MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ARCHITECTURAL STRUCTURES AND AIRFIELDS
COMPUTER TECHNOLOGIES OF AIRPORT CONSTRUCTION AND RECONSTRUCTION DEPARTMENT

TO ADMIT TO GUARD

Head of the Department

~~O.~~I. Lapenko

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QUALIFICATION PAPER

(EXPLANATORY NOTE)

SPECIALTY 192 «BUILDING AND CIVIL ENGINEERING»

Educational and professional program: «Industrial and civil engineering»

Theme: «The building of a sports school in the city of Poltava»

Performed by: Ponochovnyi Maxym Vitaliyovich

Qualification Paper Advisor: Assosiated professor PhD Nataliia Kostyra

Design rule check: Assosiated professor PhD Oleksandr Rodchenko

Kyiv 2023

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет наземних споруд і аеродромів

Кафедра комп'ютерних технологій будівництва та реконструкції аеропортів

Спеціальність: 192 «Будівництво та цивільна інженерія»

Освітньо-професійна програма: «Промислове і цивільне будівництво»

ЗАТВЕРДЖУЮ

Завідувач кафедри

__________ О.І.Лапенко

«11» травня 2023р.

ЗАВДАННЯ

на виконання кваліфікаційної роботи

Поночовний Максим Віталійович

(П.І.Б. випускника)

1. Тема роботи «Будівля спортивної школи у м. Полтава»

затверджена наказом ректора від «11» травня 2023 р. №681/ст.

2. Термін виконання роботи: з 29 травня 2023 р. по 20 червня 2023 р.

3. Вихідні дані роботи: запроєктувати двоповерхову громадську будівлю (школа) у місті Полтава на основі металевого несучого каркасу. Будівля має розміри в плані 53,6 м на 46,8 м. Висота поверху 3 метри, головний зал проходить через всю висоту будівлі без міжповерхових перекриттів. Будівля має підвальне приміщення, яке служить бомбосховищем.

4. Зміст пояснювальної записки:

- Аналітичний розділ (з урахуванням основних особливостей будівлі);
- Архітектурний розділ (архітектурні плани, фасади та візуалізації будівлі);
- Конструктивний розділ (розрахунок та проектування головних конструктивних елементів будівлі);
- Технологічна карта (вибір крану, його технічні характеристики та розміщення на будівельному майданчику);
- Охорона праці (норми поводження під час будівельного процесу та дії при можливих надзвичайних ситуаціях);
- Література (список використаних джерел);
- Додаток 1 (креслення).

5. Перелік обов'язкового ілюстративного матеріалу: таблиці, рисунки, діаграми, графіки.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1.	Аналітичний розділ	29.05-31.05	
2.	Архітектурний розділ	01.06-05.06	
3.	Конструктивний розділ	06.06-11.06	
4.	Технологічна карта	12.06-14.06	
5.	Охорона праці	15.06-19.06	

7. Консультація з окремих розділів:

Назва розділу	Консультант (посада, П.І.Б.)	Дата, підпис	
		Завдання видав	Завдання прийняв
1. Аналітичний розділ	Доцент Костира Н.О.	29.05	31.05
2. Архітектурний розділ	Доцент Костира Н.О.	01.06	05.06
3. Конструктивний розділ	Доцент Костира Н.О.	06.06	11.06
4. Технологічна карта	Доцент Костира Н.О.	12.06	14.06
5. Охорона праці	Доцент Костира Н.О.	15.06	19.06

8. Дата видачі завдання: «29» травня 2023 р.

Керівник кваліфікаційної роботи: Костира Н.О. ____________

Завдання прийняв до виконання: Поночовний М.В. ____________

CONTENT

Introduction

The topic of the diploma project is "Construction of a sports school in the city of Poltava". Today, modern sports schools include many different directions and types of sports, which differ among themselves in terms of purpose, purpose and type of loads, starting with ordinary fitness and gymnastics, ending with power sports. Schools of this type solve several problems at once for the main visitors, that is, children and their parents, namely, they remove any doubts about the safety and comfort of children, their stay during the school day.

From a structural point of view, the school is designed as a prefabricated building, which consists of many structural elements (columns, beams, trusses) that form the main frame, and hinged wall panels, which will significantly speed up and simplify the construction process. The materials used at all stages of construction are quite common, reliable, simple in the construction process and at the same time quite budget-friendly.

The goal is to study the assembly structures of the floors of the sports school building and analyze the stress-deformation state of the beams that cover the span above the building.

Calculation methods - numerical methods (finite element method (ITU)).

The main elements of my building are reinforced concrete columns in fixed formwork and I-beams of the floors, which together form the main frame of the school.

