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PREREQUISITES FOR CALCULATING THE SEISMIC RESISTANCE OF REINFORCED CONCRETE FRAME FRAME BUILDINGS AT THE ELASTOPLASTIC AND PLASTIC STAGES OF THE STRESS-STRAIN STATE

ANNOTATION The article discusses the issue of assessing the seismic resistance of reinforced concrete frame frame buildings at the elastoplastic and plastic stages of the stress-strain state. The transverse and longitudinal frames of the frame are presented as static indeterminate systems capable of resisting seismic influences outside the limits of elastic deformation, redistributing seismic forces between constituent elements and nodes.

Keywords Building, strength, seismic resistance, elastoplastic stage, plastic hinge, redistribution of forces, ultimate seismic resistance, operational seismic resistance.

The current norms of earthquake-resistant construction are proposed when calculating buildings (structures) for seismic effects can be used;

a) a dynamic calculation method for real or synthesized seismic effects typical for the construction area;

b) spectral method of calculation for seismic (conditional static) loads, determined for ideally elastic systems in accordance with the instructions in clause 2.13 [1, clause 2.6].

However, according to the scientific conviction of the authors of the article, the main part (approximately 60-70%) of the real strength of reinforced concrete structures is manifested outside the limits of elasticity. Therefore, the spectral method of calculating seismic (conditional static) loads, determined according to the guidelines [1], as for ideally elastic systems, leads to unreasonable huge reserves of seismic strength and during design allows excessive overrun of steel reinforcement and high-strength concrete.

Basic prerequisites for the calculation

To calculate the ultimate resistance of the frame to seismic effects, the following assumptions are made:

the calculation is carried out according to the fundamental tone of the oscillations;

loss of seismic strength occurs by overturning with a bend around an axis passing through the left or right bottom edge of the building;

in seismic influences, plastic deformations of sufficient length are formed, contributing to the redistribution of forces in the design sections of reinforced concrete bearing frames;

in the limiting state, plastic hinges are formed at the nodes of the remote columns from the tipping line located above the elevation under consideration, they cover only the columns, and no hinges are formed in the cross-sections of the girders, but nodal balancing bending moments appear, their total values at the node are equal to twice the values of the plastic hinges formed on the nodal sections of the columns;

constant loads acting through the columns form moments against overturning;

the efforts of the columns form moments against overturning with bending, the shoulder of which is determined by the vertical projection of the distance between the center of the column under consideration and the overturning line;

in solid walls, located along the plane of the frame, shear forces directed against the horizontal seismic force, the height of the resultant relative to the floor surface is determined as the center of gravity of the trapezoidal diagram of the distributed force.

The ultimate resistance of the frame is composed of the moments of the above mentioned efforts.

The elastic-plastic resistance of reinforced concrete multi-storey frames against overturning with bending is also determined according to the above algorithm. It is assumed that the beginning of the formation of plastic hinges occurs only on the most distant row of columns relative to the tipping line. The longitudinal forces of the remaining columns are determined by the triangular distribution law.

The operational resistance of reinforced concrete multi-storey frames against overturning with bending is also determined according to the above algorithm. In this case, it is assumed that on the most distant row of columns from the tipping line, cracks with an allowable width are formed and open, the tensile strength of the columns is ensured due to the strength of the reinforcement. The longitudinal forces of the remaining columns are determined according to the triangular distribution law.

Ultimate bending moments in normal sections of columns at the stage of onset of yield are determined by the formulas of the norms [2].

$$Mc = Mc' = \sum Asi * Rs * h_0 * \eta \quad (1)$$

Ultimate longitudinal forces in the reinforcement of the columns at the stage of the onset of yield in the state of seismic overturning:

$$[Nk] = (ns * \pi * d2/4) * Rs \quad (2)$$

Elastoplastic resistance of reinforced concrete columns on the verge of cracking arising at the level of floor slabs:

$$M_c = M_c' = R_s*(R_{bt}/E_b)*A_s*h_0+R_{bt}*W_b = R_s*(R_{bt}/E_b)*A_s*h_0+R_{bt}*(b*h_0^2/6) \quad (3)$$

Longitudinal forces in the extreme columns on the verge of cracking in the state of seismic overturning are determined by the formula:

$$[Nk] = (ns*\pi*d2/4)*Rs*(R_{bt}/E_b) + Rbt*b*h_0 \quad (4)$$

Elastic seismic resistance is determined by the formula

$$M_{crc\ i} = R_s*(R_{bt}/E_b)*A_s*h_0*(l_i/l_{max}) + R_{bt}*W_b*(l_i/l_{max}) = R_s*(R_{bt}/E_b)*A_s*h_0*(l_i/l_{max}) + R_{bt}*(b*h_0^2/6)*(l_i/l_{max}) \quad (5)$$

The value of the shear resistance of brick walls is determined by the formula (23) of the norms [3].

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