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BUTT JOINTS OF LONGITUDINAL REINFORCEMENT MONOLITHIC COLUMNS.

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In this article the variants of jointing of the longitudinal reinforcement of columns in the designing of monolithic multistory buildingsare discussed. There are made recommendations for the choice of method of jointing the reinforcement.

In the construction industry in the formation of reinforcement cages regulations for the continuity of the rebar to the entire length of the structureareprovided. As a rule, the maximum continuous length of rebar is limited as follows:

- The maximum length of rebar (from 11.7 m transportation conditions).
- Design considerations (for example, in the formation of columns installed rod length does not exceed the height of two floors).

To ensure continuity of reinforcement rods separate in-built conditions, the following methods are used:

- joints of reinforcing bars without welding lap joint (Fig. 1);
- splicing of reinforcement by welding;
- joints in reinforcing bars using special mechanical devices, for example, crimping or threaded couplings.

Fig. 1. Joints of valves without welding, The OVERLAP of rebar

The most common at the moment is the junction of the overlap, but it has a number of drawbacks, and its scope is rather limited. Among the disadvantages of this method should be noted: the consumption valves at the junction of the overlap in structures having sections where, due to the overlap of the reinforcement is doubled and there are difficulties with the concrete mixture.

Depending on conditions of valves and the number of joints in one section, overlap length leads to the loss of from 3.5 to 27% of rebar in its diameters and length of the abutting rods 6.0 m. The highest metal losses occur when matching rods of large diameters – accordingly to [1]. However, the problem is not limited to this. To guarantee the strength of such a connection requires a significant consumption of transverse reinforcement and minimum values of volumetric reinforcement should be, for example, not less than with concrete strength.

In addition, the use of lap joints for joining the armature of big diameters leads to restriction of the volume of concrete in the joint and the danger of reducing the actual strength of reinforced concrete element, which is especially dangerous in the columns and other compressed under the operation of reinforced concrete elements of relatively small cross-section.

For this reason, as shown practice, the cost of joining goes to the second plan.

The chief is the operational safety of the building. Therefore, in most countries, including the UK, USA, Germany, for splicing rebar diameter used mechanical connections, guaranteeing the reliability of the structure.

In our country is still generally accepted method of connection valves for installation welding: manual arc long seams, lap joint, and with linings, bath suture and layered seams on steel clamp-plate and arc in the cross.

For the splicing of reinforcing steel these types of arc welding can be applied almost without limit, but require significant energy consumption and labor costs, and strict systematic control.

An alternative to traditional methods of splicing reinforcement is received at the moment, a wide spread method of splicing rebar using threaded end connections. There are several concepts jointing fittings for couplings with cylindrical thread, crimp couplings and couplings with conical thread [2, 3].

The joints of the longitudinal reinforcement of the columns in monolithic multi-storey buildings are set in the top of the slab. The unit joints, due to the way the butt joint rods, and a set of design requirements.

In SNP 5. 03.01-02 it is not recommended to use lap bars with the diameter more than 25 mm, and the docking of lap bars with the diameter more than 36 mm are not allowed. Besides, the length of overlap in SNP 5. 03.01-02 reaches 40–50 diameters of the abutting rods ,which is about 40% of the height of the floor of a residential building. In this regard, the use of connecting rods of rebar overlap also becomes economically disadvantageous.

To reduce the consumption of steel and facilitate the concreting of the columns with the reinforcing bar diameter or more we should perform the splicing of rebar in the end through a bath of weld or crimp couplings [4]. When the diameter of the reinforcing bars is prior to and include the valves lapped it should be fit without welding.

Figure 2 shows a diagram of the intersection of the longitudinal bars of the column with reinforcement bars in top of slab with the same and different cross-section columns, lower and upper floors. In this case, the transfer of the rods from one floor to another column by limb releases with a slope not exceeding 1: 6. Part of the rods of the columns of the lower floor can be brought to the top of the ceiling and did not start at the top of the column, if the interrupted reinforcement by calculation is not needed in the column of the top floor [5].