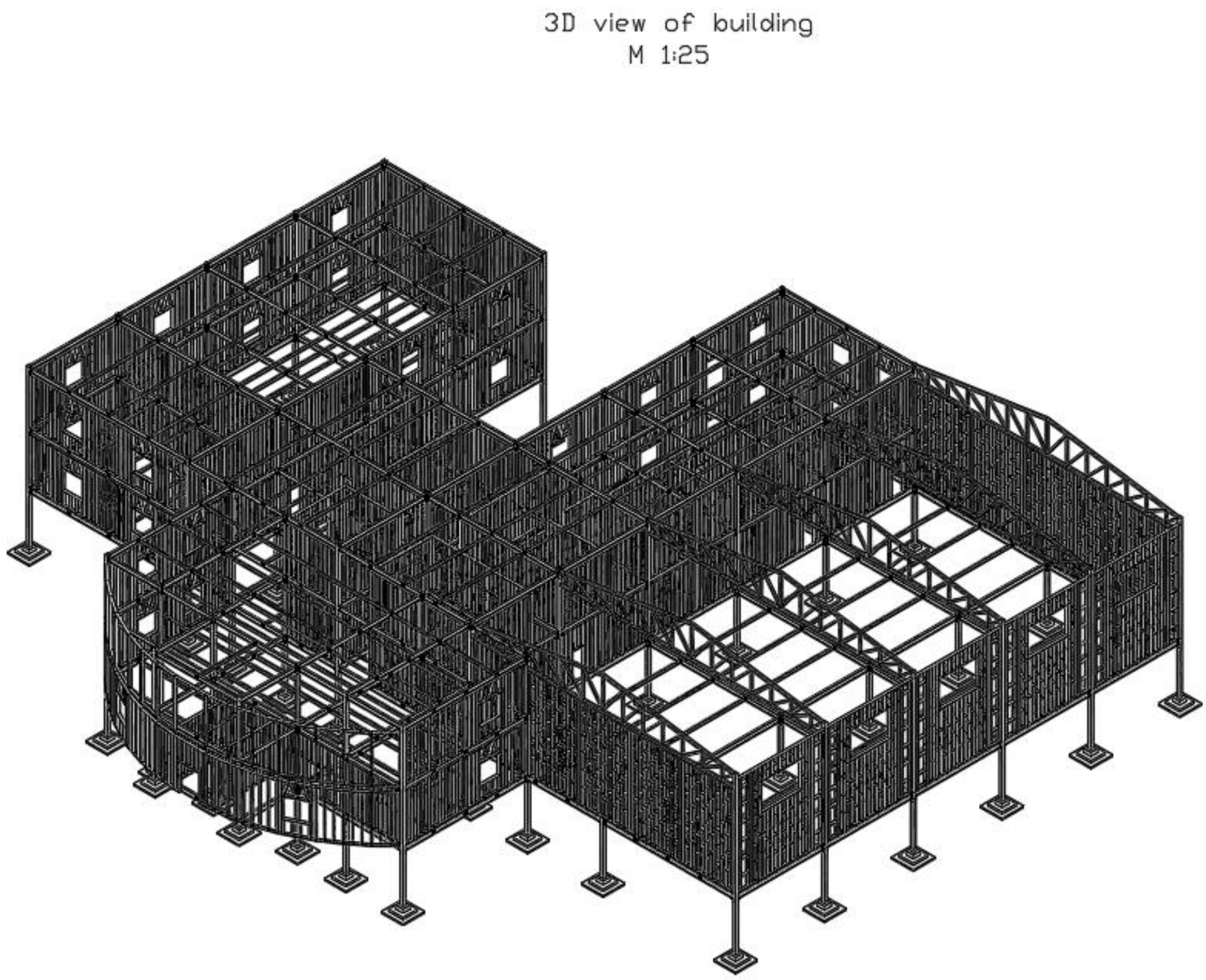
CHAPTER 1

Analytical review

1.1. General characteristics and parameters of construction

Output data:

In accordance with the task for the diploma project, it is necessary to develop a project on the topic: "Sports school in the city of Poltava".



General characteristics of construction:

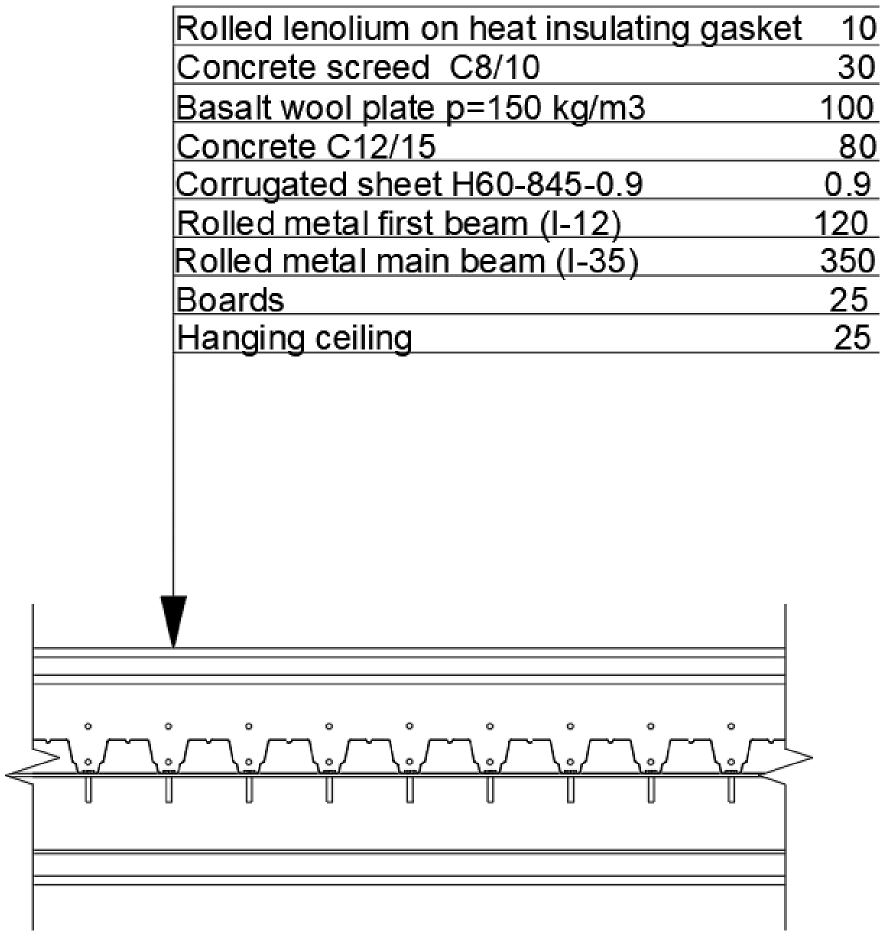
The mark of the surface of the clean floor of the first floor, which corresponds to the absolute mark, is taken as a conditional mark of 0.000.

