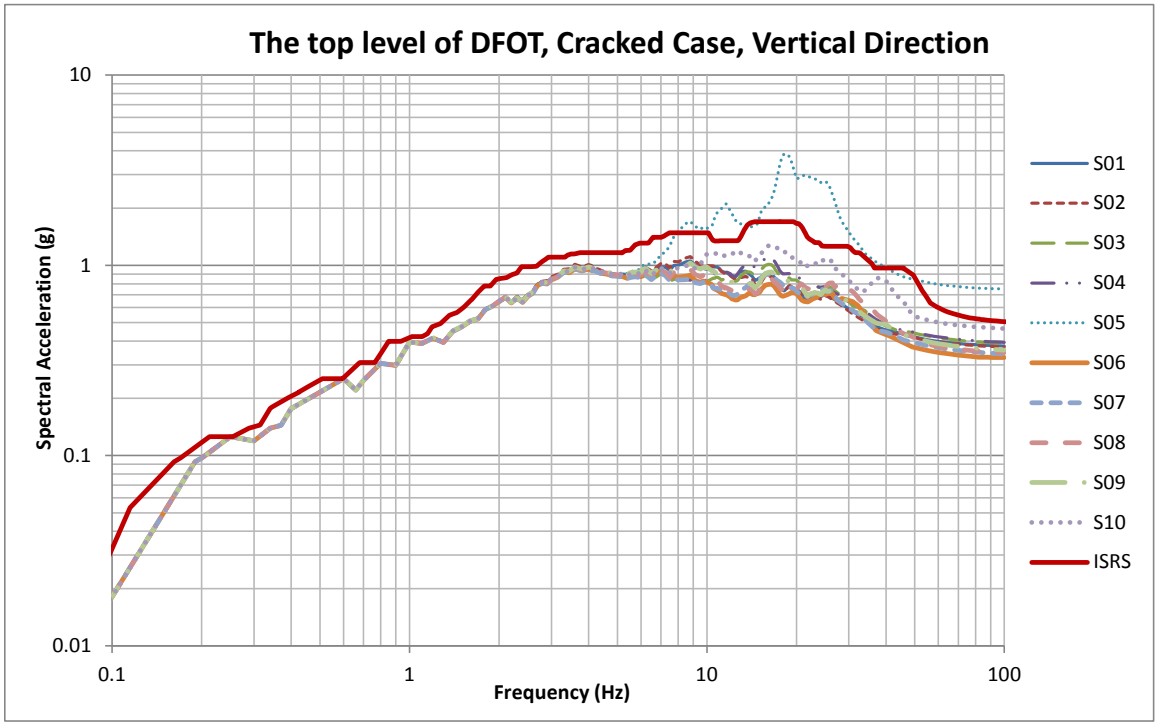


Figure 71 ISRS for top level of DFOT, Cracked Case, Vertical Direction

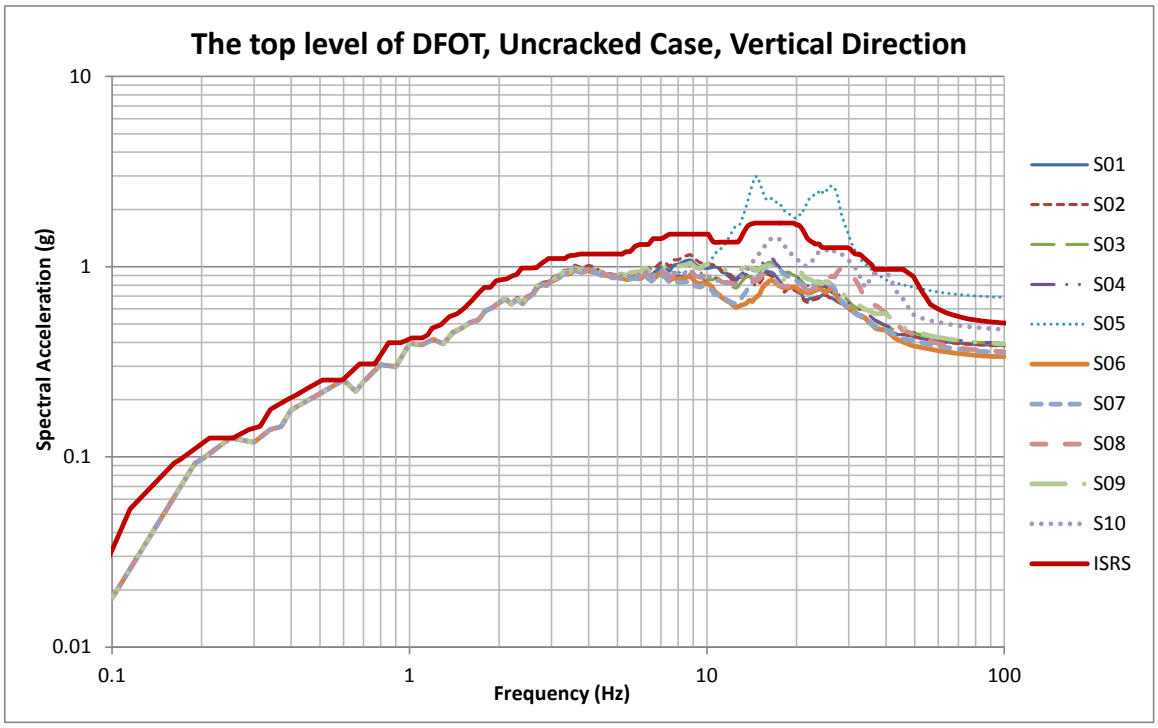
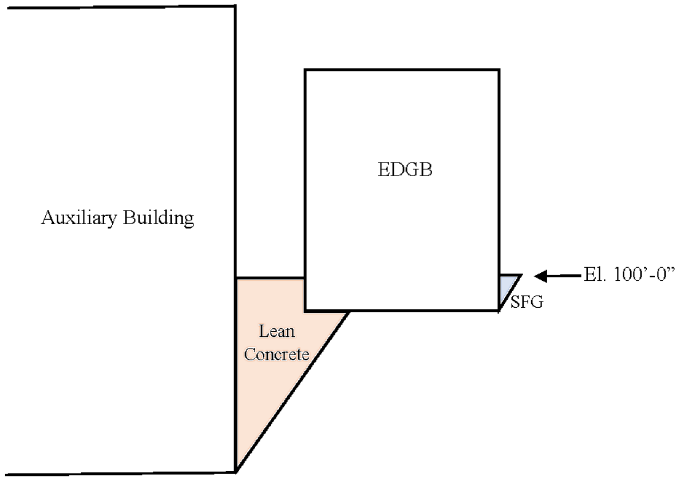
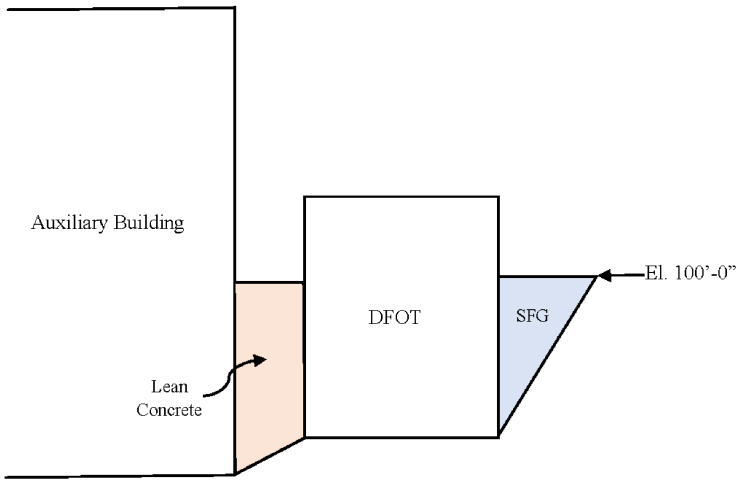


Figure 72 ISRS for top level of DFOT, Uncracked Case, Vertical Direction



(a) Schematic Outline for Lean Concrete and SFG Location between NI and EDGB



(b) Schematic Outline for Lean Concrete and SFG Location between NI and DFOT

Figure 73 Schematic Outlines for Modification of Backfill Properties in SSI Analysis Model

