Reinforcement of First Floor Reinforced Concrete Columns with Metal Ring

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ABSTRACT

This article provides a calculation of a metal clip used as a reinforcement for reinforced concrete columns of reconstructed buildings. In addition, information is produced on the materials used and the technology for performing reinforcement.

Keywords: Metal clip, square, spacers, reinforcement, flexibility, result, support, column, element.

Introduction. It is known that in order to study the real load-bearing capacity of reinforced concrete and other structures, it is necessary to check and evaluate their technical condition. The purpose of this is to make a decision on the necessity and expediency of strengthening and to choose an effective method of strengthening, to strengthen structures, to increase their load-bearing capacity, and to ensure the earthquake resistance of the building. For this, it is necessary to calculate the reinforced structures, in particular, reinforced concrete columns and the building under the influence of seismic forces [1,2,3].

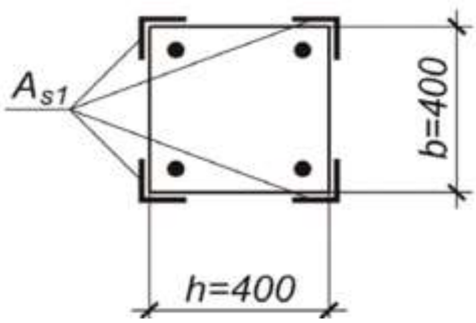
The main part. The value of the calculated longitudinal force on the column from full load N_1 = 2792.28 kN and the load carrying capacity of the column N = 1640.34. kN 3 – determined at the beginning of the section.

Required amplification factor

k= N_1/N=2792.28/1640.34=1.702, these are 70.2% excess load.

Calculation of column reinforcement with prestressed beams

In this way, the development of the column strengthening technology can be considered as providing the column with pre-stressed vertical angles, while the steel structure is reinforced with additional external reinforcements. The computational section is shown in Fig. 1.



1 – picture. The calculated cross-section of the column is reinforced with pre-stressed struts[5].

1. We determine the coefficient φ depending on the elasticity l_0 / h = 12 (see [2, Table 6.2], Table 3.3 Appendix 3) we take φ = 0.872 [4].

2. We calculate the required cross-sectional area of the pillars, we make them from equal angles.

$$A_{s1} = \frac{\frac{N}{\varphi} - (R_b \cdot \gamma_{b1} \cdot A + R_{sc} \cdot A'_s)}{m \cdot R_y} =$$

$$= \frac{2792.28}{0.872} \cdot \frac{(11.5 \cdot 10^3 \cdot 0.4 \cdot 0.4 + 280 \cdot 10^3 \cdot 804 \cdot 10^{-6})}{0.85 \cdot 240 \cdot 10^3} \cdot 10^4 == 64.76\, sm^2,$$

where m = 0.85 is the coefficient of working conditions of prestressed poles;

R_y =240 MPa- calculated resistance for beams made of C245 steel.

From the assortment (see Table 4.3, Appendix 4) we take 4L125 × 8 ($A_{s1,f} = 19.69 \cdot 4 = 78.76\, sm^2$) [4].

4. We check the flexibility during the installation of the studs in the sections where the elements are bent to the supports on the concrete above or below (Fig. 1).

$$\lambda = \frac{l_{01}}{i_1} = \frac{240}{3.87} = 62.0,$$

where $l_{01} = l_0/2$ is the actual length of the pole, we accept $l_{01} = H_{qav}/2 = 4.8/2 = 2.4$ m = =240 cm; The radius of inertia of the pole relative to the axis (see Fig. 2) is equal to the radius of one corner of the pole determined by calculation $i_1 = i_x = 3.87$ cm.

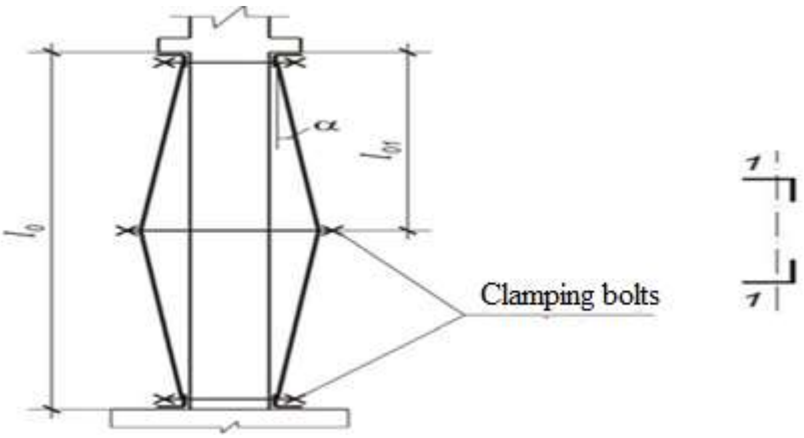


Fig. 2. To check the installation flexibility of the beam and to determine the bending value α[5].