- the building's impact class is CC2

- degree of fire resistance – IIIa
- the degree of durability is II
- climatic zone – I
- the standard depth of seasonal soil freezing is 120 cm.
- the structural system is a frame building.

The following constructive decisions were assumed in the project:

- Foundations – reinforced concrete monolithic with solid type column support with the dimensions of the sole in the plan at the mark -4.570, concrete class C15/20, reinforced with reinforcing frames A240C;
- Foundation and basement walls - made of prefabricated concrete blocks of basement walls, concrete grade C15/20, reinforced with bars of grade A240C. They are installed with the help of a crane, connecting to the columns and the floor slab. The gaps formed between the column and the panel are additionally reinforced and filled with concrete along the contour of the wall;
- Walls of the 1-st and 2-nd floor – prefabricated wall panels with an LSTK frame, insulated from the inside with mineral wool. Cladding from the inside is carried out using plasterboard and wall plaster. The facing of the facade is formed by ready-made facade hinged panels in the form of plates;
- Columns – steel-reinforced concrete (in fixed formwork), concrete grade C15/20, reinforced with bars of grade A240C. The formwork size is 200x200 mm. A steel pipe is installed in the base of the column on the foundation using a crane, after which concrete is poured into the pipe as a formwork;
- Overlapping – on a metal corrugated sheet H60-845-0.9 over I-beams, concrete C12/15 with a reinforcing mesh of grade A240C (more detailing on the scheme below);



- Internal stairs – made of a metal profile pipe, covered with facing materials with handrails mounted on the surface. And monolithic, concrete C12/15 with a reinforcement of grade A240C. Pre-fabricated parts, such as staircases, landings, which are installed with the help of a crane on the embedded parts.
- Exterior doors and windows – metal-plastic, glazed with double-glazed windows;
- Internal doors – fire-resistant of 2nd type.

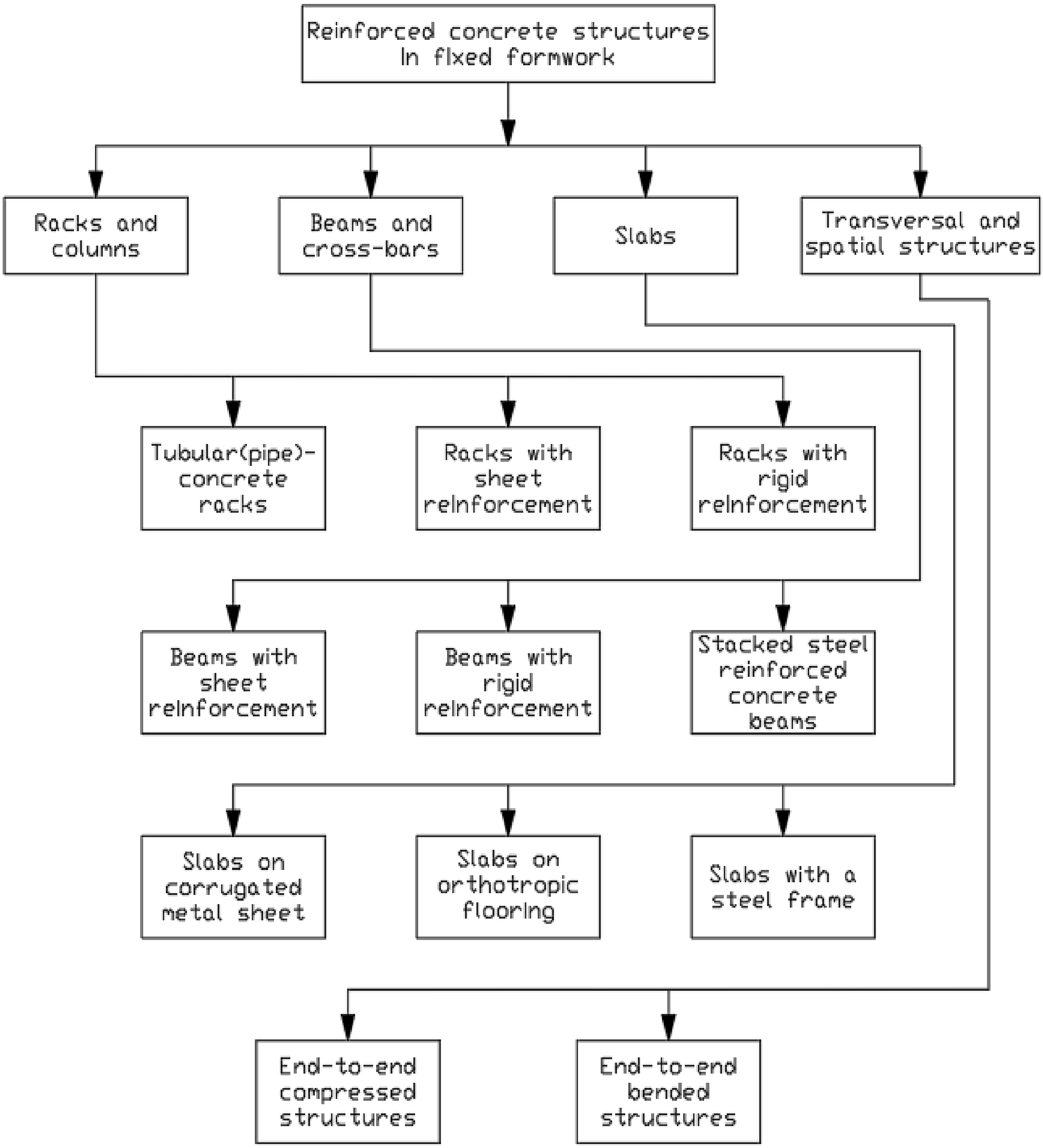
1.2. Main features and advantages of reinforced-concrete columns in steel framework

