Saimaa University of Applied Sciences

Technology, Lappeenranta

Double Degree Programme

Civil Engineering

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THE ADVANTAGES OF USING PREFABRICATED REINFORCEMENT UNITS IN CONSTRUCTION IN SAINT-PETERSBURG

Thesis 2014

ABSTRACT

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The advantages of using prefabricated reinforcement units in construction, 56 pages

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Technology

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The purpose of this thesis is to show benefits of reinforcement with prefabricated reinforcement units in Saint-Petersburg. The main prefabricated units which include in this thesis are reinforcement meshes.

The data was presented in the form of text, tables and figures. It was gathered from the relevant literature such as books, tutorials, normative documents, manuals and methodical guidelines that are directly related to the reinforcement. The thesis contains drawings and calculations, which were done during writing this thesis in NCC.

The results of the study show economical effect of using reinforcement meshes in Saint-Petersburg.

Keywords: reinforcement, construction, reinforcement meshes, unification, economy

CONTENTS

INTRODUCTION

Modern level of technical progress in the construction industry allows improving civil constructions, increase the level of quality and safety, reduce the cost of construction. This leads to the reduction in duration of construction. But this opportunities are used still insufficient by construction companies. Especially in Russia.

Nowadays there is a tendency in formation of construction economics, based on the knowledge, related first of all on using of innovative technologies in various fields, included creation and using of new progressive decisions, materials and environmentally safe technologies. Under the innovation in construction determines the process of implementation into construction industry the products of technical progress in the field of new technics and technologies, designed development, progressive ways of organization and management of construction, which provides increase of effectiveness in construction industry, improving quality of construction product and increasing competitiveness.

Construction industry mainly focused on maximizing profit, often do not use advanced technologies, applying low-skilled laborer resource and do not take in consideration many incidental expenses (safety, electricity, water, equipment rental, etc.). The senseless race for contracts for new construction leads to increasing volume of construction in progress, unsatisfied production capacity, failure targets by contractor and increasing of the estimated cost of construction.

Nowadays two of three of the construction companies do not fit into the standard period of construction. Some of them due to backward technology of construction have been completed in a period exceeding standard in two or more times.

New building technologies and saving of building materials and, above all, the reinforcement can be achieved through the application of rational definition of basic building materials and structures, taking into account their properties and features, as well as a competent design.

The design should improve the efficiency of decision-making process in the construction of the project, taking into account the whole range of costs during the construction and maintenance of buildings and structures, introducing more efficient and less labor-intensive construction techniques and products. To date, very relevant question of duration of the construction cycle. Reduction in construction time can be achieved by wide usage of prefabricated products, which will give an opportunity to significantly reduction of labor and material resources in the construction.

An example of a prefabricated product is prefabricated reinforcement mesh, which can reduce costs and period of construction, improve its productivity and quality.(1)

In NCC, there was a challenge – how to reduce cost of the building when Swedish Krona was started. As a decision came an idea to use prefabricated product: prefabricated reinforcement meshes to build an overlap. This idea helped to reduce costs and period of construction and moreover improve its productivity and quality. Nowadays, most of NCC projects in Russia have got reinforcement meshes in use: Oland, Swedish Krona, Skandi klubb.

1.1 Common information

Reinforcement is a method for increasing the bearing capacity of the construction with material that has higher strength properties relative to the main product material. Reinforcement elements are divided into stiff (I-beams, U-sections, L-steel) and flexible (individual rods smooth or periodic profile, as well as welded or woven meshes, and cages).

Collaborative work of concrete and reinforcement provides their grip on the contact surface. Coupling fixtures depends on a concrete strength, the magnitude of its shrinkage, the age of the concrete, and the sectional shape of reinforcement and its surface form.

In concrete products, mainly used reinforcement, which is represented by a interconnecting steel rods. The main ways of connecting rods - is electric welding and binding wire. Instead of tying wire are used special clips made of spring steel. Gas welding usually is not applicable.

The main types of reinforcement products:

- Flat meshes;
- Spatial reinforcement (supporting) frames.

Nowadays, many companies switches to the reinforcement by reinforcing meshes instead of separate (individual) rods.

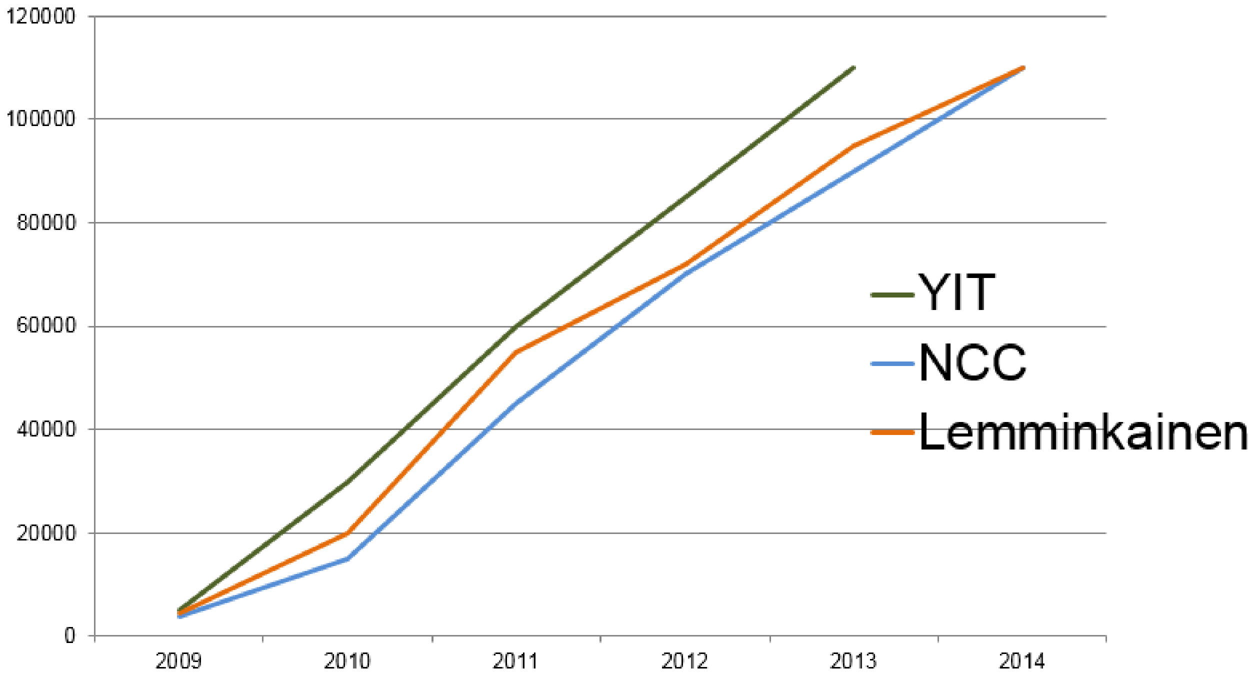


Figure 1.1 Trend of increasing usage of reinforcing meshes

The graph shows trend of increasing usage of reinforcing meshes in the leading construction corporations in Saint-Petersburg.

In the last years many factories in Saint-Petersburg started to produce prefabricated units, and also reinforcement meshes. It is also because creation of mesh is not expensive and technology is quiet simple.

Mesh reinforcement can be used in foundations, walls, slabs, etc.

2 EXAMPLES OF USE

2.1 Foundation

2.1.1 Slab foundation

Solid slab foundation is recommended to reinforce with standardized welded wire mesh and cages. The use of knitted meshes and frameworks of the individual rods is difficult. Moreover, it is recommended to use on construction sites where there is no possibility to deliver of unified reinforcement products, as well as in the case of large-diameter of main reinforcement rods.

It is also perspective to reinforce foundations with heavy meshes and cages from individual rods, jointed without welding and overlap with compression or threaded jointed elements.

Welded unified meshes are recommended to use with the main rods in one direction and to stack them one above the other in not more than four layers.

Meshes in each layer should be set without overlap in a distributional direction so that in the main layers in adjacent, reinforcement meshes held in the perpendicular direction.

Joints of main rods of the meshes are recommended to arrange with overlapping without welding.

The total area of main reinforcement of jointed meshes in one section should be no more than 50% of the total main reinforcement meshes in this direction.

Meshes, which are located on the top of the foundation, should be laid on supports in the form of welded (knitted) cages placed vertically or with an angle to each other. It is also used connecting elements from the vertically placed metal sections (angles, channels, etc.).

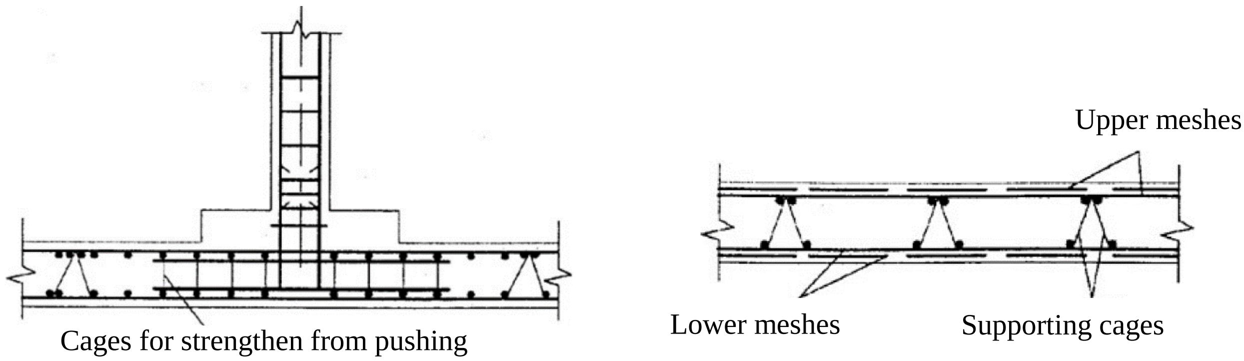


Figure 2.1 Example of reinforcement

The distance between the supports is determined from the condition to provide the necessary rigidity of upper reinforcement of the foundation to support its own weight, the weight of the workers (fitters and concrete workers) and the fresh concrete mass.

If the collapsing strength of the slab is insufficient, it should be provided special transverse reinforcement located within the edge of the pyramid punching.

Under the walls, columns and pillars of the building should be provided the free length of reinforcement from foundations. The amount and cross-sectional area of the free length are determined by calculation.

Anchoring of the free length from slab foundations and vertical load-bearing elements of the building assigned a similarly anchoring of the free length from separate foundations.(2,3)

2.1.2 Strip foundation

Monolithic reinforced concrete strip foundations under separate rack are designed mainly as T-section with a slab in the base and the stem in the top. If soils are high viscosity sometimes T-bar is used with the stem facing down (because volume of earthworks is reduced and formwork is simplified)(figure 2.2). Dimensions of base and stem of monolithic strip foundation appointed by the calculation of sufficient strength and rigidity.

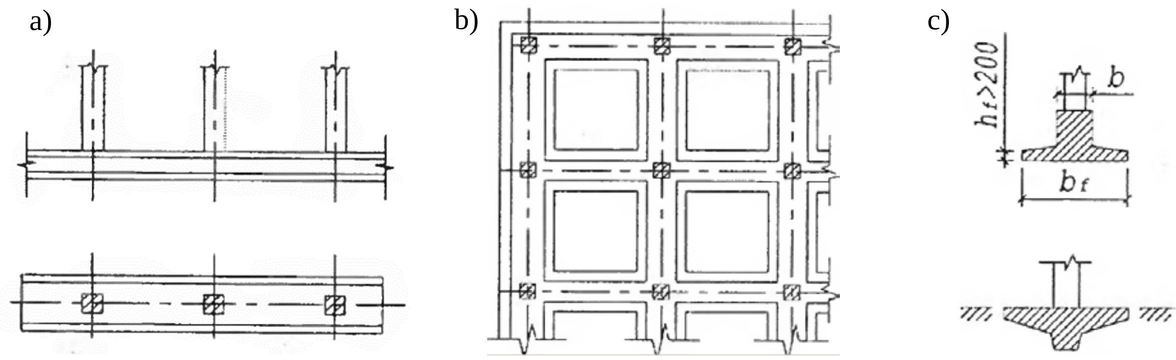


Figure 2.2 Example of reinforcement (a –strip foundation, b- cross-strip foundation, c – cross-section of strip foundation)

The bottom longitudinal main reinforcement of strip foundation is recommended to lay across the entire width.

The section of reinforcement which is located within the width of the stem must be at least 70% of the total amount of fixtures required for the calculation.

Reinforcement strip foundations should mainly done by welded wire meshes and cages.

If it is possible to get welded mesh which width is equal to the width of the slab (shelves), it is recommended to reinforce the slab with welded wire mesh with main reinforcement located in two directions by using the transverse rods of mesh as a main reinforcement shelves with work of them as consoles and longitudinal rods of mesh - as longitudinal reinforcement of strip foundation by adding it to the carcass reinforcement of stems.

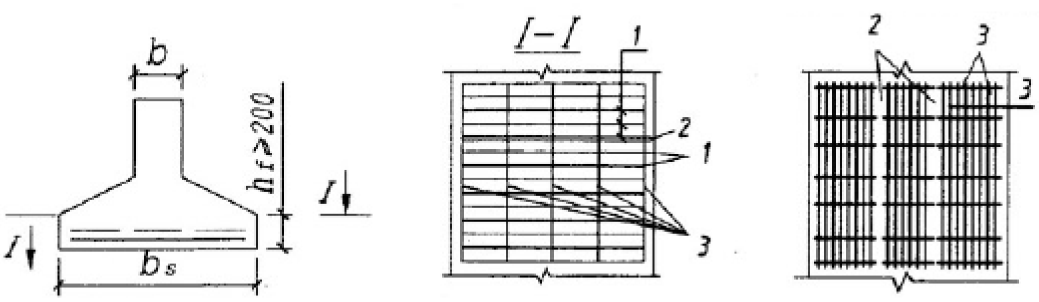
In the absence of wide mesh it is possible to reinforce slabs with narrow meshes with a main reinforcement, located in one direction, by putting the meshes at each other in two mutually perpendicular planes. Meshes in each plane are stacked next to each other without overlap.

In the direction of fixtures located along the stem should be fitted joints of main reinforcement meshes with long bypass (overlap), which determined by the calculation.

The joints of all meshes can be arranged in one cross-section of the strip foundation, if the total area of all worker rods of meshes do not exceed 50% of the section of the longitudinal reinforcement of the strip foundation.

Section area of longitudinal reinforcement of stem defines by the calculation, but in any case it is necessary to provide continuous, along the entire length of the foundation top and bottom reinforcement with reinforcement ratio of 0.2-0.4% each.

Rod spacing of transverse reinforcement in the welded cage should not exceed 20 diameters of the longitudinal reinforcement. In the cages of stems, collar clamps are provided with closed diameter of at least 8 mm with rod spacing of no more than 15 diameters of the longitudinal reinforcement. Amount of branches of the collar clamps should be at least three with b ≤ 400 mm, at least four with 400 mm <b ≤ 800 mm and not more than six when stem is wider. (2,3)



Meshes of bottom layer   Meshes of top layer

Figure 2.3 Example of reinforcement (1,3 – main rods of shelving and strip, 2 – joints of welded meshes) (2)

Reinforcement of slab by meshes allows to accelerate the process of reinforcement and achieve speed of 40-60 m2 / h (reinforcement with separate rods - 20 m2/ h).

2.2 Walls

Reinforcement of monolithic concrete walls of buildings is carried out in accordance with the calculation and design requirements of the SP 52-101-2003.

In design it is recommended to use optimal structural parameters of the walls, set on the basics of a feasibility analysis. Also cross-sectional dimensions (thickness) of the walls is recommended to be at least 18 cm, concrete class - not less than B20, the percentage of reinforcement in any section of the wall (including blocks with an overlap joint fittings) - not more than 10%.

In applying the highest percentages of reinforcement of cross-sections, designer should follow the instructions of the SP 52-101-2003, para. 8.3.3, wherein the maximum size of aggregate in the concrete mix should not exceed 10 mm.

Walls is recommended to reinforce, usually by vertical and horizontal reinforcement located symmetrically at the sides of the walls and cross-linked, connecting the vertical and horizontal reinforcement located at opposite sides of the wall and prevent vertical compression rods from buckling.

End portions of the walls and their linking in their places of intersection should be reinforced throughout the whole height with intersecting U-shaped or curved (closed) collar-clamps, that create the required anchoring of end portions of the horizontal rods and also prevents the buckling of vertical rods. Reinforcing of the ends of the walls and openings should be increased evenly with distributed reinforcement for the rest of the wall area. (2,3)

When the meshes are used to reinforce the walls it is necessary to consider the following points:

- Do not use mirrored meshes for reinforcing wall
- Minimum concrete cover for the main reinforcement of walls is 35 mm

Using of reinforcing meshes for reinforcing wall allows to accelerate reinforcement and improve the quality of work.