From 62.0 < 100, the cross-section of the accepted support angles enough Otherwise, it needs to be enlarged.

5. We determine the angle of the support in order to ensure the strength of the concrete element, because the pillars rest on them. In our case, this console is a permanent section (hidden console) 3 - picture.

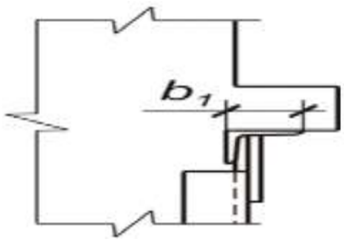


Figure 3. To calculate the angle of support [5]

$$b_1 = \frac{N}{0.8 \cdot R_b \cdot b} = \frac{275.66}{0.8 \cdot 11.5 \cdot 10^3 \cdot 0.4} = 0.075\, m = 7.5\, sm,$$

where b = 0.4 m is the width of the column section;

N is the force transmitted to the console during alignment of the studs,

$$N = \sigma_{sp} \cdot \frac{A_{s1,f}}{2} = 70 \cdot 10^3 \cdot \frac{78.76 \cdot 10^{-4}}{2} = 275.66\ kN;$$

where σ_{sp} is the prestress value of the stud, it is set in the range of 60...80 MPa.

According to the calculation results, we accept the equilateral angle L80 × 8 we do

6. We determine the amount of bending of the beam at the specified value σ_{sp} = 70 MPa (see Fig. 3) [4].

According to the graph (Appendix 5) we get i = tga = 0.03, from here a = arctg 0.03 = 1.720 [4].

We determine the load-bearing capacity of the reinforced column section.

1. We accept the coefficient φ = 0.872 [4].

2. We calculate the longitudinal force received by the column of the first floor after reinforcement.

$N_f = \varphi \cdot [(R_b \cdot \gamma_{b1} \cdot A + R_{sc} \cdot A'_s + m \cdot R_y \cdot A_{s1,f})] = 0.872 \cdot [(11.5 \cdot 10^3 \cdot 0.9 \cdot 0.4 \cdot 0.4 + 280 \cdot 10^3 \cdot 804 \cdot 10^{-4} + 0.85 \cdot 240 \cdot 10^3 \cdot\cdot 78.76 \cdot 10^{-4})] = 3041.38\ kN.$

3. Longitudinal force taking into account the load from the weight of the additional pole

$$N'_1 = N_1 + N_{qo\prime sh} = 2792.28 + 3.0 = 2795.28\ kN.$$

where N_{double} = 4·g·l = 4·15.6·10·4.8 = 2995.2 N≈3.0 kN.

$$N_f > N'_1;$$

$$N_f = 3041.38\ kN > N'_1 = 2795.2\ kN.$$

Condition fulfilled; so the load of the column after strengthening enough carrying capacity. Resilience reserve

$$\frac{N_f - N'_1}{N'_1} \cdot 100\% = \frac{3041.38 - 2795.2}{2795.2} \cdot 100\% = 8.80\%.$$

If the condition is not met, that is. $N_f < N'_1$, it is necessary to increase the cross-sectional surface of the angle of the struts ($A_{s1,f}$).

- **Reinforcement of the column with reinforced concrete prestressed beams is carried out in the following sequence:**

- floor structure up to the upper edge of the foundation (or between to the level of the cover plate) opens;
- the surface of the column is cleaned from the layer of plaster, damaged concrete parts are removed;
- concrete protective layer of the column in the upper and lower zones of the column disintegrates;
- the support angles are strictly horizontal to the cement-sand mixture is installed so that the inner surface of the vertical flange is the same as the side surface of the reinforced columns;
- the concrete surface of the columns is leveled with a cement-sand mixture;
- braces on pre-made side racks from steel angles they are made between cuts of their length and welded to the corners at the top and bottom with plates (planks);
- the studs are bent and then installed in the project position (cement-sand mixture after a set of strength equal to 70% of the project);
- upper and lower planks are attached to the column with mounting bolts;
- the nuts of the middle connecting bolts the angles of the studs are complete stretched until smooth;
- connecting planks from the middle, successively up and down welded;
- tightening bolts are removed;
- the surface of the reinforced column is plastered along the grids [4].

Calculation of the reinforcement of the column with a conventional metal ring

The calculation of the metal ring is carried out as an independent system (Fig. 4).