Steel-reinforced concrete load-bearing elements due to the inclusion of concrete in a steel pipe of any cross-section represent a special combination of concrete and steel. In such a complex element, under the action of an external load, the pipe plays the role of a shell, due to which a complex stress-deformed state occurs in the element and thereby creates favorable conditions for increasing the load-bearing capacity of the reinforced concrete element.

It has long been known that the joint work of the concrete core and the shell pipe, which contributes to the emergence of the so-called clamping effect, allows to increase the bearing capacity of reinforced concrete elements by 1.5-2 times compared to reinforced concrete elements. To date, in many countries of the world, significant experimental and theoretical studies of the load-bearing capacity and stress-strain state of steel-reinforced concrete elements have been carried out, taking into account operational and limit loads, as well as long-term processes that occur during the operation of structures. Gained some experience in calculation, design and installation of structures made of reinforced concrete elements; it is also known that for many years load-bearing structures made of 3 elements made of reinforced concrete have been successfully used in buildings of various purposes.

The use of steel-reinforced concrete structures is not determined by the requirements of production technology, aggressiveness, temperature and humidity regime of the environment, etc. The structural features of the connections of steel-reinforced concrete elements allow forming mesh systems of various shapes and sizes from them.

Classification of reinforced concrete structures made in fixed formwork



Let`s consider tubular concrete element with rod reinforcement:

Recently, tubular concrete structures with rod reinforcement have been increasingly used in construction. When constructing any buildings using these structures, it is possible to apply industrial production methods directly on the construction site. With a relatively small cross-section, tubular concrete structures with rod reinforcement have a large bearing capacity. In developed European countries, the design of these structures is carried out in accordance with the norms of Eurocode 4.

In many countries, special attention is paid to tubular concrete structural elements with rod reinforcement of the concrete core. As you know, the shell pipe in this type of elements is multifunctional. Along with the technological functions (fixed formwork), it performs the function of strengthening (reinforcing) the concrete core, so the rod longitudinal reinforcement is considered as an additional one that works only in tension or compression. At the same time, such specific properties of structural elements as fire resistance, earthquake resistance and so on are increased.

An experimental study was conducted, during which the stress-deformed state and bearing capacity of tubular concrete elements with rod reinforcement were observed under axial and off-center compression, as well as during bending.

During such studies, the geometric parameters of the element, the strength characteristics of the materials used, the reinforcement ratio, as well as the method of load transfer are important.

Class A-III (A400C) ⌀12 reinforcement was used as rod reinforcement. The inner reinforcing rods were attached to the pipe by two equal-strength welding seams at the ends, and the outer ones by a discontinuous seam.

The results of experimental studies of pipe-concrete elements with rod reinforcement made it possible to draw conclusions about the deformation characteristics of such structural elements. The general results are formulated as follows:

1. As a result of experimental studies, it was determined to what extent the height of the element, the eccentricity of the load application, and the prism strength of the concrete affect the bearing capacity of tubular concrete elements with rod reinforcement. It was established that there is no brittle failure in the

investigated elements. It has been proven that concrete, pipe and rod reinforcement work together at all stages of loading. Tubular concrete elements with rod reinforcement have 1.5-2.5 times greater bearing capacity than the same elements made of reinforced concrete core and hollow pipes.

