LOAD COMBINATIONS FOR ASEISMIC DESIGN

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Some general requirements are to be met when specifying design combinations for (non-seismic and seismic) loads: significancy for the actual risk; compatibility with general design philosophy; compatibility with computational capabilities; reasonable amount of computations. Two main aspects are to be dealt with in this field: assumptions on the seismic disturbance, having in view its features, and assumptions on the non-seismic loading, having in view the probability of its presence, at some specified values of the parameters, during earthquake occurrence.

The most significant features of seismic disturbances, to be kept in view, are their random and vectorial character. The components of this vector will refer to the degrees of freedom of the ground-structure contact zone. According to the features of the contact zone, the local motion may be represented as a three- or a six-component motion. The different components are varying non-synchronously and a most suitable tool to represent them is their correlation matrix. Computational reasons make appropriate the use of spectral density matrices. The use of relations referring to correlation matrices, in case of linear structural behavior, leads on the basis of modal expansion to correlation functions (in particular, variances) of normal coordinates of accelerations, displacements, stresses, etc. The stochastic approach permits to derive consistent simplified rules for current practice. Examples: consider not only design accelerations w_x, w_y, w_z, separately, but also combinations like $\pm w_x \cos\alpha$ and $\pm w_y \sin\alpha$ (in particular: $\pm .7o7\, w_x$ and $\pm .7o7\, w_y$) or like $\pm w_x \cos\alpha$ and $\pm w_y \cos\beta$ and $\pm w_z \cos\gamma$ $(\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1)$. Such rules are introduced already in some codes (e.g. the 197o Romanian code, or the 1974 CMEA code). The case of different ground-structure contact points leads to the need of estimating space correlations (see Sandi's paper, 5-th Europ. Symp. on Eq. Engng.). The explicit use of correlation matrices is most suitable in case of analyzing high importance structures (e.g. NPP) for which the lack of consistency of response spectrum techniques in dealing with vectorial disturbances may become significant. Correlation tensors are especially well suited as a basis for simulating ground motion in order to perform time history analysis (e.g. see 6WCEE paper of Bălan, Minea, Sandi, Şerbănescu).

It is reasonable to assume as a rule the presence of non-seismic loads at expected values of parameters. Load factors for dead load (eventually for live load, or snow load too) could lead to unsafe design due to underestimate of stress reversal risk. The relatively low variance of dead load makes often unreasonable consideration of upper and lower quantiles in the frame of different combinations. The same is valid in case of relatively low live load, snow load, etc. A different case is that of relatively high live load (note the case of silos) when non-uniform loading could be especially significant. Such cases should be handled on the basis of stochastic concepts too. Wind, crane braking, etc., should not be combined with earthquakes. The same is valid for imposed deformations, unless ductility limitations are especially severe.

It is reasonable to concentrate efforts to improve design combination rules in codes. This may be important for improving the quality of aseismic design, avoiding excessive risk or material consumption.

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