PROBABILITY EVALUATION OF THE STRENGTH OF ELEMENTS EXPOSED TO NON-CENTRAL COMPRESSION IN SEISMORESISTANT FRAMED AND FRAMELESS BUILDINGS

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ANNOTATION

The report deals with reliability and calculations of strength of eccentrically compressed r.c. elements.

There was made a statistic analysis of experimental data obtained in tests on eccentrically compressed r.c. columns subjected to destruction, there were investigated actual strength reserves of columns under short loading specified in the building norms of the USSR. Probability evaluation was made on the strength of eccentrically compressed elements in seismoresistant frame and panel buildings.

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While comparing the values of stresses occurring in structures subjected to non-linear deformations under real earthquakes and the values of breaking loads it is necessary to take into consideration the actual accuracy of calculated formulas and the paramerters of r.c. elements.

The author of the paper worked out the evaluation methodics dealing with the accuracy of calculations related to the strength of eccentrically compressed r.c. elements, besides, there was made quantitative evaluation of strength reserves specified in the building norms of the USSR depending on the main dimensionless parameters of elements: the reduced flexibility, amount of reinforcement in a section, the value of relative eccentricity, etc.

The author evaluated the parameters relevant to actual distribution of r.c. elements bearing capacity and the accuracy of calculated formulas of the first ultimate state on the basis of the results received from statistic processing of experimental data obtained from tests on 329 columns. These eccentrically compressed heavy concrete columns under short loading were tested up to the state of destruction, by 23 investigators from the USSR, the USA, the United Kingdom, FRG and other countries.

The values of ratios $\frac{N_{ex}}{N_t}$ and $\frac{N_{ex}}{N_r}$ were analysed, the first ratio characterizes the accuracy of the calculated formula, the second - the reserve coefficient (N_{ex} - the experimental value of element breaking stress under the given initial eccentricity, N_t and N_r - theoretical and rated value of this stress calculated using the mean and rated values of r.c. element parameters). In order to make a general

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evaluation of calculated formulas accuracy, the estimations of the variation coefficient $\gamma\left(\frac{Nex}{Nt}\right)$ were used besides the mean quantity $m\left(\frac{Nex}{Nt}\right)$.

The quantity $\left[m\left(\frac{Nex}{Nt}\right) - 1\right]$ denotes a systematic error which can occur while using the given formula.

While investigating the actual values of strength reserves specified by the building norms of the USSR, there were determined the required reserve coefficients on the condition that the reliability of structure is ensured. The approach recommended by Prof. A.R.Rzhanitsin was adopted as the basis for the analysis. For the required reserve coefficient an expression was proposed where consideration was given the changeable nature of structure initial parameters and errors in calculated formulas, the expression depends on the safety characteristic limiting the probability factor connected with the excess of structure bearing capacity under external stresses.

For the eccentrically compressed elements widely spread in seismoresistant construction which are characterized by high load eccentricity and which have the parameters $\lambda \leqslant 7$ and $\bar{e}_o > 0.3$, it was established that the norms specify the reserve coefficients within the limits 1.4 up to 1.5 ($\lambda = \frac{l_o}{h}$ - the reduced flexibility, the ratio of the element rated length to the dimension of a section along the bending moment; $\bar{e}_o = \frac{e_o}{h}$ - quantity of initial relative eccentricity, e_o - initial eccentricity. For such eccentrically compressed elements it was also obtained that the value of the systematic error of the formula $/m\left(\frac{Nex}{Nt}\right) - 1/$ - the first characteristic of accuracy makes up 0.05-0.1, the second characteristic of accuracy - the value of variation coefficient of systematic error equals 0.12.

In these works the ratios $\frac{Nex}{Nt}$ and $\frac{Nex}{Nr}$ were analysed on the assumption that the value of eccentricity e_o is unchangeable, i.e. the bending moment M and longitudinal force N increase and decrease in proportion to one and the same value. For seismoresistant frame and large-panel buildings in which the main load is a horizontal one, the coefficients of strength reserve are characterized by the ratios of the breaking and rated bending moments $\frac{Mex}{Mt}$ and $\frac{Mex}{Mr}$ but not by normal forces. These bending moments should be determined either on condition that the values N are the same (case I) or the rated values M_r should be determined on condition that longitudinal forces are high (case II). The latter is connected with the fact that the coefficient of overload included in the calculation as well as vertical acceleration of soil under seismic loads can lead to less reliability of structures.

The calculations show that the methodics of calculation used in the existing norms do not ensure the necessary strength reserves for the considered eccentrically compressed r.c. structures. For case I the ratio $\frac{Mex}{Mr}$ under constant longitudinal force makes up only 1.2-1.25, and for case II when longitudinal force increases by 10 per cent (for example, due to vertical constituent of seismic effects) the ratio can equal 1.1-1.2 with the required values of these ratios being 1.4-1.5 to ensure the reliability.

In this way, the comparison of structures strength with the stresses due to real seismic effects calculated on the basis of the clarified rated schemes, is made with strength reserves being lower. The design calculations must guarantee the strength reserves to be not lower than the required ones in order to ensure the reliability; the system of different coefficients (particularly, using the coefficient of ultimate states in new seismic norms of the USSR) can contribute to the solution of this problem.

The analysis is done for static regimes of loading, its further application for dynamic regimes of loading is a matter of future investigations.

References

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