ABSTRACT

The present thesis refers to the investigation of the effect of the seismic incident angle on structural response using the response spectrum method. The case of 5 different types of buildings subjected to two horizontal components in terms of response spectra from 8 different earthquake recordings is being examined. The vertical component is not taken into account.

The five buildings which are examined have differences in the following characteristics: the number of stories, the plan symmetry or asymmetry and the regularity in plan and elevation. The structures are discrete, linear systems with viscous damping (5%). For all models, the variation with incident angle of response quantities N (axial force), M_X – M_Y (bending moments) at the base of a certain column and the displacements δ_X - δ_Y at the top of the building is being investigated. The results are compared with the respective ones which have been derived from dynamic analysis of the same structures using the Linear Time History Method.

For each one of the 8 earthquake records, a new spectra - called SRSS Spectra - is been constructed by the square root of sums of squares of the response spectrum of the 2 seismic components. Response spectrum analysis is performed for each model, applying the SRSS spectra along both directions (X and Y) of the structural axes.

The results from the two methods (Response Spectrum and Time History Analysis) had significant differences between them. The values of the critical angle which resulted from response spectrum analysis did not coincide with the ones from the Time History Analysis. Also, the values of critical response were usually grater (sometimes up to 50%) with the Time History Analysis. The variation of response with incident angle, for the response spectrum analysis, has the form of a trigonometrical equation which is proved in Chapter 5. This equation is expressed by simple parameters such as the participation and correlation factors, the spectrum accelerations for each mode and the modal responses. It can easily be used for the evaluation of the critical response and the critical angle without performing more than one analysis for each case of earthquake.

Furthermore, the results from the spectrum analysis show that the value of critical angle that yields the maximum response almost does not depend on the seismic excitation, depends though on the structure characteristics and the type of the response quantity itself. For structures with one-way plan symmetry, the critical angle is either 0º or 90º. The spectrum shape of the two horizontal seismic components influences the ratio $\frac{|R_{,\theta}|}{|R_{,\theta=0}|}$ where $|R_{,\theta}|$ is the value of response for θ in the range 0^o-180^o and $|R_{,\theta=0}|$ is the response value for θ = 0 (along structural axes).

The values of response quantities which were derived from spectrum analysis when applying the SRSS spectra along the structural axes are larger than the critical responses of the other two methods where the pair of horizontal components applied along any arbitrary direction, except of a few cases where the values from time history analysis are slightly grater.

In order to investigate which of the structure characteristics affect – and in which way – the variation of response with the angle of incidence, time history and response spectrum analysis were performed on a single-story building having elastic plan symmetry in both directions and mass eccentricity in one direction. The parameters which were examined are: (i) the variation of mass eccentricity, (ii) the structural stiffness (T_X) and (iii) the relative stiffness between the 2 directions of the structure (T_X/T_Y), where T_X and T_Y are the uncoupled structural periods for the X and Y direction. From the results of the analysis it was observed that the responses depending only from one of the two translational modes of the structure are not influenced from none of the three above parameters. The ratio T_X/T_Y affects the value of the critical angle of the responses depending from both of the two translational modes. Specifically, the more this ratio increases, the more we approach the case where $\theta_{cr}=0^o$ or 90^o. The structural stiffness (T_X) affects the ratio $\frac{|R_{,\theta}|}{|R_{,\theta=0}|}$, more intensively as the parameter T_X/T_Y or the mass eccentricity e_{0Y} increases. The eccentricity e_{0Y} does not appear to have any kind of influence on the value of the critical angle; however it has some kind of influence on the ratio $\frac{|R_{,\theta}|}{|R_{,\theta=0}|}$.