Selection of minimum mesh sizes gives ability for rapid installation. (1)

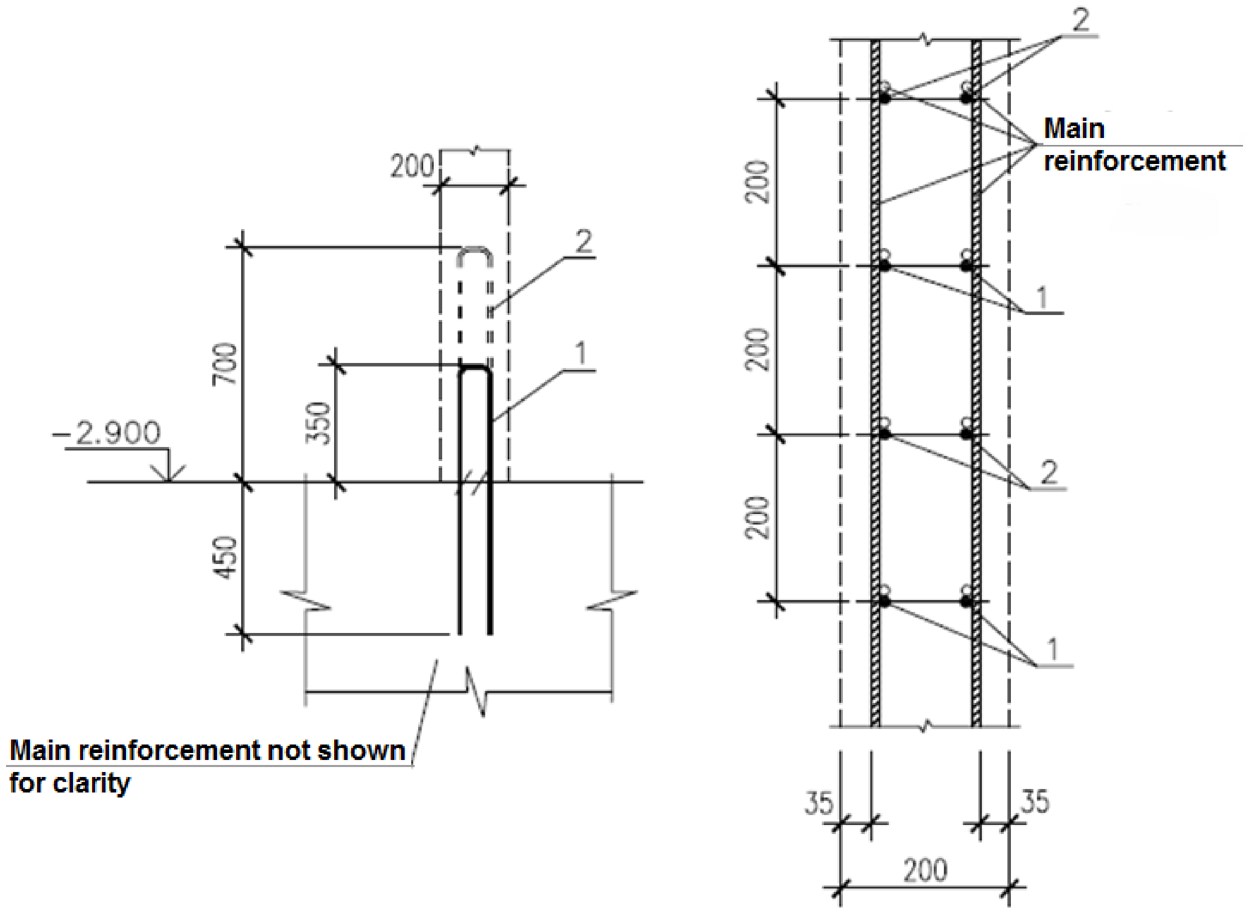


Figure 2.4 Example of reinforcement, Oland, Saint-Petersburg

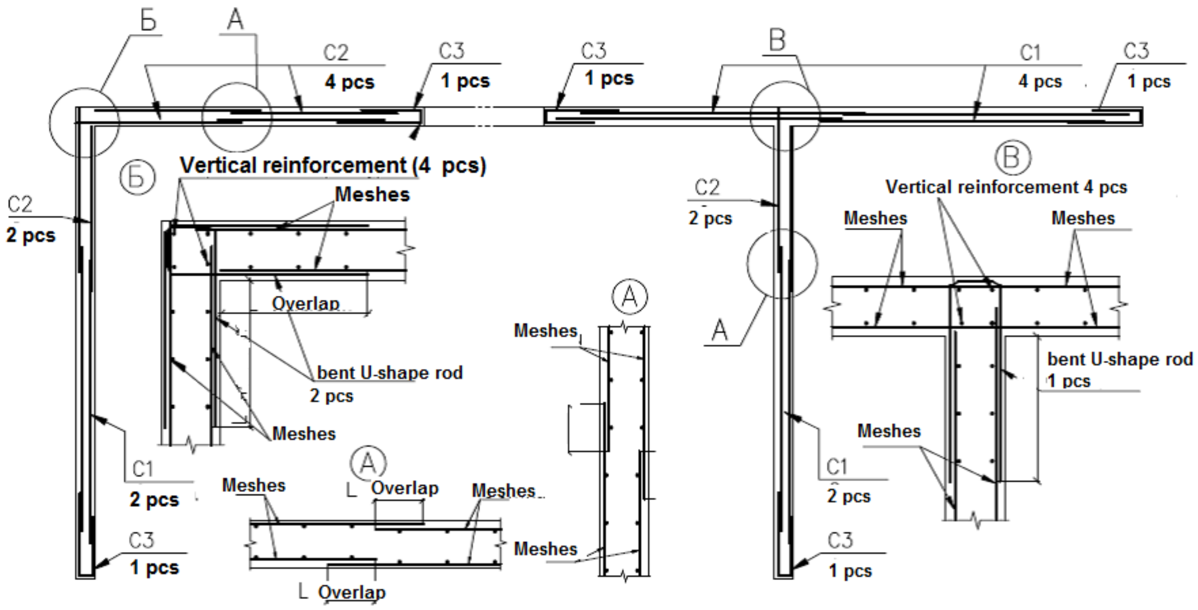


Figure 2.5 Example of reinforcement Oland, Saint-Petersburg

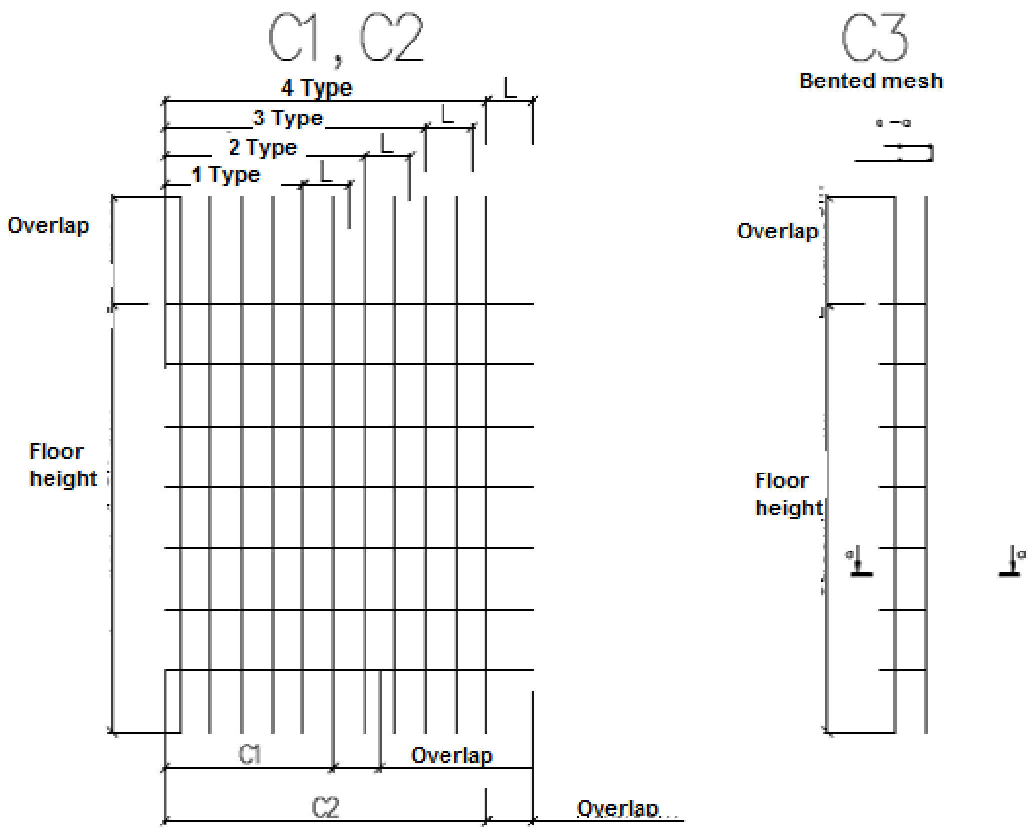


Figure 2.6 Example of reinforcement Oland, Saint-Petersburg

2.3 Overlaps

Monolithic reinforced concrete slabs of overlaps can be fully or partially supported by perimeter, with free support or jamming on the supports. In practice of monolithic construction are quite common slabs, which clamped along one edge (console) and supported at the points (corners), for example slabs of beamless overlaps.

By design scheme slabs is divided into beam (single-span - cutting, uncut - multi-span, cantilever) and working in two directions, which can be a single-span (with hinged or non-hinged leaning on the edges) or multiple-span continuous slab.

If the forces which acting in the same direction, are negligibly small compared to the force acting in the opposite direction the slab is called beam slab. Beam slabs include: a evenly loaded rectangular flat slab that supported on two opposite sides, as well as a slab supported on a contour or clamped on three or four sides with span more than a certain limit value.

All non-beam slabs, including nonrectangular at plan view (circular, annular, etc.), and also supported along the points (e.g., slab beamless overlap) are ranked as operating in both directions. In beamless overlaps of monolithic buildings, slab may rely directly on columns without or with broadening, called head of the column (capital). If span is up to 6-8 m monolithic slab is recommended to perform flat, for large values - flat with capitals or the between-column beams or walls, ribbed or hollow core. For big halls with spans of 12-15 m are recommended to use caisson and use ribbed and hollow core slab when leaning on the four sides of the beams and walls.

When the spans more than 7 m it is recommended to use an additional prestressed reinforcement from high-strength ropes class K-7 without adhesion to concrete.

When choosing a constructive solution of how to lean the slab on the column without capitals it should be provided with additional reinforcement of these areas of the slab in order to avoid forcing it under operational loads.

The thickness of the beam monolithic slabs with an aspect ratio of $l_2 \cdot l_1$,> 2 should be not less than, mm:

For intermediate floors of residential and public buildings ─ 70

Intermediate floors for industrial buildings ─ 80

For covering ─ 60

Under the passages ─ 100

For slabs of lightweight concrete classes B7.5 and lower in all cases ─ 70

The thickness of the concrete slab with caissons multiribbed overlaps should be at least 25-30 mm.

Monolithic slab thickness h, mm, is recommended to take 40, 50, 60, 70, 80, 100, 120, 140, 160, 180, 200, 250, 300, 100 fold more.

The minimum thickness of the concrete protective layer for the main reinforcement slabs in normal operation - 20 mm. (2,3)

The minimum thickness of the slabs depending on the span can be tentatively accepted by the table:

Table 2.1: Minimum thickness of slab (2)

Types and character of support	**Type of concrete**	
	Heavy	**Light**
Beam:		
With free support	(l/35)l	(l/30)l
With elastic restraint, working in two directions:	(l/45)l	(l/35)l
Bearing on perimeter with free support	(l/45)l1*	(l/38)l1
Same, with elastic restraint	(l/50)l_1	(l/42)l_1
Caisson multiribbed slabs with free support	(l/30)l_1	(l/25)l_1
Same, with elastic restraint on perimeter	(l/35)l_1	(l/30)l_1
Beamless slabs with column support with capital	(l/35)l_2	(l/30)l_2
Same, without capitals, but not less than 16 sm	(l/32)l_2	(l/27)l_2

* l_1 and l_2 — smaller and bigger spans of slab.

Thickness of continuous or single-span slabs monolithically connected with reinforced concrete beams, taken as elastic restrait, and the thickness of the slab supported on the wall should be the same as with free support.

Monolithic reinforced concrete slabs are reinforced with knitted reinforcement and standard welded wire mesh.

Diameter of main rods of welded rebar are recommended to take at least 3 mm, and knitting - at least 6 (5.5) mm.

When the slab thickness h <150 mm the distance between the axes of the main reinforcement rods in the middle of the span slab (bottom) and over the support (multi-span slabs above) should not be more than 200 mm, h> 150 mm - and not more than 1,5·h and 400 mm .

The distance between the main rods that brought to the support slab should not exceed 400 mm, the cross-sectional area of this rods for 1 m wide slab should be at least 1/3 of the area of the rods in section in span, determined by calculating of maximum bending moment.

Sectional area of main reinforcement of slabs must be not less than specified in Table 2.2. The diameter and rod spacing of the reinforcement can be selected according to the same table.

Table 2.2 Sectional areas of main reinforcement (2)

Rods space, mm	**Rods diameter, mm**												
	3	4	5	6	8	10	12	14	16	18	20	22	25
100	0,71	1,26	1,96	2,83	5,03	7,85	11,31	15,39	20,11	25,45	31,42	38,01	49,09
125	0,57	1,01	1.57	2,26	4,02	6,28	9,05	12,31	16,08	20,36	25,13	30,41	39,27
150	0,47	0,84	1,31	1,84	3,35	5,23	7,54	10,26	13,4	16,96	20,94	25,33	32,72
200	0,35	0,63	0,98	1,41	2,51	3,93	5,65	7,69	10,05	12,72	19,71	19,00	24,54
250	0,28	0,50	0,79	1,13	2,01	3,14	4,52	6,16	8,04	10,18	12,56	15,20	19,64
300	0,23	0,42	0,65	0,94	1,68	2,61	3,77	5,13	6,70	8,48	10,47	12,66	16,36
350	0,20	0,36	0,56	0,81	1,44	2,24	3,23	4,44	5,74	7,27	8,97	10,86	14,00
400	0,18	0,32	0,40	0,71	1,25	1,96	2,82	3,50	5,02	6,36	7,86	9,50	12,49

Main reinforcement of the shorter span is placed lower than reinforcement of the longer span. Consider of that location of reinforcement, working height of slab section for each direction is different and will be differ on dimension of the diameter of reinforcement.

When solid beam slab with thickness more than 120 mm is reinforced by welded meshes, with the content of the extended main reinforcement up to 1,5 %, the distance between rods of the distributional reinforcement is allowed to increase up to 600 mm.

Reinforcement spaces of slabs with width up to 3 m and length up to 6 m is constructed as flat solid welded mesh, which transverse rods are main reinforcement.

When diameter of main reinforcement is more than 10 mm, slabs could be reinforced by plate narrow unified meshes. Their length should satisfy the width of the slab, which could be more than 3 m.

Longitudinal rods of the meshes are main reinforcement, transverse – distributional, jointed in slabs without welding.

Upper-support reinforcement of continuous slabs is designed as two meshes with motion or one mesh with transverse working rods, placed along the supports. Upper-support meshes could be rolled.

Multispan beam monolithic slabs with thickness up to 100 mm with main reinforcement of middle spans and supports up to 7 mm is recommended to reinforce with welded rolled typical meshes with longitudinal main reinforcement. Roll should be rolled out across secondary beams, and transverse rods of the meshes, which are distributional reinforcement of slab, should be jointed without welding. At the tail spans and at the first intermediate supports, where usually additional reinforcement is needed, the additional mesh is placed on the main one. The additional mesh should be bring for ¼ of span over the side of the first intermediate support into the second span. Instead of additional mesh could be placed separate rods by knitted them to the main mesh.

Slabs which working in two directions also recommended to reinforce with welded meshes. Slabs which have dimensions no more than 6x3 m, could be reinforced in span by one continuous welded mesh with main reinforcement in both directions. In case of economy of reinforcement it is recommended to use welded meshes with variable reinforcement in two directions, according to area of moments, or using different size meshes placing on each other in places of maximum bending moments. The width of outer line is determined by calculations.

When slab is reinforced by narrow welded unified meshes with longitudinal main reinforcement, rods are placed in span in two layers in mutual perpendicular directions. Meshes, which are placed along lesser span of the slab, should be below. Wiring rods of meshes of each layer are placed back to back without abutting, what is more, in bottom meshes they should be under main reinforcement into it protective cover, but into top meshes – above.

Upper-support reinforcement that works in two directions in continuous multispan slabs with flat meshes in spans is designed same as upper-support reinforcement of beam slabs.

Multispan continuous slabs which works in two directions with diameter of main reinforcement up to 7 mm, could be reinforced by typical rolled meshes with longitudinal main rods. For this, slab is divided in each direction into three stripes: two on sides (but ¼ of lesser span) and middle one. Rolls at the spans are placed in two layers, rolled out into mutual perpendicular directions only on middle stripes of the slabs. Upper-support reinforcement of slab corners in this case can be designed as square plane meshes with main rods in both directions. This meshes are placed at intersection of slab’s webs (beams), while rods can be parallel to webs (beams) or placed with 45° angle to them.

Reinforcing with welded meshes beamless slabs with pointed support of slabs on columns should be done as written above. In this case, usually, there is a need of additional reinforcing by axes of columns and in places of bearings slabs on the columns by certain rods or flat vertical gratings. Necessity of additional reinforcement and its amount is determined by calculations.

Upper-support reinforcement in distributional direction is designed in amount no less than 73 section of main reinforcement in span.

In slabs with thickness more than 120 mm some of spans rods (in case of economy of reinforcement) are recommended to continue on supports (it calls uninterrupted reinforcement). In slabs with thickness up to 150 mm, rods should be bended up with angle of 30°, with thickness more than 160 mm – with angle of 45°.

Tied reinforcement of slabs, that works in two directions, designed same as in beam slabs. In case of economy of reinforcement, slab is recommended to be divided in three stripes in each direction: two on sides with width of ¼ of lesser span and the middle one. In stripes on sides cross-sectional area of reinforcement could be decreased in two times, but not less than three rods on 1 m of width of the slab. Rods which are on direction of short side are placed below. Upper-support main reinforcement is placed evenly along the entire length on each side of slab.

On the end supports of monolithically tied with reinforced concrete hammer beam slabs, upper-support designed reinforcement are embed into hammer beam. On side free supports of slabs, span reinforcement is brought in over the edge of the support not less than 5 diameters of reinforcement.

Cantilever slabs with cantilever up to one meter are designed with constant width. If cantilever is more than one meter, width of slab in place of rigid is determined by calculation, and on the free end should be not less than 50 mm.

Cantilever slabs are typically reinforced only with above reinforcement. Cantilevers which are parts of one- or multispan slab are reinforced with the slab with same reinforcement – meshes or individual rods.

It is allowed to interrupt the half of main rods in the middle of length of a cantilever while reinforcing cantilever slabs with length of a cantilever more than 1000 mm.

