OPTIMAL PARAMETERS ANALYSIS OF MULTI-STOREY BUILDINGS FOR SEISMIC AREAS

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Structural response analysis under severe seismic motions and earthquake effects demonstrate that bearing capacity of structures and their deformability are determined to a great extent by the capacity to absorb external disturbance energy. By means of varying the distribution of height-dependent strength and rigidity parameters of structures it is possible to design highly effective eseismic structures.

The problem of optimization of multi-storey earthquake-resistant buildings parameters is discussed. The condition of extremum for the functional of energy dissipation rate or dissipation power is taken as an optimum criterion for frame and braced frame systems. The problem is to find minimax of non-elastic deformation energy. At the first stage in fixed conditions of yielding(plasticity) and structural scheme the extreme principle of maximum for dissipation energy rate is used and the kind of real velocities of all kinematically possible(permitted by restraints) rates of deformation is obtained. At the second stage the principle of minimum for deformation energy is applied.

The variation problem for n degree-of-freedom hysteretic system in Boltz form is solved and relationships between optimal values of limit restoring forces for building storeys $R_{i,max}$ are found for arbitrary mass distribution $\eta_i = m_i/m_1$

$$R_{i,max} = r_i R_{i-1,max}; \quad r_i = \left(1 + \frac{\eta_{i-1}}{\eta_i} - \frac{\eta_{i-1}}{\eta_i + \eta_{i+1}}\right)^{-1}; \qquad r_n = \left(1 + \frac{\eta_{n-1}}{\eta_n}\right)^{-1}.$$

The efficiency factor of structural design $C_{cd} = \sum_{i=1}^{n} R_{i,max} / M_{sp}$ is proposed that characterizes relative expenditures on the provision of bearing capacity of a structure under seismic actions per unit of its mass. The efficiency factors are related to the coefficients of constructional quality of structural material $C = R/\gamma$, the quantity of materials per unit of gross area or structural volume of the building and the seismic coefficients. The factor C_{cd} allowes to estimate the quality index of dynamic systems, the development of structural design and the degree of conformity of structures to maintainance and economic requirements according to current codes. In addition the efficiency factor can be used in analysing the earthquake effects and the results of structural response investigation.

The analysis showed that buildings with varying height-dependent parameters of limit restoring forces are more effective under seismic motions. The comparison of the efficiency factors for buildings of various structural materials and so on allowed to determine the fields of rational application for multi-storey buildings of different types. Frame buildings are economically justified to the height of 8-10 storeys. For 8-16 storey structures the braced frames are more efficient. Shear-wall systems should be limited up to 7-9 storeys and space braced frames are more rational for higher structures. For towers above 20-25 storeys the space shear-wall systems with cores, space diaphragms and lattice structures(e.g. tube-in-tube or rigid tube) are most promising.

References

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