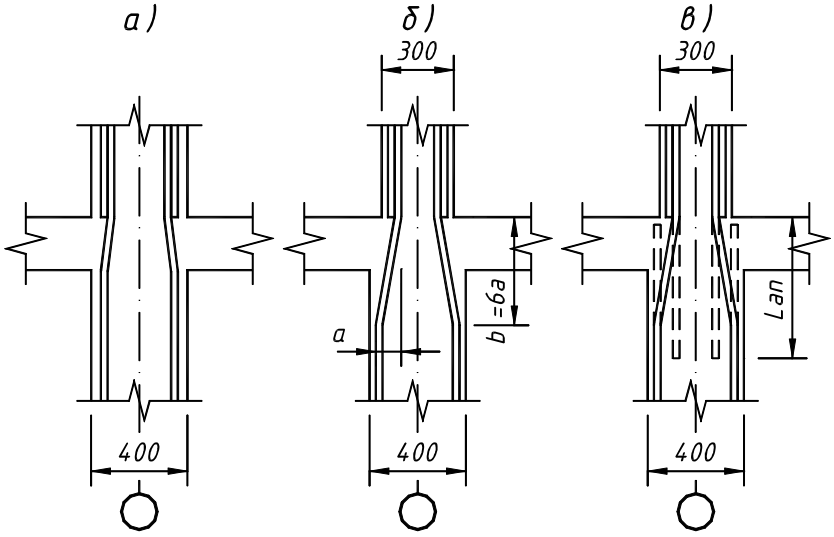

Fig. 2. Diagram of intersection of the longitudinal bars of the column with reinforcement bars in top of slab (transverse reinforcement of columns, reinforcement of the floor slab is not shown):
a) with the same cross section of columns, lower and upper floors;
b) at various cross-section columns, lower and upper floors;
c) at various cross-section columns, floors and breakage of the longitudinal the bars of the lower column

In accordance with the recommendations given in [5], when constructing the longitudinal joint of rods of monolithic columns with reinforcement bars bar diameter is not limited to diameter $d_s = 18$ mm, and to $d_s > 28$ mm and to reduce the consumption of rebar at floor height or less 3,6 m when the joints of the longitudinal bars of the column are made through the floor.

The calculation of the required anchorage length shall take into account the type of reinforcing steel and properties of adhesion to cores is determined by the formula [6; 7, the formula (3.41)].

$$l_{bd} = \alpha_1\alpha_2\alpha_3\alpha_4\alpha_5 l_{b,rqd} \geq l_{b,\min},$$

Where α1, α2, α3, α4 and α5 shown in Table 8.2 [6] factors:

α_1 – to account for the influence of the shape of rods with adequate protective layer;

α_2 – to account for the effect of the minimum thickness of the protective layer of concrete;

α_3 – to account for the effect of enhancing the transverse reinforcemen;

α_4 – to account for the influence of one or more cross-weldedrods (∅t > 0,6∅) along the effective length of anchoring;

α_5 – to account for the influence of transverse pressure to the plane of splitting along the design anchorage length.

$$l_{b,rqd} = \frac{\varnothing}{4} \cdot \frac{\sigma_{sd}}{f_{bd}} = \frac{\varnothing}{4} \cdot \frac{\sigma_{sd}}{2{,}25\eta_1\eta_2 f_{ctd}},$$

the basic length of the anchoring, which in turn depends on the design resistance of the reinforcement f_{yd} to tension, the estimated resistance of concrete to tension f_{ctd} .