Thick slabs, for example foundation, are recommended to reinforce with volume reinforced concrete block, which are combined from plane welded gratings and meshes. They should be placed with spacing of width of reinforced concrete block. Into spacing, horizontal welded meshes into top and bottom layers of blocks should be placed. Wherein it is necessary to provide rigid of reinforcement by placing additional rigid connections, for example cross brace from reinforcement, L-form etc. (2,3)

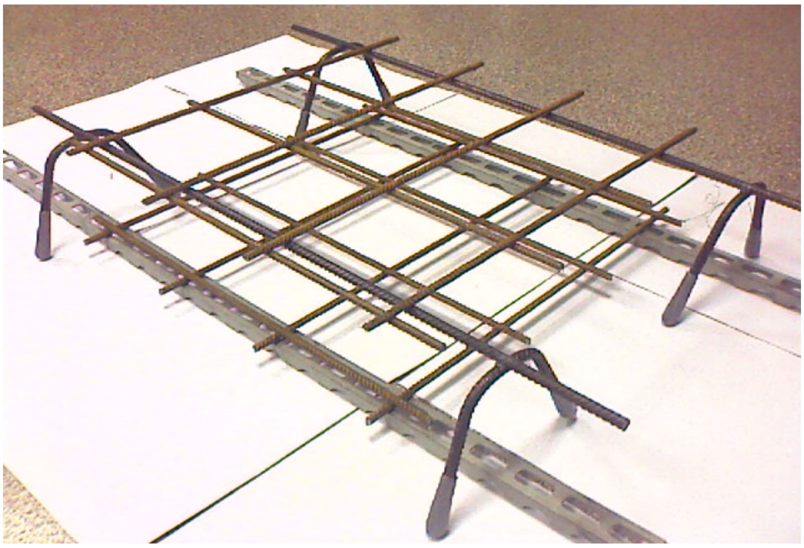


Figure 2.7 The scheme of reinforcement slabs with meshes (5)

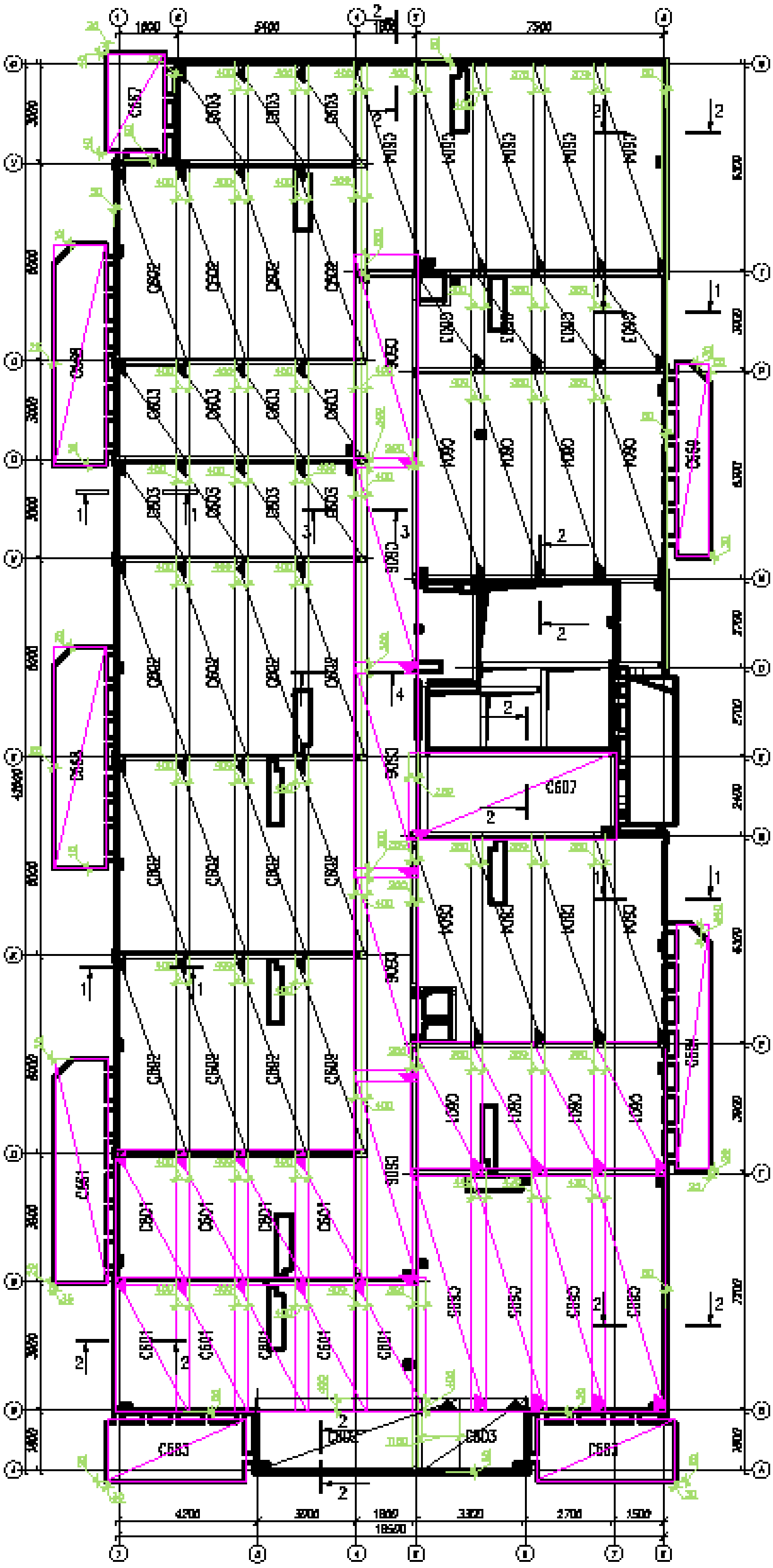


Figure 2.8 Typical solution of bottom reinforcement with meshes Oland, Saint-Petersburg

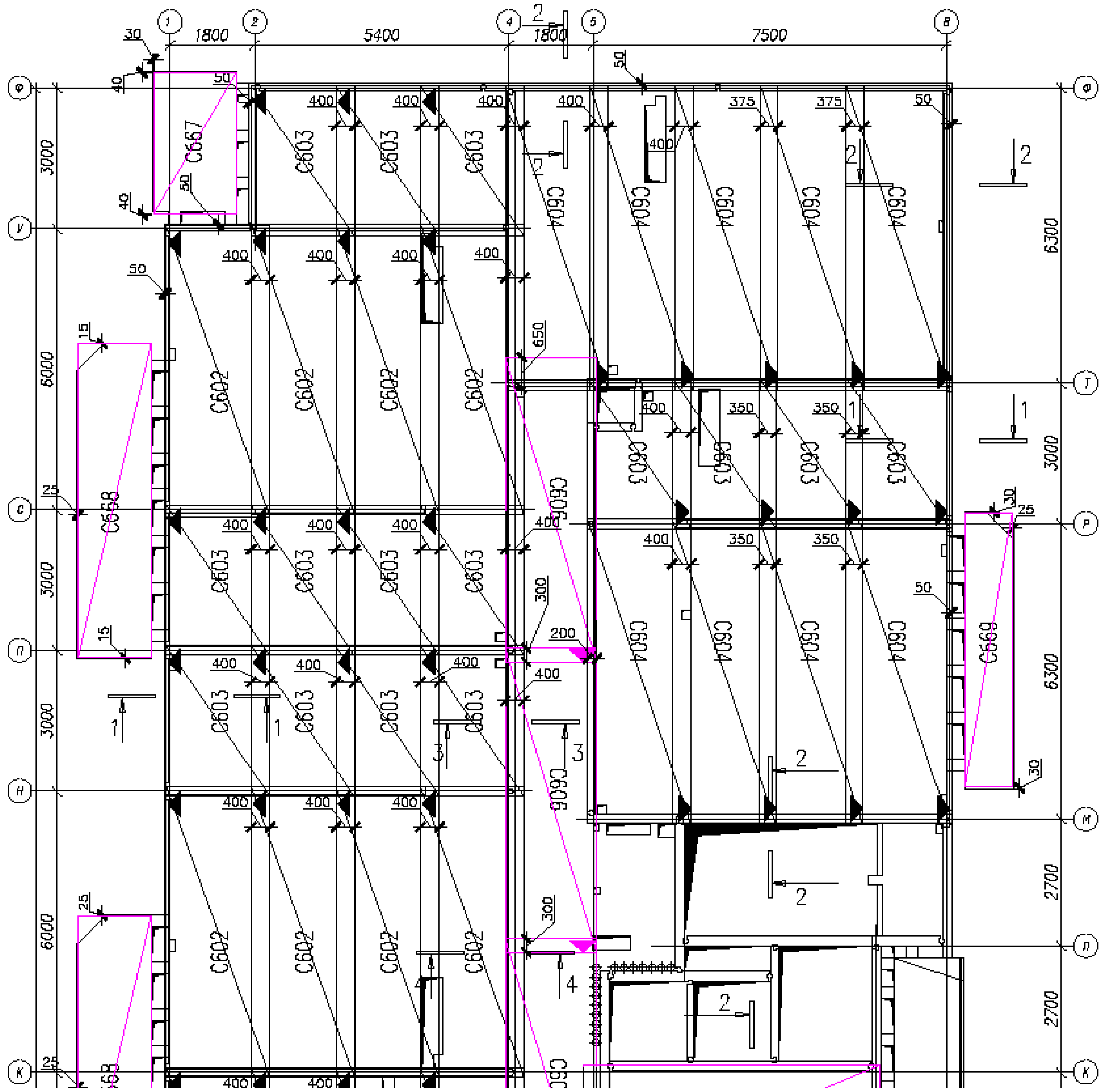


Figure 2.9 Typical solution of bottom reinforcement with meshes (zoom of figure 2.8) Oland, Saint-Petersburg

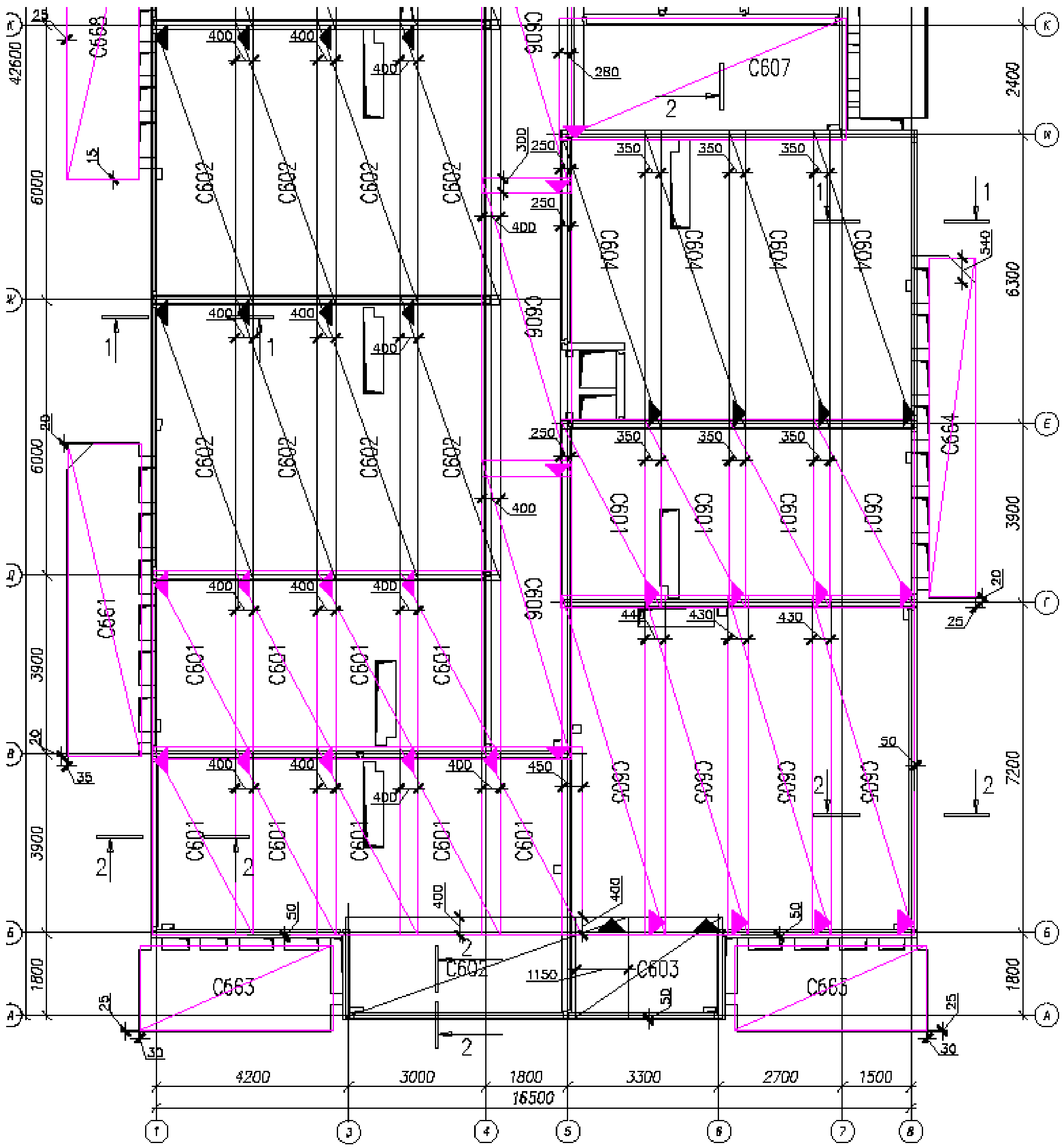


Figure 2.10 Typical solution of bottom reinforcement with meshes (zoom of figure 2.8) Oland, Saint-Petersburg

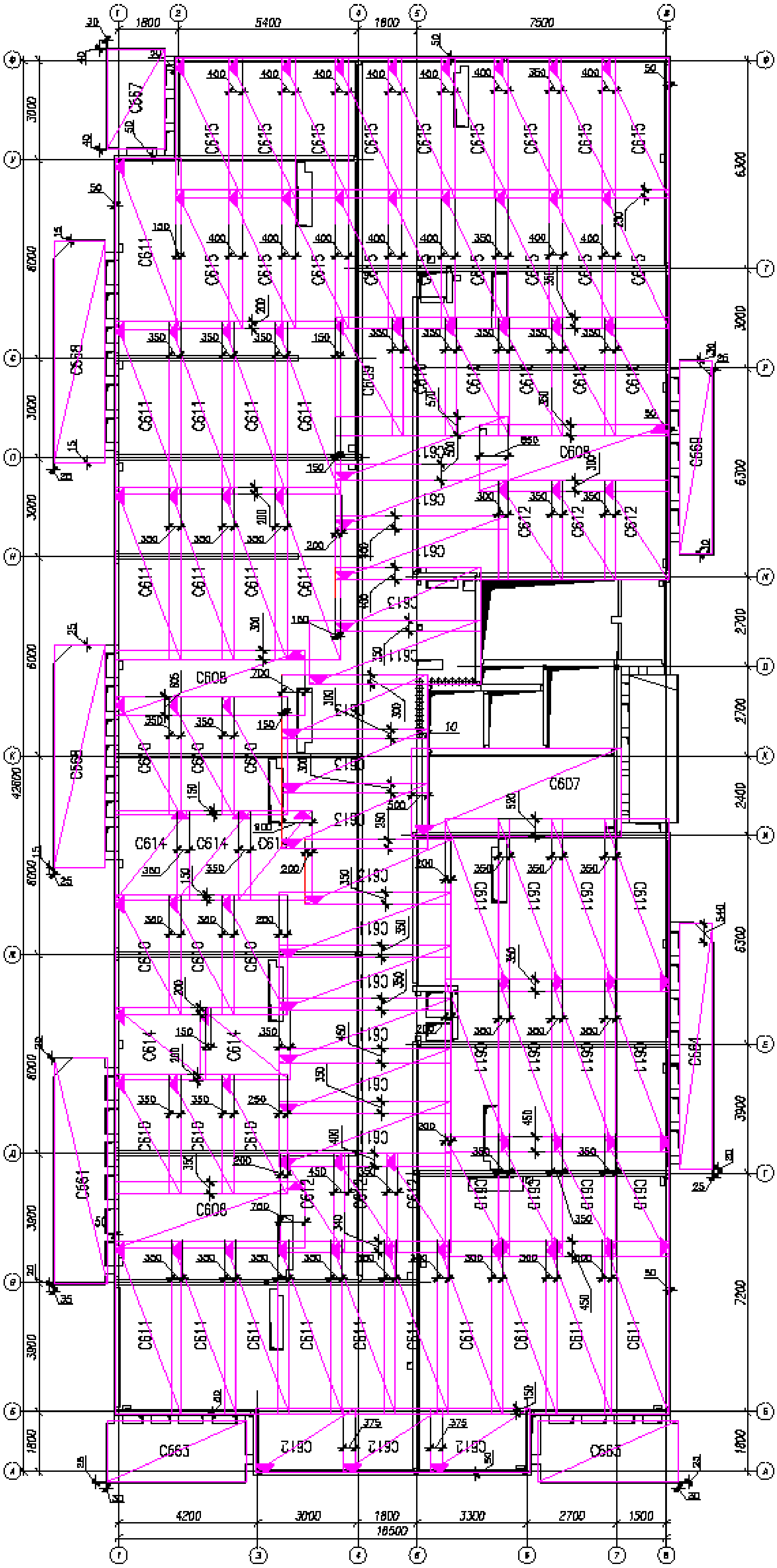


Figure 2.11 Typical solution of top reinforcement with meshes Oland, Saint-Petersburg