2. At the moment of reaching the limit state, the strength of concrete in tubular concrete with rod reinforcement exceeds the prism strength by 1.28-1.89 times.
3. The introduction of the reinforcing frame makes it possible to increase the strength and rigidity of tubular concrete structures, as well as to increase their fire resistance.
4. A simplified method for determining the load-bearing capacity of compressed and flexural tubular concrete elements with rod reinforcement is proposed by reducing the actual cross-section to the metal one using normative table values of longitudinal bending coefficients.
5. Production of pipe-concrete elements with rod reinforcement is possible with the use of technologies and equipment used in plants of reinforced concrete structures. At the same time, a reduction in labor costs and a high quality of concrete in the core are guaranteed.
6. Tubular concrete elements with rod reinforcement are advisable to use in structures that perceive large compressive loads. At the same time, a significant technical and economic effect is achieved due to saving materials, labor costs and reducing the cost of construction structures in general.
7. For the full use of rod reinforcement, it is necessary to use metal pipes with a strength close to the strength of additional rod reinforcement.
8. When filling the pipes with concrete of different strengths, the load-bearing capacity of the pipe-concrete elements increased by 1.6-1.9 times as the class of concrete increased in terms of compressive strength. So, the load-bearing capacity of a pipe with a section of 80x80x3 mm with core concrete class B40 was 244 kN, and with concrete class B60 - 415 kN, for samples 180x180x8 mm with concrete class B40, the load-bearing capacity was equal to 1409 kN, and with concrete class B60, the load-bearing capacity was 2248 kN.

1.3. Fire protection of steel structures

The melting point of steel is about 1500 °C. However, during a fire, thtemperature, as a rule, does not exceed 800-900 ° C. It may seem that steel is not afraid of fire, but this is not entirely true.

In conditions of high temperatures, many things change. The strength characteristics of steel structures decrease on an open fire. And it happens quite quickly. Changes start after 10-40 minutes. And according to fire safety requirements, this period of time should be much longer - from 25 minutes to 2.5 hours. That is, a reserve of time is needed before the arrival of the fire department and the start of extinguishing the fire. If this does not happen, then irreversible changes will occur in the metal structures, and the building will have to be dismantled. Or it may fall.

In the design, first of all, it is necessary to determine the degree of fire resistance of the building. In Ukraine, these requirements are enshrined in state building regulations. Such as DBN B.1.1-7:2016, DBN B.2.2-24, DBN B.2.2-15, etc.

There are two main methods of protecting steel from fire. All materials used for fire protection of metal structures are divided into the following groups:

- passive;
- reactive.

The protective effect of the first group is based on the characteristics of the material, which is resistant to exposure to open fire and high temperatures. They are actually an additional barrier between the flame and the metal. These can be plasters (gypsum and cement), plates and sheets (plasterboard, silicate, etc.) and other heat-insulating materials (blocks, bricks, etc.).

Plaster is usually the most economical way of protection. It is applied to metal structures in a layer of 10-50 mm. It is advisable to use it on steel structures of complex shape.

The choice between cement and gypsum plaster depends on the level of humidity in the room, operating conditions and the duration of preservation of the necessary protective properties.

At the same time, the main advantage of protective plates is their lack of direct contact with metal. You also need to understand that these are dry construction technologies that do not require additional equipment (unlike plasters). After all, they have a longer service life. And the class of fire resistance of steel structures with this method of fire protection is much higher.

Reactive materials are special flame retardant paints. They are aqueous, organic solvent, epoxy. Recently, foamed paints or materials with thermally expanded graphite have become increasingly popular. Another name is used - intumescent type paints.

Under normal conditions, they are no different from ordinary decorative paints. But when a certain surface temperature is reached, they foam and form an additional layer that separates the metal from the fire. They have both advantages over plasters and protective plates.

In any case, fire protection of metal structures is a responsible process that should be performed by experienced specialists. And the materials used for this purpose must necessarily have the necessary certificates of conformity.

CHAPTER 2

Architectural part

2.1. Object passport

The building has a complex configuration with dimensions on the plan of 53.3×47.3 m, has two floors and a basement.

Floor height:

- basement with a height of -3.530 to +0.000;
- the first floor with a height of +0.000 to +3.955;
- the second floor with a height of +3,955 to +7,900.

The maximum height of the building is +9,400
(according to DBN V.1.1.7-2016 Fire safety of construction sites).