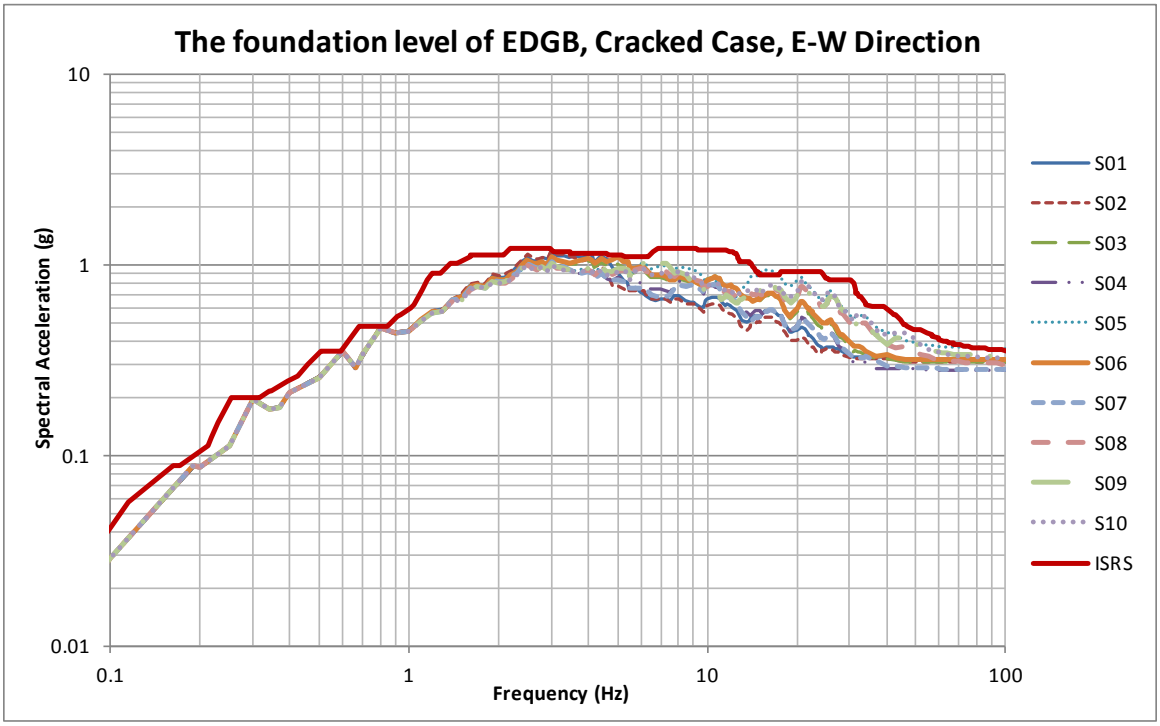


Figure 74 ISRS for foundation level of EDGB, Cracked Case, E-W Direction

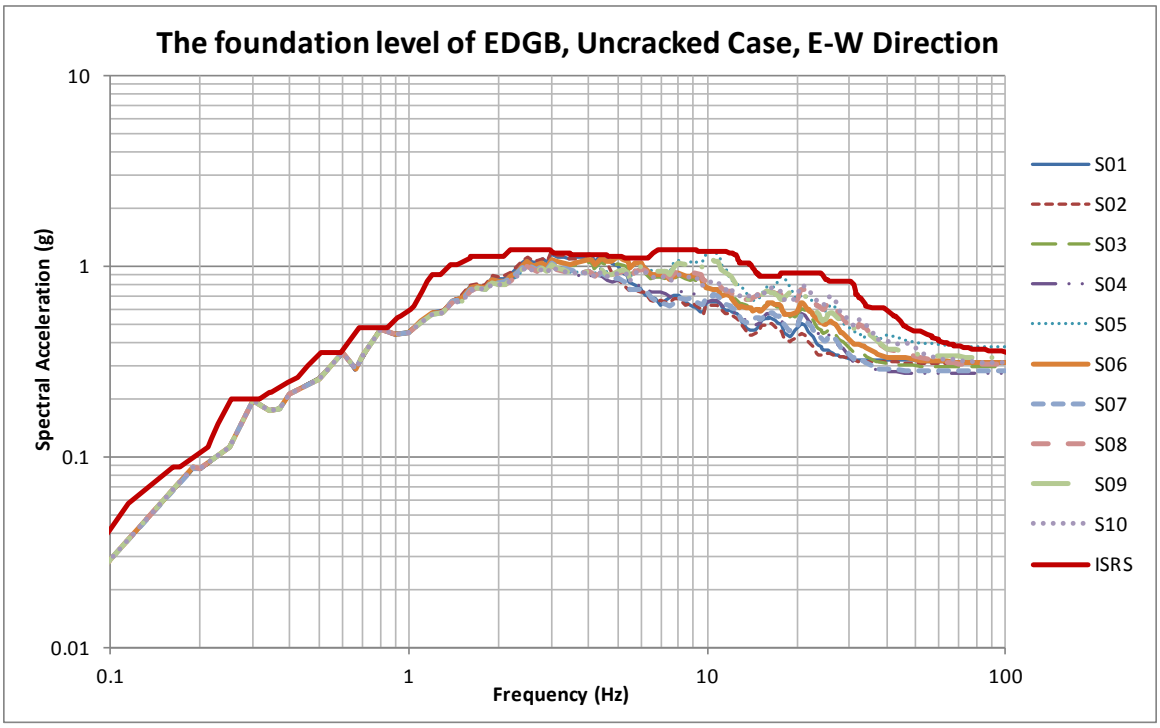


Figure 75 ISRS for Foundation Level of EDGB, Uncracked Case, E-W Direction

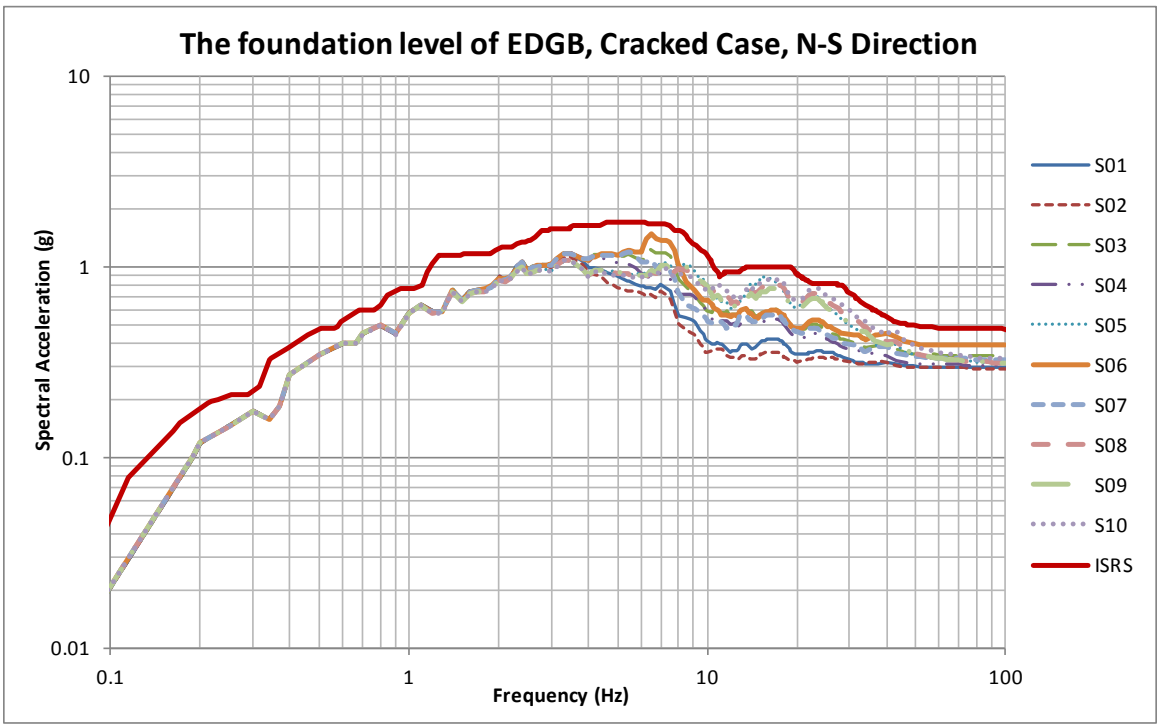


Figure 76 ISRS for Foundation Level of EDGB, Cracked Case, N-S Direction

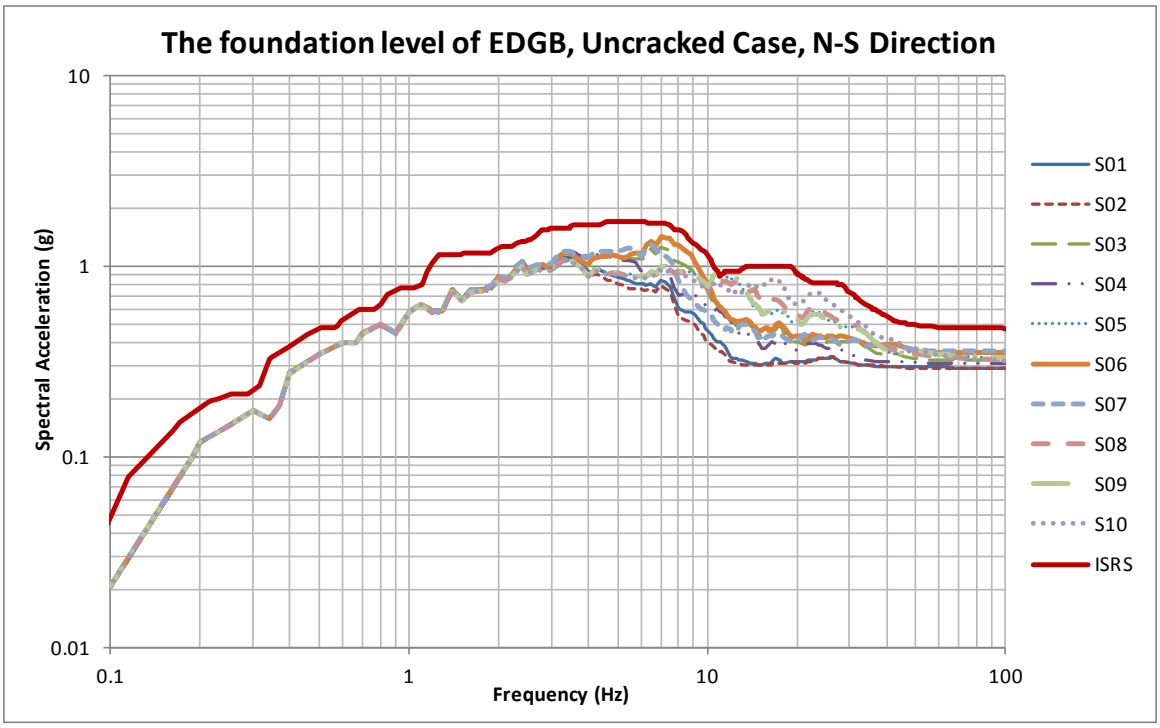


Figure 77 ISRS for Foundation Level of EDGB, Uncracked Case, N-S Direction

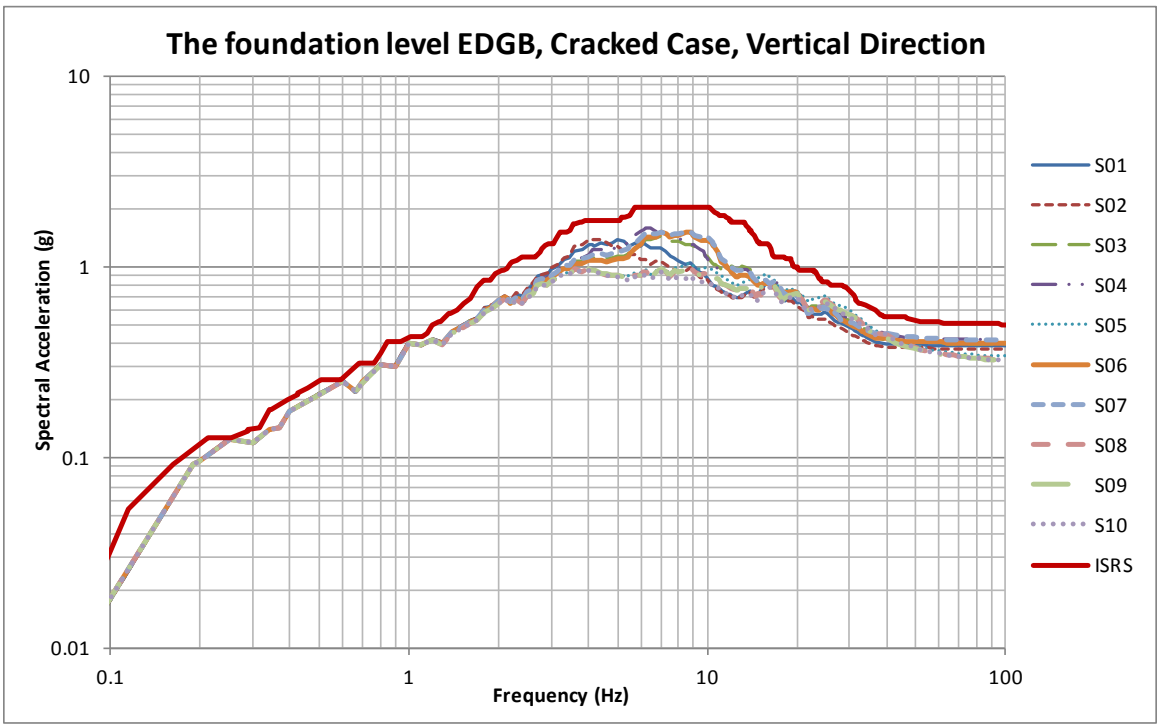


Figure 78 ISRS for Foundation Level of EDGB, Cracked Case, Vertical Direction

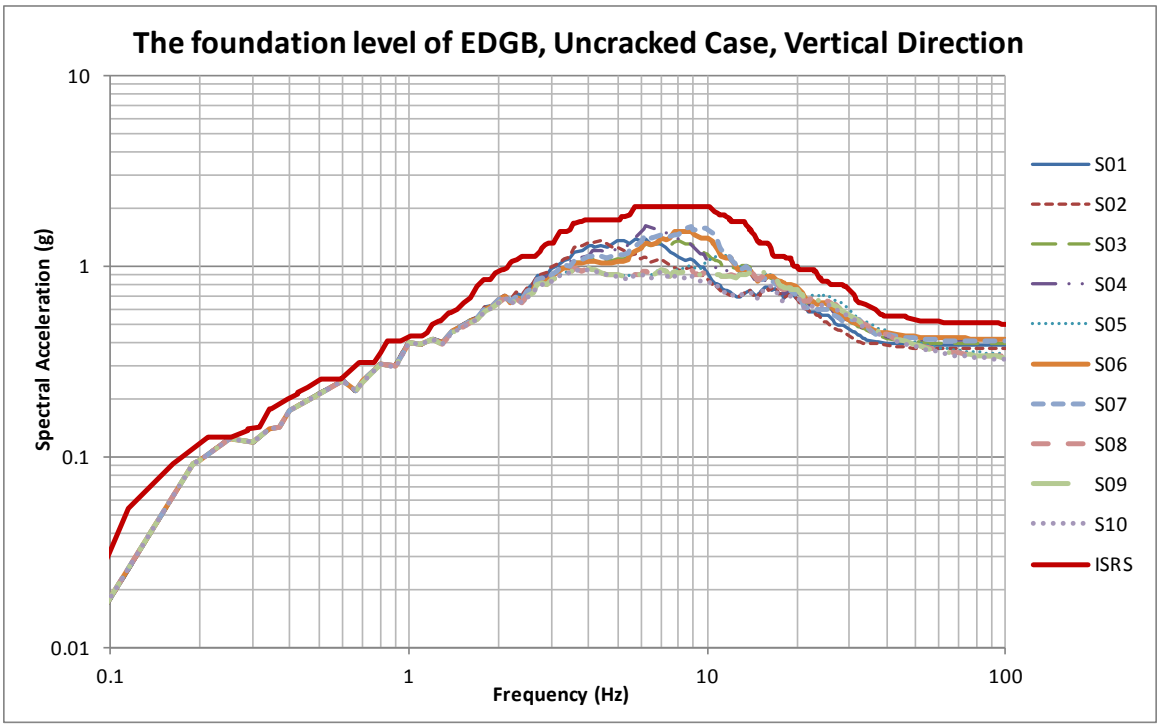


Figure 79 ISRS for Foundation Level of EDGB, Uncracked Case, Vertical Direction

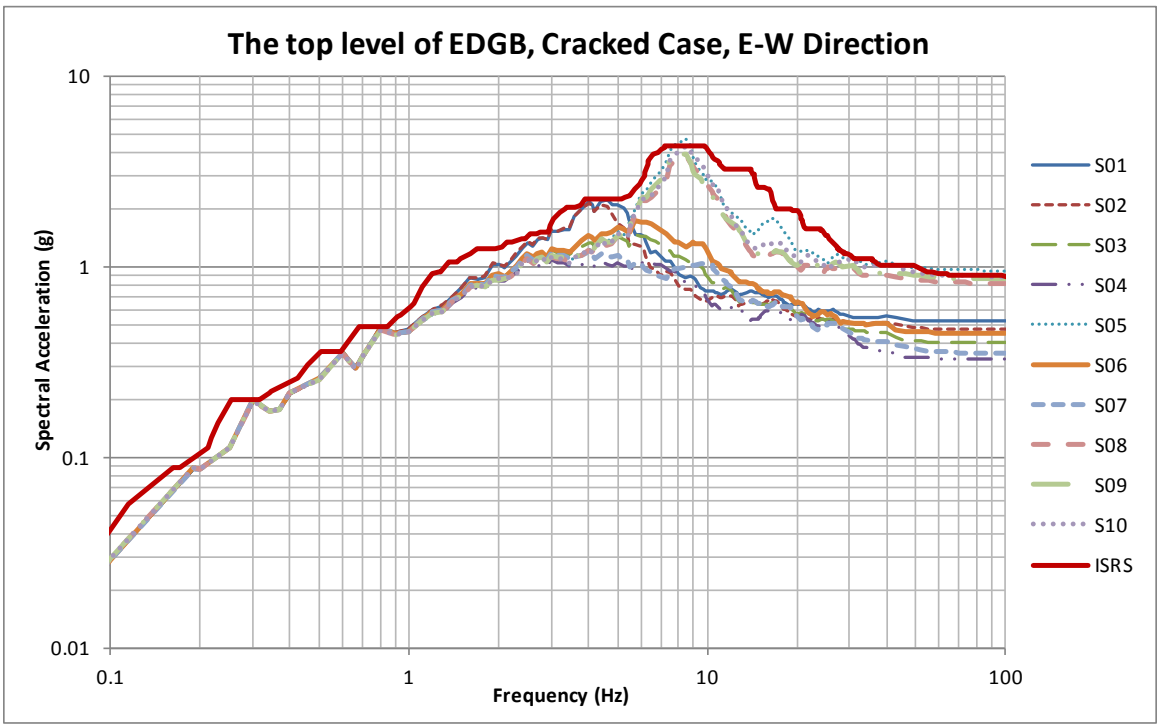


Figure 80 ISRS for Top Level of EDGB, Cracked Case, E-W Direction

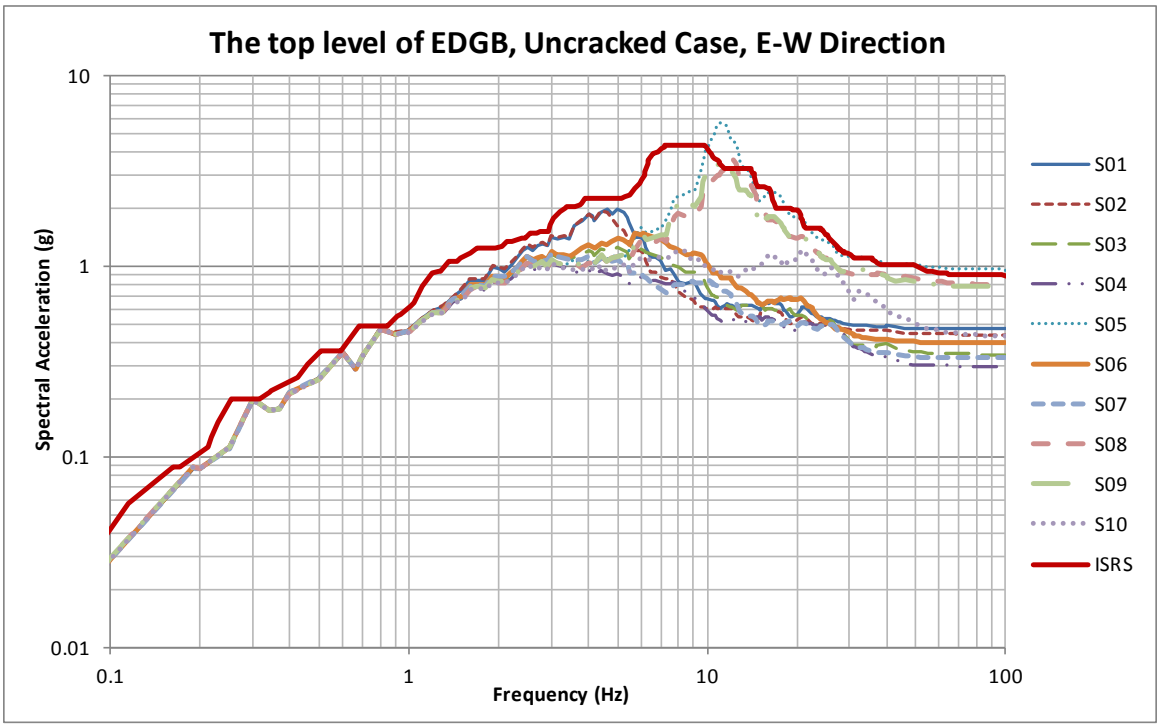


Figure 81 ISRS for Top Level of EDGB, Uncracked Case, E-W Direction

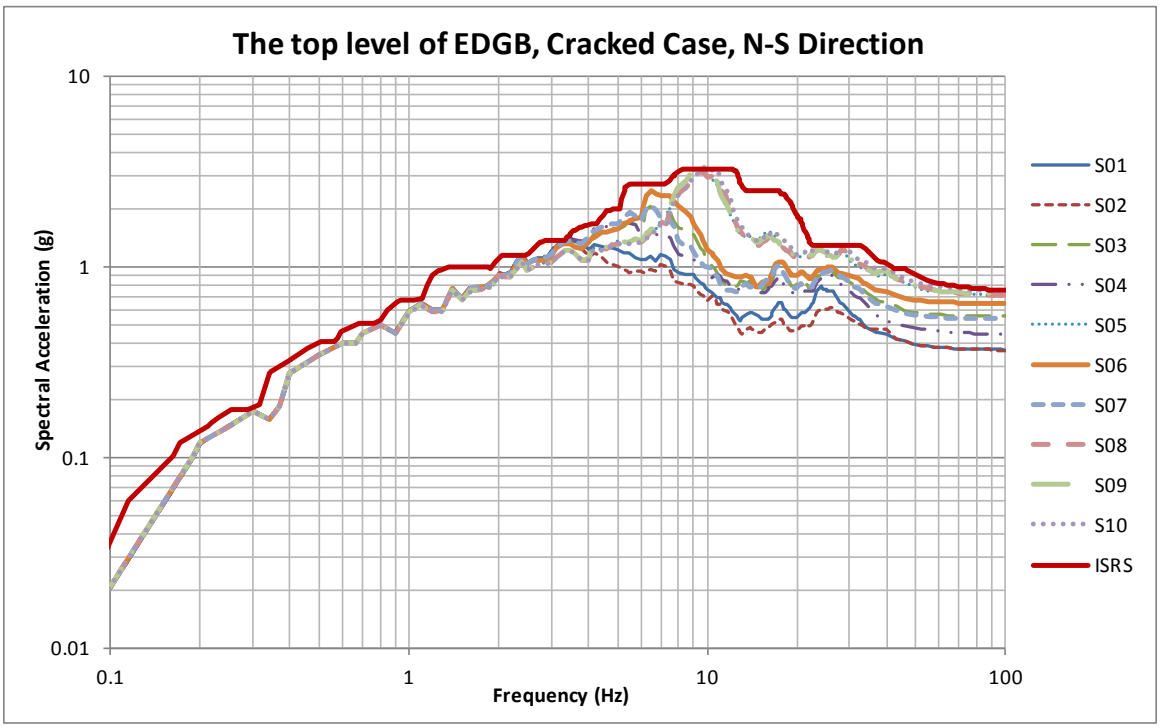


Figure 82 ISRS for Top Level of EDGB, Cracked Case, N-S Direction

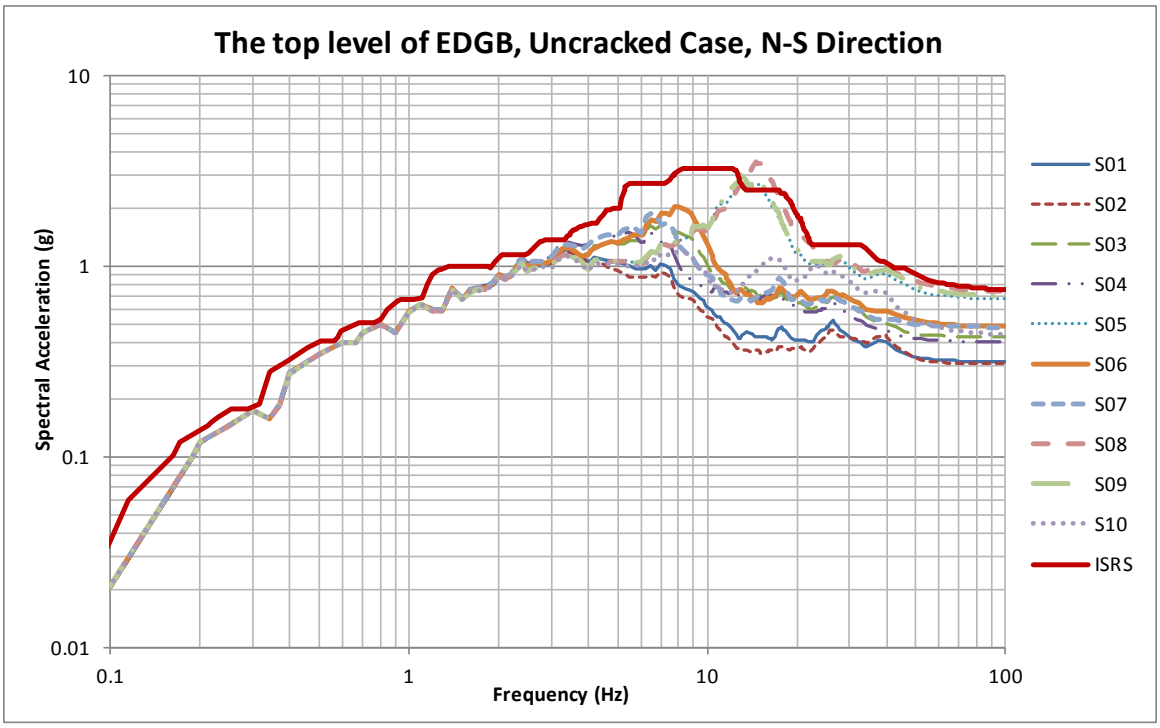


Figure 83 ISRS for Top Level of EDGB, Uncracked Case, N-S Direction

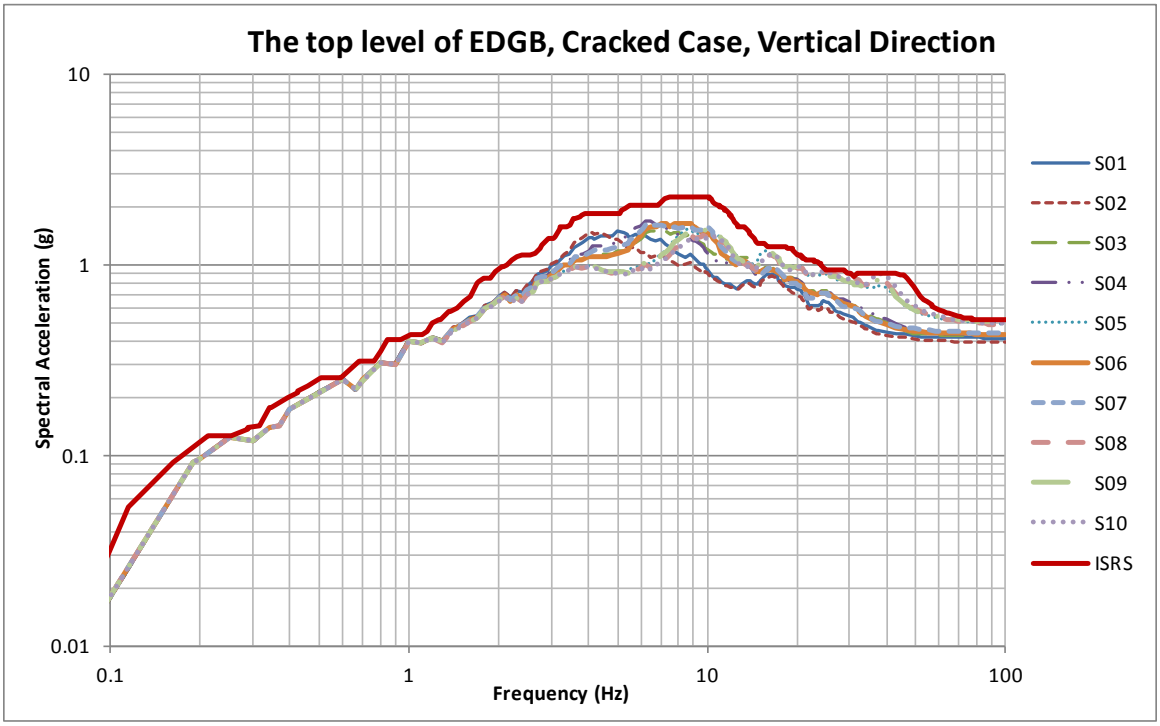


Figure 84 ISRS for Top Level of EDGB, Cracked Case, Vertical Direction

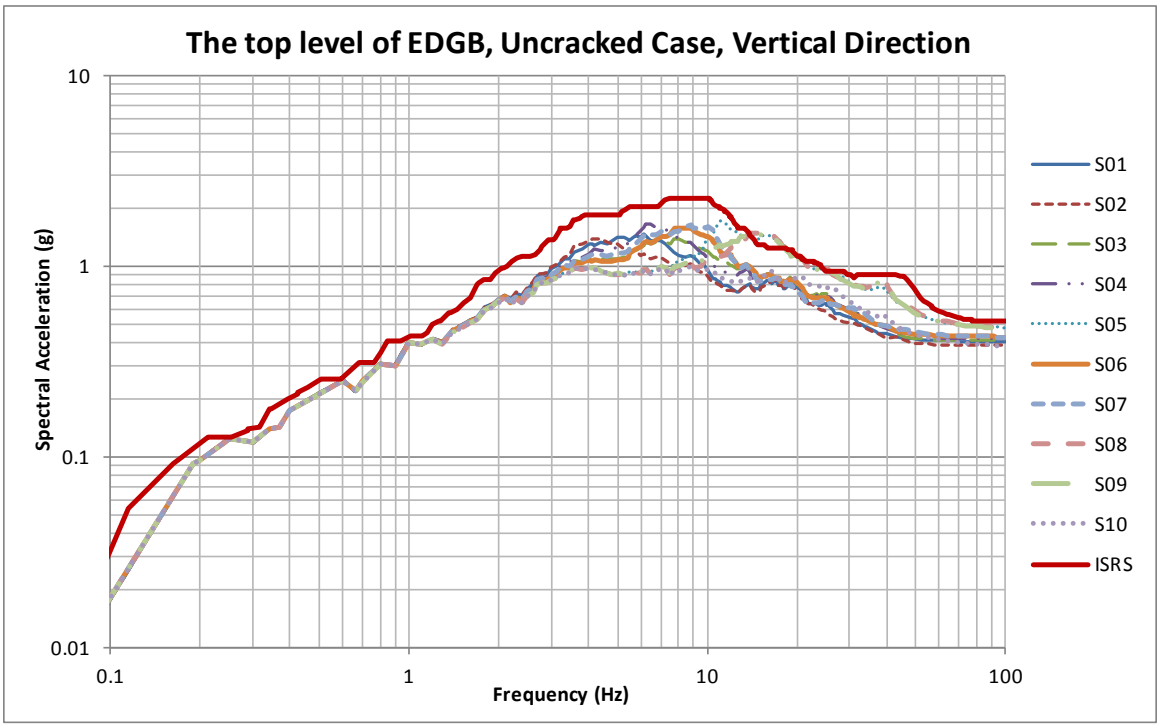


Figure 85 ISRS for Top Level of EDGB, Uncracked Case, Vertical Direction

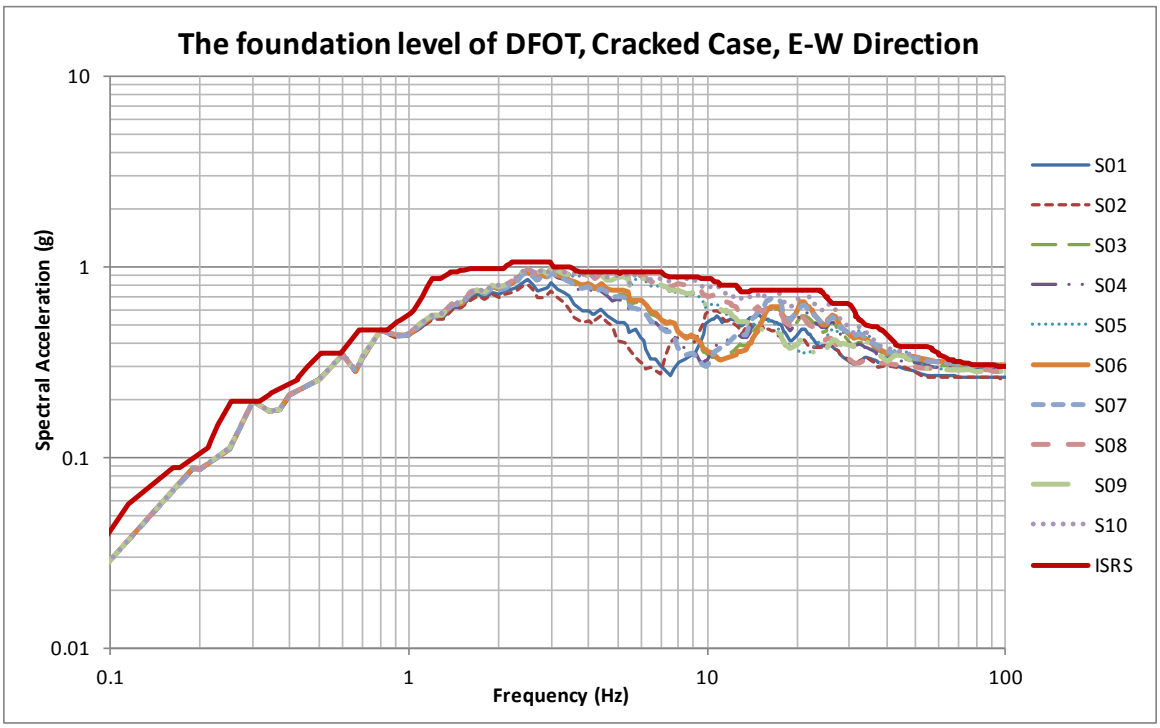


Figure 86 ISRS for Foundation Level of DFOT, Cracked Case, E-W Direction

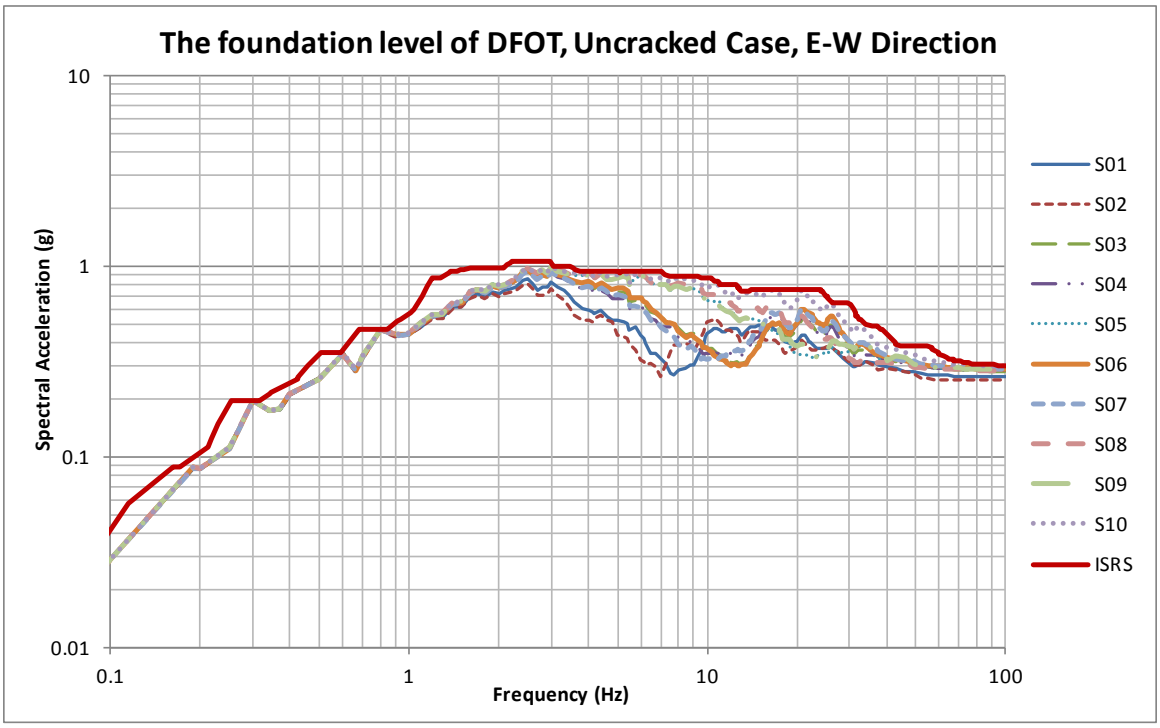


Figure 87 ISRS for Foundation Level of DFOT, Uncracked Case, E-W Direction

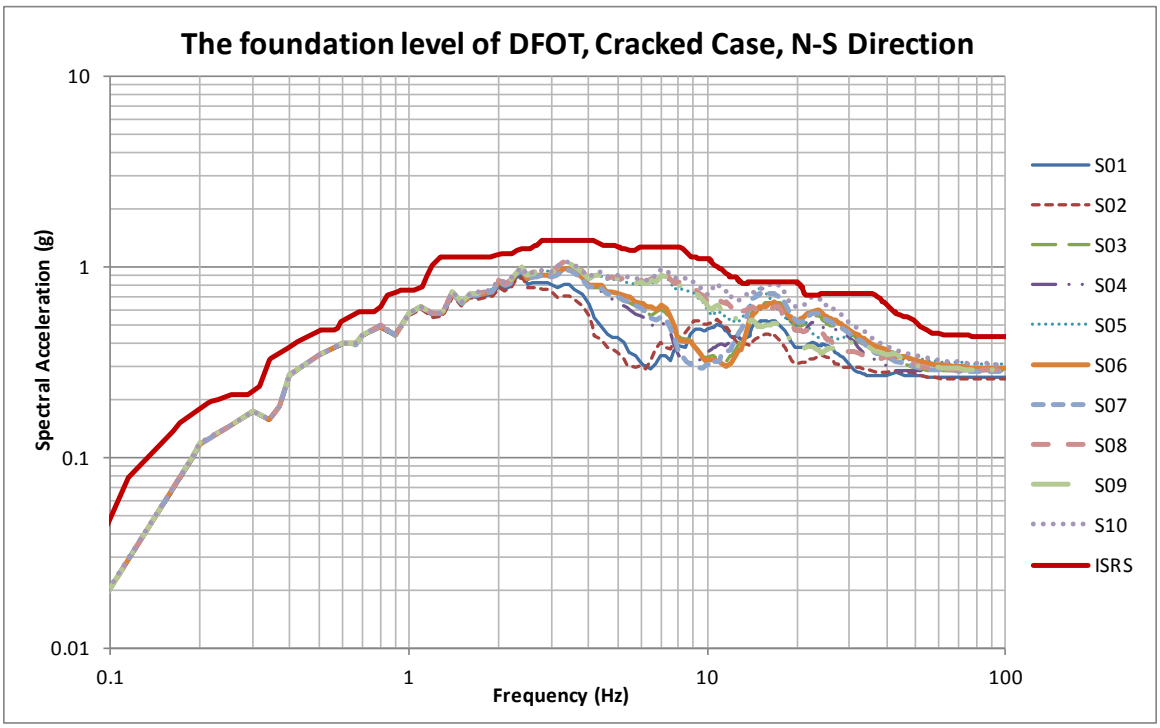