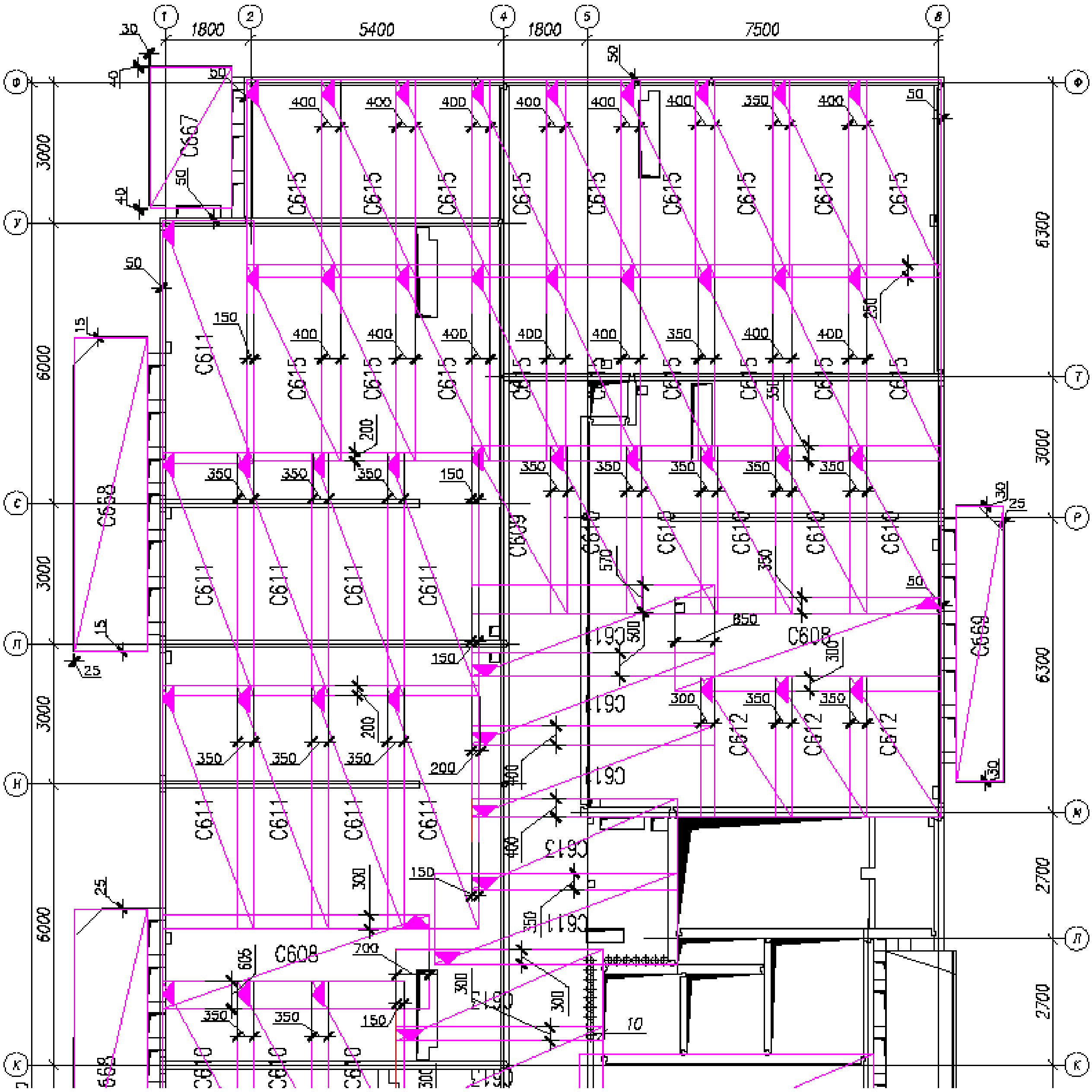


Figure 2.12 Typical solution of top reinforcement with meshes (zoom of figure 2.11)
Oland, Saint-Petersburg

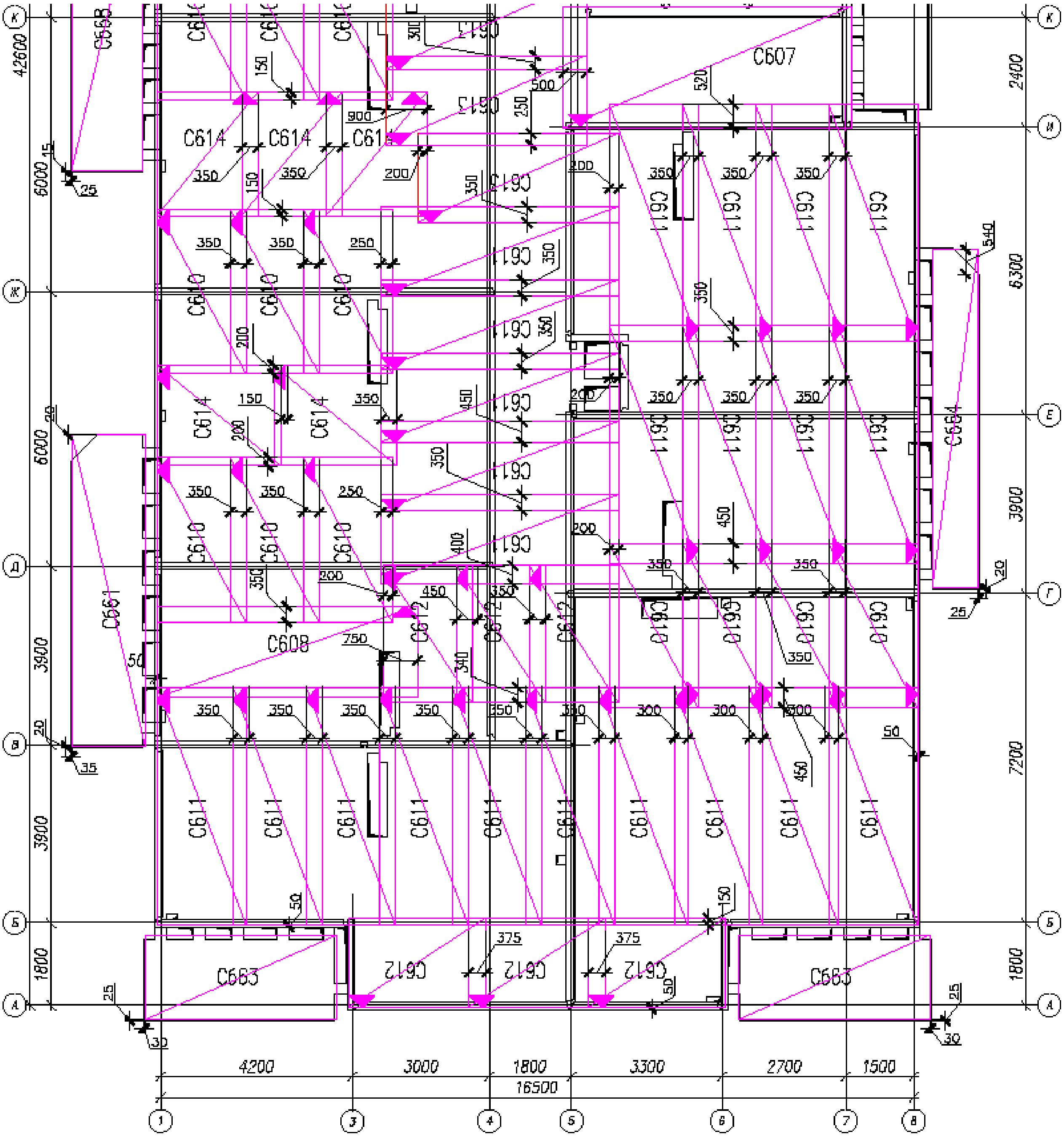


Figure 2.13 Typical solution of top reinforcement with meshes (zoom of figure 2.11) Oland, Saint-Petersburg

Selection of minimal typical dimensions of meshes allows to rapid the process of reinforcement.

Total top reinforcement with meshes prevents shrinkage crack in concrete.

Usage of welded meshes allows:

- Reduce the time of reinforcement slabs, and amount of workers
- Reduce steel spread
- Unifies meshes of top and bottom layers of reinforcement

3 EXAMPLE OF MESH PRODUCTION

Firstly, workers put individual rods into machine.

Figure 3.1 First step in production of reinforcement meshes

After that, machine pushes this rods step by step and welding cross rods to them:

Figure 3.2 Second step in production of reinforcement meshes

Than, the meshes are stored together:

Figure 3.3 Third step in production of reinforcement meshes

Than, the meshes are packed and ready to go to the site.

Figure 3.4 Last step in production of reinforcement meshes

4 CALCULATION OF THE LENGTH OF OVERLAPS

The lengths of reinforce overlaps of floor slab. Initial data:

- Reinforcing with meshes

- All reinforcement are overlap in one section

- Whole stress is transferred through reinforcement overlap

4.1 Result of calculation according to Finland norms (BY50, 2004)(10):

$$l_j = 0.25 k_j \frac{f_{yd}}{k_b f_{ctd}} \emptyset$$

Coefficient of overlap k_j (BY50, table 2.12) is determined in addition of amount of reinforcement which is overlaps in given section. In case of when all reinforcement rods are overlapped in one section - k_j=1.5.

Adhesion coefficient k_b (BY50, 2004) is determined according to class of reinforcement and location of reinforcement rods. Class of reinforcement set B500K, rods are located near the lower part of construction – k_b=2.4.

For reinforcement B500K the calculation value of tensile strength f_{yd}=426.7 Mpa.

For concrete K30 the calculation value of tensile strength f_{ctd}=1.287 Mpa.

For reinforcement rods with diameter 8 mm the length of overlap is equal l_j=405 mm.

4.2 Result of calculation according to Russian norms (SP 52-101-2003)(9):

Basic length of anchoring:

$$l_{0,an} = \frac{R_s A_s}{R_{bond} u_s}$$

The calculation value of adhesion of reinforcement with concrete:

$$R_{bond} = \eta_1 \eta_2 R_{bt}$$

$$\rightarrow l_{0,an} = 0.25 \frac{R_s}{R_{bt} \eta_1 \eta_2} \emptyset$$

If diameter of reinforcement is less than 36 mm $\eta_2 = 1.0$.

The length of overlap:

$$l_l = \alpha l_{0,an}$$

$$\rightarrow l_l = 0.25\alpha \frac{R_s}{R_{bt}\eta_2} \emptyset$$

Coefficient α is determined according to amount of rods, which are jointed in one section.

If all rods are jointed in one section – $\alpha = 2.0$.

Adhesion coefficient η_1 is depend on structure of reinforcement surface. For reinforcement B500 – $\eta_1 = 2.0$.

For reinforcement B500 the calculation value of tensile strength R_s=416.7 Mpa.

For concrete B25 the calculation value of tensile strength R_{bt}=1.050 Mpa.

For reinforcement rods with diameter 8 mm the length of overlap is equal l_l=794 mm.

4.3 Result of calculation according to European norms (EC 2)(11):

Basic length of anchoring:

$$l_{b,rqd} = 0.25 \frac{f_{yd}}{f_{bd}} \emptyset$$

For reinforcement rods with high-bond bar the calculation value of adhesion resistance:

$$f_{bd} = 2.25\eta_1\eta_2 f_{ctd}$$

$$\eta_1 = \eta_2 = 1.0$$

$$\rightarrow l_{b,rqd} = 0.25 \frac{f_{yd}}{2.25 f_{ctd}} \emptyset$$

The length of overlaps:

$$l_b = \alpha_1\alpha_2\alpha_3\alpha_4\alpha_5\alpha_6 l_{b,rqd}$$

$$\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 1.0$$

$$\rightarrow l_b = 0.25\alpha_6 \frac{f_{yd}}{2.25 f_{ctd}} \emptyset$$

Coefficient α is determined according to amount of rods, which are jointed in one section.

If all rods are jointed in one section – $\alpha = 1.5$.

For reinforcement B500K the calculation value of tensile strength R_s=434.8 Mpa.

For concrete C25 the calculation value of tensile strength R_{bt}=1.200 Mpa.

For reinforcement rods with diameter 8 mm the length of overlap is equal l_l=483 mm.

4.4 Comparison of European norms and SP

Here is the comparison of overlapping lengths calculated with different norms.

Figure 3.1 – Concrete B25, reinforcement class – B500

Figure 3.2 – Concrete C25, reinforcement class – B500K

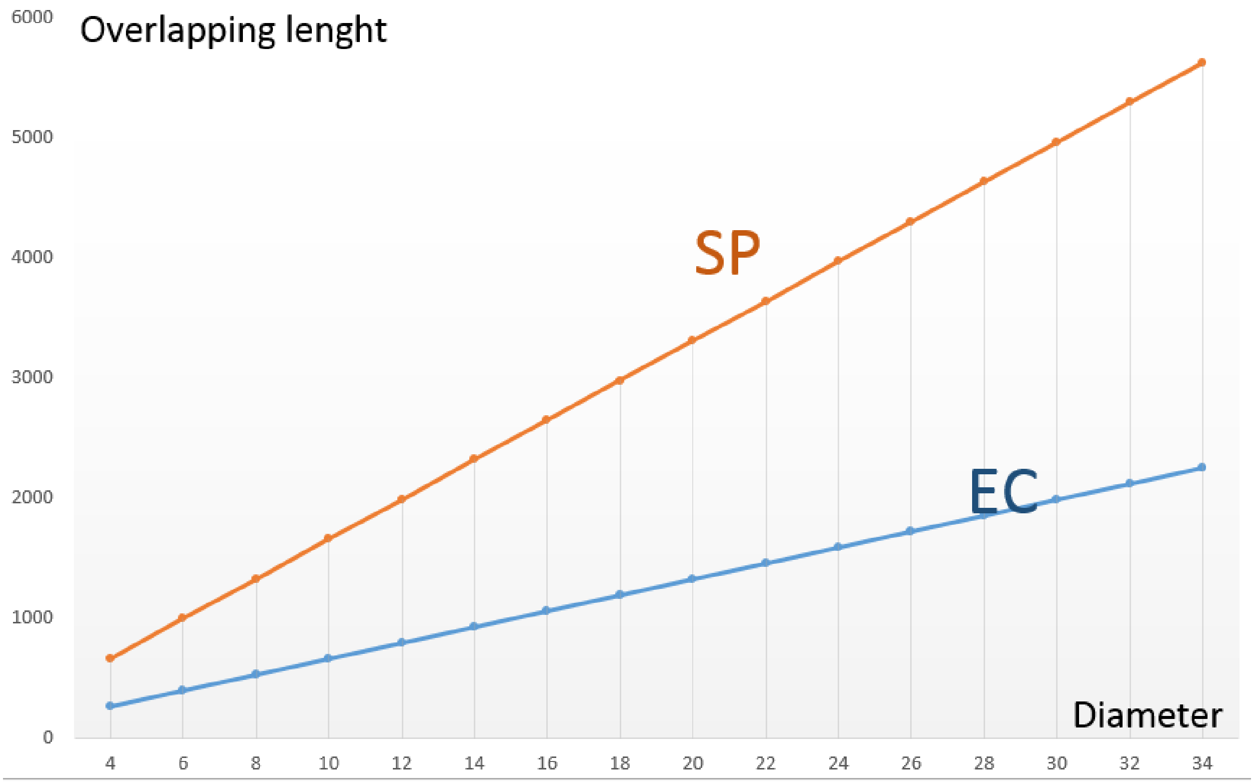


Figure 4.1 Comparison of length of overlapping

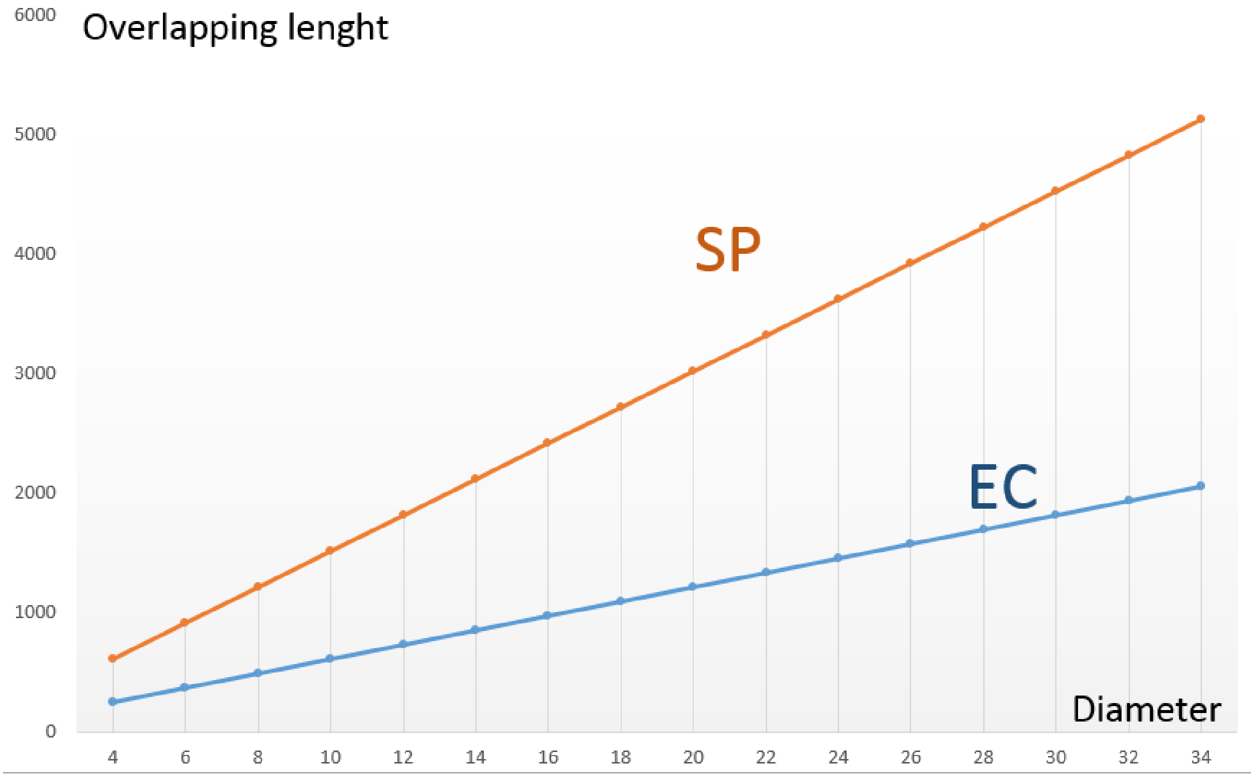


Figure 4.2 Comparison of length of overlapping

According to charts, it is clear, that by using Russian norms it will be bigger design stock, than using European norms.

5 EXAMPLE OF REINFORCING TYPICAL SLAB WITH MESHES.

Initial data:

20-storeyed monolith-brick residential building.

Loads from SNiP 2.01,07-85*.

Dead loads:

- Thickness of slab 200 mm – 5 kPa
- Light partition walls – 0.5 kPa
- Surface of floor – 0.5 kPa

Live loads:

- Living rooms – 1.5 kPa
- Stairs and corridors – 4 kPa

— Balcony – 2 kPa

Area of overlap – 650 m^2. Speed of installing meshes – 70 m^2/h total.

