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THE STRENGTH AND DEFORMATION OF THE JOINTS OF COLUMNS AND CROSSBARS IN BUILDINGS FROM LOW-CYCLIC - SEISMIC LOADS

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Abstract:
Examining damaged reinforced concrete buildings, low concrete strength was noted, errors in the installation and joining of fittings, the absence or small number of clamps, etc. As a result, a frame building made of monolithic reinforced concrete may collapse.

Keywords: Reinforced Concrete Nodes, Columns, Crossbars, Rebars, Deformation, Stiffness Of Nodes, Destruction, Testing, Frames.

INTRODUCTION:

Any building is a complex structure, the quantitative assessment of which, even in the simplest case of static impact of uniform vertical loads, can be made only approximately, with more or less serious deviations from the actual working conditions of buildings. [6].

The main part: As it was established, buildings with a frame of monolithic reinforced concrete and steel successfully withstood the test of seismic resistance in many strong earthquakes. [8,9]. At the same time, it was found that with poor-quality work, and sometimes due to errors made in the project, both reinforced concrete and steel frame structures were subjected to significant damage, and in some cases, collapses.

P.M. McCafferty and M.L. Moody [1] investigated the dynamic characteristics of reinforced concrete units, which are a connection of an I-beam column with a size of 30.5 x 38x412 cm. with a rectangular cross-section crossbar with a size of 30.5 x 46x182 cm. The longitudinal reinforcement was assumed to be the same, while the transverse reinforcement varied within the joint. In one of the series, there were no clamps within the joint. The dynamic impact simulated the El Centro earthquake in 1940, the intensity of which was reduced by 5 times. The intensity of the impact was varied to obtain various degrees of destruction of the sample. Some nodes are tested by static loading. At each stage of the test, a constant load of 453 kN was applied to the column, which the column carries under normal operating conditions. At the first stage, the sample was tested until small cracks appeared, which are common in operational conditions. On II -until the appearance of medium through cracks within the joint. On III - until complete destruction. After each stage, dynamic characteristics were determined.

Natural frequencies, attenuation coefficients, moments of inertia of the bolt, respectively, were: 18 Hz, 2.3% and 1.15 * 105 cm4 (after stage I); 11 Hz, 2.7% and 1 • 105 cm4 (after stage II); 9 Hz, 2.4-6% and 0.88* 105 cm4 (after stage III).

The transverse reinforcement outside the node had practically no effect on its dynamic characteristics. On the contrary, the transverse reinforcement within the joint significantly affected the nature of the destruction. When testing all types of samples, chipping of the surface layer of concrete was observed, excluding those samples (type 3) in which 4 clamps (Ø≈9.5 mm) were placed within the joint. The authors note that such an amount of transverse reinforcement within the joint is half of the minimum amount required by the norms.

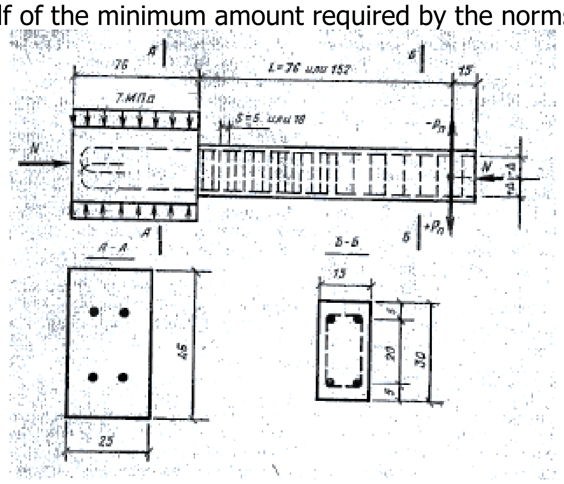

Fig.1. A sample (cm) simulating a frame assembly

The work [2] is devoted to the study of the bearing capacity of reinforced concrete frame nodes under repeated loads in the inelastic stage. The column is connected to the crossbar by means of anchor rods, which are a continuation of its working fittings (Fig. 1). The column had less reinforcement compared to the crossbar (p = p' = 0.006 or 0.0104).

A repeated alternating load ±Ph was applied vertically at the end of the console.

The maximum deflection during the test exceeded the permissible Δy by 5-10 times. Some of the samples were tested with additional loading with a constant axial force equal to 0.5 and 0.75 and a limit value at which the bolt loses stability.