Figure 88 ISRS for Foundation Level of DFOT, Cracked Case, N-S Direction

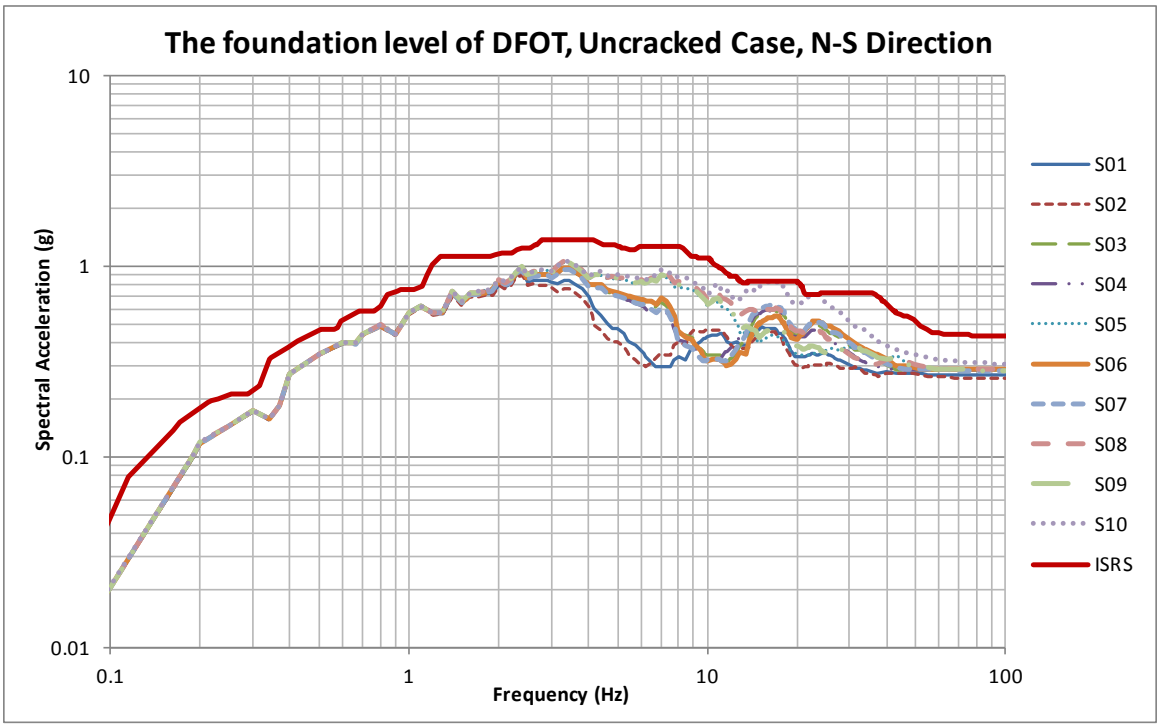


Figure 89 ISRS for Foundation Level of DFOT, Uncracked Case, N-S Direction

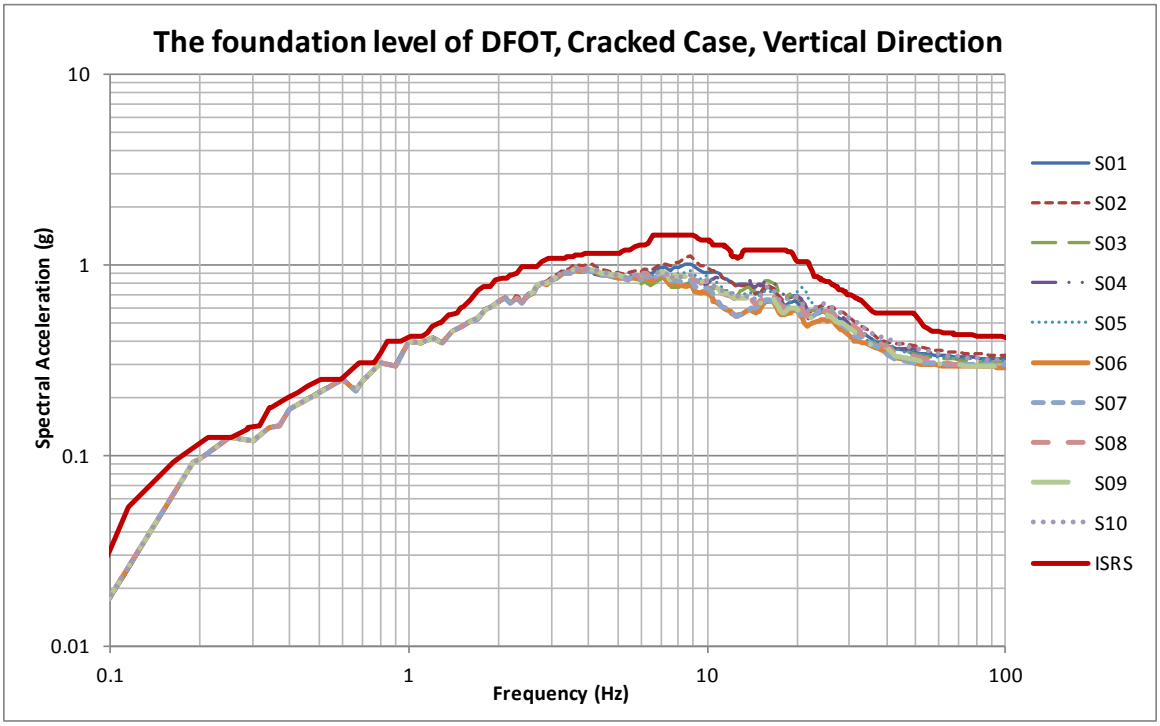


Figure 90 ISRS for Foundation Level of DFOT, Cracked Case, Vertical Direction

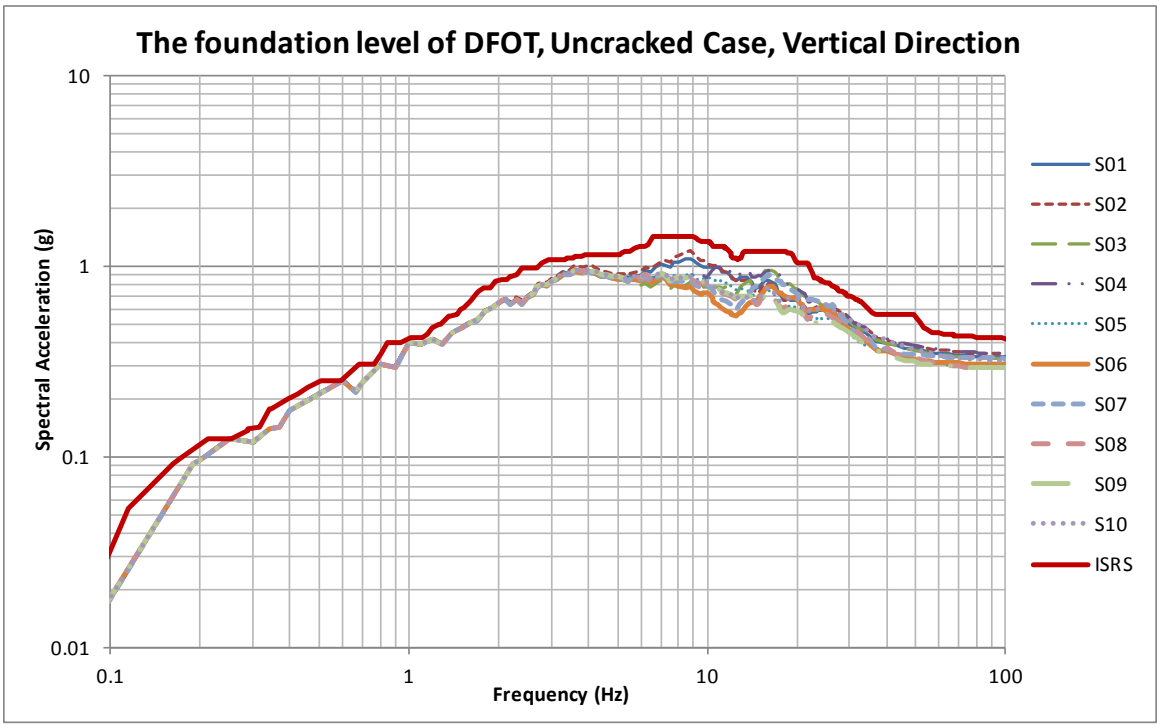


Figure 91 ISRS for Foundation Level of DFOT, Uncracked Case, Vertical Direction

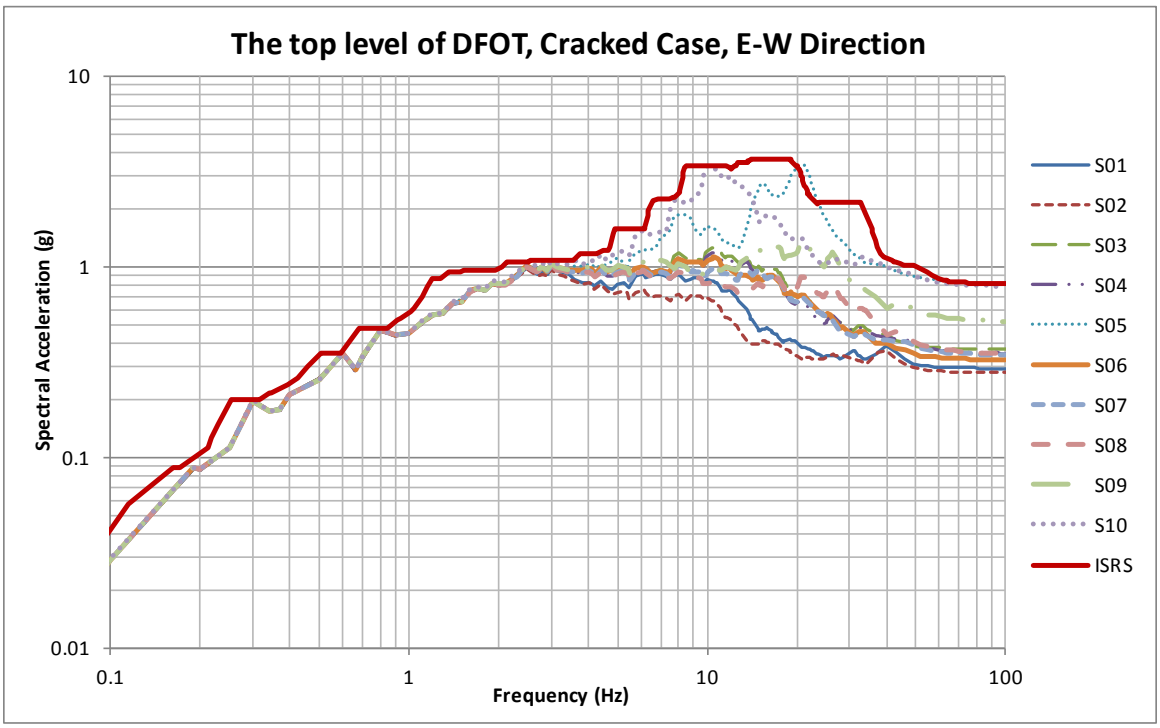


Figure 92 ISRS for Top Level of DFOT, Cracked Case, E-W Direction

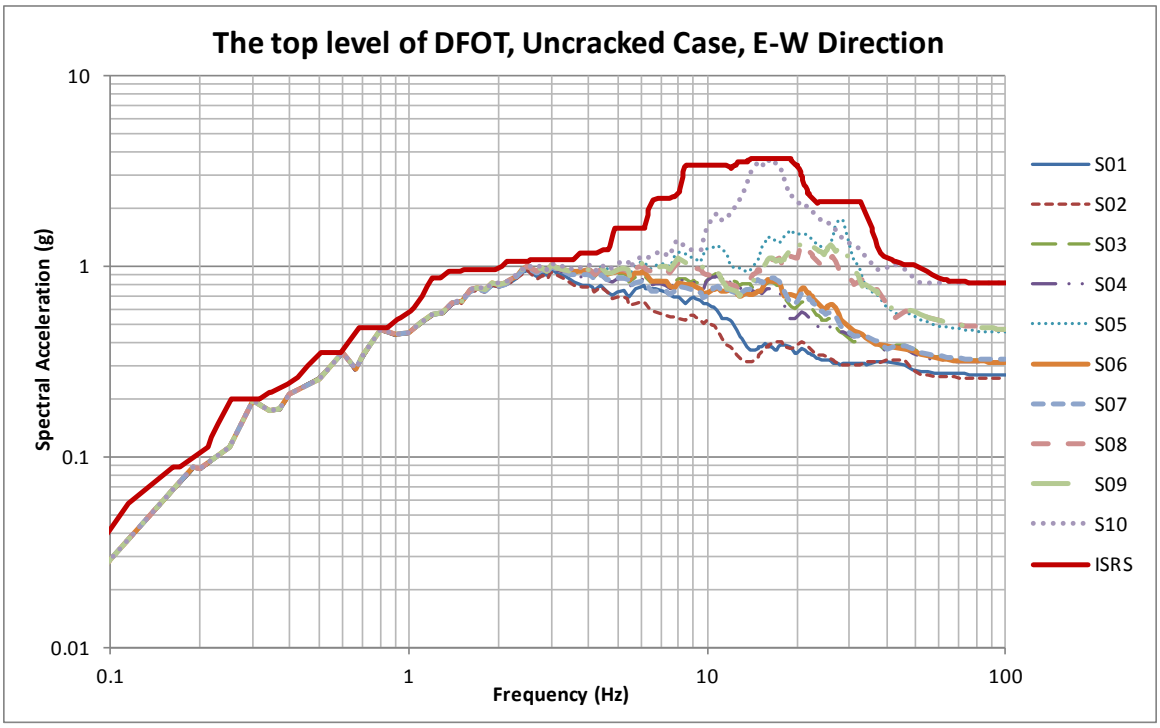


Figure 93 ISRS for Top Level of DFOT, Uncracked Case, E-W Direction

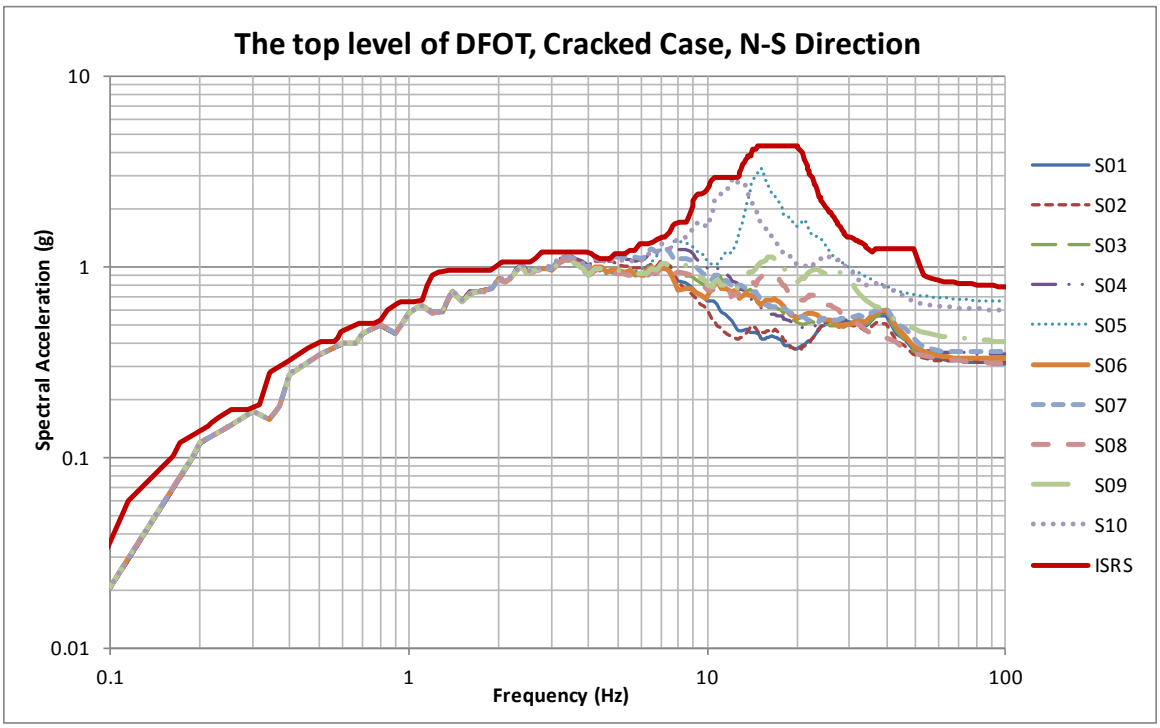


Figure 94 ISRS for Top Level of DFOT, Cracked Case, N-S Direction

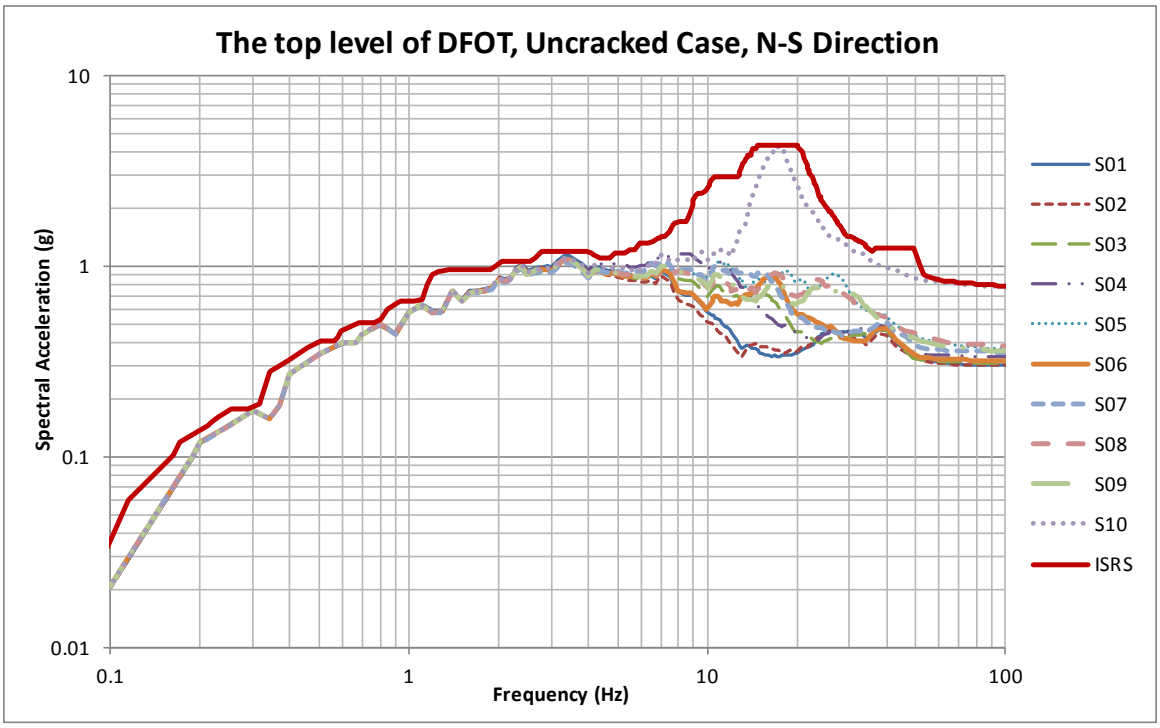


Figure 95 ISRS for Top Level of DFOT, Uncracked Case, N-S Direction

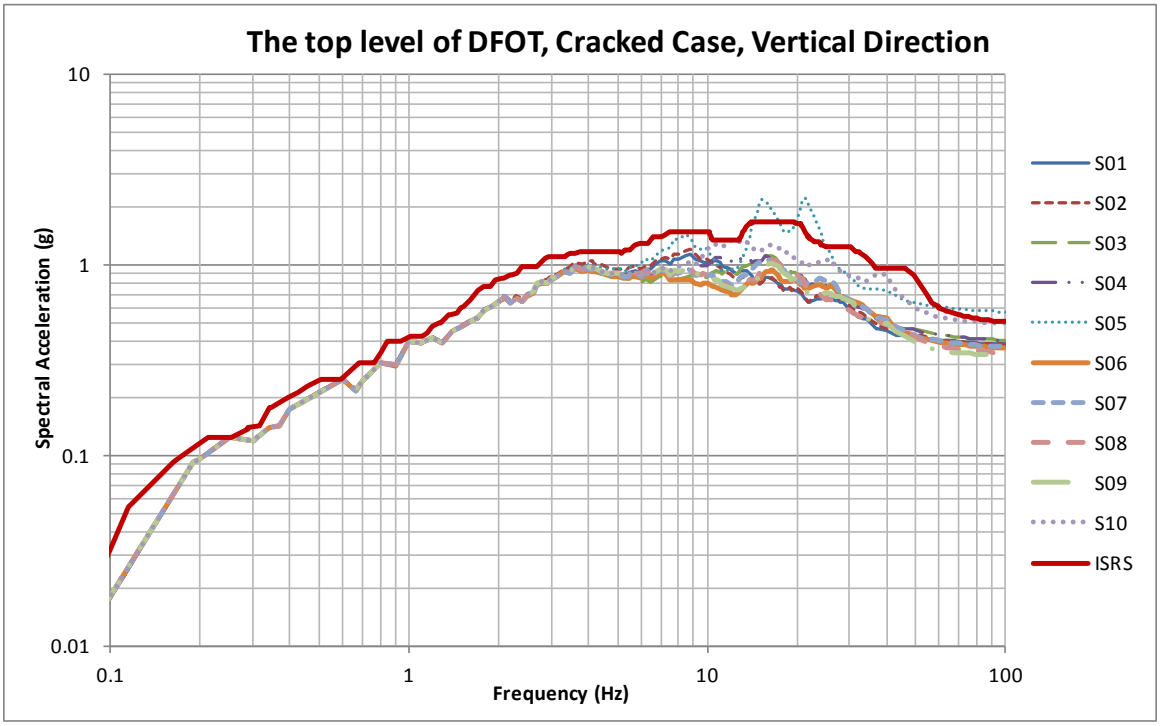


Figure 96 ISRS for Top Level of DFOT, Cracked Case, Vertical Direction

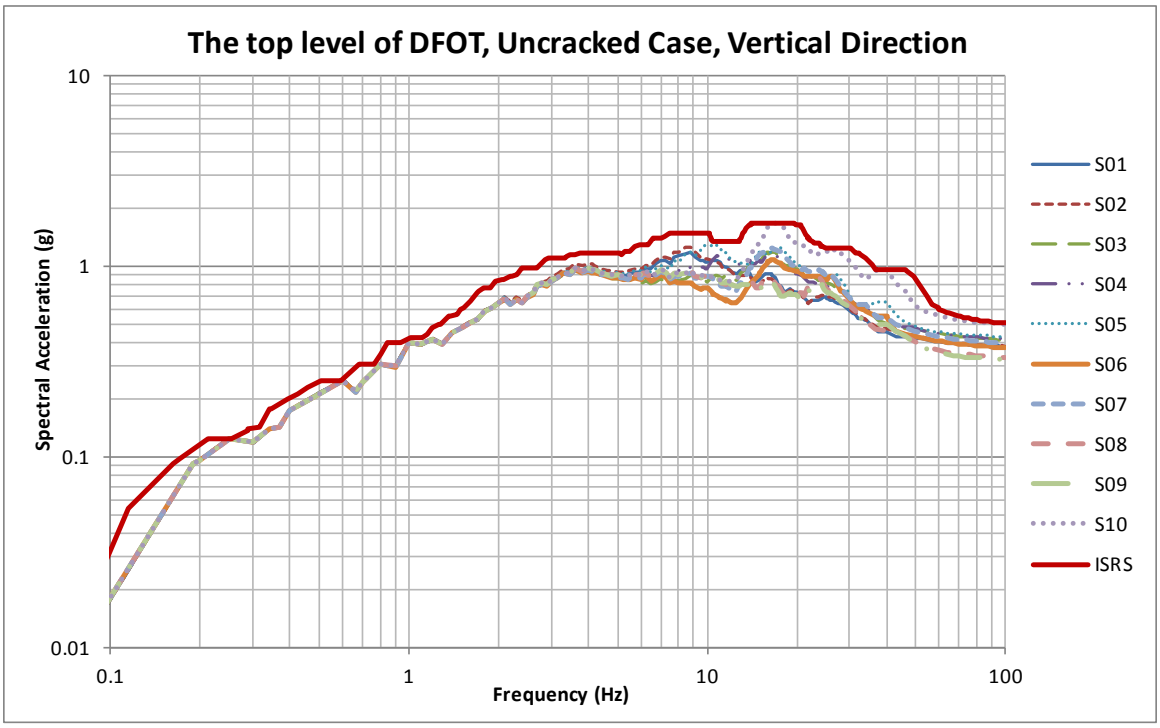


Figure 97 ISRS for Top Level of DFOT, Uncracked Case, Vertical Direction

Table 3.7-23

Maximum Response Accelerations of EDG Building

EDG Building

Slab Elevation	E-W (g)	N-S (g)	Vertical (g)
100′-0″	~~0.59~~	~~0.49~~	~~0.33~~
135′-0″	~~0.82~~	~~0.82~~	~~0.45~~

0.61	0.52	0.34
0.9	0.84	0.47

DFOT Room

Slab Elevation	E-W (g)	N-S (g)	Vertical (g)
63′-0″	~~0.48~~	~~0.37~~	~~0.38~~
100′-0″	~~0.81~~	~~0.90~~	~~0.45~~

0.48	0.37	0.38
0.81	0.9	0.45

Table 3.7-24

Maximum Relative Displacements of EDG Building

EDG Building

Elevation	E-W Direction (in)	N-S Direction (in)	Vertical Direction (in)
135′-0″	~~0.139~~	~~0.085~~	~~0.003~~
	0.162	0.075	0.113