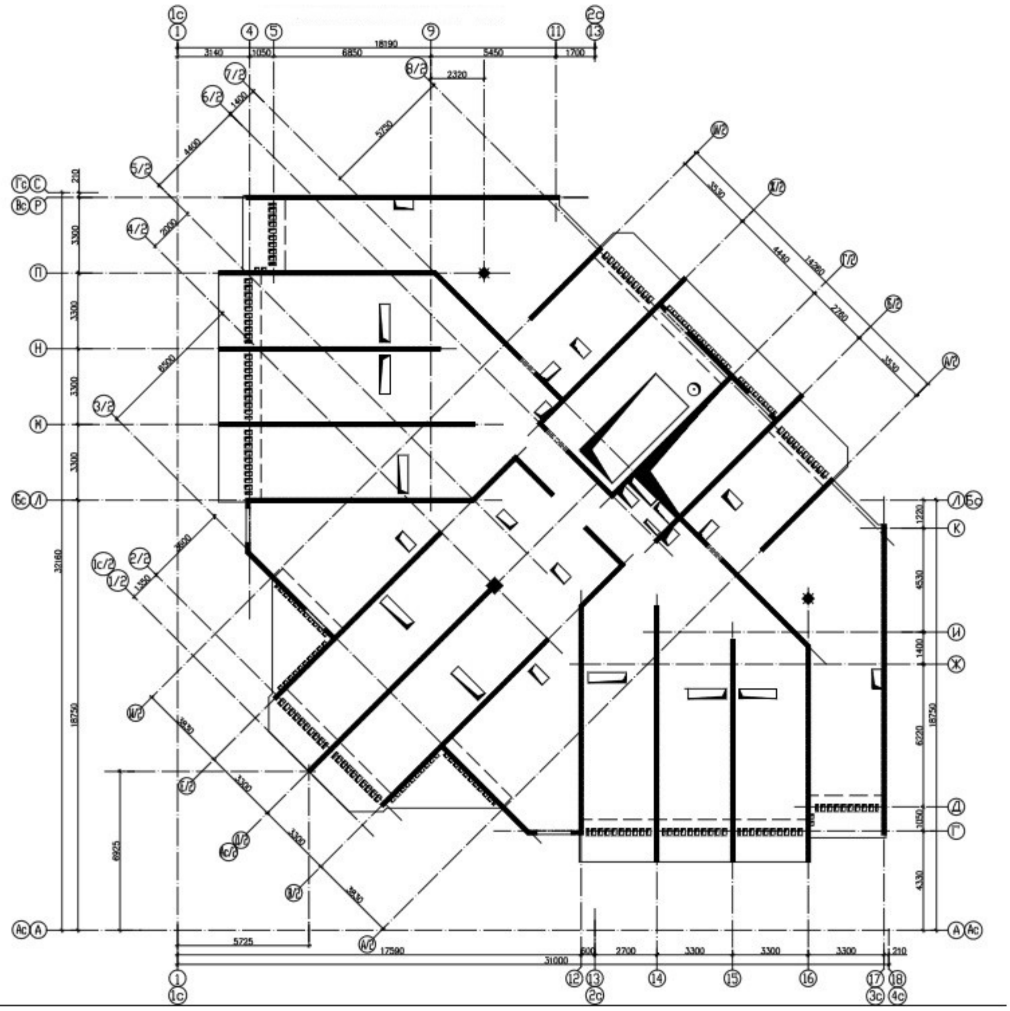


Figure 5.1 Calculation scheme of Swedish Krona, Saint-Petersburg

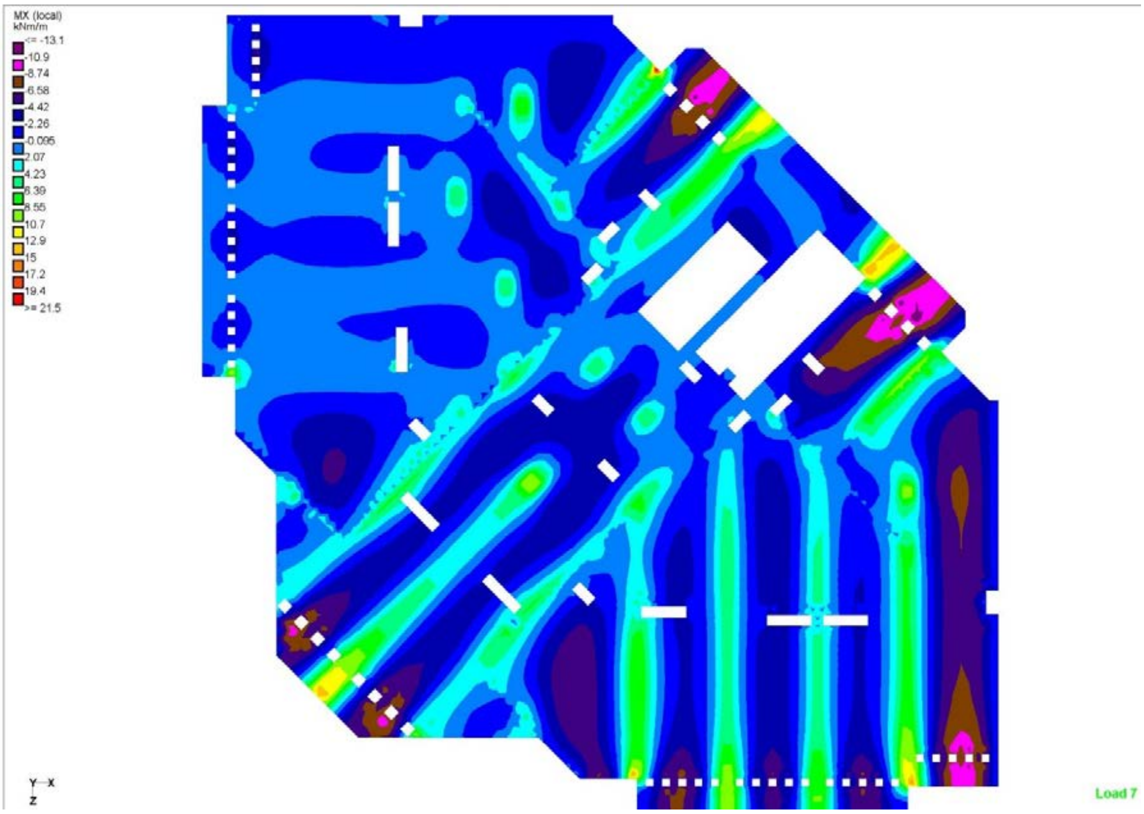


Figure 5.2 Calculation of MX value. Maximum loading combination. Average value of MX=5

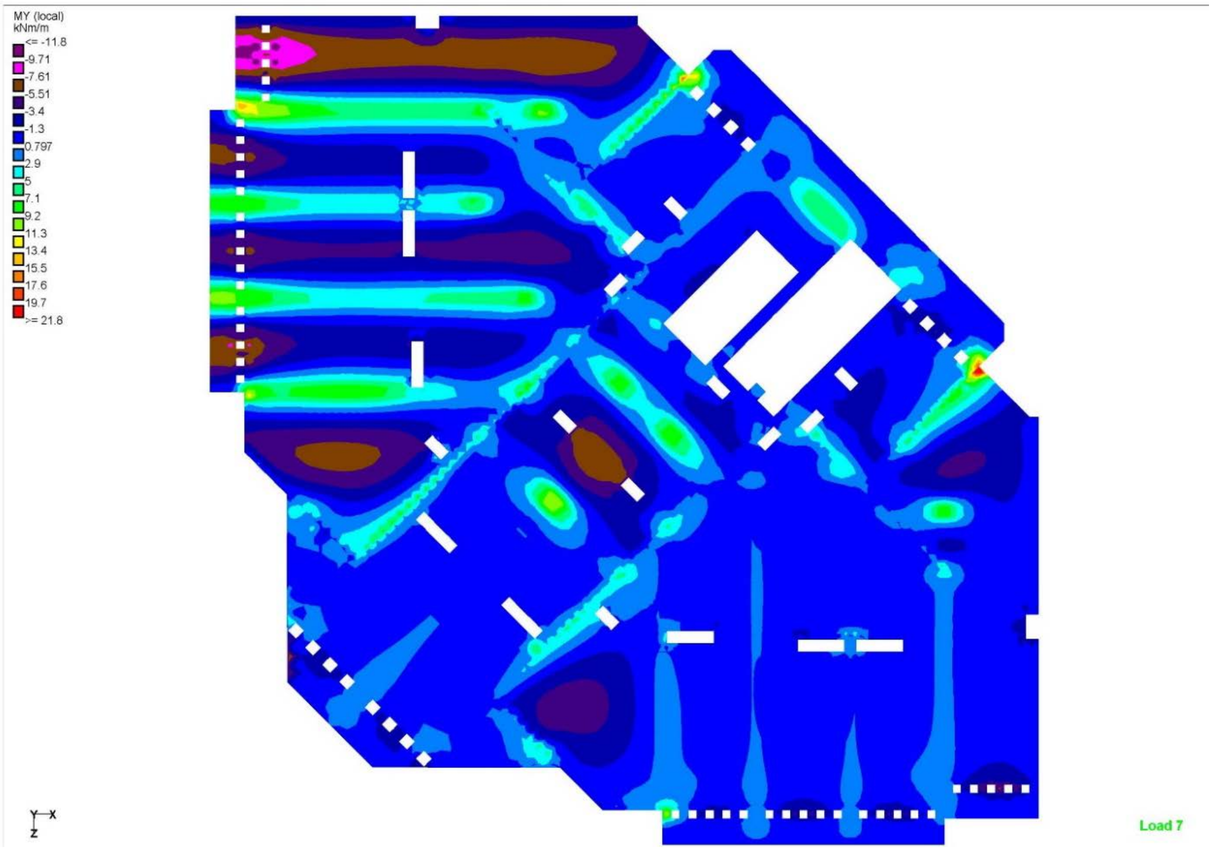


Figure 5.3 Calculation of MY value. Maximum loading combination. Average value of MX=6

5.1 Reinforcing with separate (individual) rods

Example of reinforcing with separate rods:

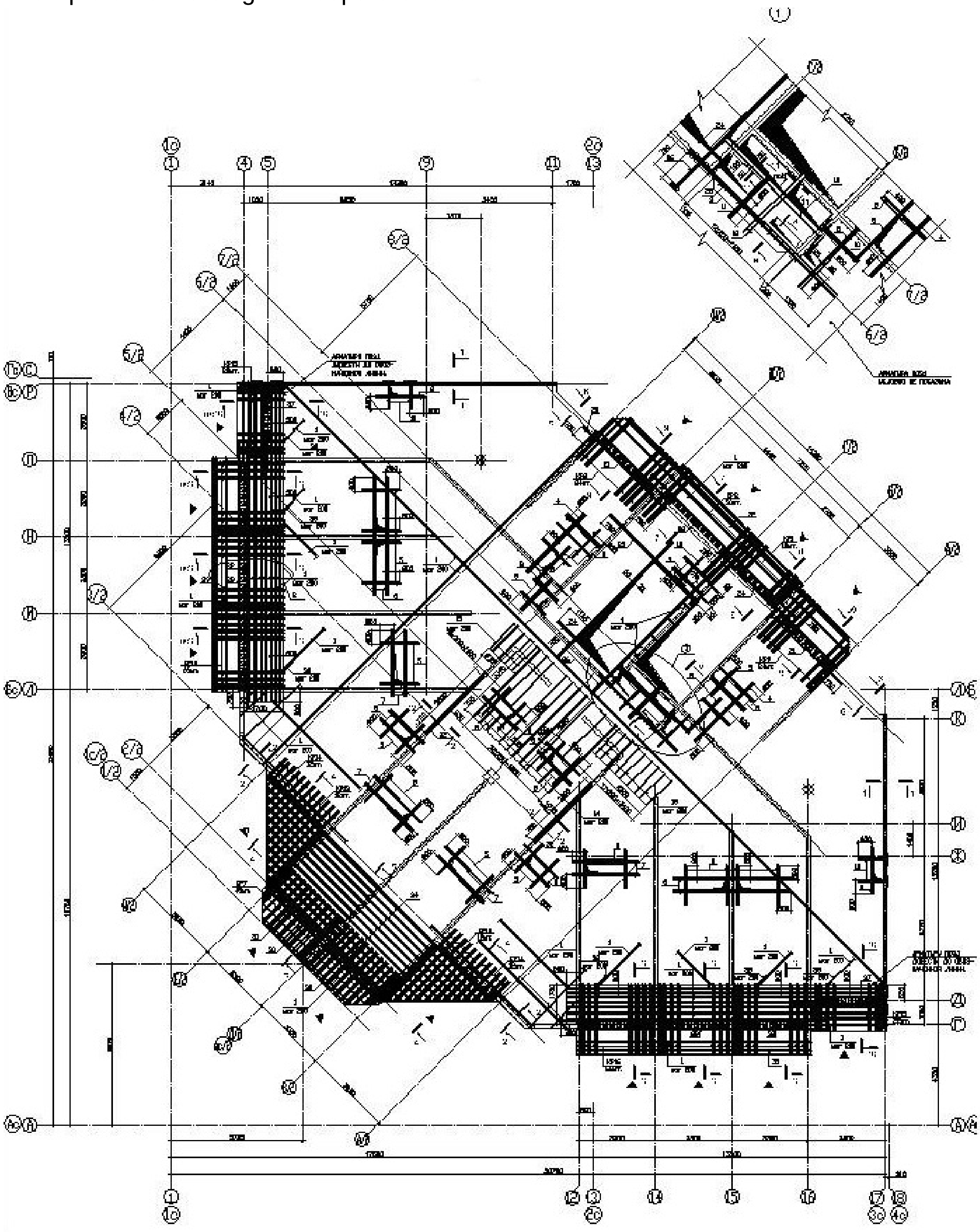


Figure 5.4 Bottom reinforcement

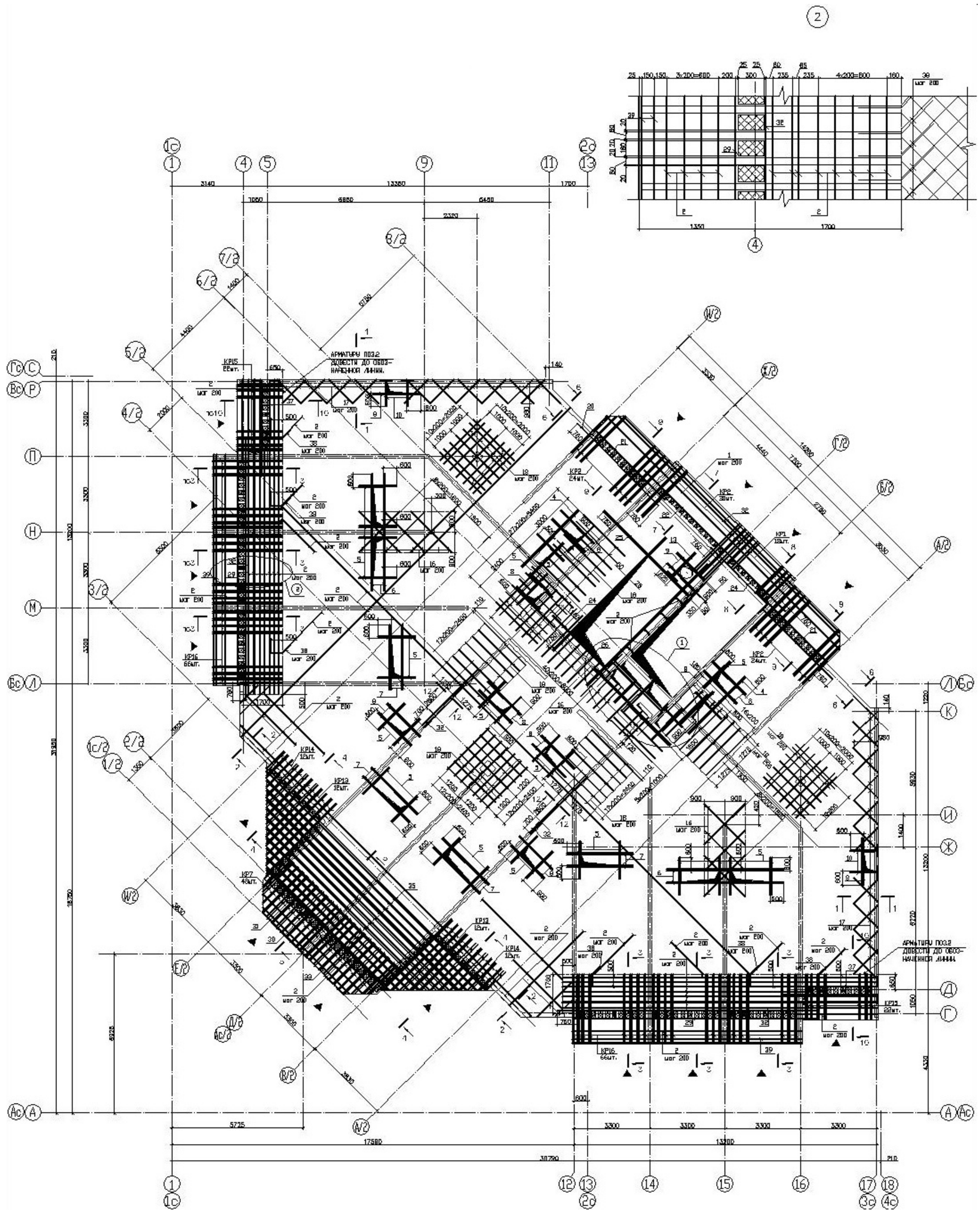


Figure 5.5 Top reinforcement

5.2 Reinforcing with meshes

Example of reinforcing with meshes:

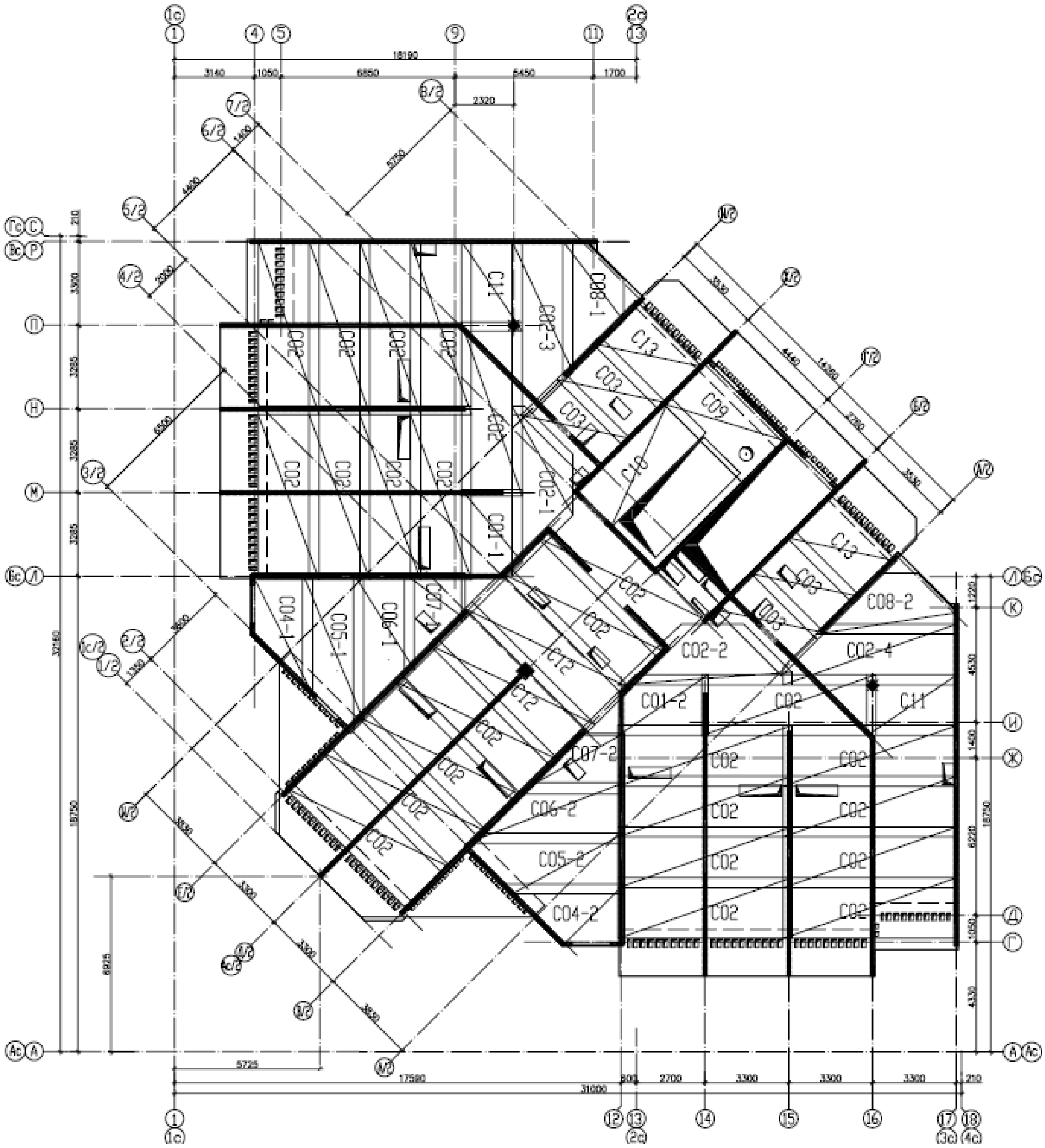


Figure 5.6 Bottom reinforcement

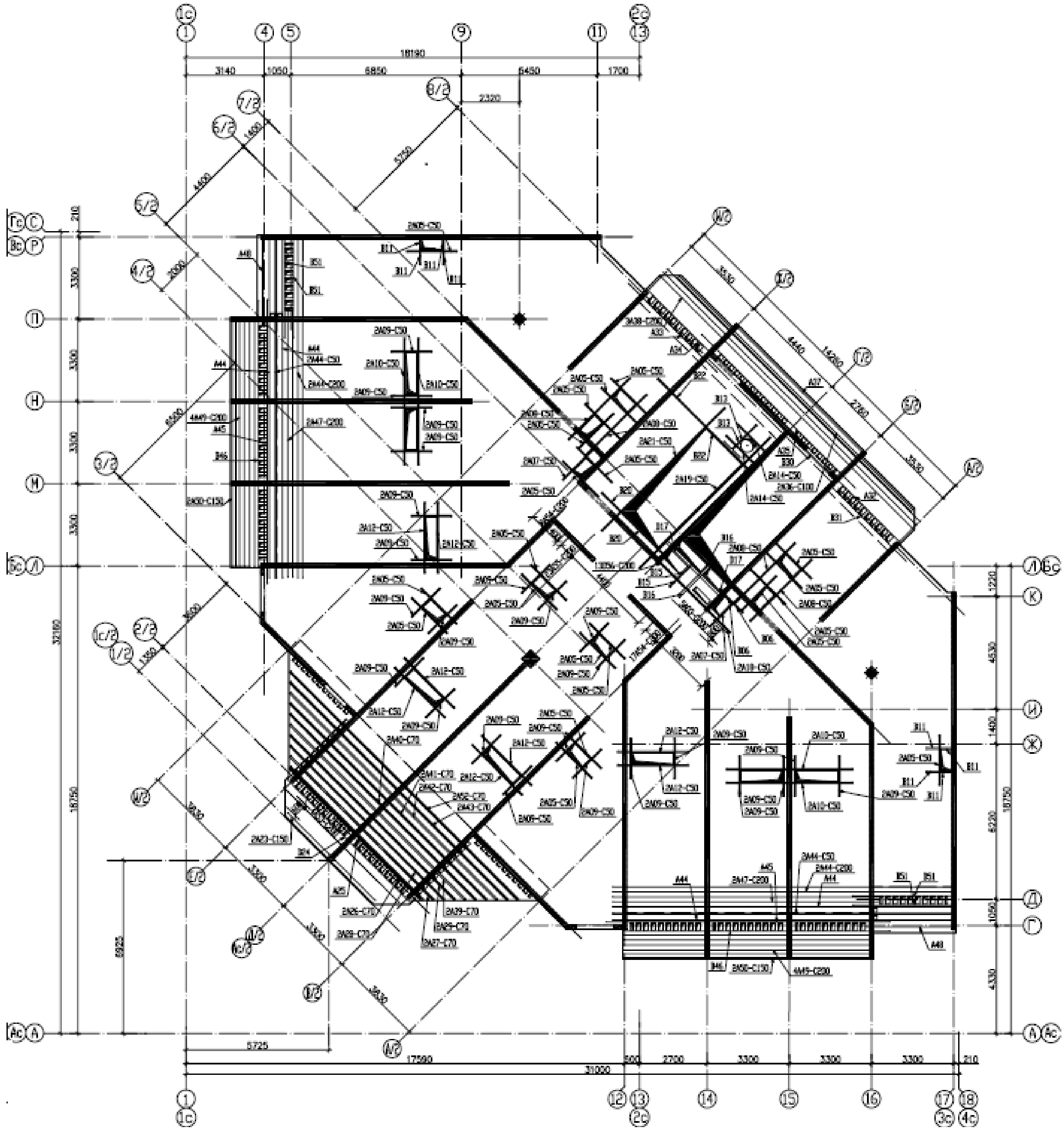


Figure 5.7 Additional bottom reinforcement

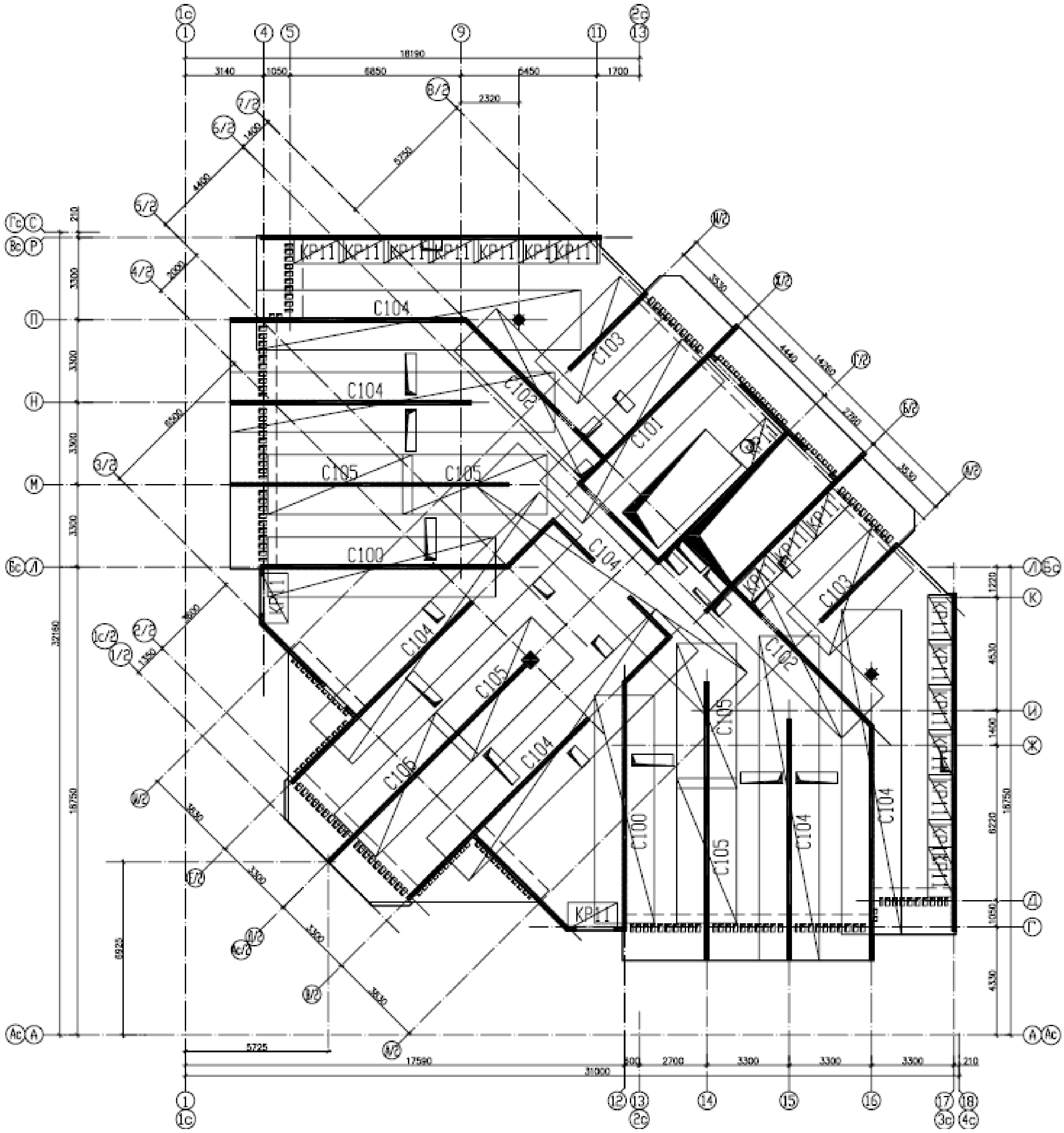


Figure 5.8 Top reinforcement

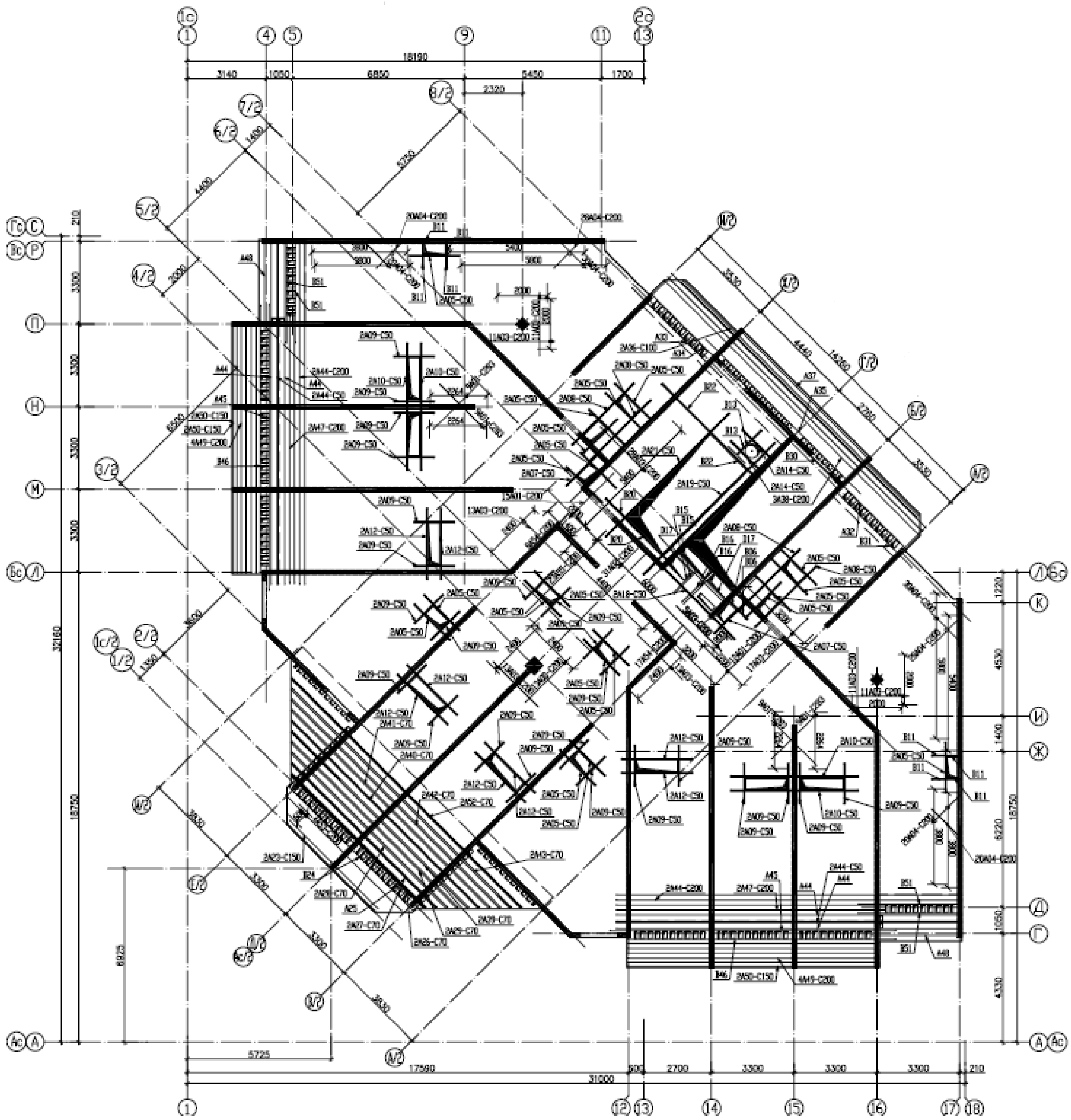


Figure 5.9 Additional top reinforcement

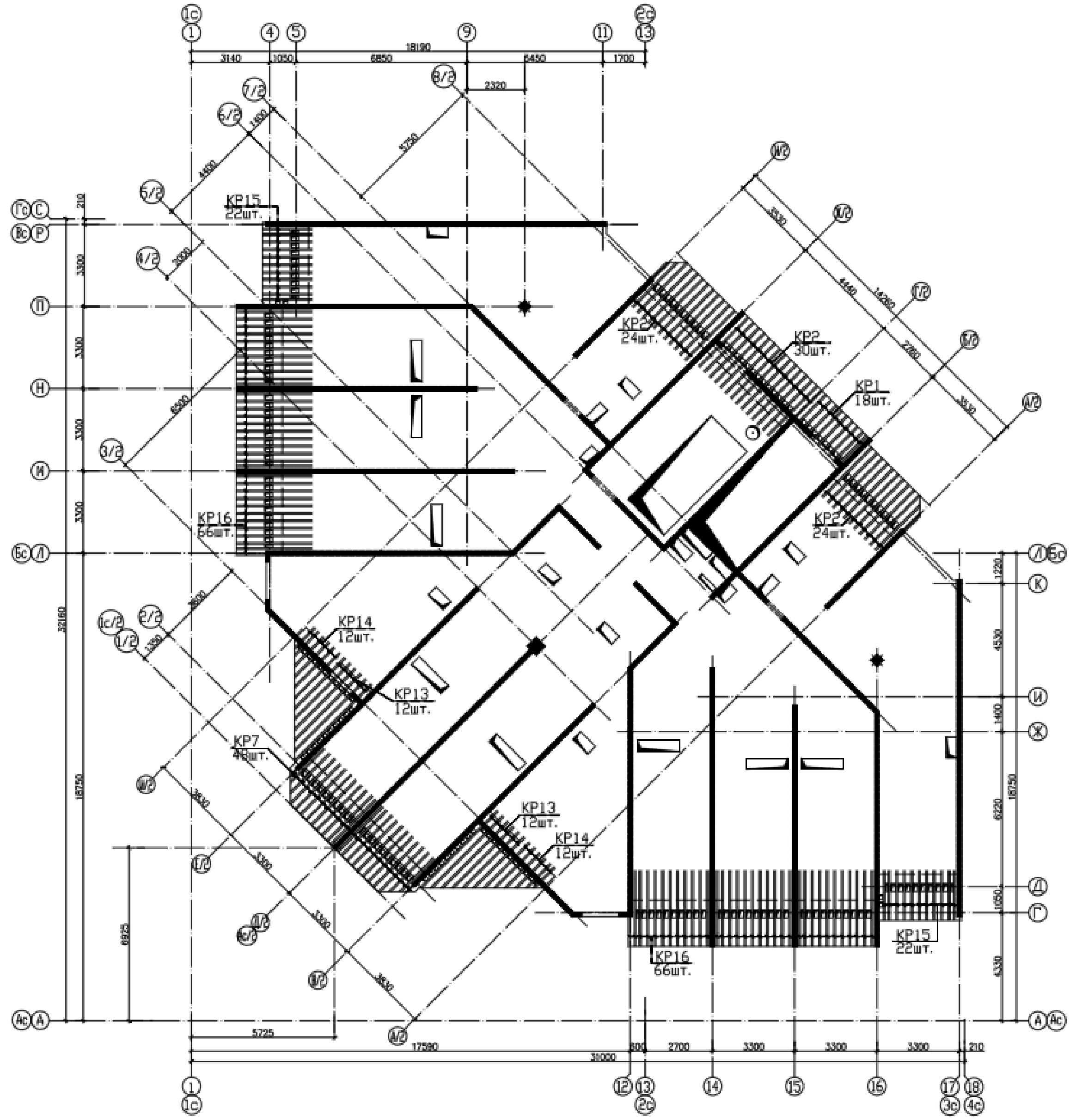


Figure 5.10 Installing cages of reinforcement on balconies

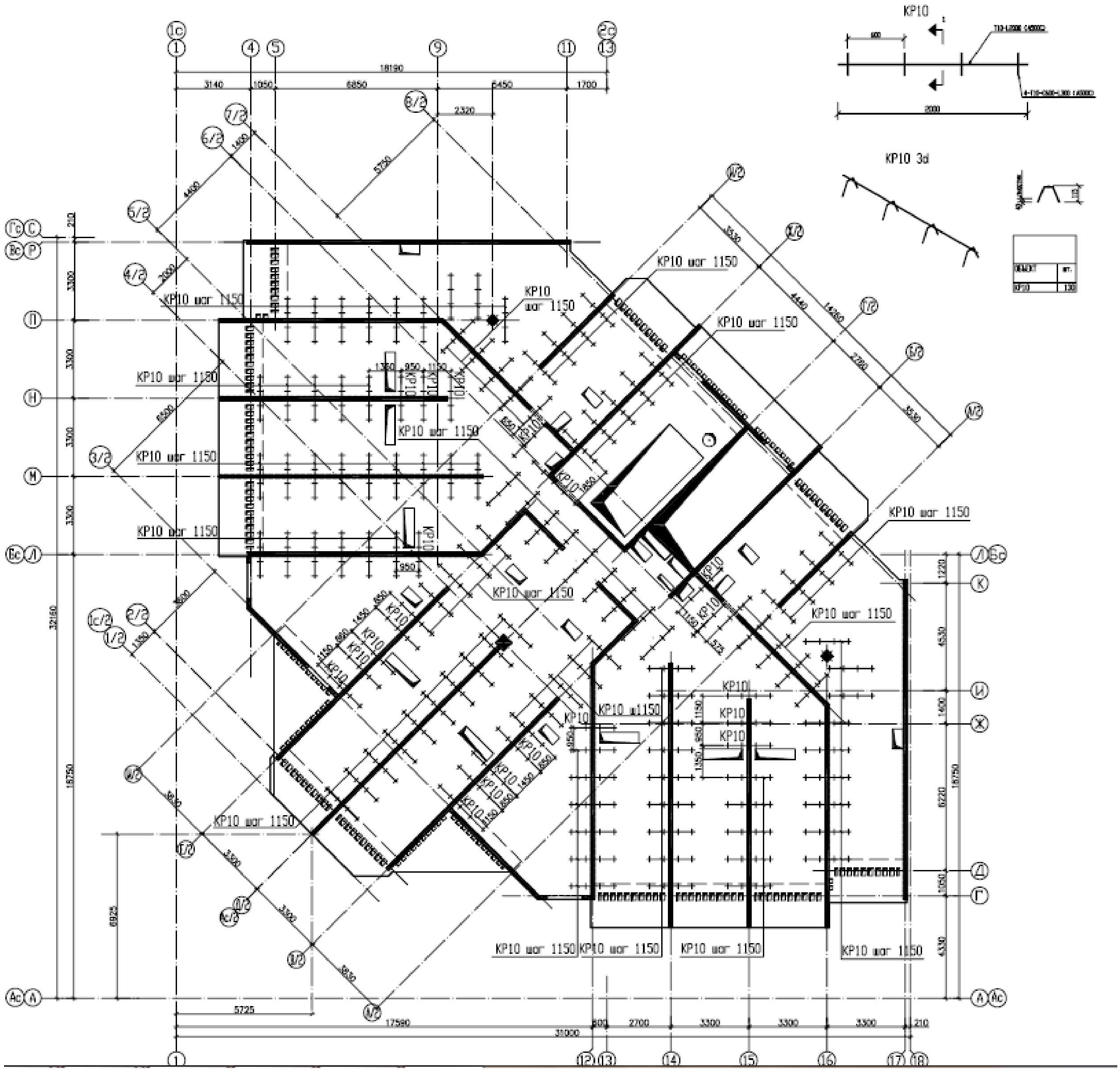


Figure 5.11 Installing supporting cages for setting upper reinforcement

Main index:

Bottom reinforcement: amount of meshes – 52; maximum weight of the mesh < 47 kg (it could be placed with 4 workers); average time of installation with additional reinforcement – 7 min/one mesh; total time for installing bottom reinforcement – 52*0.07=6 hours.