η_1 – the factor taking into account the quality of the grip conditions and position of bars during concreting:

η_1 = 1,0 – if achieved good adhesion and

η_1 = 0,7 – for all other cases and for structural elements that were made with the use of slip formers, unless it can be shown that provided good adhesion;

η_2 – the factor taking into account the diameter of the rod:

η_2 = 1,0 (∅ ≤ 32 mm);

η_2 = (132 – ∅)/100 (∅ > 32 mm);

Piece $\alpha_2\alpha_3\alpha_5 \geq 0{,}7$;

for anchorage in compression:

$$l_{b,min} \geq \max\left[0{,}6 l_{b,rgd};\ 10\varnothing;\ 100 \text{ mm}\right].$$

In any case, the actual length of embedment shall not be $0,6\ l_b$, and equally and no less $15\varnothing$.

So when used for the erection of monolithic pillars of concrete $C20/25$ and installation of rebar in the column, the base of Dean Embedment is:

$$l_{b,rqd} = \frac{\varnothing}{4} \cdot \frac{\sigma_{sd}}{f_{bd}} = \frac{18}{4} \cdot \frac{435}{1{,}82} = 1075 \text{ mm},$$

$$f_{bd} = \eta_1 \cdot \eta_2 \cdot f_{ctd} = 0.7 \cdot 1 \cdot 2{,}6 = 1{,}82 \text{ MPa}.$$

In the absence of stock on the valves and the compressive stress of the longitudinal bars of the column (α = 0,9), the length of the reinforcing editions is:

$$l_{bd} = \alpha_1\alpha_2\alpha_3\alpha_4\alpha_5 l_{b,rqd} \geq l_{b,\min},$$

$l_{bd} = 0{,}7 \cdot 1052 = 752{,}5 \geq 645$.

Figure 3 shows an example of a device of the joint of reinforcing bars by using the reinforcement bars in top of slab. The length of the reinforcing editions of four rods in the corners of the column is the $2 \times l_1 = 2 \times 550 = 1100$ мм . Length of the reinforcing releases for the rest of the rods of the column is thus 550 mm, the area of the longitudinal bars of the column, docked in one place, is 50%.

If the column is reinforced with four longitudinal bars, the joint bars without extension arearranged.

The length of the reinforcing editions of leaves:

$$l_{bd} = \alpha \cdot l_b \cdot \frac{A_{s,req}}{A_{prov}} = 2 \cdot 785 \cdot 1 = 1570 \text{ mm}.$$

It should be noted that columns in the modern multi-store multi-use buildings are characterized by the emergence of considerable effort because of the increased cargo space of columns, number of storeys of buildings and loads. Therefore, the provisions of [4] allowed the increase of the reinforcement ratio of the columns (including the areas with lap joint rebar) before 10% .