It was found that with an increase in the percentage of longitudinal reinforcement from 1.5 to 2.62%, the shear force perceived by the sample increases. With an increase in the distance between the clamps from 5.1 to 12.7 cm, the number of cycles before destruction decreases. The samples reinforced with steel with yield limits of 315 and 420 Mpa had almost the same strength and rigidity. Samples with a length of 152.4 cm with a lower shear force withstood a greater number of cycles before destruction than samples with a length of 76.2 cm withstood. An increase in the deflection amplitude from 5 Δy to 10 Δy led to a decrease in the number of cycles before failure. In samples with a deflection of 10 Δy, plastic deformations developed intensively in the sealing of the crossbar, which contributed to intensive energy absorption. Violation of the adhesion of anchor rods with concrete led to the destruction of the sample after two cycles.

Axial loading had a slight effect on the change in the bearing capacity and stiffness of the node.

A significant difference in the nature of destruction was observed in samples tested with and without axial load. Samples tested without axial loading were destroyed by shear. With an increase in the number of loading, the strength and rigidity of the samples decreased. They are characterized by large shear deformations, which led to the formation and opening of vertical and diagonal cracks. The loaded samples were destroyed by shear with buckling of the rods as a result of longitudinal bending. Bulging was accompanied by severe destruction and staining of concrete in the node area.

It has been established that the main reason for the destruction of a 20-storey reinforced concrete frame building in Venezuela caused by the 1967 earthquake is the achievement of maximum tensile stresses in the columns that were not taken into account by calculation.

V. Townsend and R. Hanson [3] investigated the effect of axial stretching on the bearing capacity of nodes during repeated loading. The prototypes were calculated according to the existing American standards for the design of earthquake-resistant structures. When determining the bearing capacity of the nodes, the yield strength of steel was introduced into the calculation. The strength of concrete was 28.1 MPa.

A transverse repeated load was applied at the ends of the crossbar, and a constant axial load was applied along the axis of the column. The load level was assumed so that plastic deformations occurred in the reinforcement. With an increase in the level of plastic deformation, the stiffness of the node decreased intensively.

R. Park and T. Pauley [4] subjected the external interstitial nodes of the reinforced concrete frame to repeated alternating loads simulating a strong earthquake. The samples of the four series were full-size nodes (Fig. 2), consisting of a column 38x33x266 cm and a crossbar 25x45x175 cm. The length of the free ends of the crossbar and column was chosen so that the ends of the elements coincided with the zero points of the plots of the bending elements of the frame.

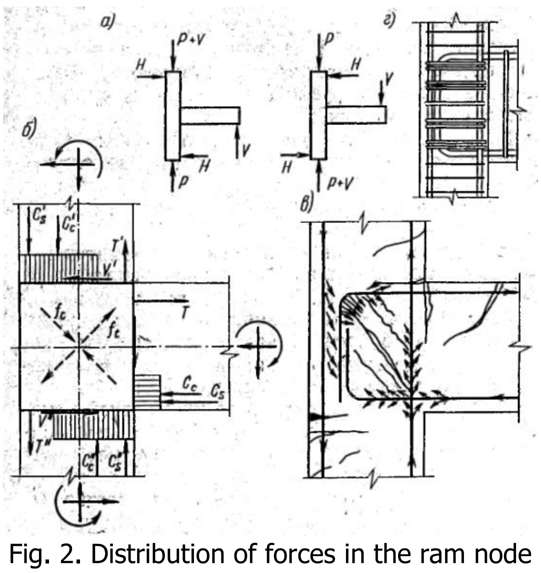

Fig. 2. Distribution of forces in the ram node

a - the loading scheme of the node; b - the stress state in the central zone of the node;

c - distribution of stresses from the forces of adhesion between concrete and steel; d, d - reinforcement of the central zone of the node

In the neutral zone of the node, the main tensile ft and compressive fc stresses arise (Fig. 2., b). These stresses can reach a significant value and cause oblique cracks in the node zone. At the site of the bends of the anchor rods, the main stresses increase (Fig. 2., c), therefore, as already noted in [1], the central part of the node needs transverse reinforcement to perceive shear forces. Since the authors [4] were interested in the bearing capacity of the central zone of the node, the samples were designed in such a way that the plastic hinge appeared either in the crossbar or in the column. So, in the samples of two series, the bearing capacity of the crossbar was less than the total bearing capacity of the column. On the contrary, in the samples of the other two series, the appearance of a plastic hinge was expected, first of all, in the column.