DFOT Room

Elevation	E-W Direction (in)	N-S Direction (in)	Vertical Direction (in)
100′-0″	~~0.075~~	~~0.081~~	~~0.004~~
	0.088	0.102	0.065

Table 3.7-25

Maximum Member Forces of EDG Building

EDG Building

Seismic Force and Moment (kips, ft)						
Elevation	Fx	Fy	Fz	Mx	My	Mz
135′-0″	~~2860~~	~~2847~~	~~1576~~	~~50245~~	~~37590~~	~~19318~~
100′-0″	~~9995~~	~~8745~~	~~5578~~	~~347885~~	~~342807~~	~~66603~~

DFOT Room

Seismic Force and Moment (kips, ft)						
Elevation	Fx	Fy	Fz	Mx	My	Mz
100′-0″	~~1051~~	~~1170~~	~~591~~	~~19570~~	~~15292~~	~~22701~~
63′-0″	~~4569~~	~~3865~~	~~3361~~	~~138428~~	~~155258~~	~~39058~~

3027	2847	1576	40785	41617	19517
7135	6056	4002	297640	322366	47285

1051	1170	591	19570	15292	22701
3518	2695	2770	118858	139966	21081

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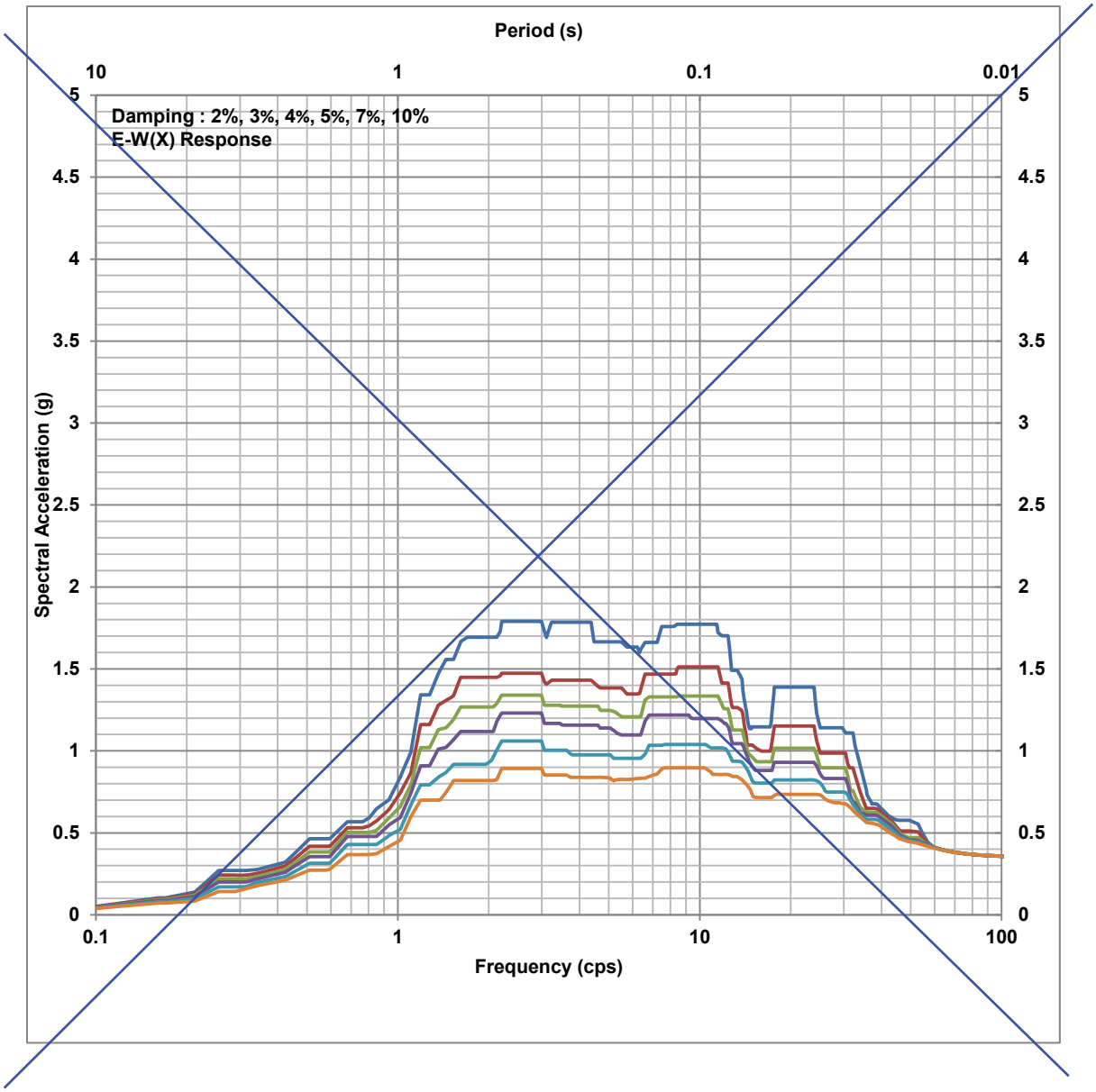

Figure 3.7A-78 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.100′-0″, E-W, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

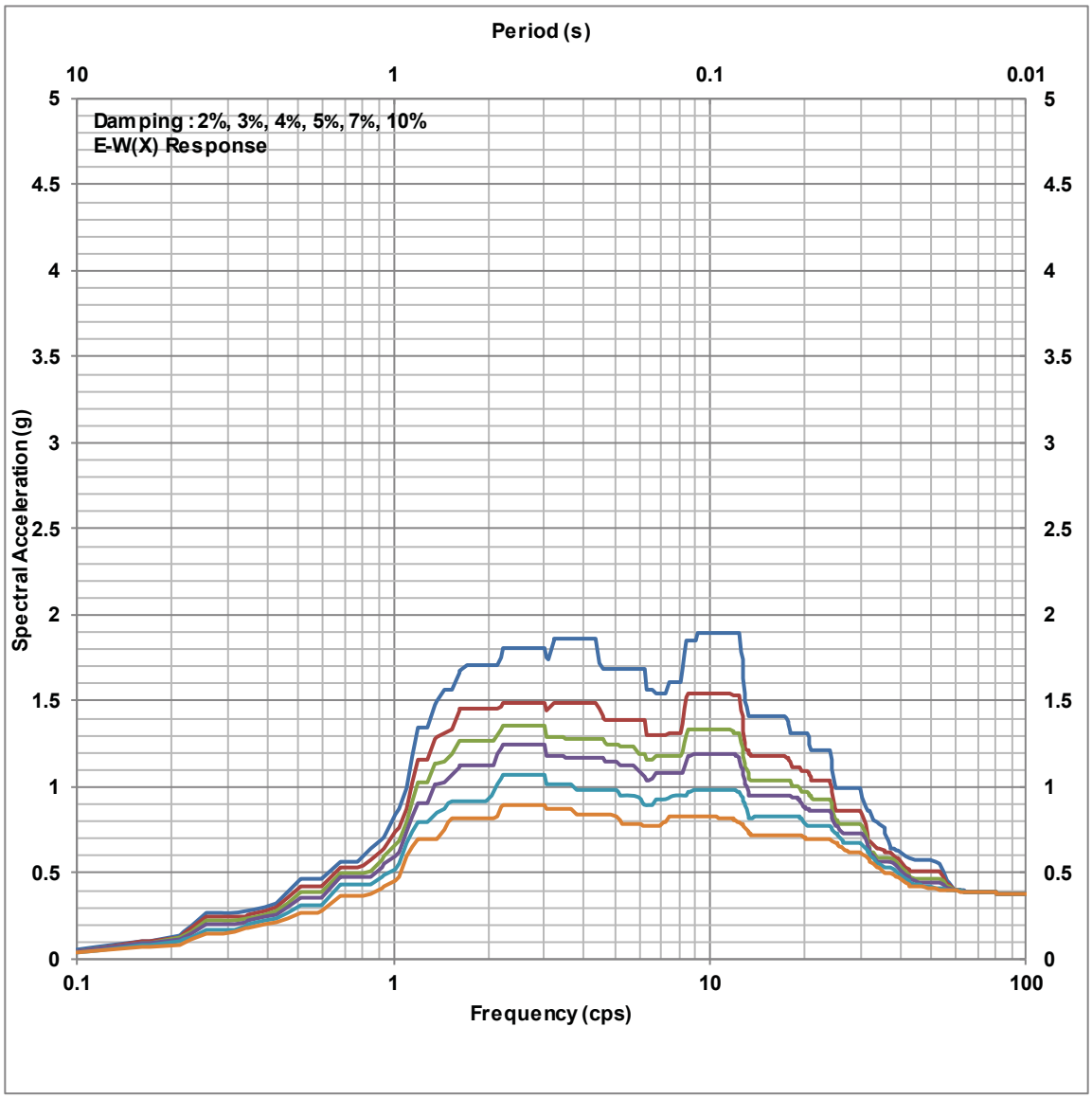

Figure 3.7A-78 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.100'-0", E-W, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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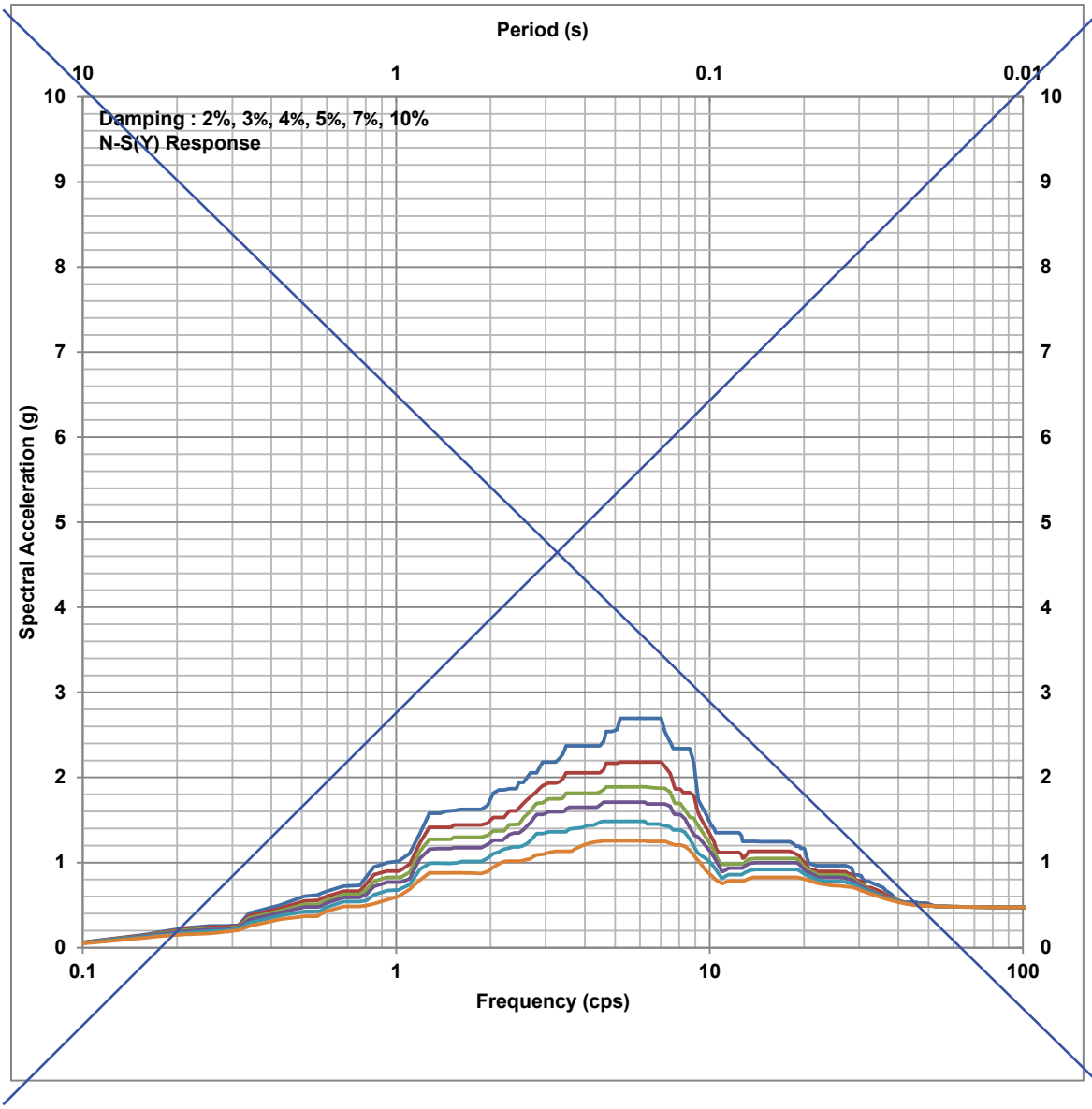

Figure 3.7A-79 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.100′-0″, N-S, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

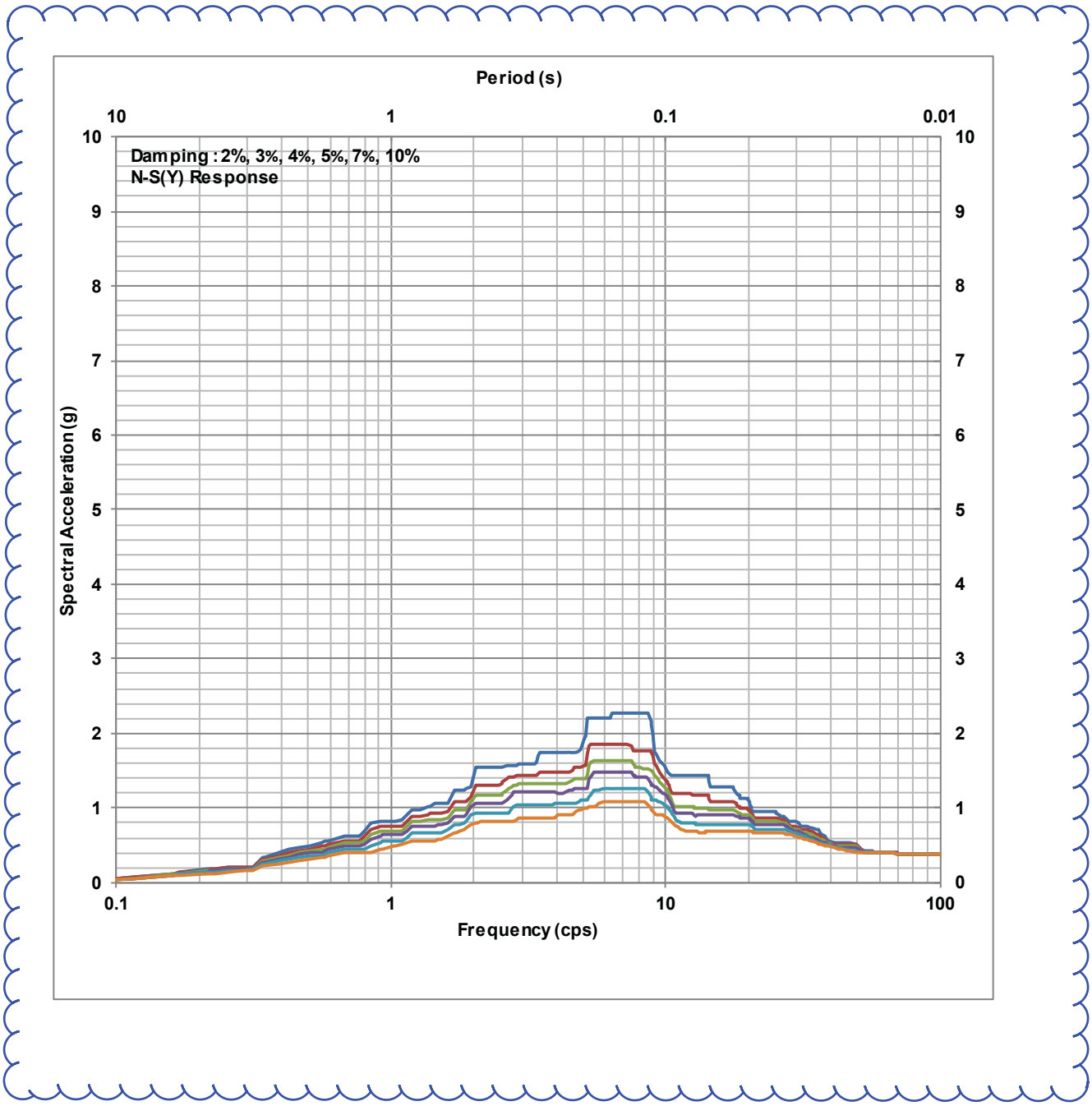

Figure 3.7A-79 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.100'-0", N-S, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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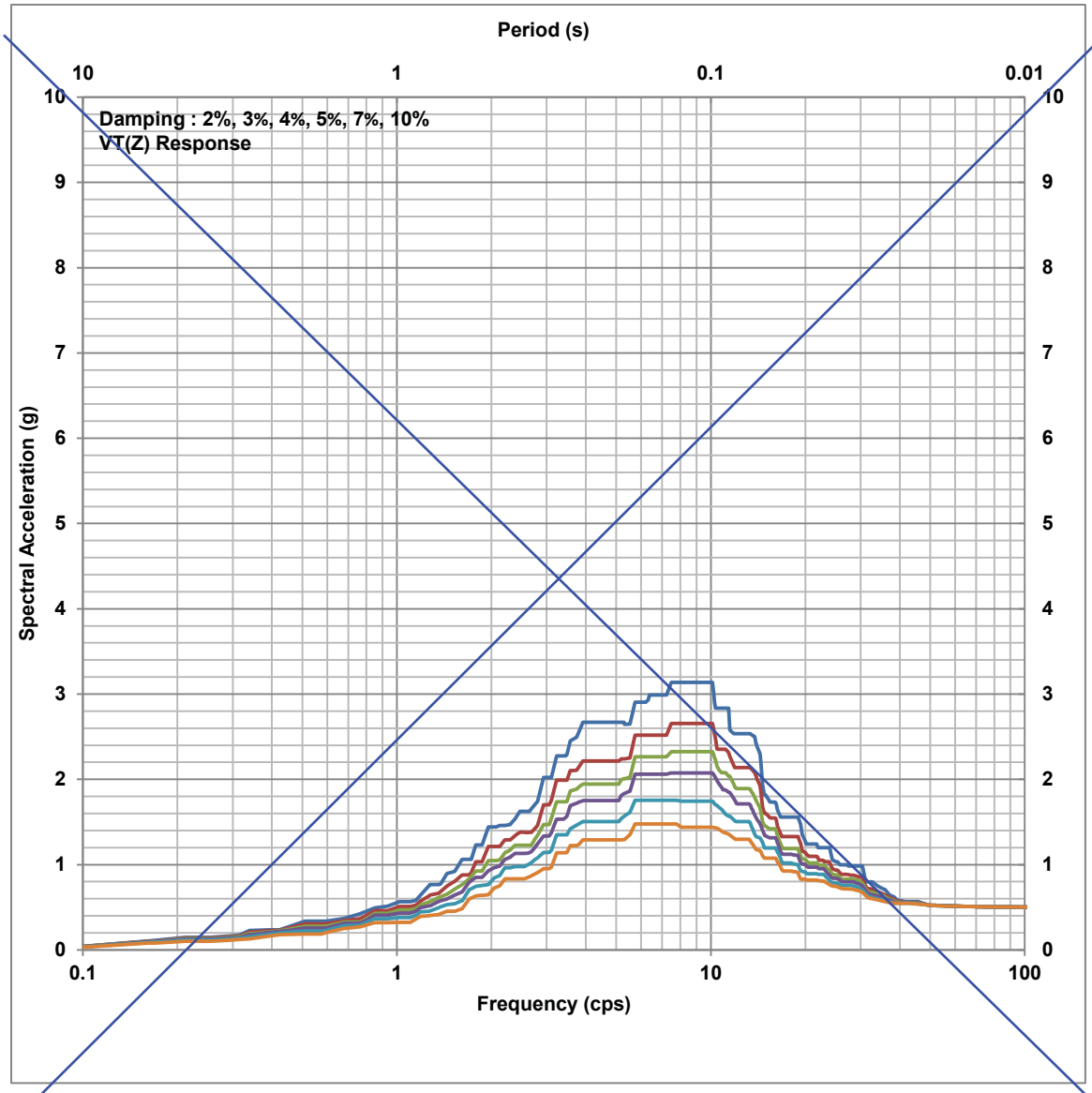

Figure 3.7A-80 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.100′-0″, Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%n

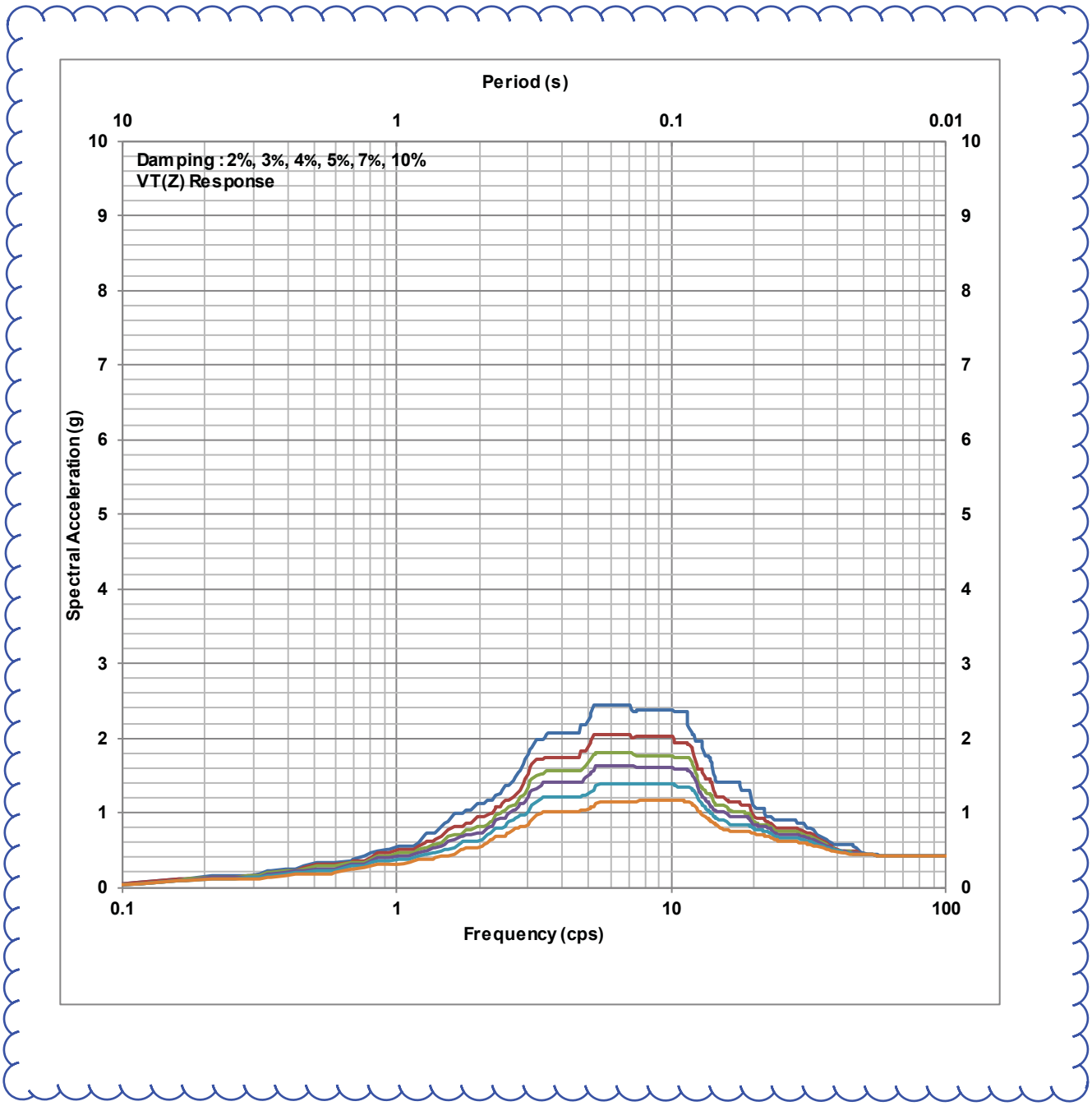

Figure 3.7A-80 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.100'-0", Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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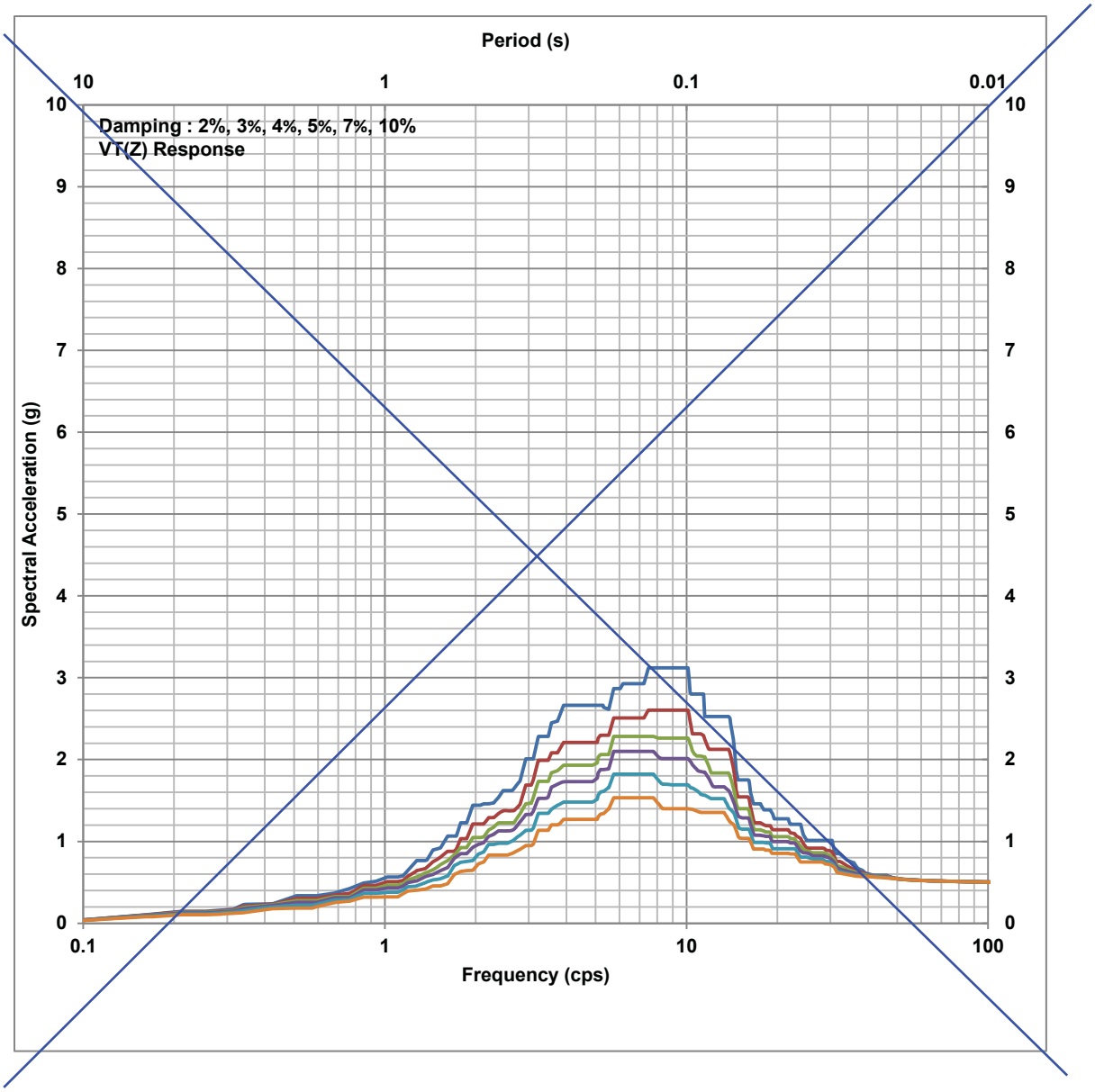

