Simone Kaldas simone.kaldas@ext.f4e.europa.eu

F4E_D_2R9EE2 Generation of Simplified FRS v.1.0

Fusion for Energy - Software Corner routine

Name: Generation of Simplified FRS

Description:

Generate a Floor Response Spectrum using input data from a modal calculation.

Contents:

- simpl_FRS.m
- Documentation
- License

Motivation:

The seismic qualification of components by calculations or by tests require an input seismic Floor Response Spectrum (FRS). Efficient and accurate determination of floor response spectra, which are used as input for the assessment of equipment behavior, is a high-priority task in seismic design of nuclear facilities.

ASN guide recommends that FRS can be generated by time history analysis, or other methods. When time history or modal transient analyses is used, a large number of sets of three-directional time histories are required to obtain a reliable description of the expected FRS. This procedure is therefore not only difficult to apply but also computationally expensive.

Simplified formulae for determination of FRS are provided by guidelines or draft codes. Only design spectra and basic modal information of the building structure, including natural frequencies, participation factors, mode shapes and modal damping, which can be easily obtained from a modal analysis, are needed. These analytical methods can be used as alternative tools, to check FRS from time history analysis of large FE models representing complex nuclear buildings, in order to get confidence in the obtained results.

The validity of the solid and reliable approach developed as a routine in Matlab, based on simplified formulae, is shown in the following example.

Example:

A simple model of building considered is a 2-DOFs system, provided of lumped masses $m_1 = m_2 = 1 \times 10^4 kg$, and springs of stiffness $k_1 = k_2 = 1.65 \times 10^7 N/m$.

Main modal parameters that will be used as input, are obtained easily through a modal analysis:

Variables - eig_freq
eig_freq
2x1 double

	1
1	3.9955
2	10.4604

Variables - pfact
pfact
2x1 double

	1
1	-137.6382
2	32.4920

Variables - mode_shapes
mode_shapes
2x1 double

	1	2
1	-0.0085	
2	-0.0053	

Variables - xi
xi
1x1 double

	1
1	0.0500

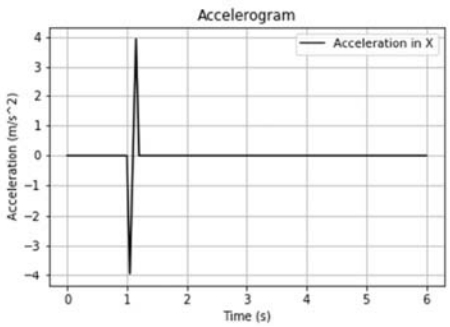
Variables - xi_struct
xi_struct
1x1 double

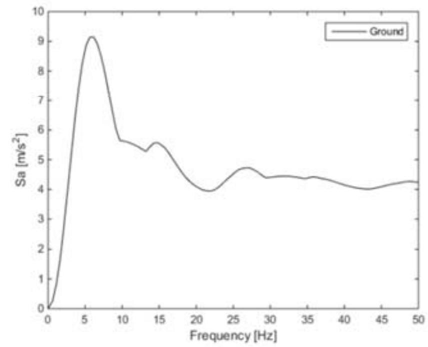
	1	2
1	0.0500	

Natural frequencies, participation factor and modal shapes are input as column vector of dimensions (Nx1), where N is the number of modes extracted. Modal damping are instead input as scalar values, expressed as decimal numbers.

Modal shapes refer to the modal displacement of the single node selected in the single direction under study. Participation factors refer to the same direction.

Other input is given by the seismic excitation considered here reported as an accelerogram, together with the associated input response spectrum:





Variables - ground

ground

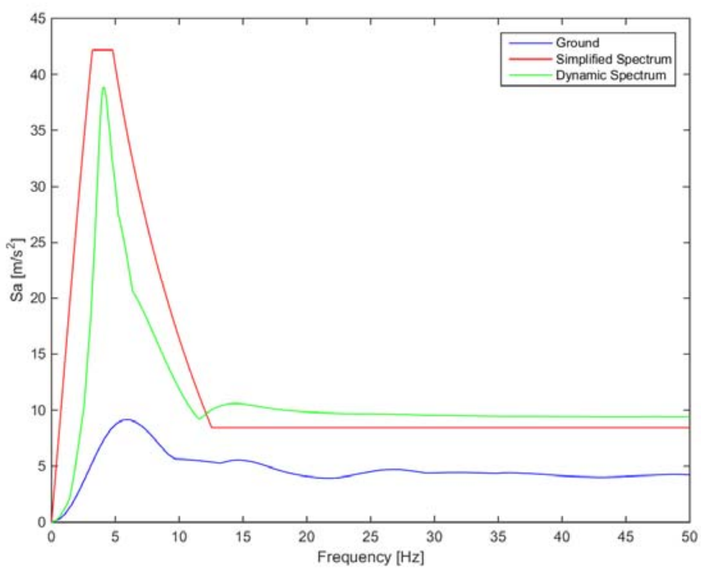
5001x1 double

	1
1	0
2	0.0044
3	0.0087
4	0.0131
5	0.0174
6	0.0218
7	0.0261
8	0.0305
9	0.0348
10	0.0392

The routine takes the input signal as a column vector (n_points x 1) containing its spectral values.

From the input signal, the routine needs as input the equivalent upper corner frequency of the design spectrum indicated by NRC 19.2. A qualitative value can be chosen, and in our example fc was set to 8Hz.

ATTENTION: output FRS and input spectrum must be vectorized for the same corresponding frequency values that are assigned in the "f" frequency input vector (n_points x 1). If this is not happening, additional pre-processing in Matlab is needed before running the routine.



The execution of the routine allows us to derive the simplified FRS as output vector (n_points x 1). The results obtained are reported here (in red) together with a comparison to a FRS from a full transient analysis (in green) for the same system.

As we can see from the plot, the simplified FRS approximates with reasonable accuracy the FRS from the transient analysis, being also conservative in the resonance region to deal with any possible uncertainty of the dynamic analysis.