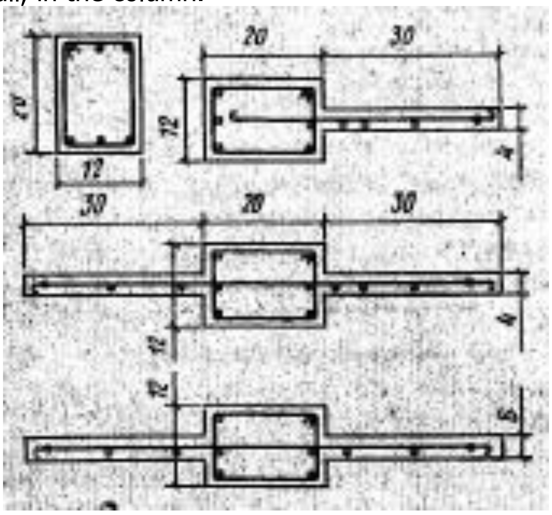

Fig. 3. Cross sections of reinforced concrete crossbars

Repeated loading of the node was carried out by a static alternating load V and H (Fig. 2., a), corresponding to a plasticity coefficient of 2.5-10, and in some cases 15-20 (the plasticity coefficient is equal to the ratio of curvature 0 at any load V to the curvature 0u corresponding to the elastic limit of the concrete crossbar). Half of the samples were tested with an axial load equal to 16% of the maximum bearing capacity of the column. [7].
All samples were destroyed outside the central zone of the node. With an increase in the number of loads, the bearing capacity of the node decreases. The minimum load-bearing capacity was for samples with anchoring of the longitudinal reinforcement in the form of a closed loop.

An increase in the percentage of reinforcement of transverse reinforcement in the central zone of the node contributed to an increase in the crack resistance of concrete and the bearing capacity of the node. It is noted that the destruction of concrete in the central part of the node from repeated loading occurs when the transverse reinforcement reaches the yield strength. Compared to other samples, nodes with protrusions had the maximum load-bearing capacity. The intensity of the decrease in their bearing capacity with an increase in the number of loads is significantly less, therefore it is recommended to increase the number of transverse reinforcement in the node area, the free length of the anchor, and also provide protrusions in the nodes.

The work [5] is devoted to the research of reinforced concrete elements under skew-symmetric alternating repeated loadings in the elastic-plastic stage. Prototypes in 1/3 of the natural size were made of four types (Fig. 3., a), a crossbar with a cross section of 20x12 cm; a crossbar-a wall on one side; a crossbar-a wall with a thickness of 4 and 6 cm, on both sides (3rd and 4th types).

The skew-symmetric repeated load was applied in stages, increasing after 3-4 cycles by 1/3 - 1/4 of the magnitude of the destructive load (Fig. 3., b). At the beginning of the test, a part of the samples was tested with a repeated load corresponding to the elastic stage of work, and then, with a smoothly increasing single load, it was brought to destruction.

MAIN CONCLUSIONS

1. The nature of the destruction depended on the size, shape, transverse and longitudinal reinforcement.
2. A separate crossbar and a crossbar in combination with the upper wall were destroyed at the support from bending.
3. The longitudinal stretched reinforcement reached the yield strength (388-409 Mpa), and concrete with a compressive strength of 15-20.3 Mpa was destroyed by extreme tensile stresses.
4. In most samples, the destruction of the compressed zone of the concrete wall was observed during bending. Some of them collapsed from the cut.
5. The destruction from the cut occurred in samples with a very small percentage of transverse reinforcement of the walls and the crossbar.

LITERATURE

1. McCafferty R. M. Moody M. L. Dynamic Characteristics of Reinforced Concrete Beam Column Specimens for Various Levels of Cracking.
2. Jirsa J.O. Factors Influenoing the Hinging Behaviour of Reinforced Concrete Member under Cyclic Overloads.
3. Tso W.K. Pollner E. Heiderbrecht A.C. Cyclic Loading on Externally. Reintorced Masoniry Walls.
4. Park R. Paulay T. Behaviour of Reinforced Concrete External Beam - Column Joints under Cyclic Loading.
5. Higashi Y., Ohkubo M., Lida K. Elasto – Plastic Behaviour of Reinforced Concrete Beams with Spandrel Walls under Anti - Symmetric Cyclic Loads.
6. Rzhevskiy V. A. "Study nestatsionarnykh elastoplastic systems with multicomponent seismic effects (structural mechanics and calculation of structures)", 1989, No. 3, pp. 54-58.
7. Skladnev N. N., Glades I. S. "Building design diagrams of deformation of reinforced concrete structures under cyclic alternating loads (scientific and technical abstract collection de La direction)", 1987, ser. 28. issue 14, pp. 16-18.
8. Rzhevsky V.A. "Seismic resistance of reinforced concrete frame buildings (Architecture and construction of Uzbekistan)". 1992 No. 1 p. 1-6.
9. Rzhevsky V.A., Novoselya A.V. Investigation of seismic resistance of reinforced concrete frame with elements of rigidity (Architecture and construction of Uzbekistan) 1992 No. 5, pp. 31-34.