Figure 3.7A-81 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.100′-0″ (Slab), Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

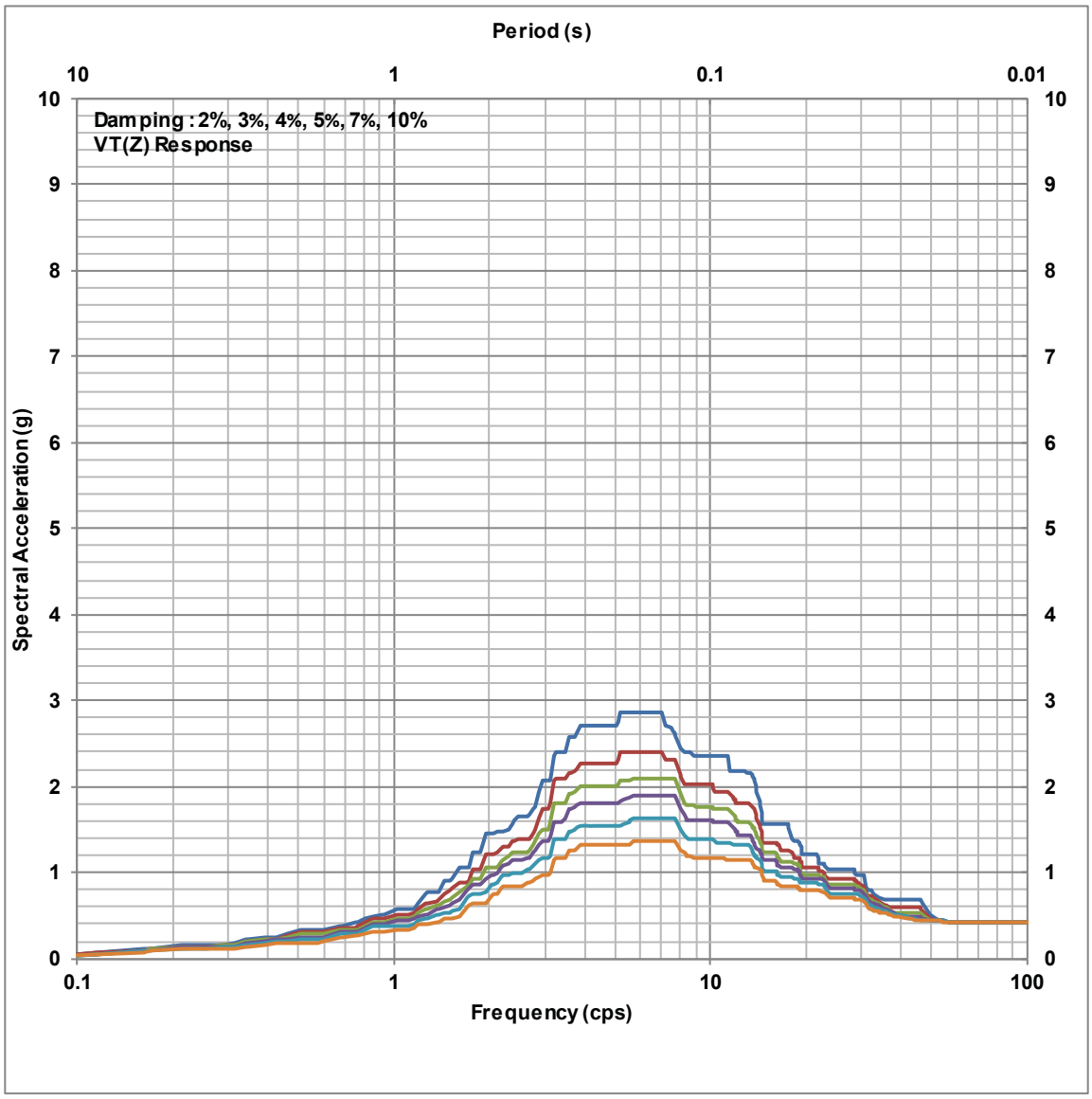

Figure 3.7A-81 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.100'-0" (Slab), Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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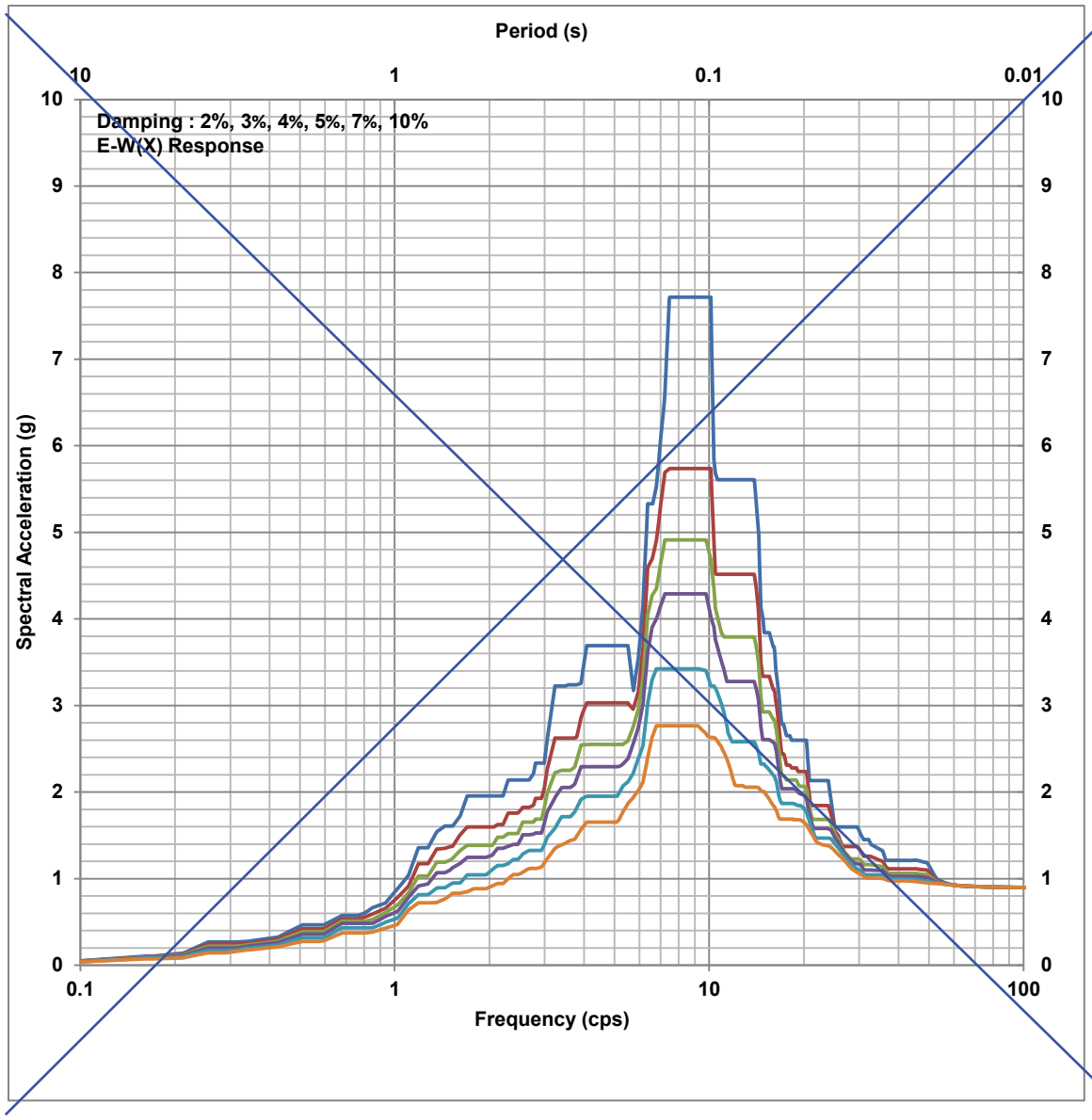

Figure 3.7A-82 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.135′-0″, E-W, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

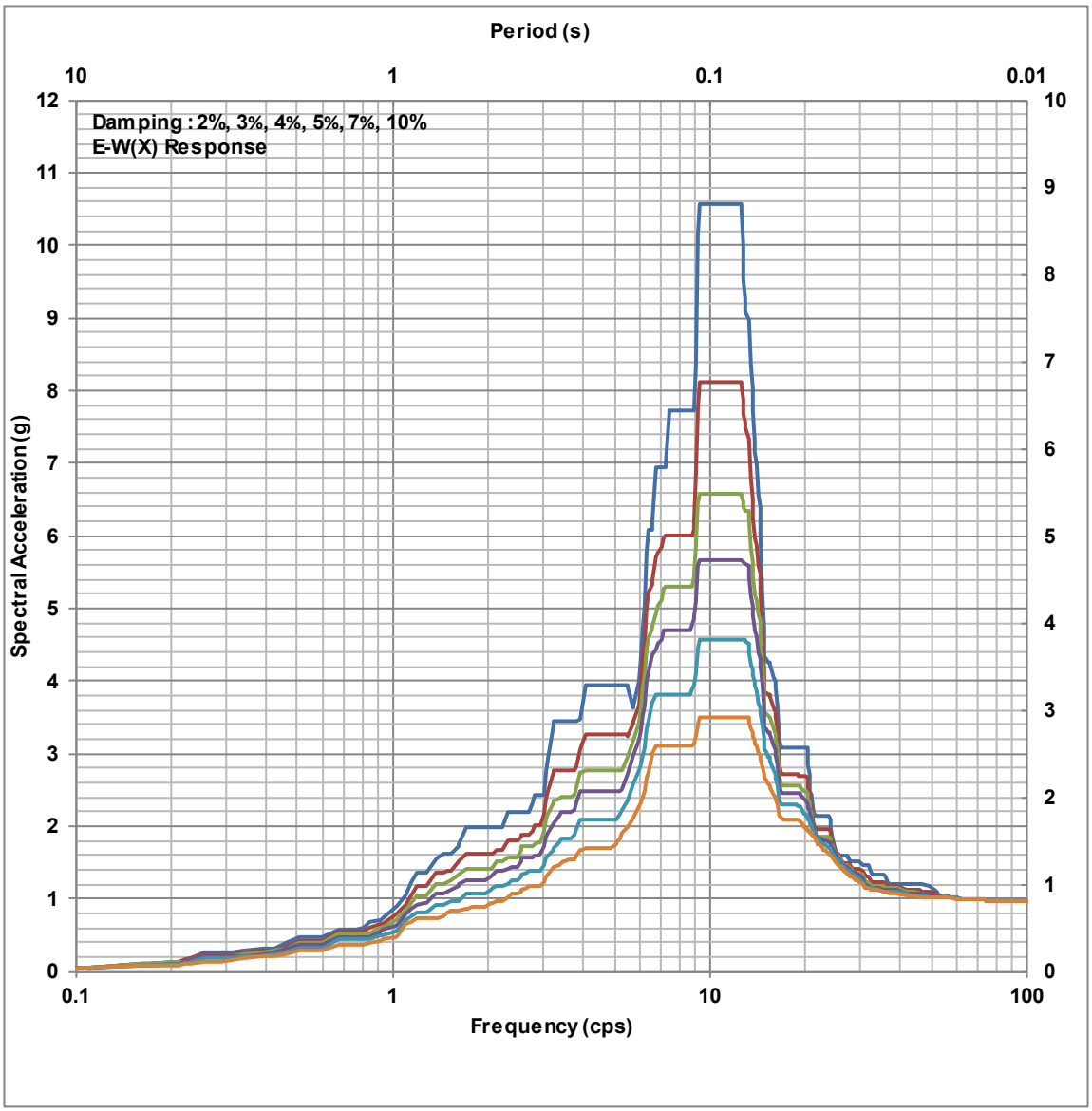

Figure 3.7A-82 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.135'-0", E-W, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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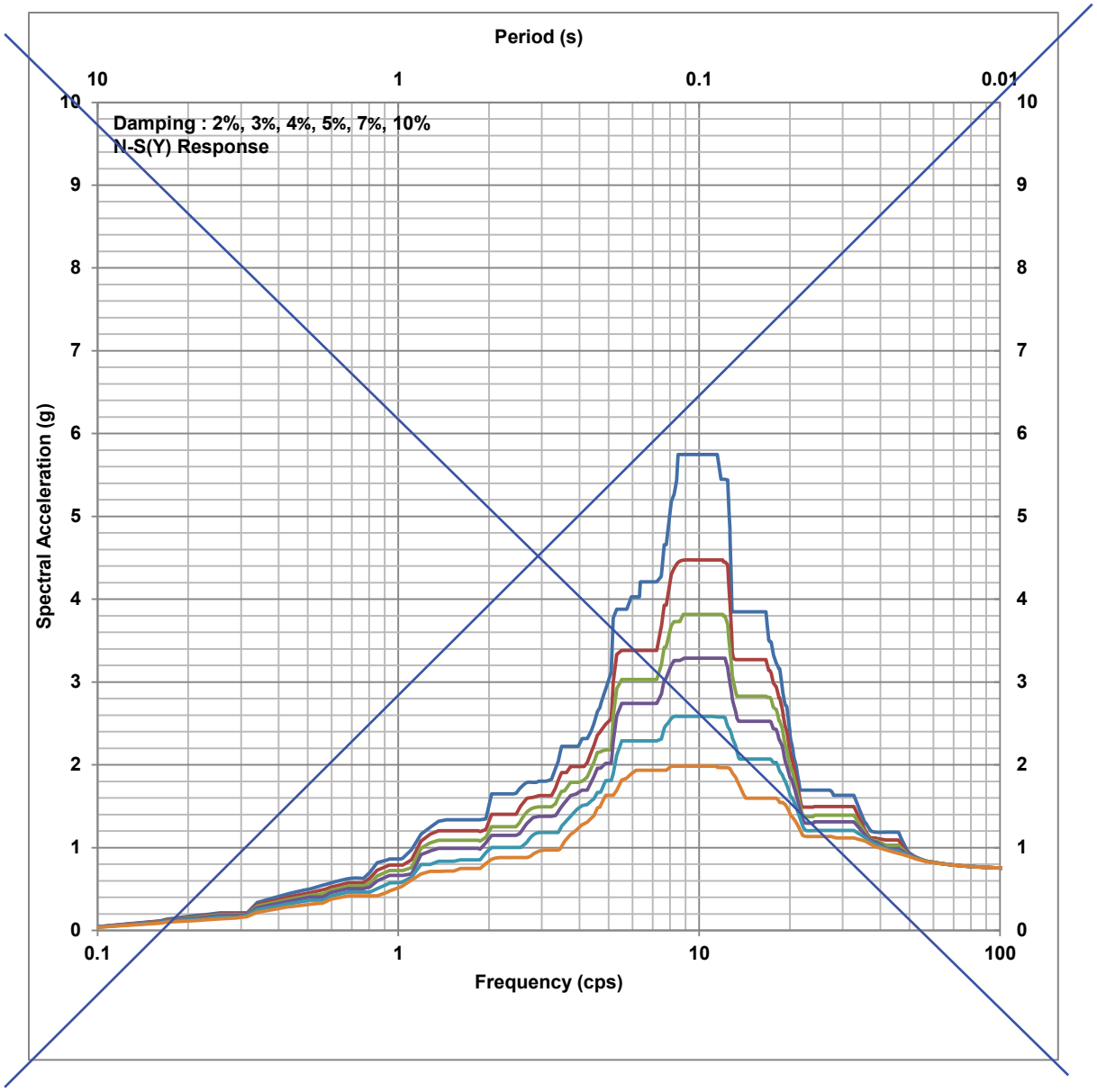

Figure 3.7A-83 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.135′-0″, N-S, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

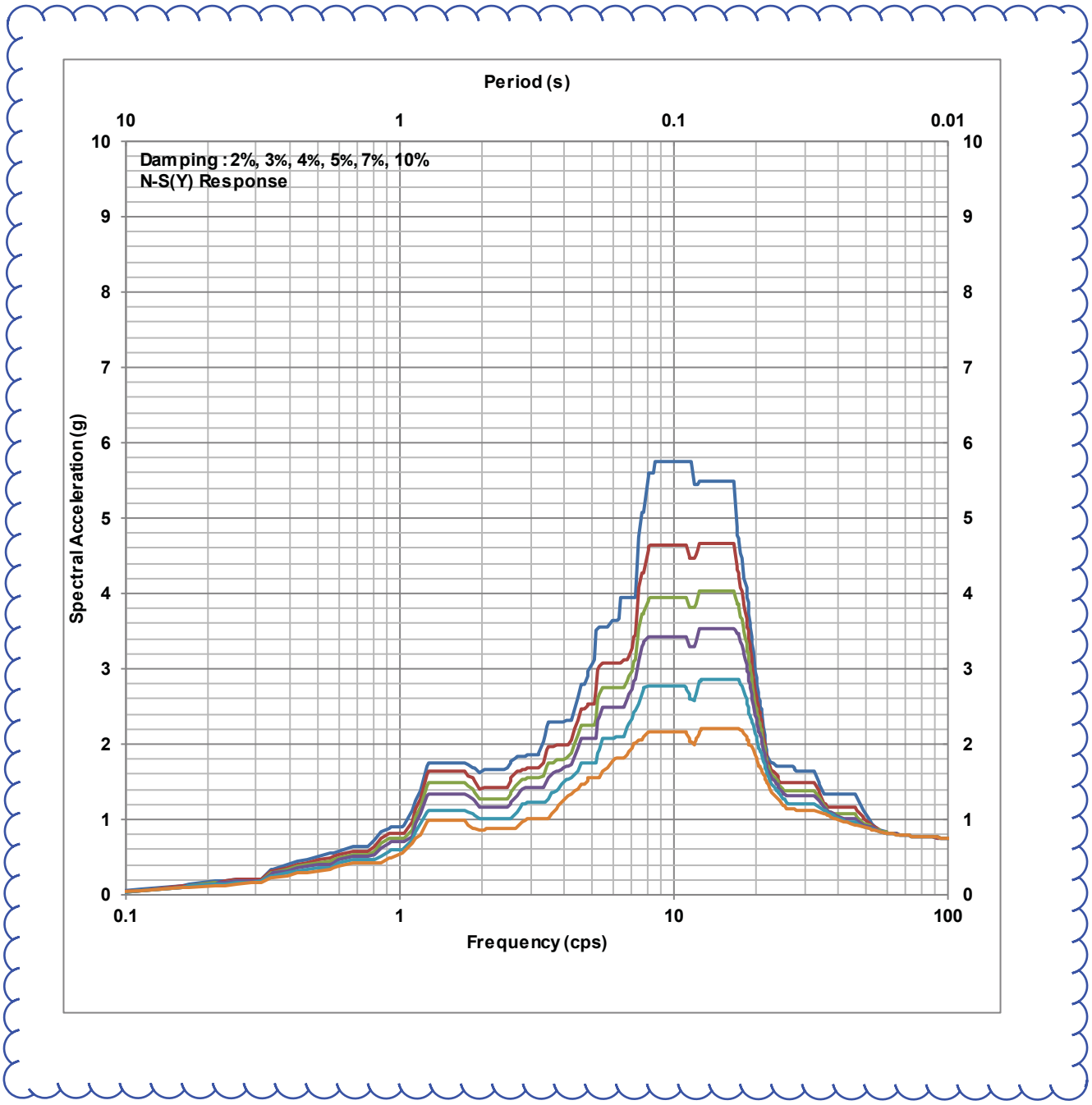

Figure 3.7A-83 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.135'-0", N-S, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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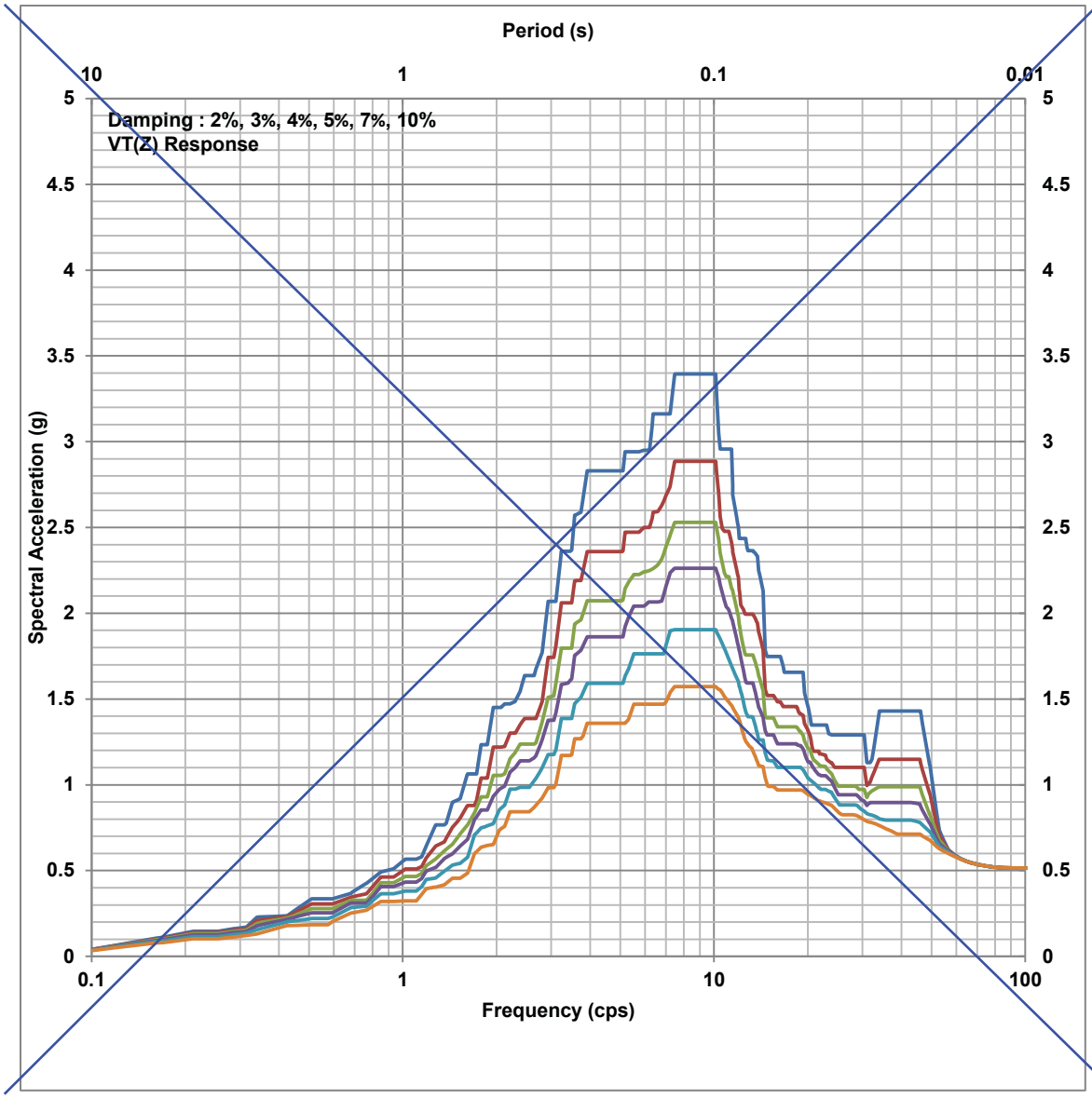