Visualization of the school

Table 2.1

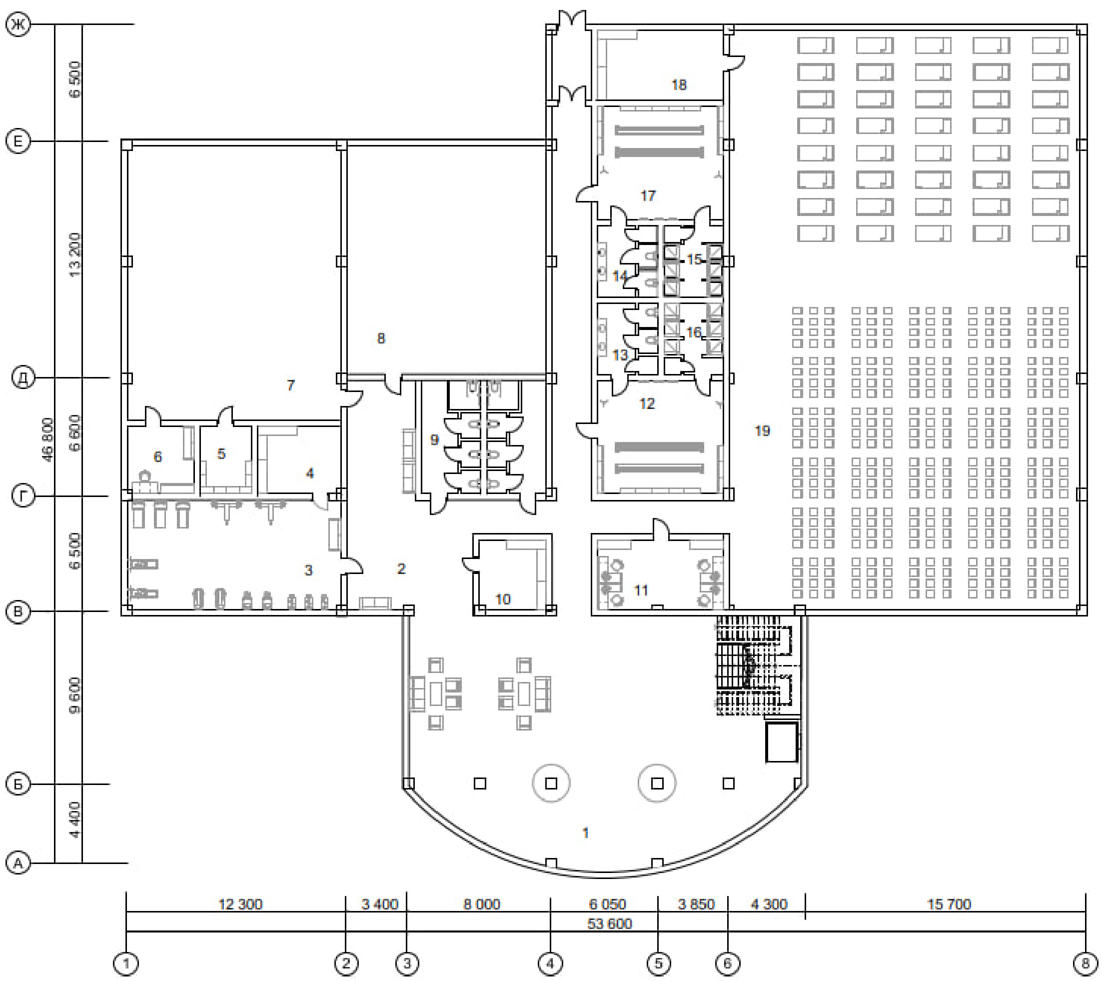
Area parameters of the building

Name	Un. of measurement	Number
1. Building area	m^2	2521,09
2. Total area	m^2	1168,41
3. Working area	m^2	4081,98
4. Building volume	m^2	20948,00

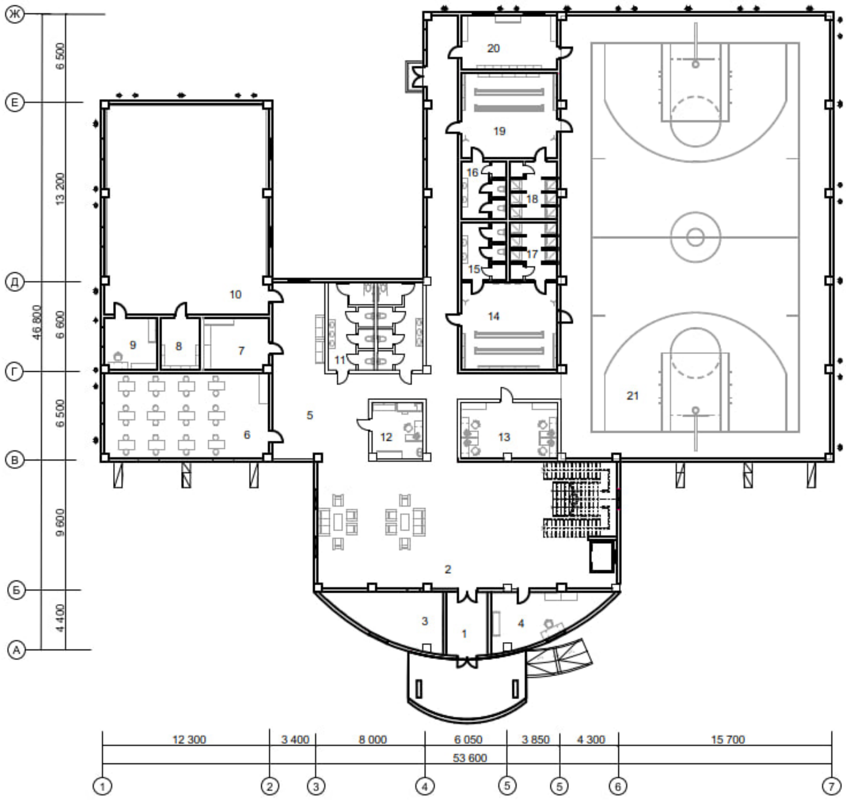
These renderings show the approximate appearance of the building at the final stage of construction.

