Scaling Structure Loads for SMA

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1. Introduction

When the Seismic Margin Analysis(SMA) is conducted, the new structural load generation with Seismic Margin Earthquake(SME) is the time consuming work. For the convenience, EPRI NP-6041[1] suggests the scaling of the structure load. The report recommend that the fixed-base(rock foundation) structure designed using either constant modal damping or modal damping ratios developed for a single material damping. For these cases, the SME loads can easily and accurately be calculated by scaling the spectral accelerations of the individual modes for the new SME response spectra[1]. EPRI NP-6041[1] provides two simple methodologies for the scaling structure seismic loads which are the dominant frequency scaling methodology and the mode-by-mode scaling methodology. Scaling of the existing analysis to develop SME loads is much easier and more efficient than performing a new analysis. This paper is intended to compare the calculating results of two different methodologies.

2. Scaling Approach

EPRI NP-6041[1] provides the scaling approaches which are called dominant frequency scaling approach and mode-by-mode frequency scaling approach. For simple structures with dominant response in a single mode, the scaling of total load in a structural member can be approximately done using the applicable spectral accelerations and damping for the dominant mode.

2.1 Dominant Frequency Scaling Approach

If the individual SSE modal response is not known, a reasonably accurate scaling of the SSE loads can be accomplished by scaling the spectral accelerations at the dominant(usually fundamental) frequency of the structure, provided that the general shapes of the SSE and SME are similar. If the scaling approach is used, the analyst should justify it based on the adequacy of structural models, foundation characteristics, and similarity of input ground motions. The scaling can be figured out with ratio SME to SSE at the dominant frequency [i.e., eq. (1)].

$$P_{SME} = P_{SSE} \times Sa_{SME} / Sa_{SSE} \quad (1)$$

2.2 Mode-by-Mode Scaling Approach

When the structural model is relatively complicate and the individual SSE modal responses can be obtained, the mode-by-mode scaling approach would be available. When the mode-by-mode structural member loads are available, then the scaled load for SME can be derived from:

$$P_{i,jSME} = P_{i,jSSE}[Sa_{jSME} / Sa_{jSSE}] \quad (2)$$

Where $P_{i,j}$ is the seismic load in element i for mode j, Sa_{jSME} is the spectral acceleration from the SME for mode j at SME modal damping and Sa_{jSSE} is the spectral acceleration for the SSE for mode j at mode j modal damping. The element load P_{SME} can be calculated with the SRSS of P_{ijSME}.

3. Comparison

EPRI NP-6041[1] described the scaling approach can be used when specific conditions are justified. Comparing dominant frequency scaling approach and the mode-by-mode scaling approach, there are only a few differences in the scaling loads.

EPRI NP-6041[1] describes that when the scaling approach is performed, the mode-by-mode approach is more accurate. However there is nothing to do with the advantages to use the mode-by-mode approaches from the results. Since the difference from the only below 1% is found(See Table I).

Table I : Comparison of the Scaling Approach

Scaling Approach	Shear Force(kips)	Scaling Factor	Scaled Shear Load(kips)
Dominant	6916	1/1.83	3779.2
Mode-by-Mode	3784	1	3784*

Note * : Shear force is already considered the scaling factor for all modes

To explain the similar results, the comparison study is conducted to figure out the reason. The average ratio of the SSE to SME for each mode is 1.81 and COV is 0.04. Even though the ratio at the dominant frequency is 1.83, the difference of two methodologies is 1% only. Thus if the spectral shape between SSE and SME[2] is relatively similar then the ratio of each mode(as shown in Figure. 1) is inherently not much varied. So the scaling results will be similar whether strength factor is calculated by the mode-by-mode approach or the dominant scaling approach.

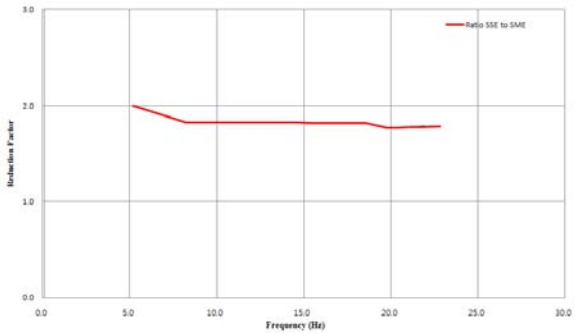

Figure. 1. Scaling Factor of Each Mode for the Strength Factor

4. Conclusions

For the structural seismic margin analysis, the shear wall as the main lateral resistance should be focused on calculating the shear loads. Scaling methodology from EPRI NP-6041[1] report describes two approaches which can be called the dominant frequency scaling approach and the mode-by-mode frequency scaling approach. Whether the structural model is simple or complicated, the scaling results are not much different. Since the SSE and the SME is relatively similar, so the ratio of SSE to SME is not much varied. Although EPRI NP-6041[1] report suggests two different approaches, there is no advantage of using the mode-by-mode approach. If the input response spectrum is similar including the basic condition such as damping and model condition then it may safely be said that the dominant frequency approach will be available even if the results for every mode can be obtained.

REFERENCES

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