Figure 3.7A-84 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.135′-0″, Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

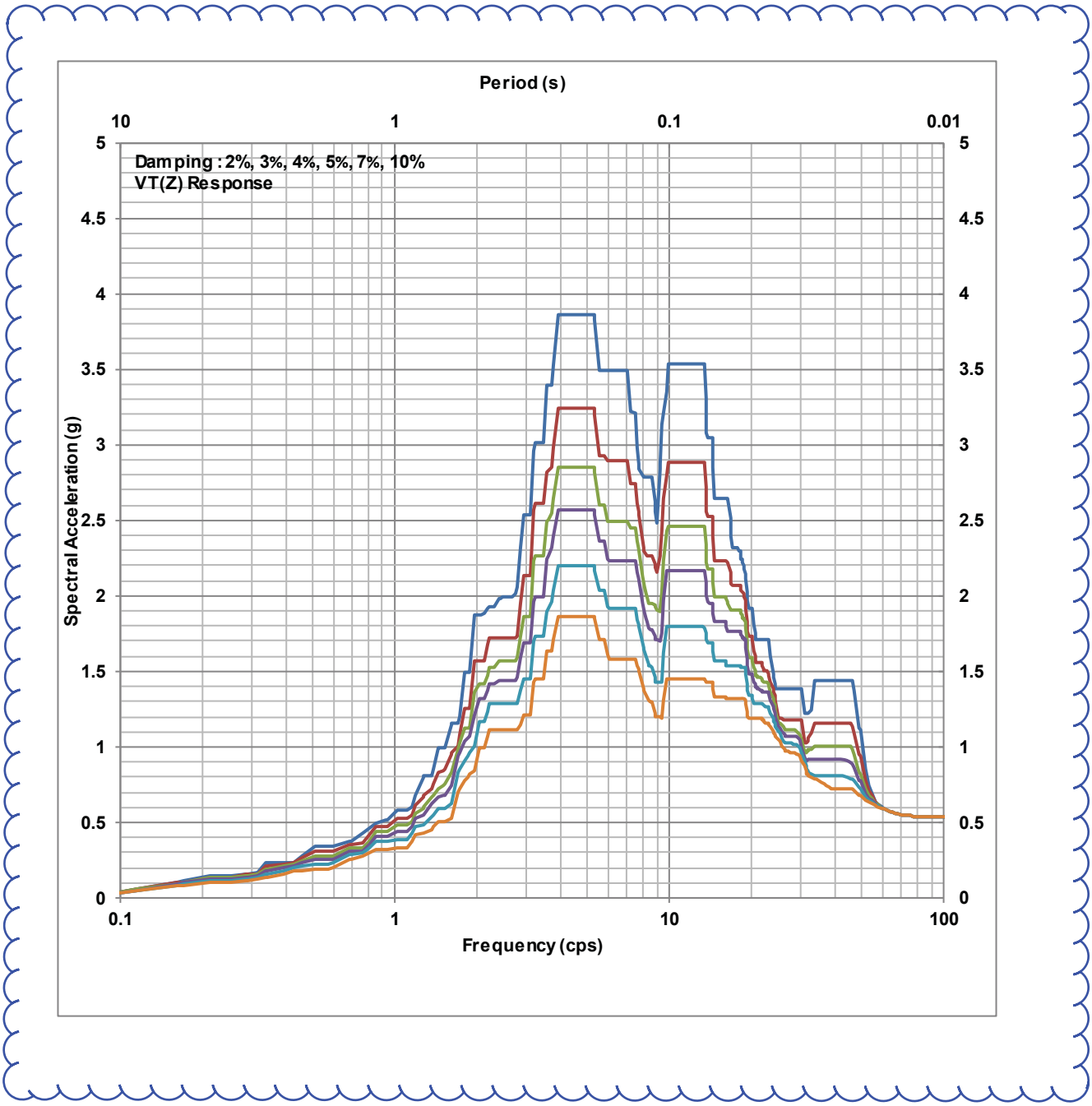

Figure 3.7A-84 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.135'-0", Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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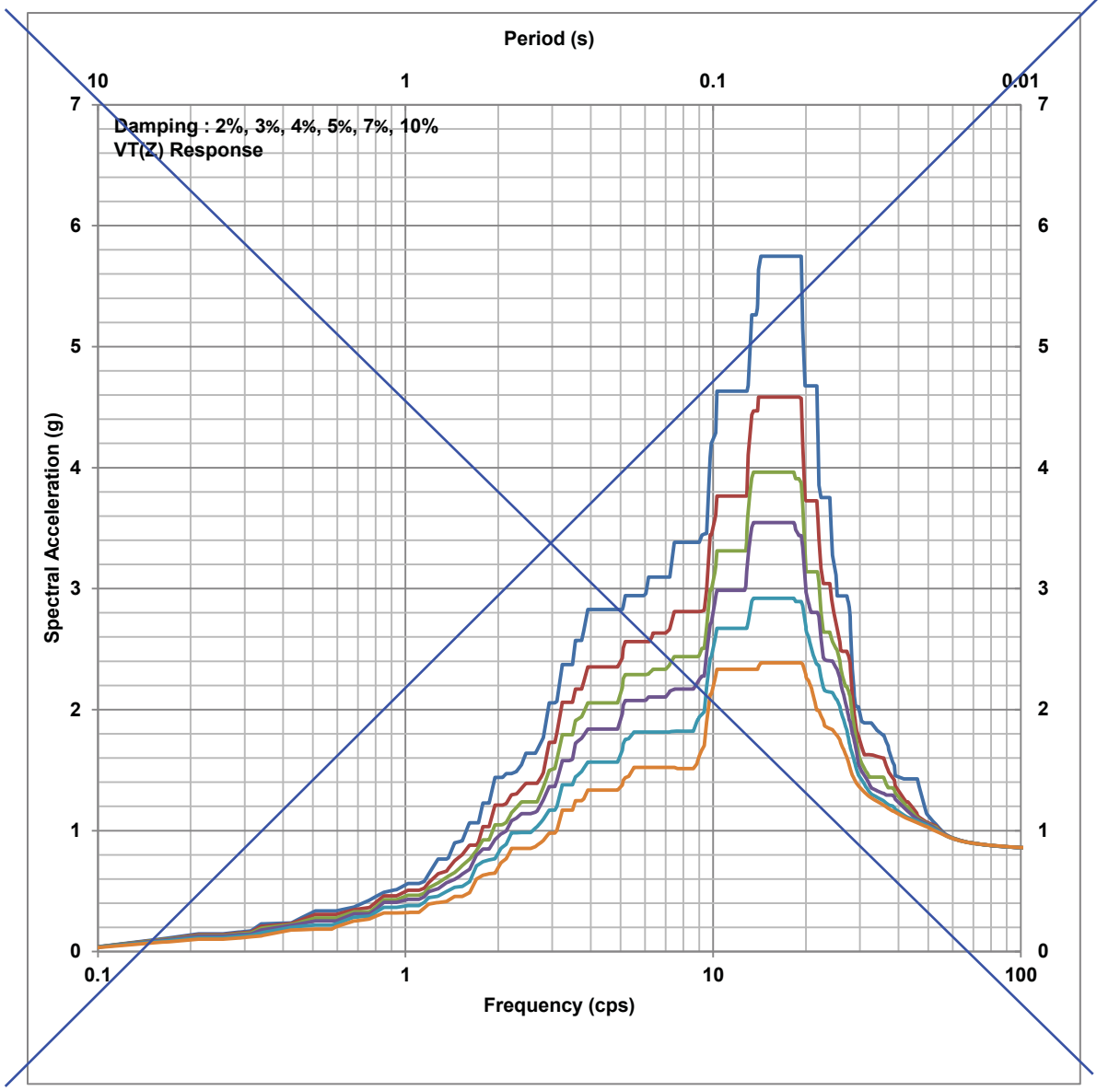

Figure 3.7A-85 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.135′-0″ (Slab), Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

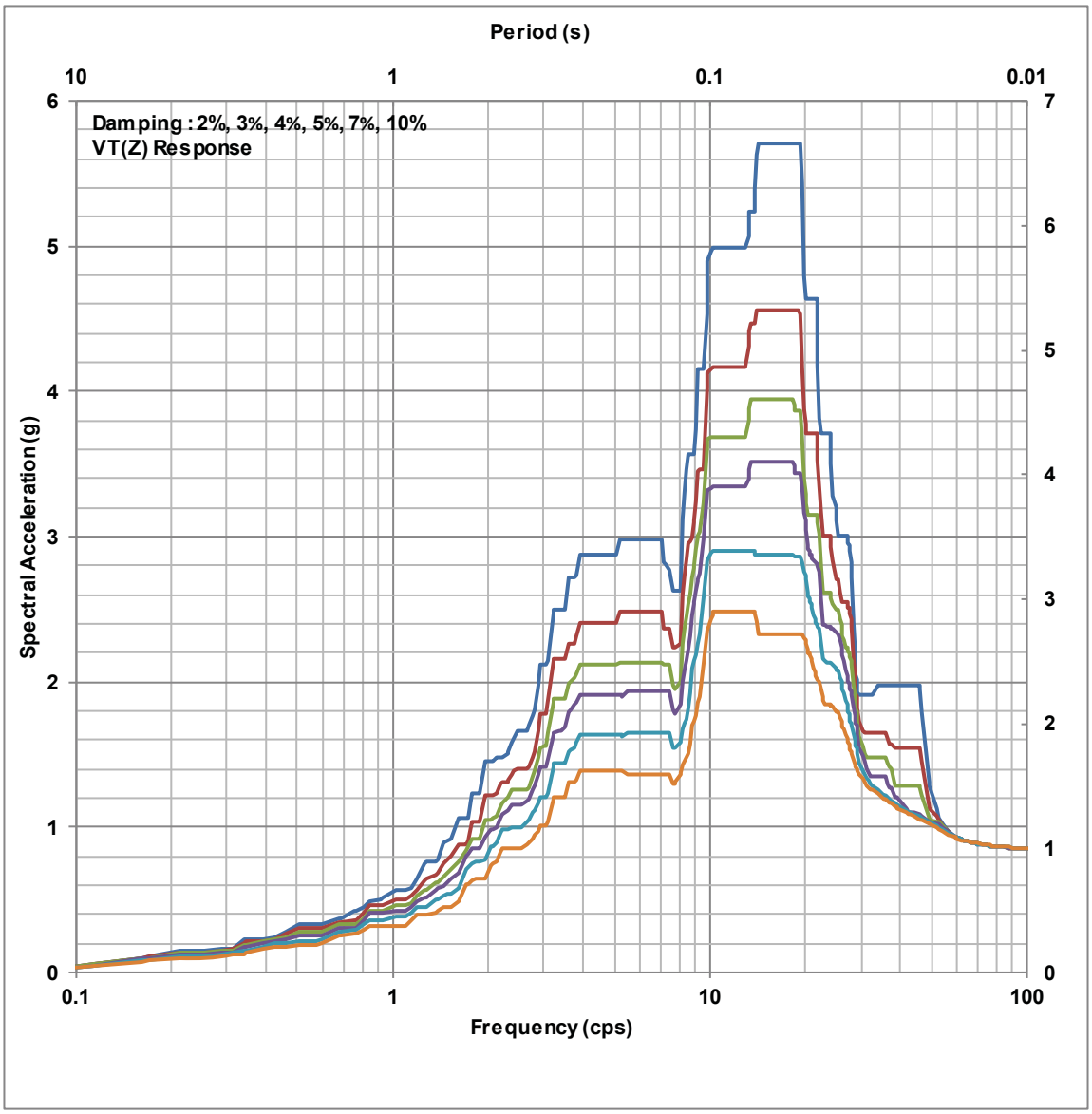

Figure 3.7A-85 Enveloped ISRS for SSE, Emergency Diesel Generator Building at EL.135'-0" (Slab), Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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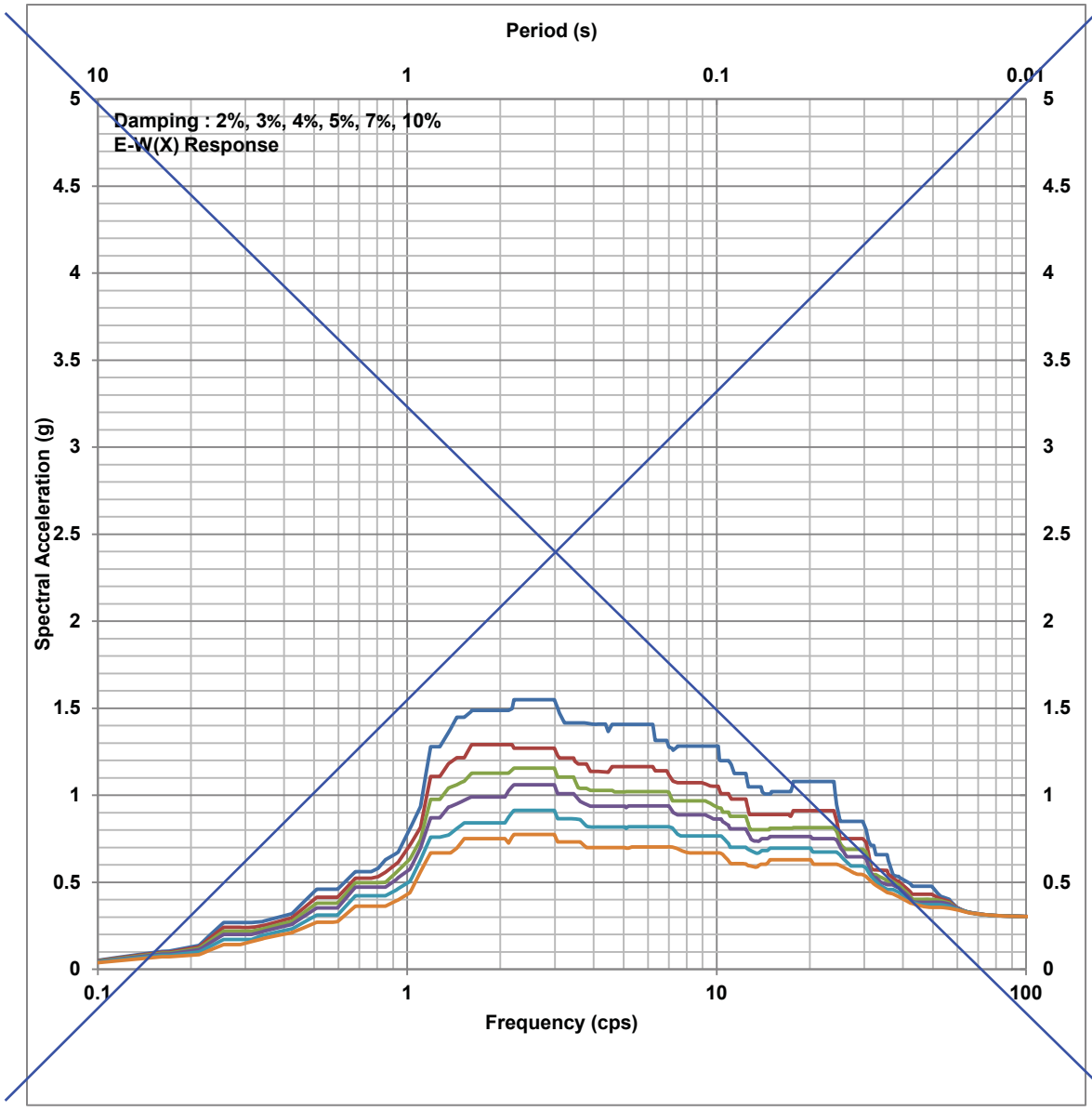

Figure 3.7A-86 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.63′-0″, E-W, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

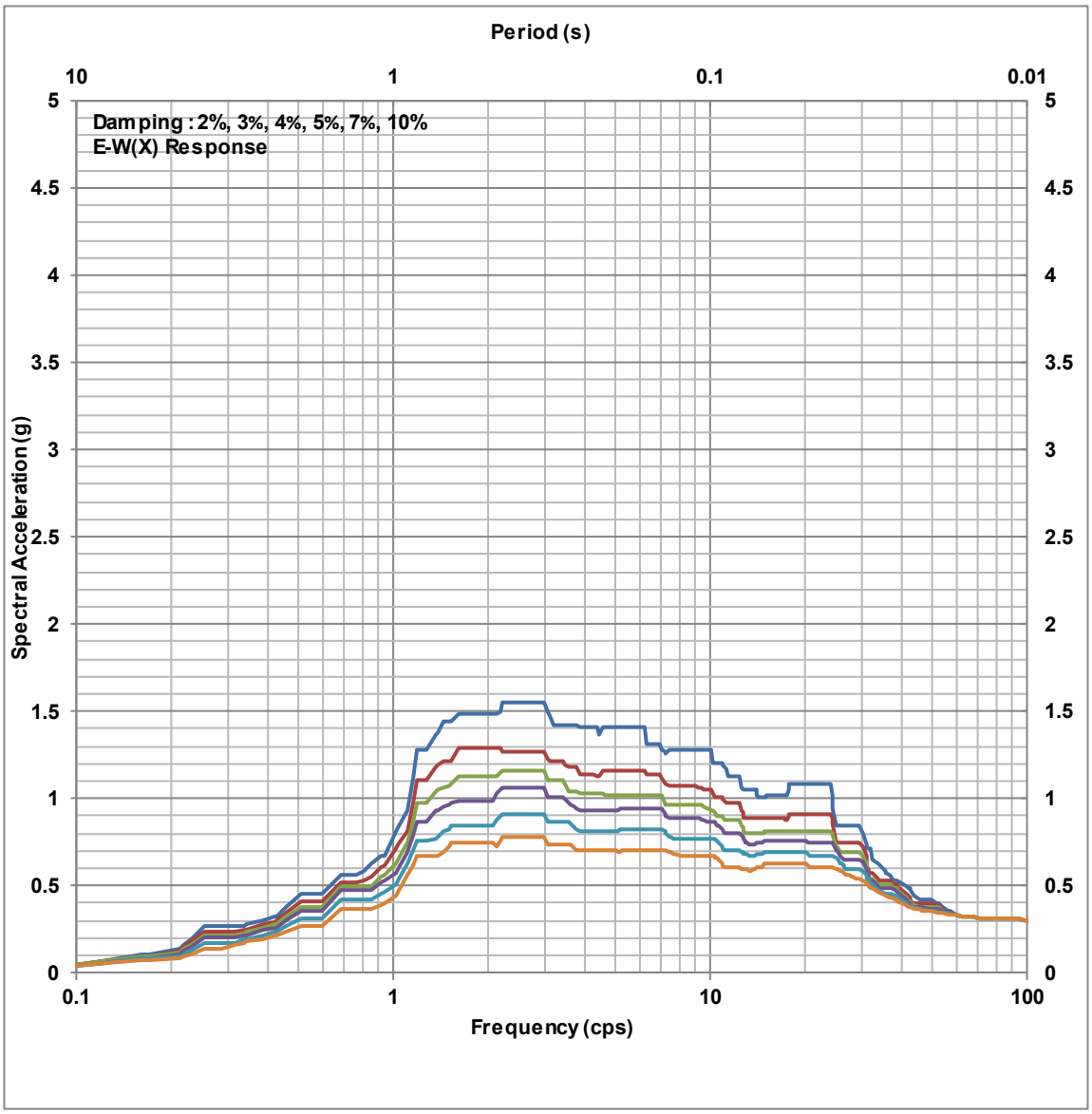

Figure 3.7A-86 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.63'-0", E-W, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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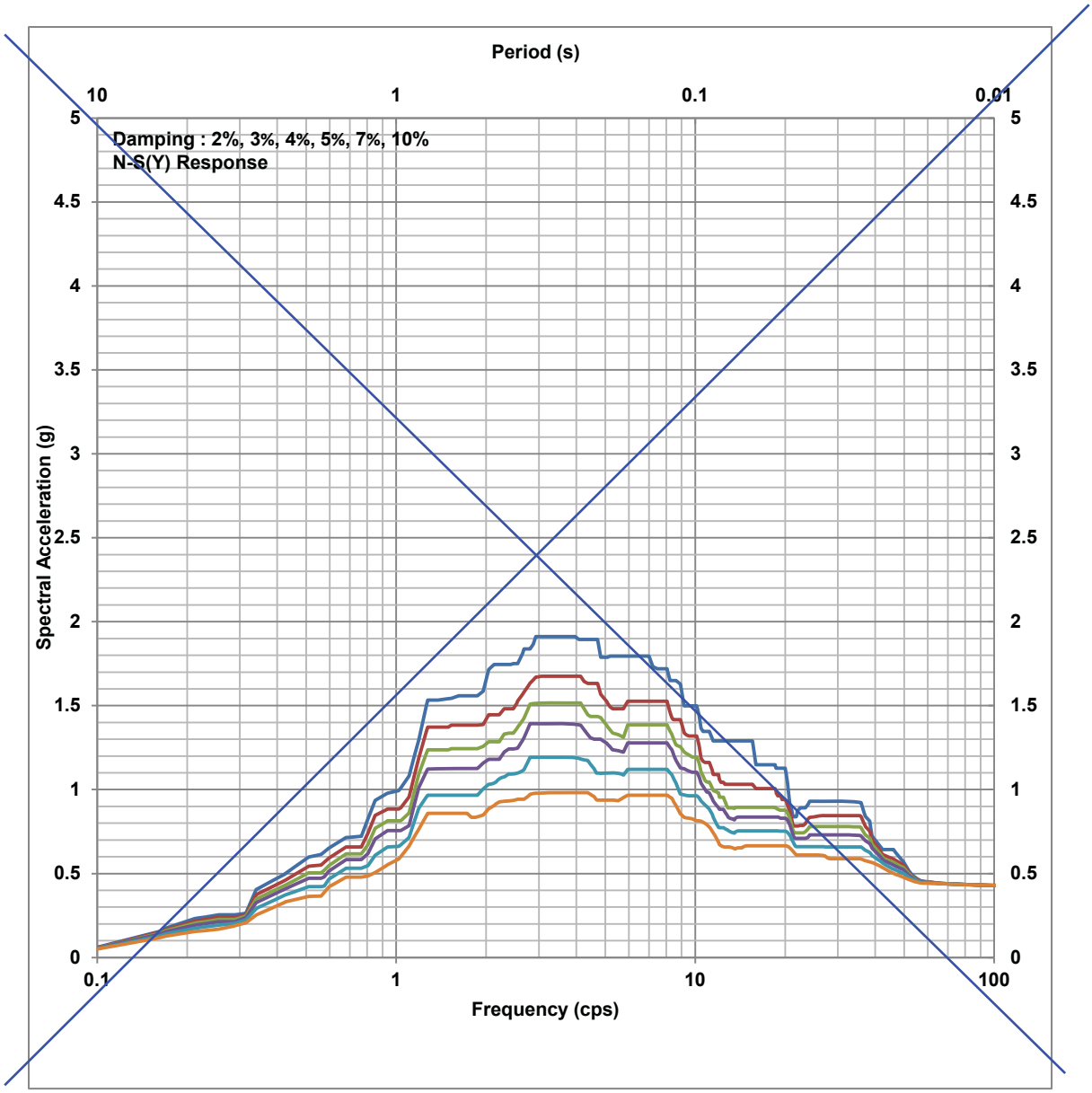

Figure 3.7A-87 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.63′-0″, N-S, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