2.2 Architectural-constructive solution

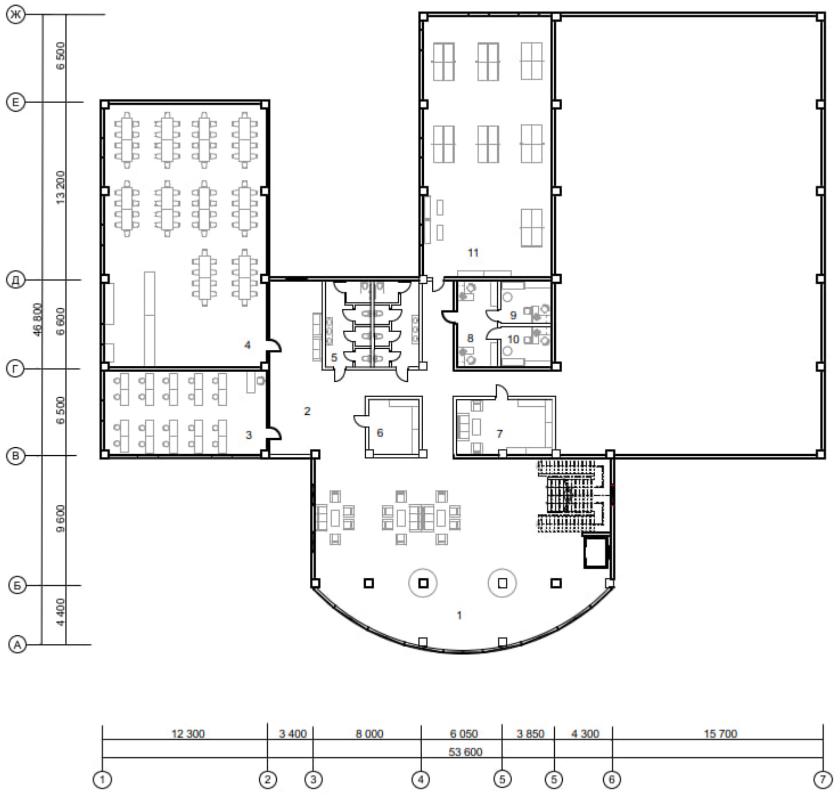
Architectural facades of the school



Architectural plan of the basement



Architectural plan of the 1-st floor



Architectural plan of the 2-nd floor

Table 2.2

Explication of premises of the school

Number	**Name of room**	**Area, m2**
0.1	Hall 1	204.43
0.2	Hall 2	43.18
0.3	Chess room	76.7
0.4	Inventory room	17.13
0.5	Inventory room	11.17
0.6	Trainer`s office	14.4
0.7	Gymnasium	182.9
0.8	Boxing gym	140.94
0.9	WC	21.0
0.10	WC	20.93
0.11	Medical room	15.97
0.12	Trainer`s office	31.76
0.13	Women`s locker room	46.8
0.14	Men`s WC	13.45
0.15	Men`s shower room	14.6
0.16	Women`s WC	13.45
0.17	Women`s shower room	14.6
0.18	Men`s locker room	44.24
0.19	Storehouse	31.32
0.20	Main gym	654.35
The total area of the basement		**1616.32**
1.1	Tambour	14.1
1.2	Wardrobe	21.55
1.3	Guard post	21.55
1.4	Hall 1	204.4

Table 2.2

1.5	Trainer`s office	14.96
1.6	Inventory room	12.2
1.7	Storehouse	18.4
1.8	Chess room	76.7
1.9	Medical room	16.63
1.10	Trainer`s office	31.76
1.11	Hall 2	43.18
1.12	Gymnasium	185.26
1.13	WC	21.97
1.14	WC	21.95
1.15	Women`s locker room	46.8
1.16	Men`s WC	13.45
1.17	Men`s shower room	14.6
1.18	Women`s WC	13.45
1.19	Women`s shower room	14.6
1.20	Men`s locker room	44.24
1.21	Storehouse	31.32
1.22	Main 2-storey gym	654.35
The total area of the first floor		**1515.47**
2.1	Hall 1	263.54
2.2	Classrom	76.7
2.3	Inventory room	16.63
2.4	Teacher`s room	31.76
2.5	Hall 2	43.18
2.6	Buffet	234.82
2.7	WC	21.97
2.8	WC	21.95
2.9	Waiting room	20.35

Table 2.2

2.10	Director`s assistant office	12.27
2.11	Director`s office	12.0
2.12	Tennis hall	195.02
The total area of the first floor		**950.19**
The total area of the whole building		**4081.98**

List of designed structural elements:

The foundations are monolithic under the columns. Since the main load-bearing elements of the building are steel-reinforced concrete columns, the foundations for them consist of reinforced concrete slabs with a trapezoidal cross-section measuring 3,9 x 3,9 m. The slabs are laid on sand preparation 100-150 mm thick.

The depth of laying the foundations under the walls is 4,570 m on all axes of the building.

Wall prefabricated panels for the foundation are assembled on the solution with mandatory binding of vertical seams. The thickness of the seams is assumed to be equal to 20 mm. The vertical wells between the blocks are filled with mortar, and the outer surface of the panels bordering the soil is waterproofed with two layers of hot bitumen.

Stairs - the building has internal stairs between floors - made of a metal profile pipe of rolled steel, connected by welding, and stairs to the basement – monolithic concrete. They consist of separately installed reinforced concrete platform slabs, reinforced concrete prefabricated platform beams, prefabricated reinforced concrete kosours. All stair elements are connected to each other with the help of embedded parts. Reinforced concrete platforms rest on the beams, and the steps are installed with the help of cement mortar on the kosours, which are previously treated with a fire-retardant substance to ensure the fire resistance limit - R 60, MO.

The walls are prefabricated wall panels insulated from the inside with mineral wool. The walls are made as a sandwich panel, the frame of which forms an LSTK profile, which is fastened together with self-tapping screws. This frame is filled with insulation, namely mineral wool, and then sheathed on both sides. The outer surface is made of facade panels, and the inner surface is made of plasterboard with further cladding from the middle of the building.