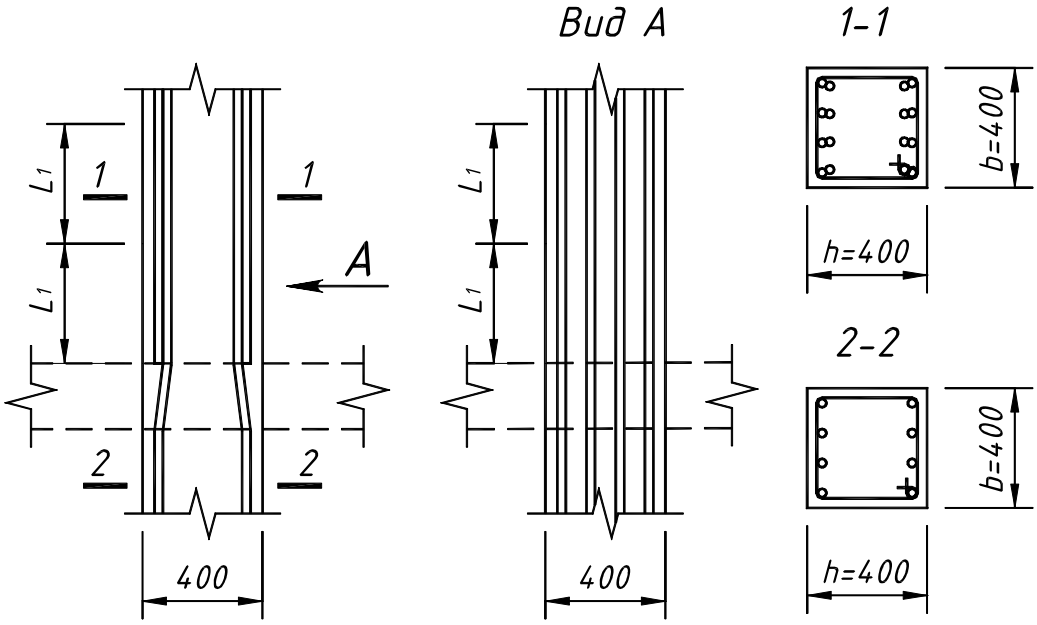

Fig. 3. An Example of a device of the joints of the reinforcing bars are spliced without welding

The reinforcement ratio may be reduced by the use of welded and mechanical joints of reinforcement due to the absence in these compounds the pen start, and accordingly the thickening of the valve.

Figure 4 a shows the design of the junction of the rods the longitudinal reinforcement of the column using a bath welding ($d_H = 20-40$ mm, $d_H / d_H' = 0,5-1$, S500).

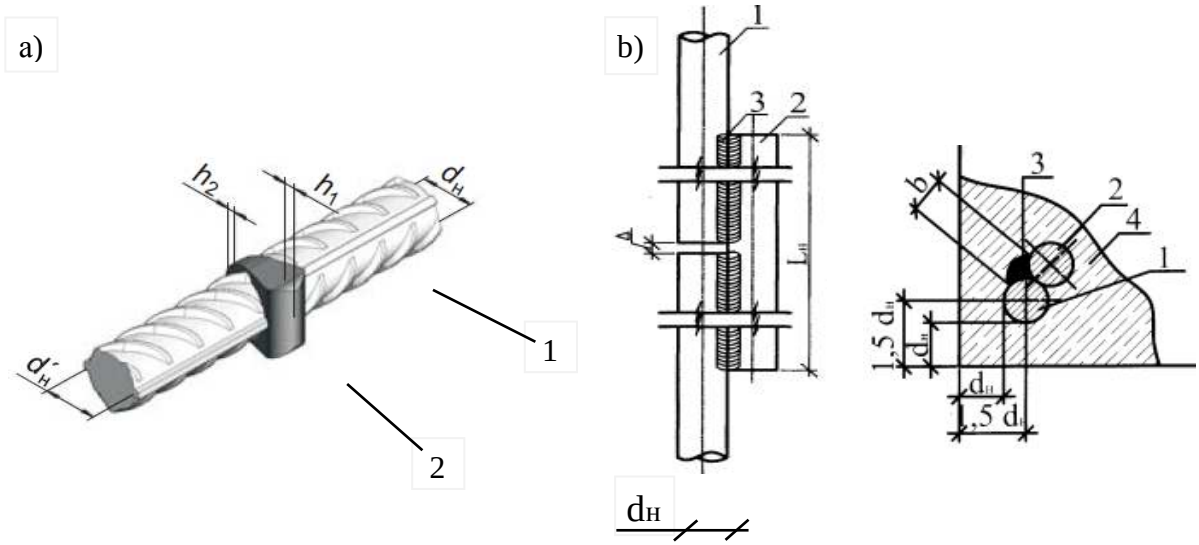

Fig. 4. The design of the junction of rods longitudinal reinforcement
columns with the use of welding bath:
a) no overlays: 1 – working-valves, 2 – weld;
b) pick guard: 3 – panel, 4 – concrete columns

When connecting the valve with the use of welding bath in selection, design and dimensions of the joint shall be in accordance with the procedure outlined in [10].

The joint of rods of longitudinal reinforcement with the use of welding bath and overlays is shown in figure 3b ($d_H = 20-32$ mm, $d_H = d_p$, $S500$) [11].

The design of the building, the choice of junction of the longitudinal bars of the columns by welding must be technically and economically feasible, as related to the technological capabilities of construction organiza-

tions in terms of the availability of equipment, qualified welders and the ability to organize the regulation of quality control of welding works.