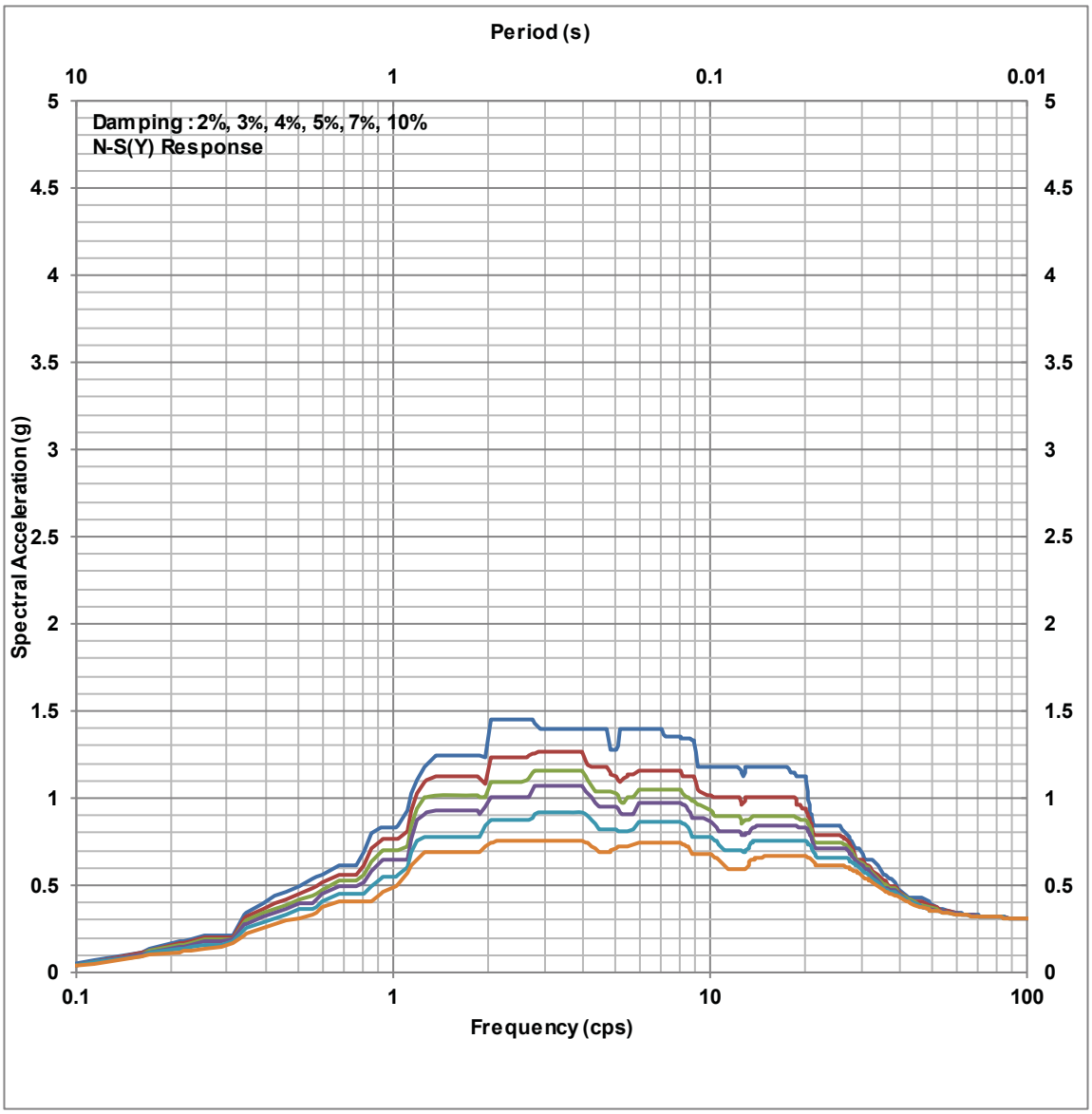

Figure 3.7A-87 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.63'-0", N-S, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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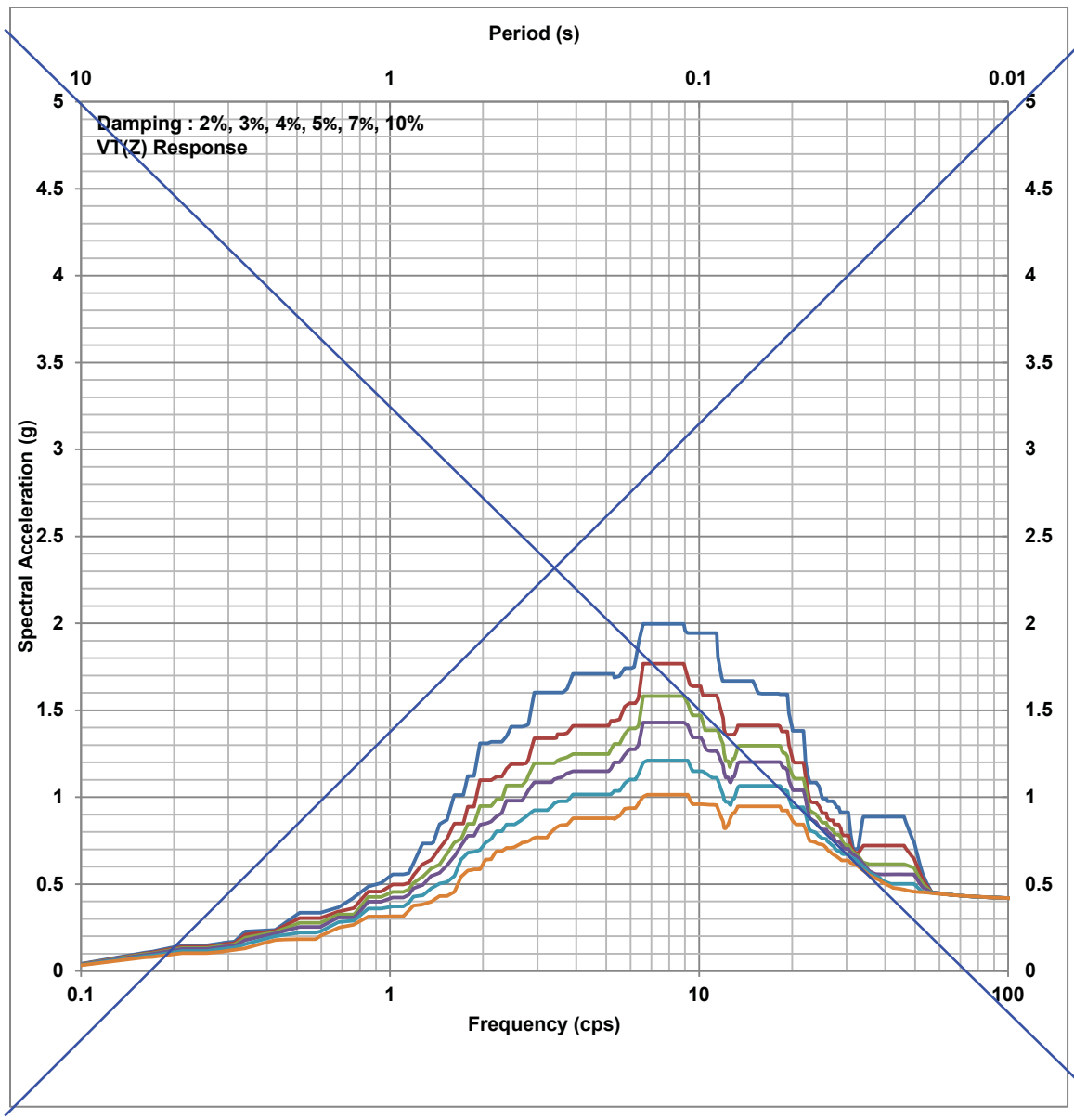

Figure 3.7A-88 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.63′-0″, Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

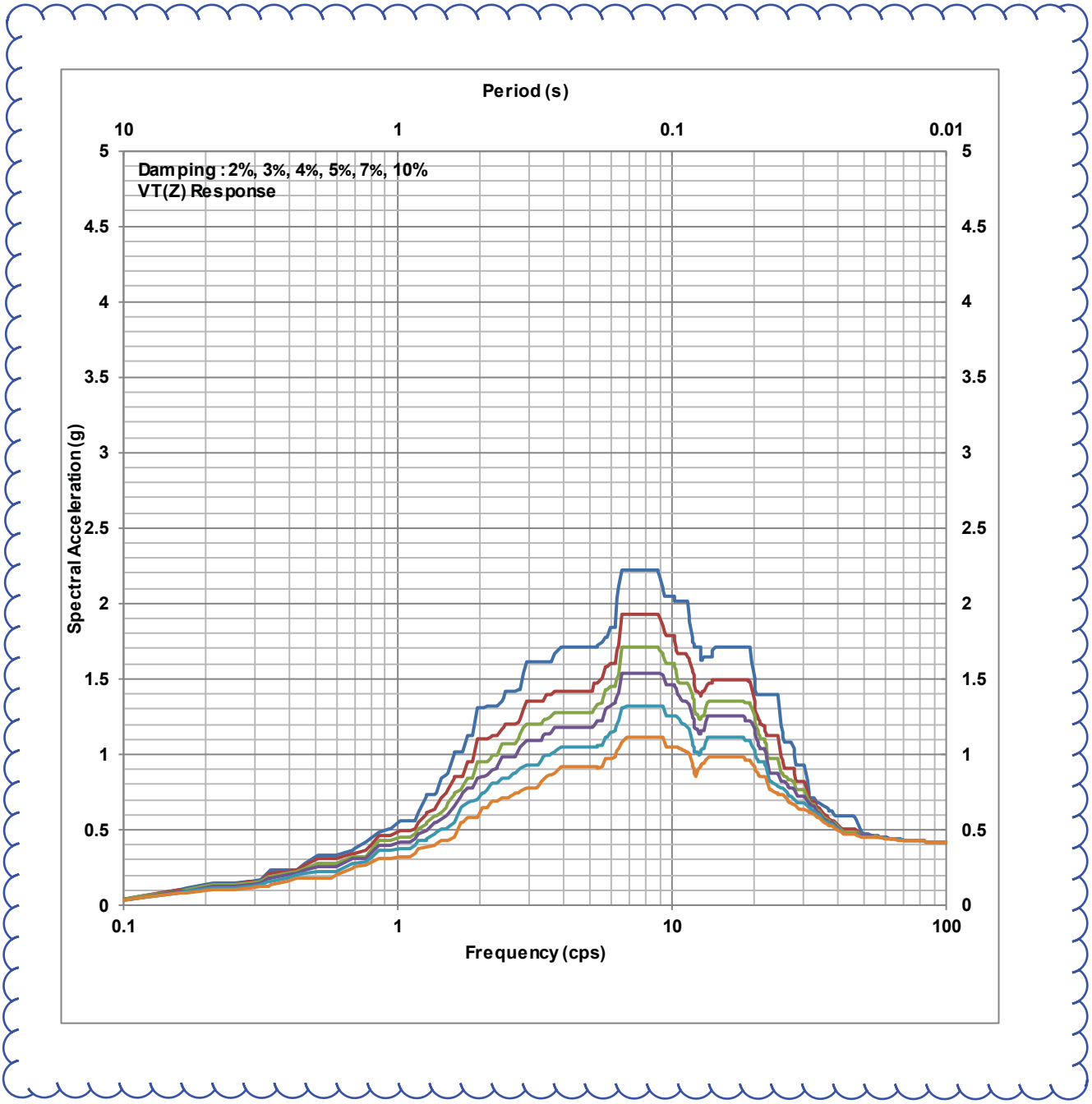

Figure 3.7A-88 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.63'-0", Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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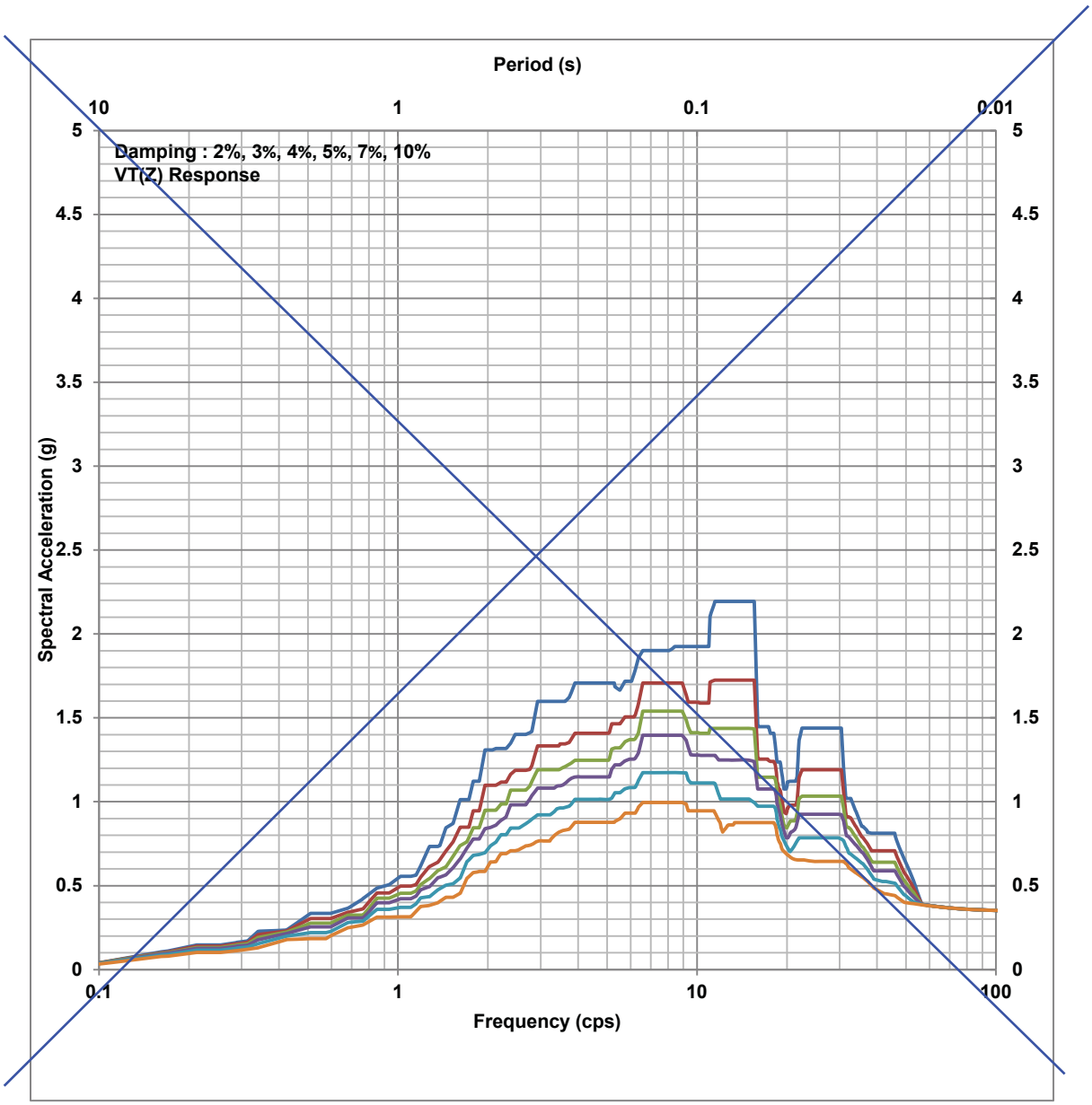

Figure 3.7A-89 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.63′-0″ (Slab), Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

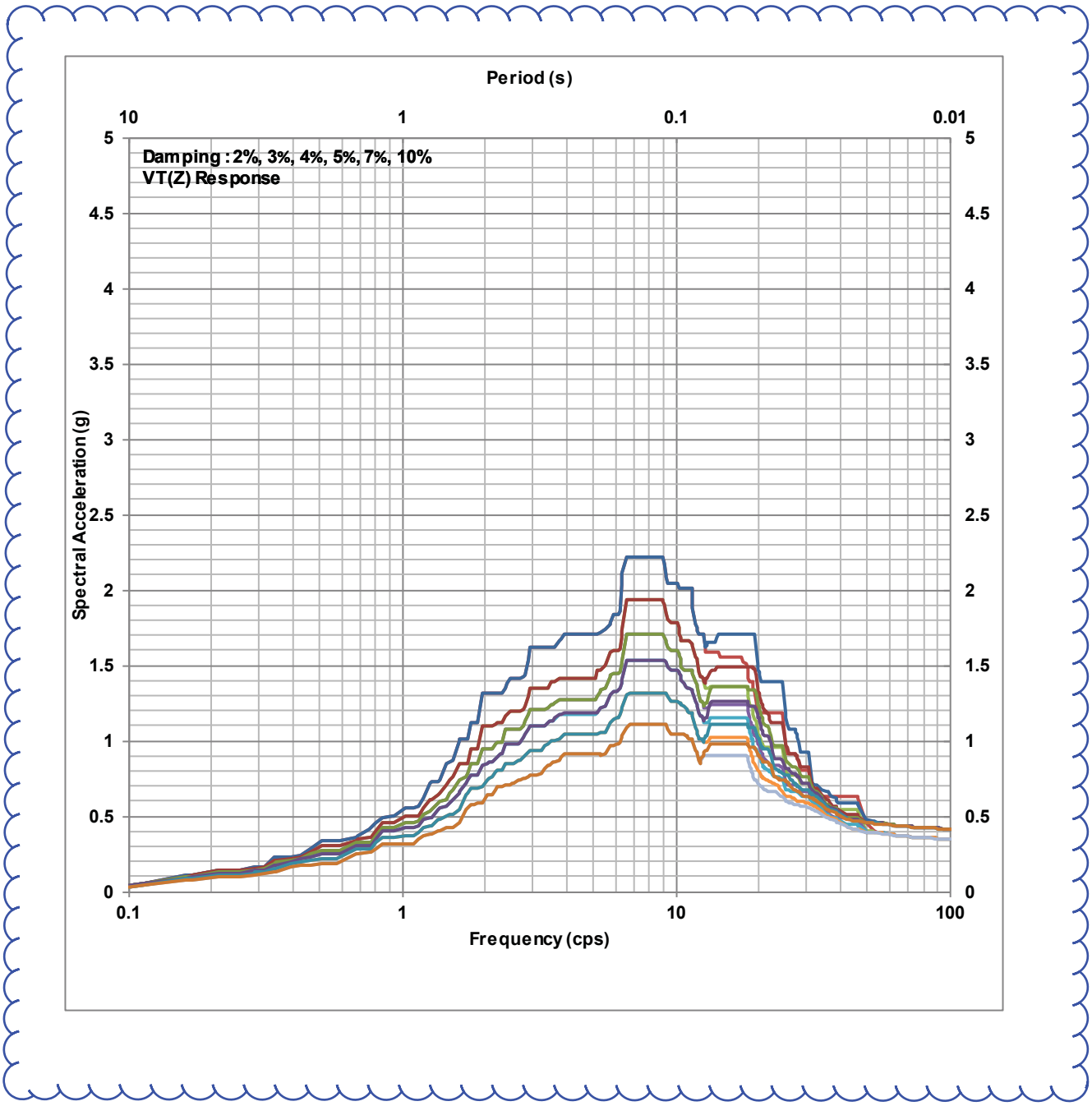

Figure 3.7A-89 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.63'-0" (Slab), Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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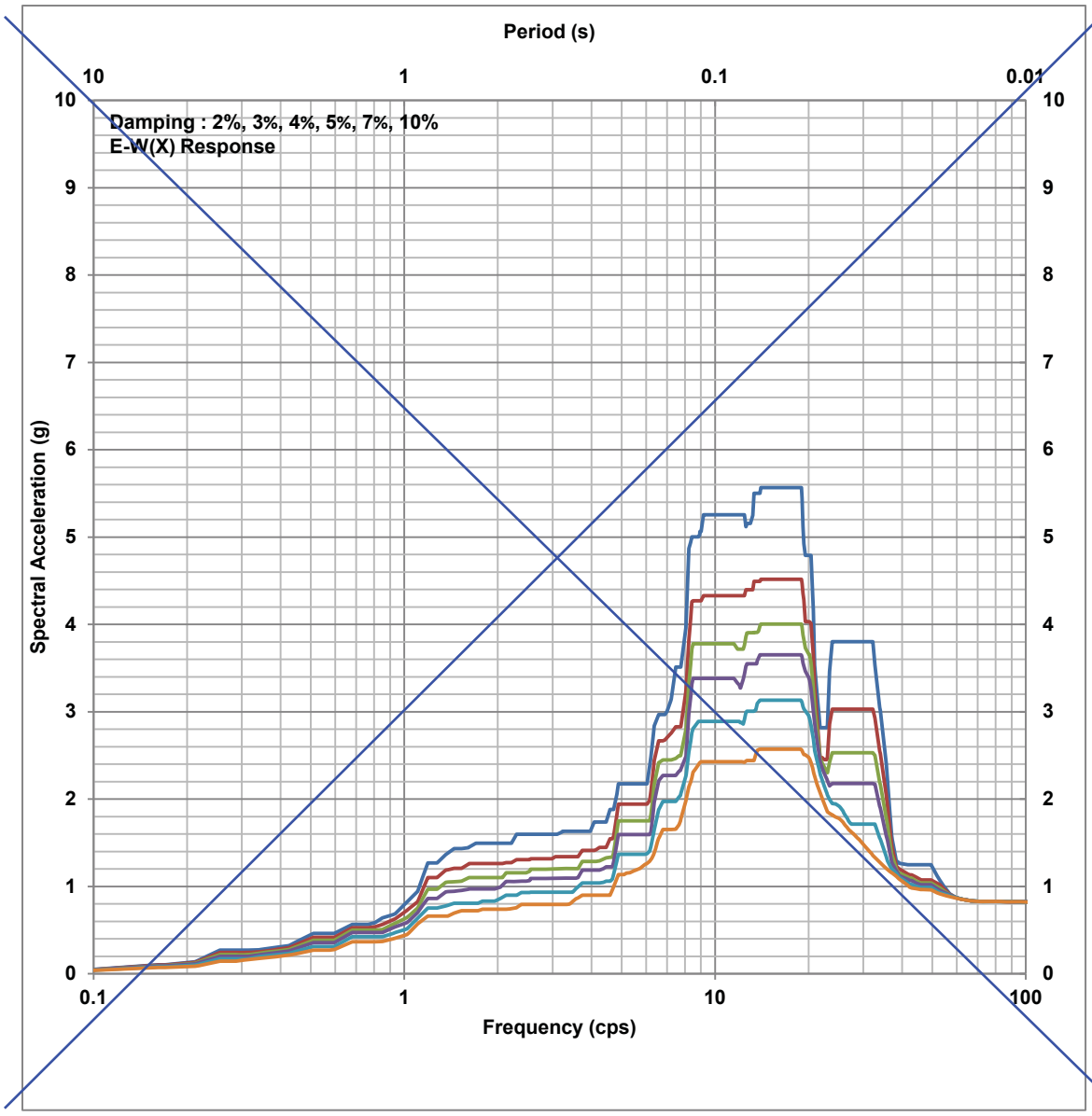

Figure 3.7A-90 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.100′-0″, E-W, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