Top reinforcement: amount of meshes – 20; maximum weight of the mesh < 95 kg (it could be placed with 4 workers); average time of installation with additional reinforcement – 7 min/one mesh; total time for installing top reinforcement – 20*0.07=2.5 hours.

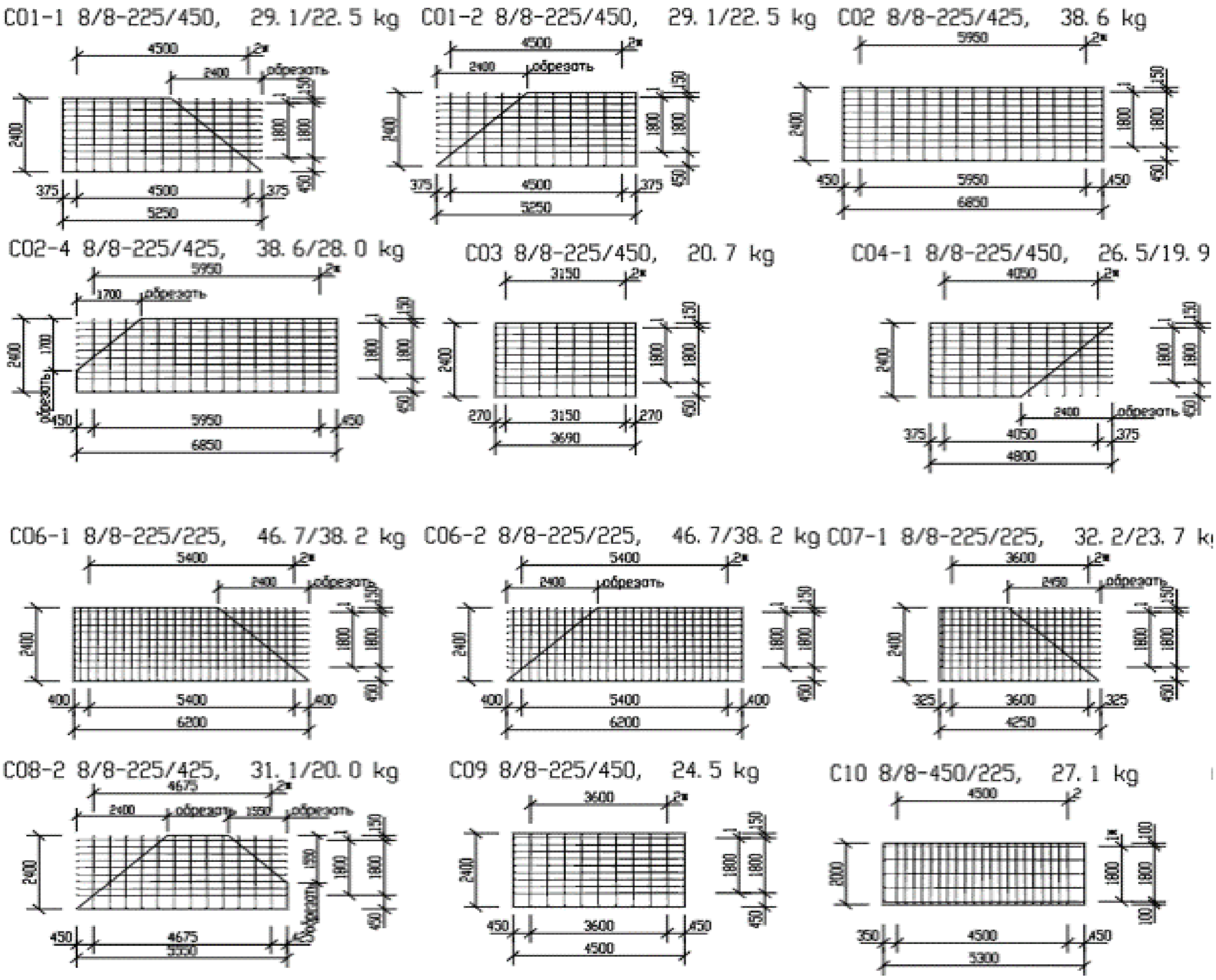


Figure 5.12 Types of reinforcement meshes

6 GENERAL PROCEDURE OF REINFORCING OVERLAPS WITH MESHES

1) Start with one reinforcement mesh

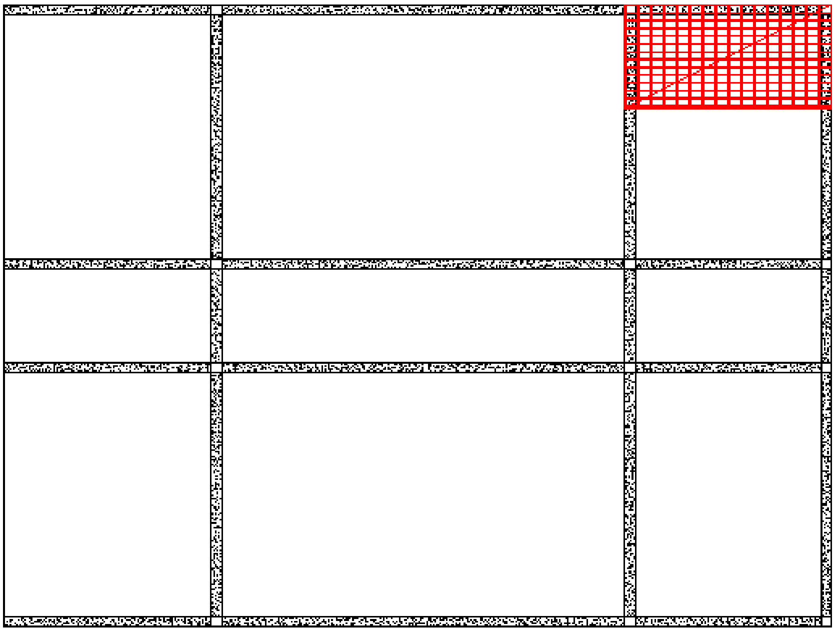


Figure 6.1 First step of reinforcing overlaps with meshes

2) Installing next meshes as column:

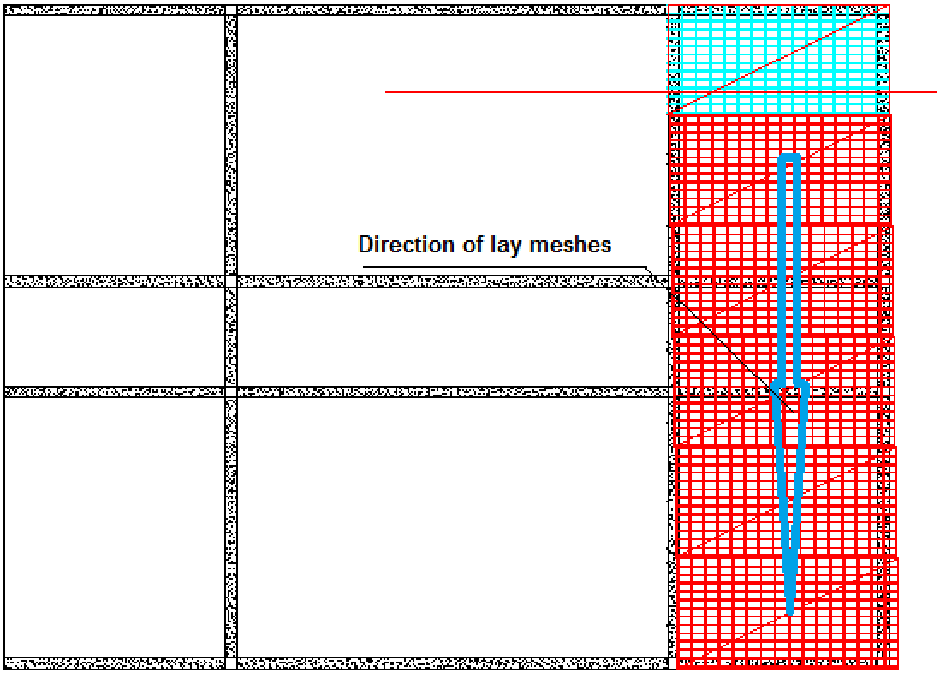


Figure 6.2 Second step of reinforcing overlaps with meshes

3) Installing next meshes as pictured:

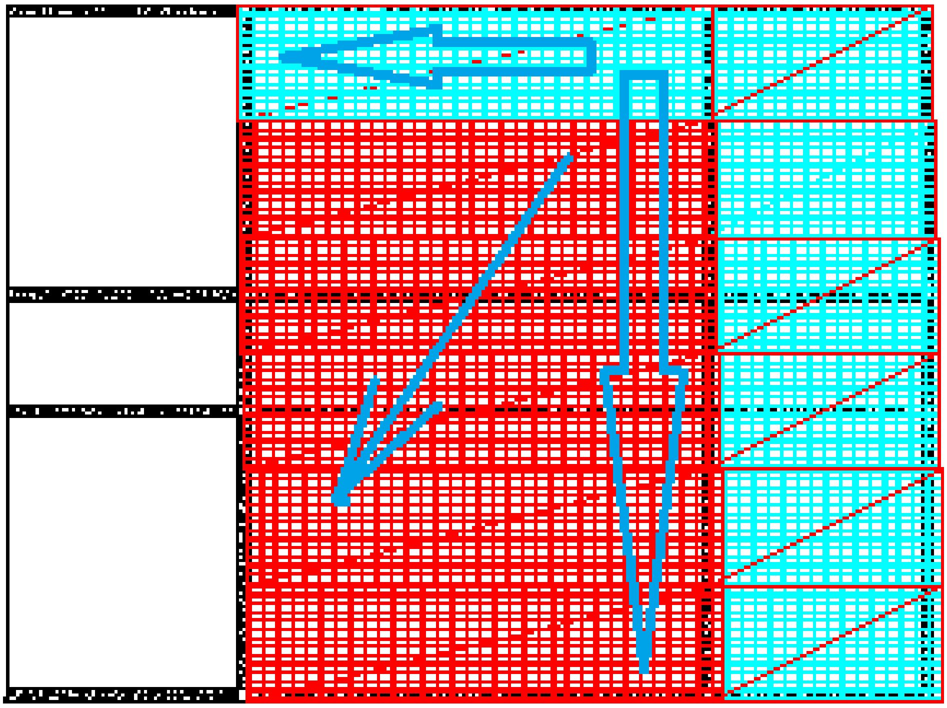


Figure 6.3 Third step of reinforcing overlaps with meshes

4) Installing cages of reinforcement on the slabs edges

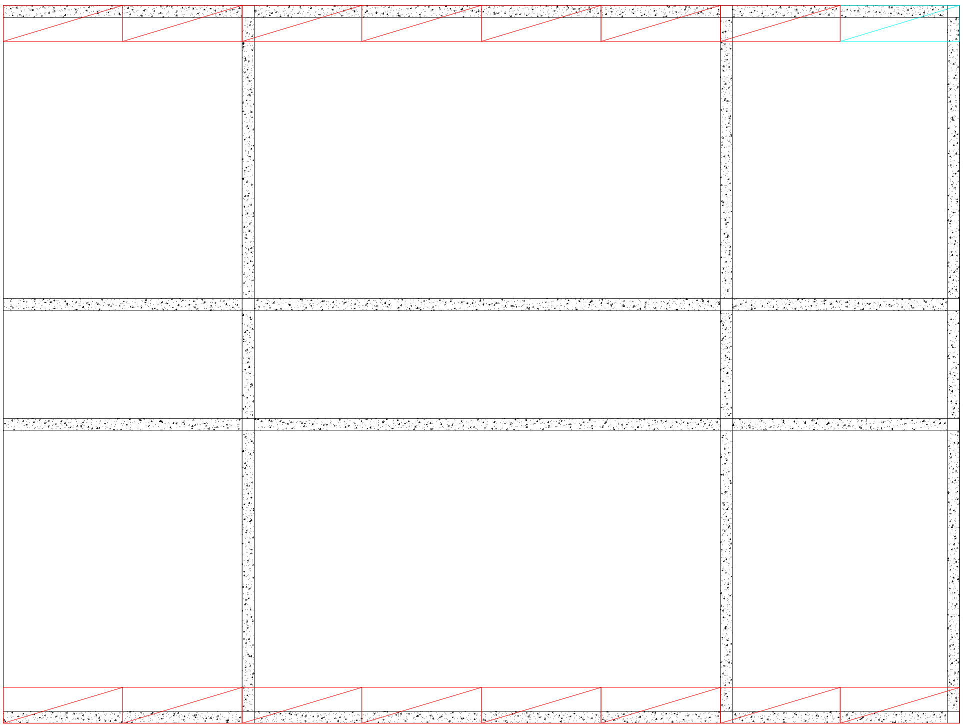


Figure 6.4 Installation places of supporting cages

5) Installing supporting cages for upper meshes

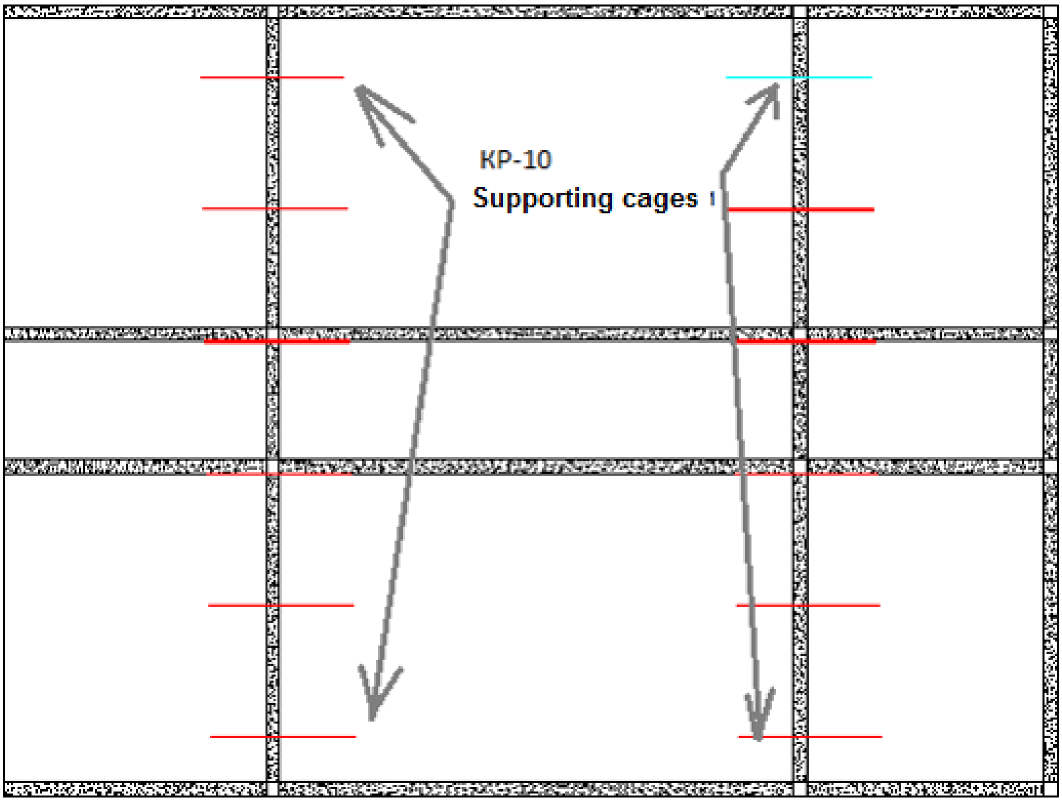


Figure 6.5 Installation places of supporting cages

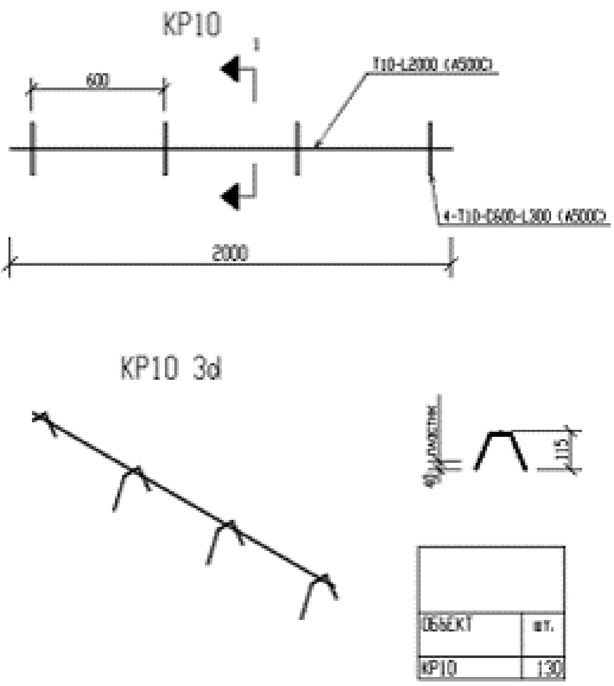


Figure 6.6 Supporting cage – KP10

6) Installing top meshes

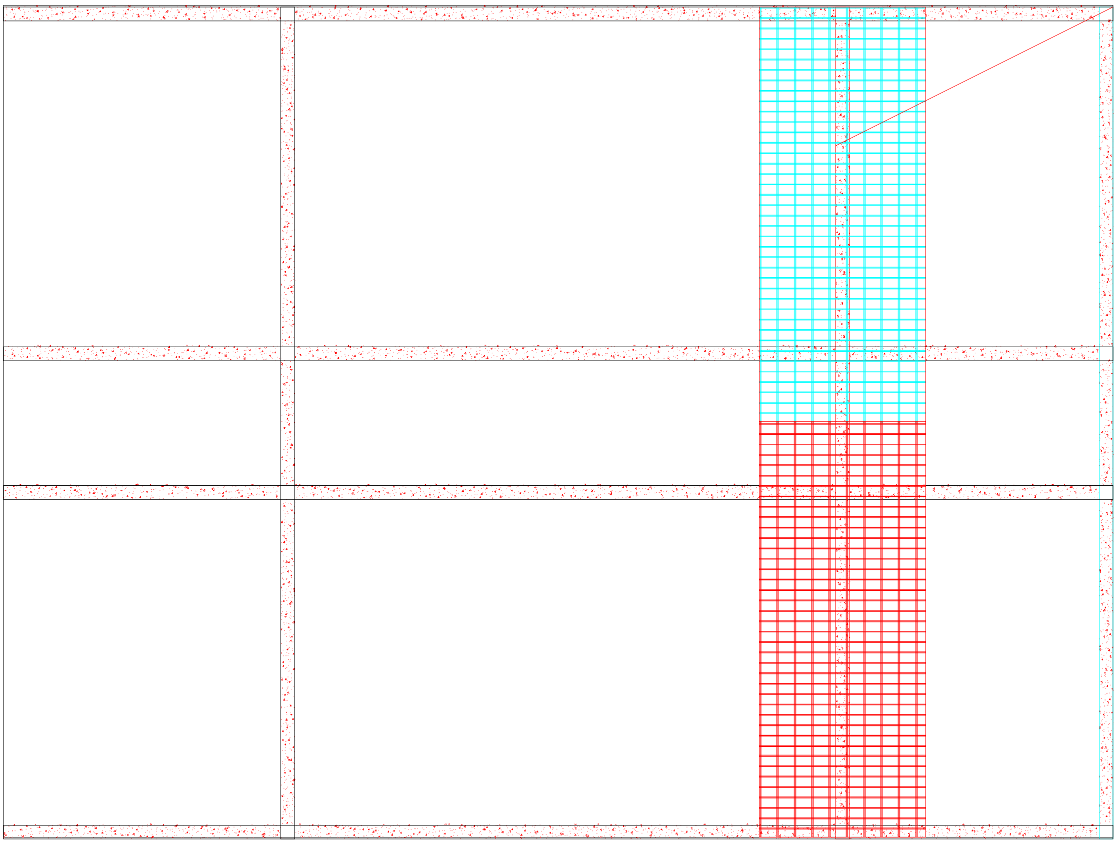


Figure 6.7 Final step of reinforcing overlaps with meshes

7 COMPARISON OF WAYS OF REINFORCEMENT

7.1 Comparison of steel spread

Comparison table about steel spread on slab reinforcement (april 2014)

Table 7.1 Reinforcement with separate rods

	kg	**kg/m^2**	**kg/m^3**
Additional reinforcement	4799.1	7,38	50,6
Main reinforcement (separate rods)	10325.5	15,89	108,7
Balcony cage reinforcement	2188,1	3,4	23,1

Total	17312.7	26,63	182,2
Area of the slab — 650 м2			

Table 7.2 Reinforcement with meshes

	kg	**kg/m²**	**kg/m³**
Additional reinforcement	3007,6	4,62	31.7
Main reinforcement (meshes)	3512.6/ 5486.8	5,1/8,5	37/58
Balcony cage reinforcement	2194,3	3,4	23,1
Total	8714,5/ 10688,7	13,5/ 16,5	91.73 / 112,6
Area of the slab — 650 м2			

Note: In ratio the value for meshes with diameter 8 mm (from calculation), in numerator is value for meshes with diameter 10 mm (using project decision)

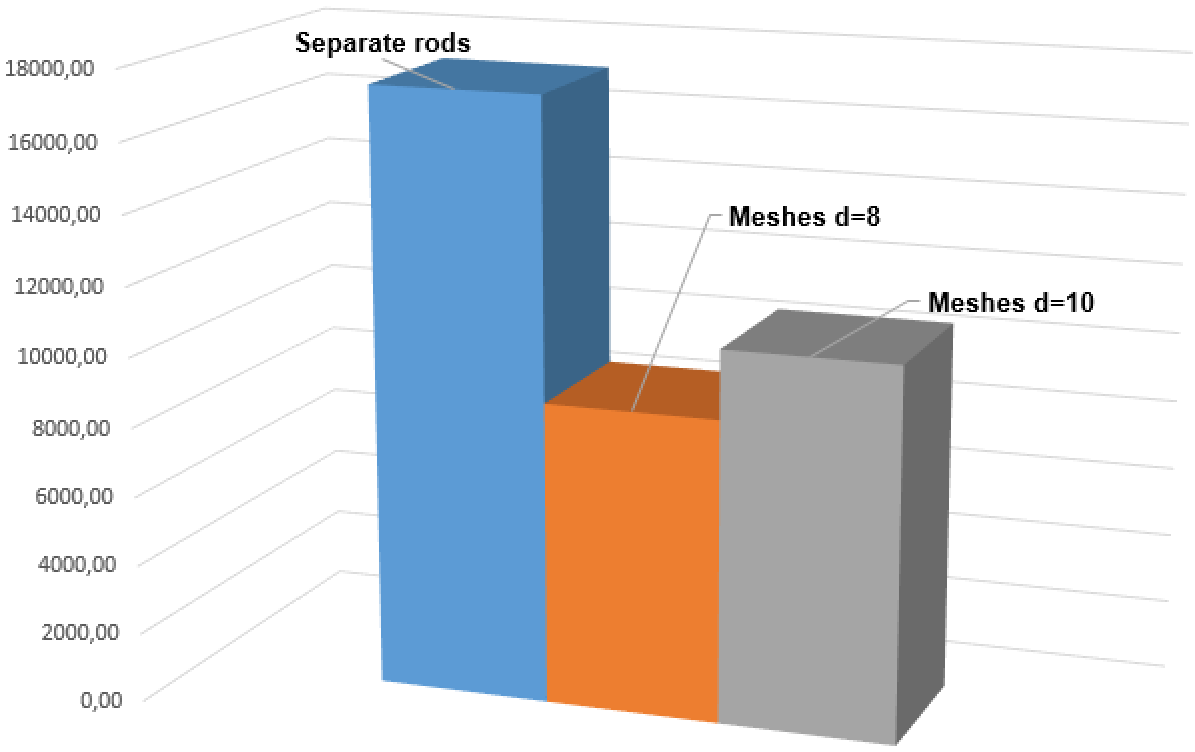


Figure 7.1 Comparison of total amount of reinforcement, kg

7.2 Comparison of rate of flow:

Table 7.3 Reinforcement with separate rods

Project	17,3 t + (5 %) = 17,9 t (waste taking into account)	650 m2
Cost of materials	447500 rub	
Time of reinforcement	16 h (2 shifts)	

Table 7.4 Reinforcement with meshes

		Economy
Project	8,7 t / 10,7 t	-9,2 t / -7,2 t
Cost of materials	297540 /365940	= -149000 /81560 rub
Economy of time	8,5 h (1 shift)	= -7,5 h

Note: In ratio the value for meshes with diameter 8 mm (from calculation), in numerator is value for meshes with diameter 10 mm (using project decision)

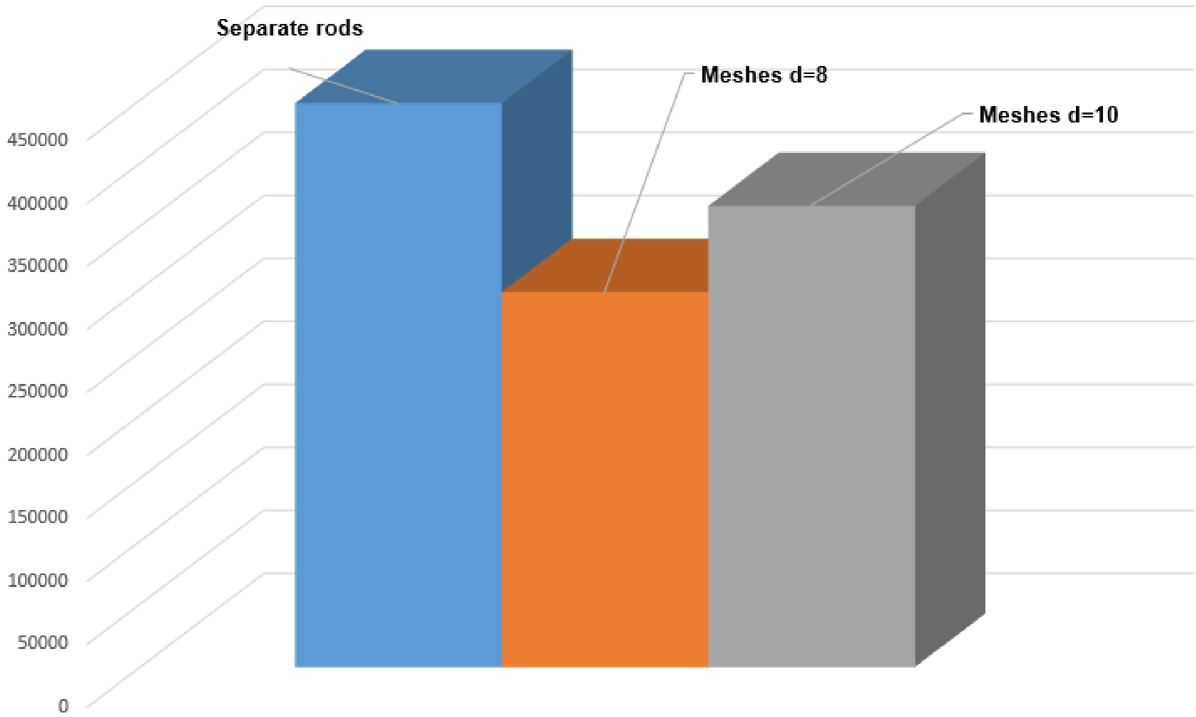


Figure 7.2 Comparison of cost of materials

7.3 Economical efficiency

Economic benefit from using unified reinforcement meshes and cages in construction is achieved from:

- Using reinforcement units, casted from new effective classes of reinforcement (A500C, A500CП and B500C), abd using them instead of reinforcement class A400 (A-III) allows to decrease steel spread on 10%; moreover, using reinforcement class A500SP, which has increased adhesion with concrete, allows to decrease the length of anchoring, increase crack strength and decrease deformability of reinforcement concrete structures;
- Decrease of labor intensivity and cost of project works because of exception from design the great amount of individual separate reinforcement units;
- Decrease of hand-knitted of reinforcement, decrease of labor intensivity and cost of reinforcement works.

Using of unified, quality prefabricated reinforcement units (reinforcement meshes, cages etc.) allows to decrease cost, increase productivity and quality of construction, decrease time.

8 OFFER TO INCREASE TECHNO-ECONOMIC EFFICIENCY OF REINFORCEMENT IN RUSSIA

Nowadays, considerable volume of reinforcement structures fabricated in specialized reinforcement assembly shops, equipped with mechanized and automated production lines. Especially high economical effect comes out if the big volume of reinforcement units are produced. Techno-economic calculations shows that in centralized reinforcement assembly shops is reasonable to produce main types of popular reinforcement units and bring them to precast concrete fabric. Factory update this units or make reinforcement structures from them, including volume and needed availability.

One of the effective ways to organize the process of reinforcement work – prefabricate volume reinforcement cages of entirely whole reinforcement structure. After that, reinforcement cage divided into separate blocks, convenient to transport and conveyance to installation site. Structure from reinforcement blocks is casted in place, by creating welded joints of rods of the blocks. Especially profitable this method with difficult and high reinforcement cage. In reinforcement assembly shops of precast concrete fabric is also reasonable to produce non-typical reinforcement units by using same method.

Productivity of installation of reinforcement substantially depends on equipment arrangement in reinforcement assembly shop. For more effective using of serial equipment by decreasing time of its checkout, it is necessary to do analyze of project parameters of reinforcement units to standardize them. The effectiveness of reinforcement process could be increased by using reinforcement with more rational surface, for example – screw-shaped. It make joints, grips and anchoring easier while tensioning. Decreasing steel spread and weight of reinforcement structure could be done by using for reinforcement production the steel with high strength properties. It could be done by special additional treatment of steel, like thermal treatment and grading it chemical compound.

Welded meshes with rational placement of reinforcement (with periodical spacing and diameter, which takes in calculation stress block while unit is loaded) should be using wider. In stressed structures, it is necessary to use untensioned reinforcement more rationally that provides to take in account ratio of reinforcement more accurate. The practice shows that in some cases it is rational to produce and use reinforcement units from one buckled mesh, which creates three-dimensional reinforcement.

Effectiveness of pre-stressed reinforced concrete units could be increased by using the method of release concrete by transferring stresses on hardened concrete without injection of openings, that provides to maintain constant stress because of additional pre-stressing reinforcement in concrete at the period of maintenance. This is due to the fact that as a result of concrete creep, steel relaxation, deformation of anchoring nodes. Temperature drops and other factors, pre-stress in concrete can be decreased.

There are also back-ups of steel economy while designing and producing concrete inserts, assembling reinforcement and lifting eyes. Moreover, delivering on precast concrete fabrics at least for commodity of reinforcement with close tolerance allows to decrease steel waste. Wasteless process of preparing reinforcement of given size can be organized by cutting bar-in-coil. For this, range of diameters of reinforcement delivered in coils should be increased.

Reduction of labour intensity and spread of materials can be achieved by optimal supply of complete set of assembly shop. In existing industry instead of using special machines reinforcement often on one power-operated machine. On this machine, firstly long rods are cut, and then, this rods divided into shorts rods, that unavoidable creates wastes of steel and increase labour intensity. Sizable (up to 7%) steel spread appears , when rods joint with overlap. Big spread of energy and metal appears when reinforcement tensioned by electrothermal method. The economy of the material can be achieved by using welding by friction instead of spot welding.

By change pneumatic equipment of spot-welding machine for mechanic energy usage is going to decrease. In reinforcement cages and especially meshes, welding of all crossings of rods is unnecessary. Because of it, changing to welding of nodes of reinforcement meshes in check order allows to decrease energy usage. Moreover, energy usage could often increase because of disturbance of optimal mode of spot-welding, that provides to big settlement and metal burning of reinforcement.

Based on above, rational equipment arrangement in reinforcement assembly shop with automatic technological equipment, developing of work organization, increasing qualification of rod benders, using effective reinforcement steel and reinforcement units, optimizing modes of spot-welding machines, constant modernization of technological processes and using other backups allows to seriously increase techno-economical effectiveness of production and reinforcement works. (2,3)

9 CONCLUSION

Every year in construction industry comes a lot of new technology adoption. It happens, firstly to rapid construction process, secondly – to make this process wasteless and to maximize durability, sustainability and comfort.

One of the strong example of usage new technologies is usage precast reinforcement meshes to reinforce main constructions.

The aim of thesis was to show up profits of using reinforcement meshes to construct buildings.

In this thesis was done research which shows trend of increasing usage of precast reinforcing mesh in the leading construction corporations, that provides time reduction of construction and consumption reduction of capacity direct on construction site. Technology of reinforcement by meshes of foundation, walls and slabs are given. Calculation of length of overlaps for various norms (BY 50,2004; SP 52-101-2003; EC2) is done. Analysis of economical effect of using reinforcement meshes is done.

The example of calculation of reinforcement typical slab with area 650 m^2 of 20-storryied brick-monolith residential building by meshes and separate rods is given. That allows to clearly demonstrate profits of reinforcement with meshes technology.

At last, some advises of how to increase techno-economical effectiveness of reinforcement were created. Decrease of steel spread of reinforcement concrete structures was demonstrated.

The given decisions of how to use precast reinforcement meshes to reinforce concrete structures brings big economical effect in the field of reduction of construction time, economy construction resources and reduction of operating personnel and machines.

In Saint-Petersburg the first step towards the development of the market have already taken. Construction activity is not reducing as much as in other regions. Moreover, there are many European and Turkish construction companies, which are often uses technology of prefabricated materials. That, of course, has a positive effect on the development of reinforcement industry. Therefore, St. Petersburg is currently the leader in improving the technological reinforcement products in Russia.

FIGURES

TABLES

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