The butt joint of the reinforcing rods can be provided without welding with couplings (crimp and screw).

Equipment for mechanical connections using crimp couplings represented in the domestic construction market hydraulic crimping presses SN-50/80, SN-90/80, PP-A80. Press and crimp couplings designed for joining of reinforcing bars of the same diameter Ø16-40mm and different diameters Ø36/Ø32, Ø36/028, Ø32/Ø28, Ø32/Ø25 mm classes A400, A500C, A600C [12, 13].

The advantage of the connection reinforcing bars using crimp couplings is saving of rebar compared to the butt lap joint, the simplicity of training and the relative speed of execution of the junction (10 min) in comparison with a welded joint. However, the size (650 × 250 × 160 mm) and weight (35 kg) crimping tool can make it difficult to use crimp couplings for joining rods of the longitudinal reinforcement of monolithic columns in a specific building project.

Threaded couplers for splicing reinforcement in the construction market presents couplers Lenton Dutch ERICO. They are used for splicing reinforcing bars periodic profile with a diameter from 12 to 40mm of classes S400, A500C. The abutting members can be of the same diameter (standard coupler connection type A12) and different diameters (transition joints connection type R11). While one of the rods must rotate freely. Mechanical joint type A12 and R11 are manufactured on equipment of the company ERICO by cutting tapered threads on the ends of the reinforcing rods and their coupling through the coupling with the corresponding studs thread. Tapered thread couplers Lenton allows to reduce the size of the couplings, as well as to avoid stress concentrations in the joint. Splicing two reinforcing bars of large diameter is not more than 5–10 minutes. NIIJP issued technical conditions for the application of couplers Lenton [14].

If for the reinforcement of columns used screw reinforcement bars, in this case, the threading at the ends of the reinforcing bars is not required and splicing of rebars simplified [13, 15].

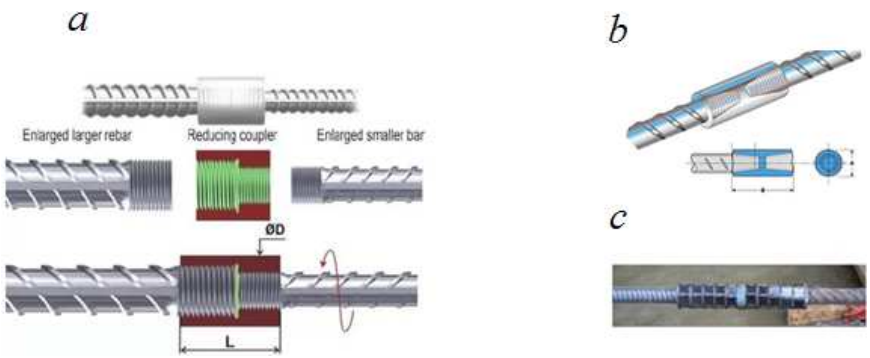

Fig. 5. The design of the junction of the rods the longitudinal reinforcement of the column with the use of special mechanical devices:
a – Coupler with parallel thread Bartec;
b – threaded couplers (couplers Lenton tapered thread);
c – cu compression (crimp) couplings

If for the reinforcement of columns used screw reinforcement bars, in this case, the threading at the ends of the reinforcing bars is not required and splicing of rebars simplified [15, 17].

The test results of the strength of the couplings on the thread, given in [16], provided a basis for recommending to perform the joints of the rods of the longitudinal reinforcement of the column extension. That is, the number joined in one cross-section of the column bars shall be not more than 50%. The distance between the closest edges of the coupling taken not less than 0.5×lan and at least 40% of the length of the coupling. At the junction it is necessary to provide additional transverse reinforcement.

Conclusion: It should be noted that inclusion in standards for designing reinforced concrete monolithic structures of buildings [4] recommendations for the splicing of rebar with screw and crimp couplings can be seen as a recognition of the connection method of reinforcement popular and economically viable.

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