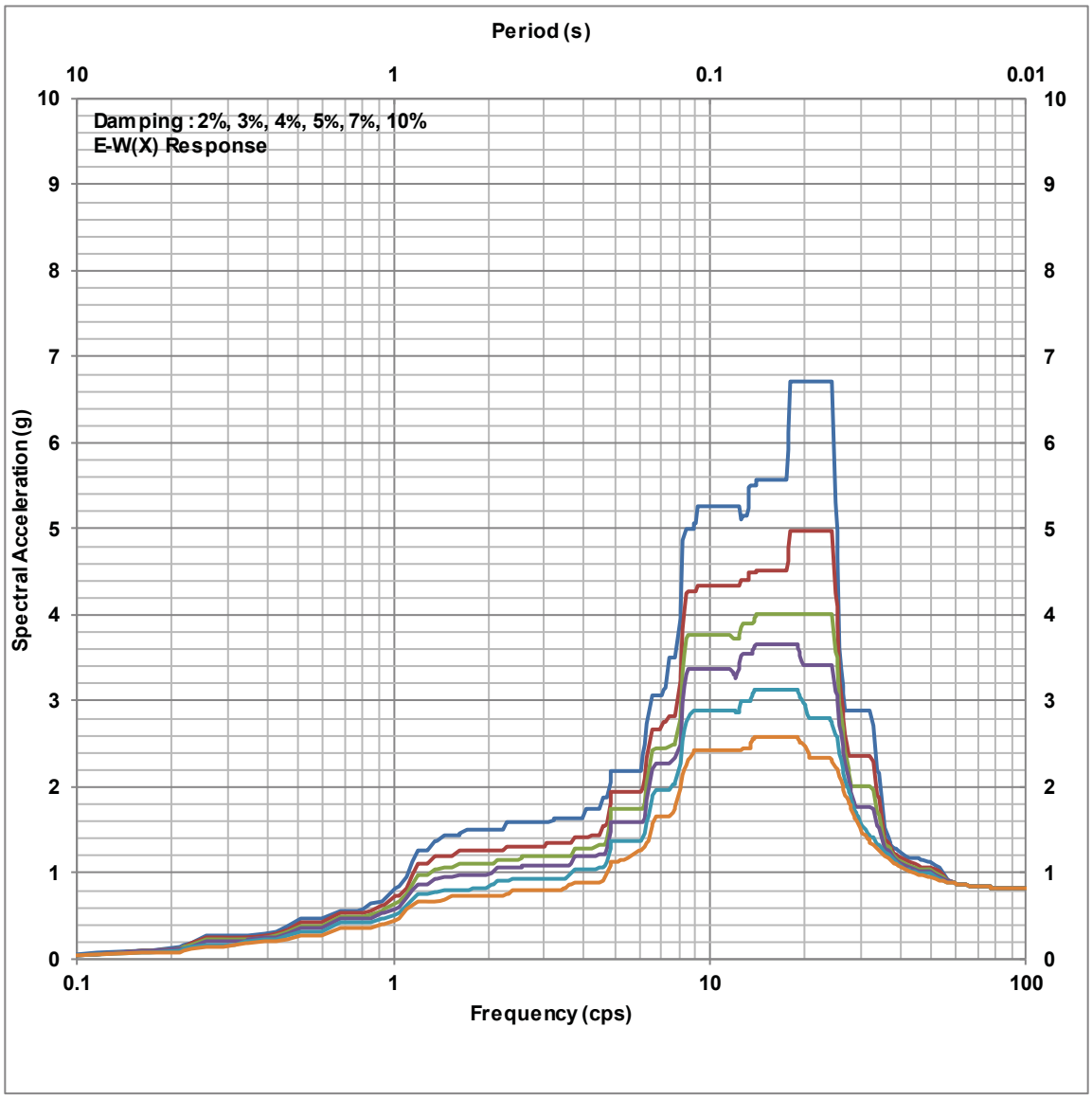

Figure 3.7A-90 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.100'-0", E-W, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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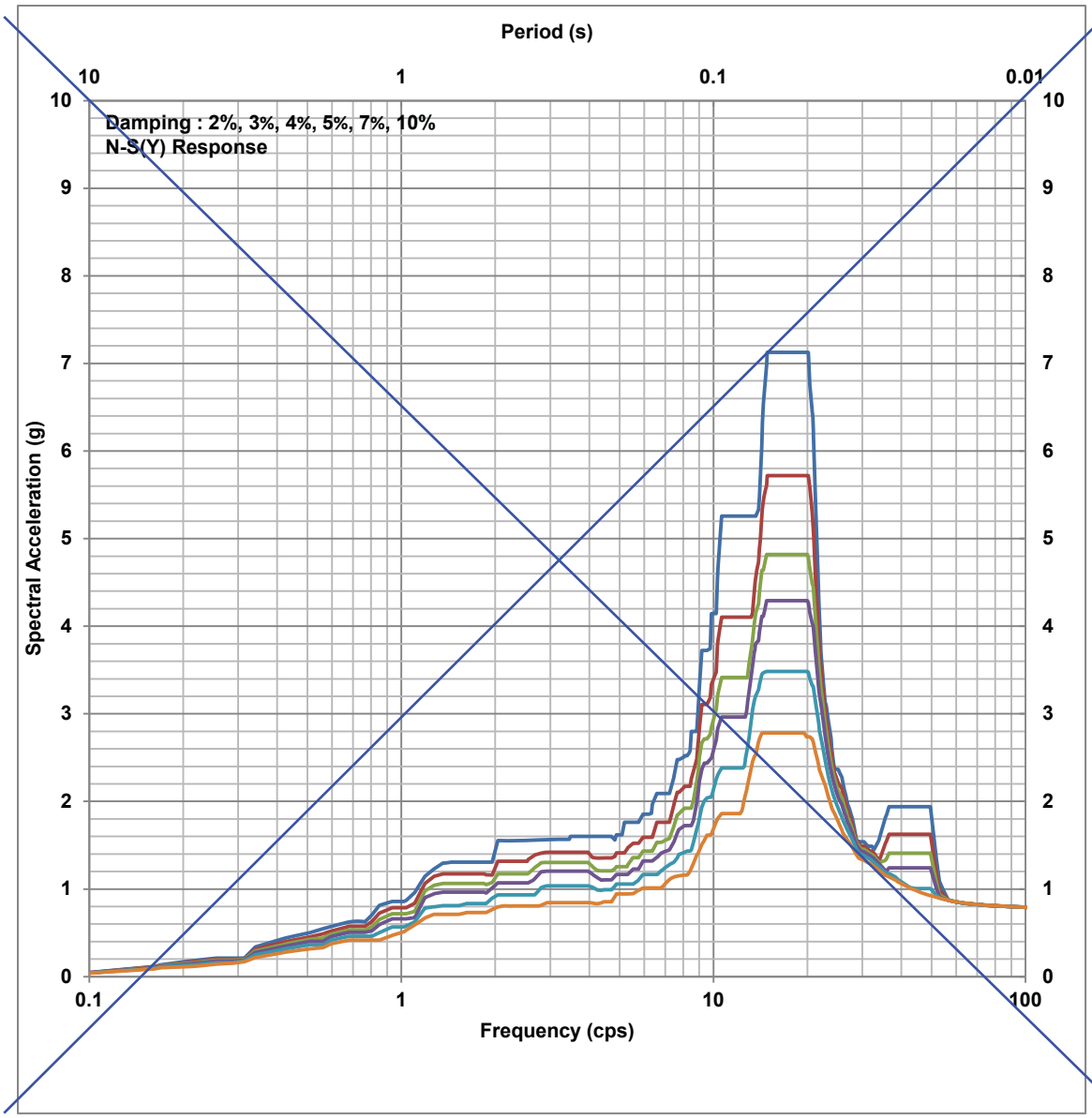

Figure 3.7A-91 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.100′-0″, N-S, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

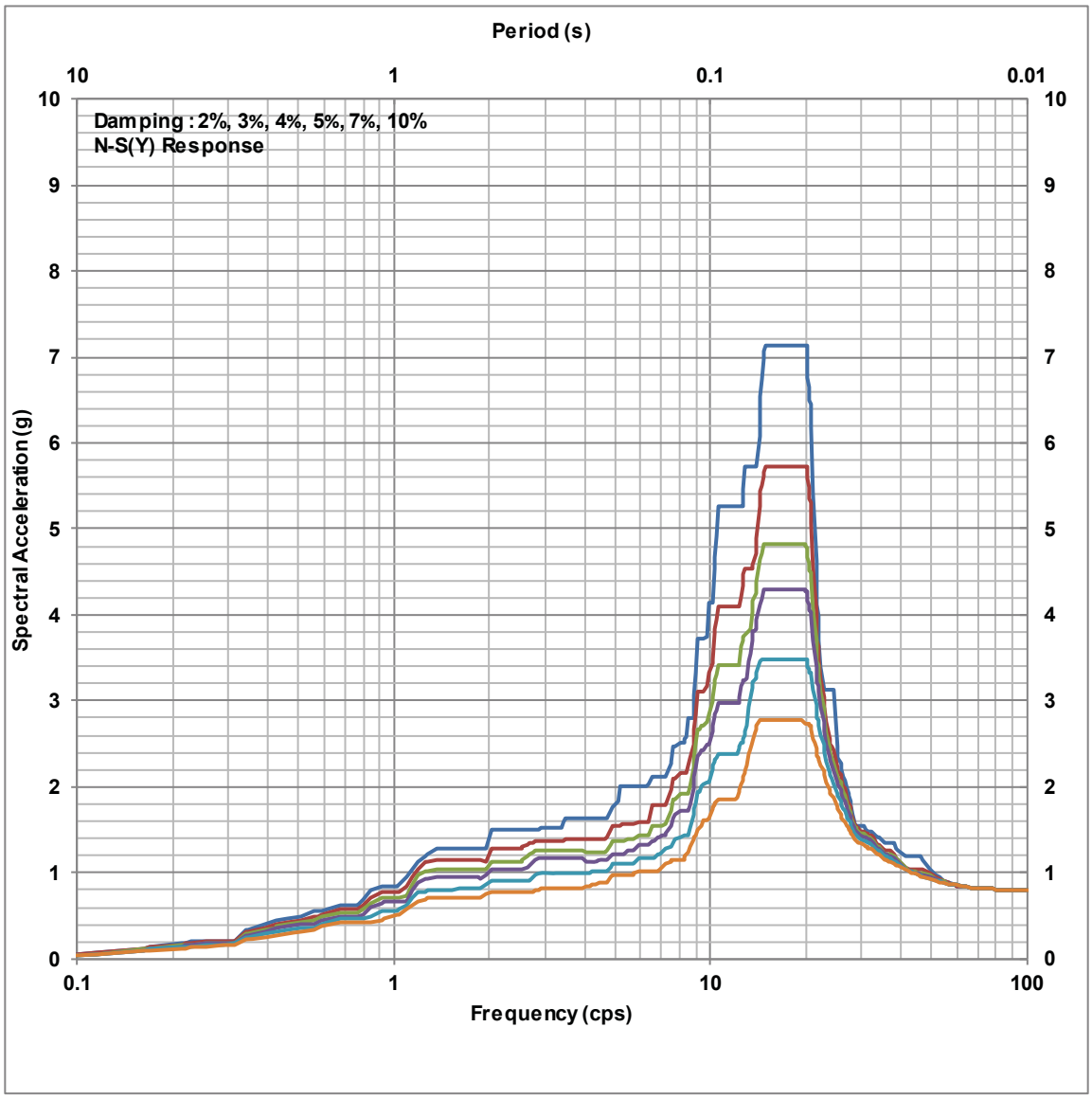

Figure 3.7A-91 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.100'-0", N-S, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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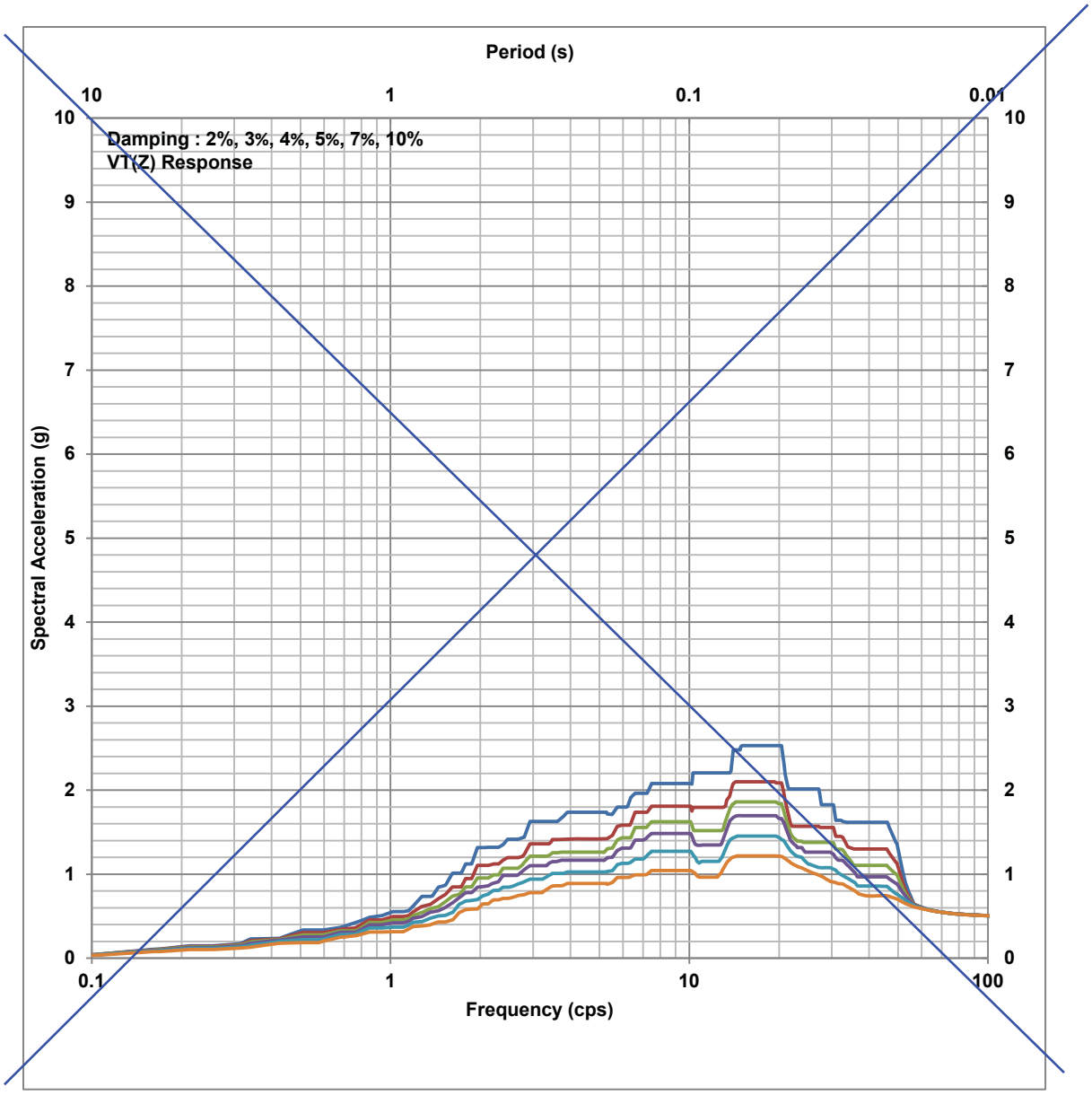

Figure 3.7A-92 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.100′-0″, Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

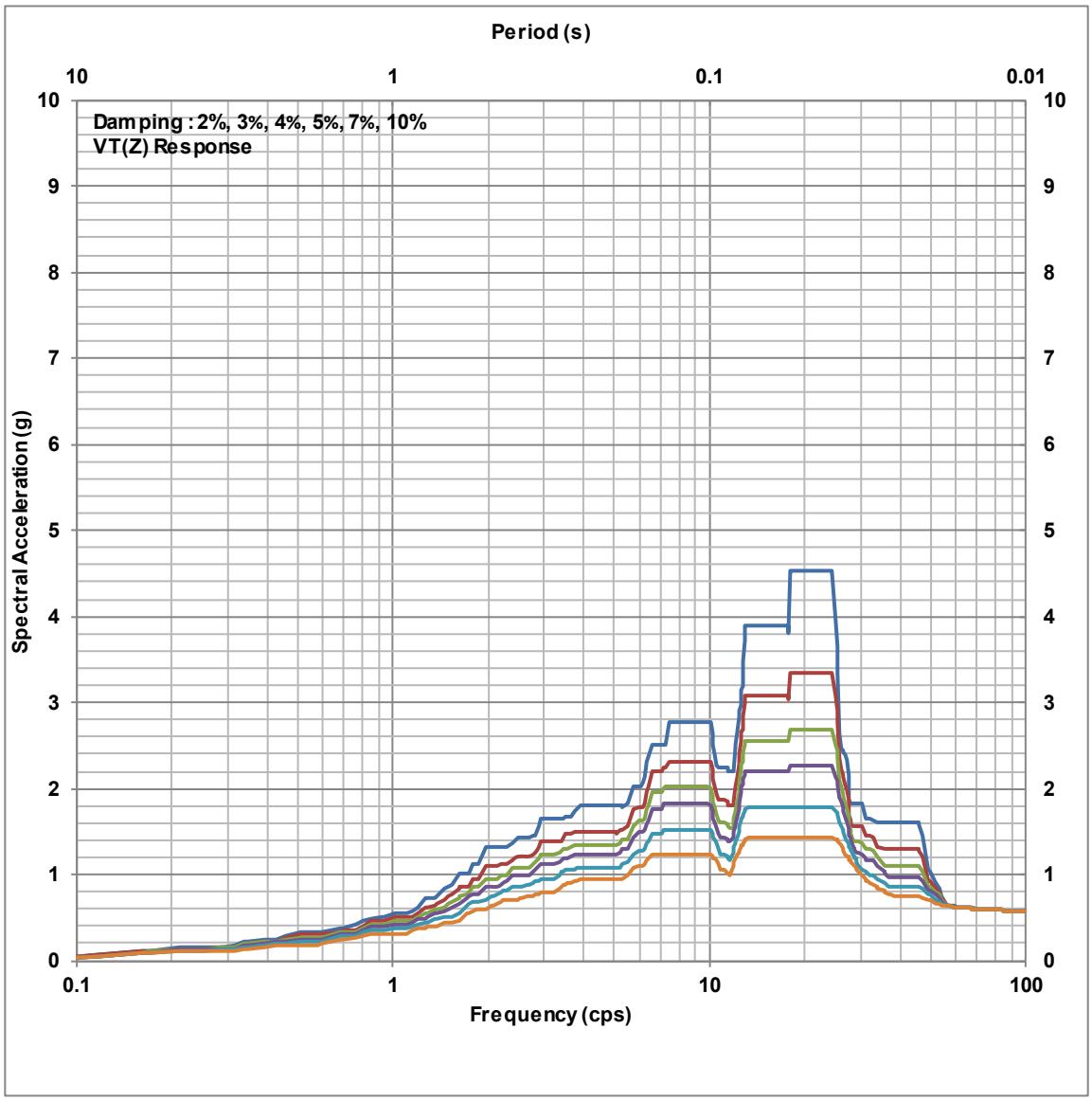

Figure 3.7A-92 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.100'-0", Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

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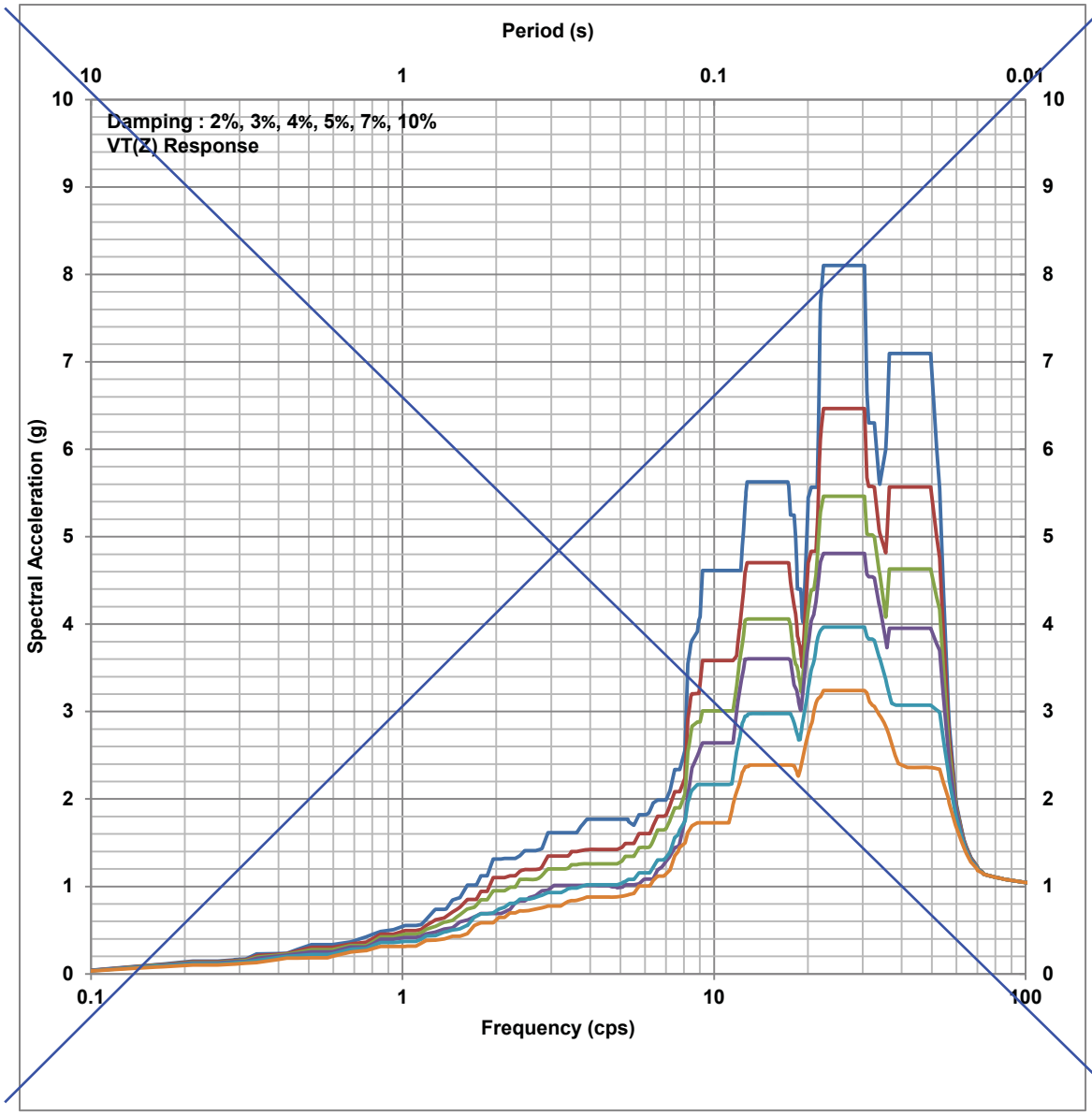

Figure 3.7A-93 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.100′-0″ (Slab), Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%

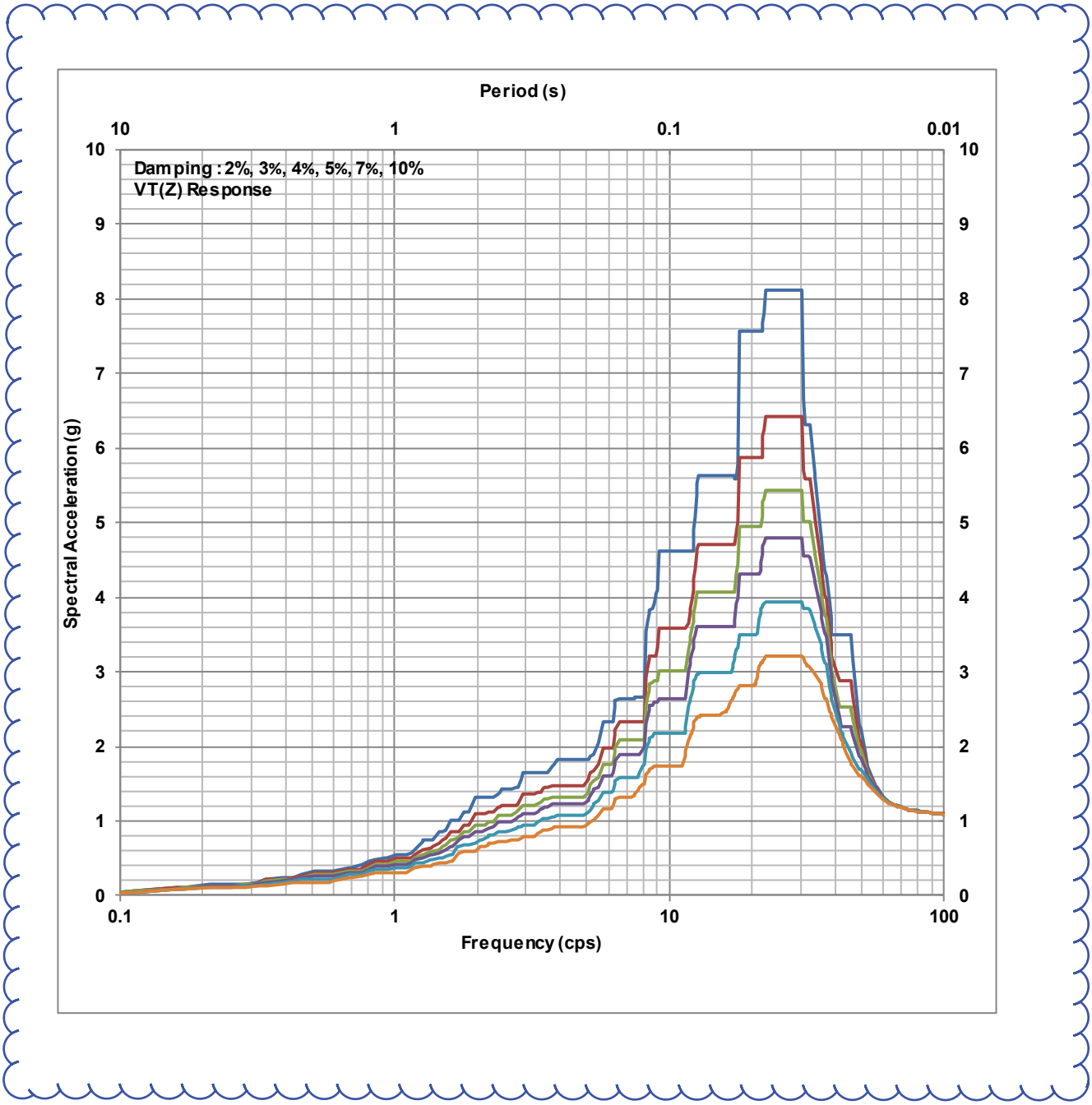

Figure 3.7A-93 Enveloped ISRS for SSE, Diesel Fuel Oil Tank Room at EL.100'-0" (Slab), Vertical, Damping Ratio 2%, 3%, 4%, 5%, 7%, 10%