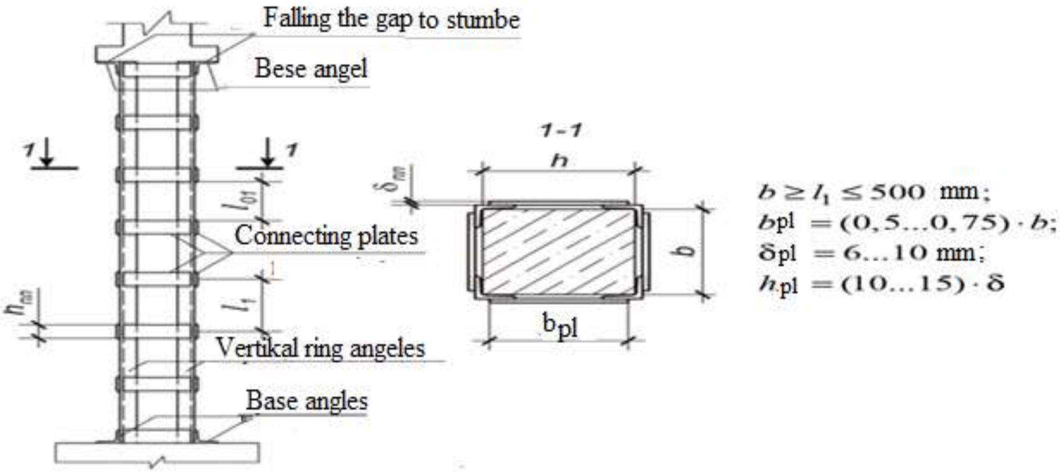
1.We determine the calculated longitudinal force transmitted to the metal open column, surrounded by the existing reinforced concrete - reinforced structure:

$$N' = N_1 - N = 2792.28 - 1640.34 = 1151.94\ \text{kN}.$$

2. We calculate the required cross-sectional area of right angles through the accepted φ = 1.0,

$$A_{s1} = \frac{N'}{\varphi \cdot R_y \cdot m} = \frac{1151.94}{1 \cdot 240 \cdot 10^3 \cdot 0.8} \cdot 10^4 = 60.0\, sm^2,$$

where m is the coefficient of operating conditions depending on the degree of load shedding (m = 0.7 - by 25% in discharge; m = 0.8 - by 50%; m = 0.9 - by 75%; m = 0.95 - at full discharge). When reducing to 50%, we get m = 0.8.



4- picture. The scheme of strengthening the column with a traditional metal ring [5].

4.100×8 ($A_{s1,f}$ = 15.60· 4 = 62.40 cm^2 ; ix = 3.07 cm) can be accepted according to the required cross-sectional surface of vertical angles.

We determine the actual load-bearing capacity of the metal ring

1.The relative length of the right angles of the ring to their reinforced concrete column is determined taking into account its installation and fastening with transverse planks. Conditionally (with a reserve of strength) we get the calculated length of the corner l_{01} = l_1 = b = 400 mm = 40 cm, where b=400 mm is the width of the column section.

2.Flexibility

$$\lambda = \frac{l_{01}}{i_x} = \frac{40}{3.07} = 13.0,$$

where ix = 3.07 cm is the radius of a corner. [6, ch.. 72] we accept φ = 0.979 [4].

3.The calculated value of the longitudinal force received by the vertical corners of the metal ring is equal to:

$$N'_f = \varphi \cdot R_y \cdot A_{s1,f} \cdot m = 0.979 \cdot 240 \cdot 10^3 \cdot 62.4 \cdot 10^{-4} \cdot 0.8 = = 1172.92\, kN > N' = 1151.94\, kN \cdot$$

The load-bearing capacity of the corners of the metal ring is sufficient.

The stability reserve will be:

$$\frac{N'_f - N'_1}{N'_1} \cdot 100\% = \frac{1172.92 - 1151.94}{1151.94} \cdot 100\% = 1.82\%.$$

It is necessary to increase the reserve strength of the reinforced column if, the cross-sectional area of the right angles should be increased $A_{s1,f}$.

• Work on strengthening the column with a metal ring is carried out in the following sequence - is done as follows:

- as many loads as possible are unloaded from the reinforced column;
- floor structure up to the upper edge of the foundation (or intermediate covering to the level of the plate) opens;
- the concrete surface is leveled (split) along the faces of the column;
- steep reinforcement corners are installed on the cement-sand mixture and it is fastened to the pole with clamps;
- minimum cross-section of a column reinforced with transverse planks at the

corners welded with a step no larger than;

- network supports of the ring in the elements of the intermediate cover and

column console,strengthening is carried out by welding the supporting corners at the top and bottom of the structure;

- the gap between the upper support corners of the column consoles

after filling with expanding cement by pouring a cement-sand mixture over it (or by hammering steel studs), vertical reinforcement angles are put into operation;

- the surface of the reinforced column is plastered along the grids [4].

Conclusion. A damaged building to be reconstructed the calculation method mentioned in the article can be used to calculate the strengthening of reinforced concrete columns. According to the results of the calculations, it is possible to find an answer to the question of whether the reinforcement can provide sufficient additional load-carrying capacity. Based on the results of the calculations, it is possible to make appropriate recommendations, and their application helps to ensure the reliable operation of the construction being strengthened.

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