Response-spectrum analysis

Response-spectrum analysis (RSA) is a linear-dynamic statistical analysis method which measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of an essentially elastic structure. Response-spectrum analysis provides insight into dynamic behavior by measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a given time history and level of damping. It is practical to envelope response spectra such that a smooth curve represents the peak response for each realization of structural period.

Response-spectrum analysis is useful for design decision-making because it relates structural type-selection to dynamic performance. Structures of shorter period experience greater acceleration, whereas those of longer period experience greater displacement. Structural performance objectives should be taken into account during preliminary design and response-spectrum analysis.

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Damping and RSA:

- RSA provides insight into how damping affects structural response. A family of response curves may be developed with variable levels of damping. As damping increases, response spectra shifts downward.
- The International Building Code (IBC) is based on 5% damping. This accounts for incidental damping from hysteretic behavior, which is not explicitly modeled during RSA.
- Viscous dampers do not affect structural stiffness, are not modeled during RSA, and are not accounted for in the IBC provision for 5% damping.

Additional notes on RSA:

- All response quantities are positive, therefore RSA is not suitable for torsional irregularity. A static lateral-load procedure is best for measuring accidental torsion. The same applies when considering uplift and compression during foundation design.
- Modal response may be combined using SRSS, CQC, ABS, or GMC methods. CQC is best when periods are closely spaced, with cross-correlation between mode shapes. SRSS is suitable when periods differ by more than 10%.
- Ritz vectors are recommended for RSA because this formulation is computationally efficient. Only pertinent mode shapes which occur in the horizontal plane are identified. Eigen vectors use the full stiffness and mass matrices, which also account for vertical modes. Eigen formulation is useful when considering floor vibration, out-of-plane vibration of shear-wall systems, etc. Eigen application is also useful for locating modeling errors.