The overlap is based on a profile sheet, on top of which a layer of C12/15 concrete with a reinforcing mesh 100/100/6/6 is placed. This structure rests on I-beams 35B2 (DBN V.2.6-198:2014 Steel structures). The beams, in turn, are attached with the help of metal corners on bolts to the main floor beams.

Windows - window openings are adopted based on the maximum illumination of the interior. The design of the windows is made of metal-plastic, glazed with double-glazed windows.

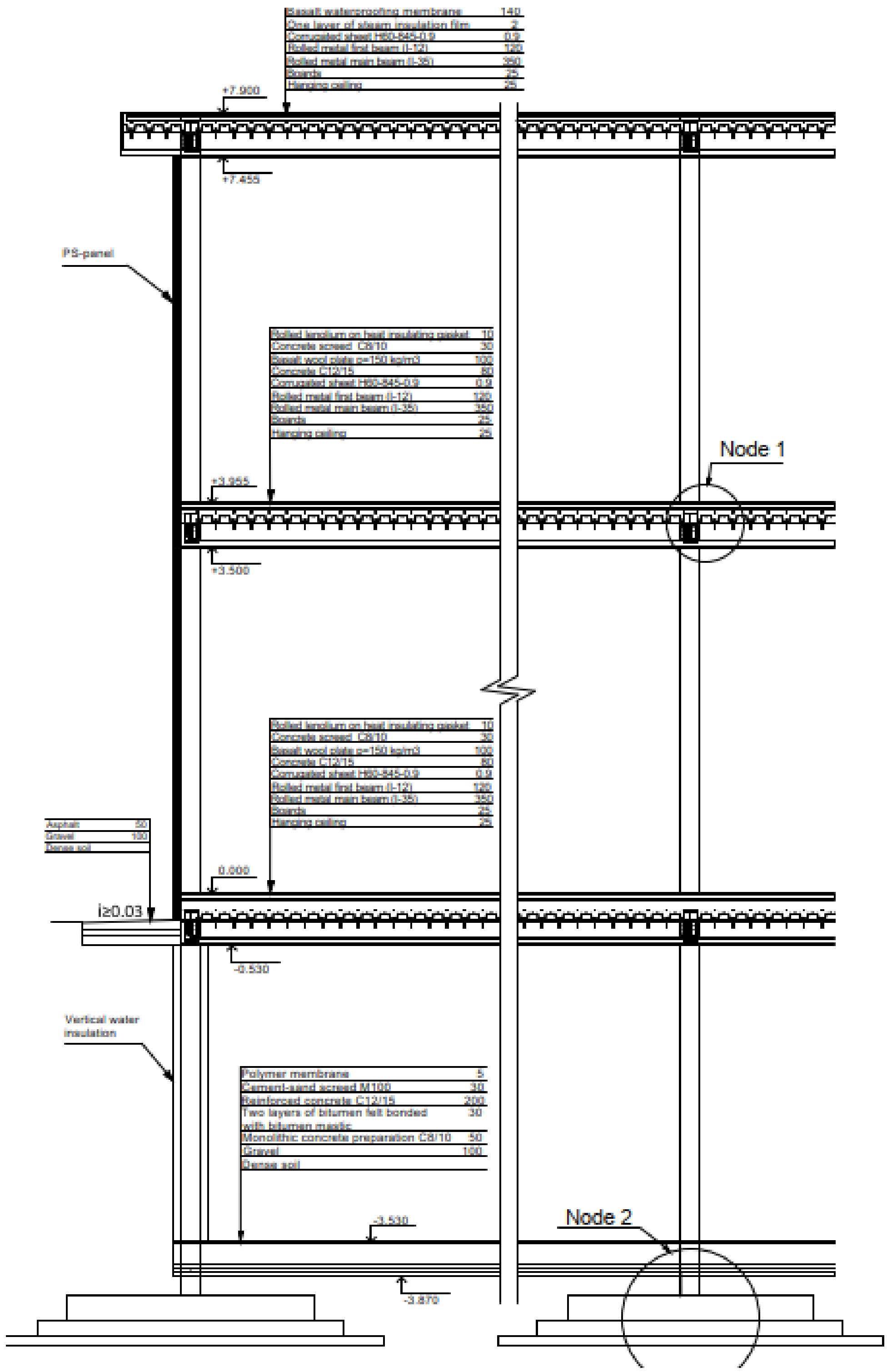
The doors are designed external metal-plastic, glazed with double-glazed windows, internal MDV and fire-resistant type 2.

The floor – in the building is designed in accordance with current building regulations.

CHAPTER 3

Structural decision

3.1. Main cross-section



3.2. Calculation and designing of the I-beams

3.2.1. Variant designing of the beam cage working platform

The working platform intended to support various types of material handling equipment or stack materials and overhead track hoist. The skeleton of a working platform consists of a platform, columns, load-bearing beams (beam cage), vertical braces, ladders and balustrade.

Normal scheme is characterized by two types of beams: main beam and first beam.

Main beam is a plate girder between flanges and web. To avoid non structural decision of arrangement of the beams we remove first beam in a half of spacing between beams.

If we have reinforced concrete platform with thickness 80-180mm, the spacing between first beam is ranged between 1.5-3m.

In accord with type of beam cages there are 3 types of connection beam to each other:

1. The first beams are joint over main beam;
2. The first beams are joint to the main beam in one level;
3. Low connection beam to each other (is assumed for complicated type of beams` cage);

My building variant of beam cage – normal type with reinforced concrete platform

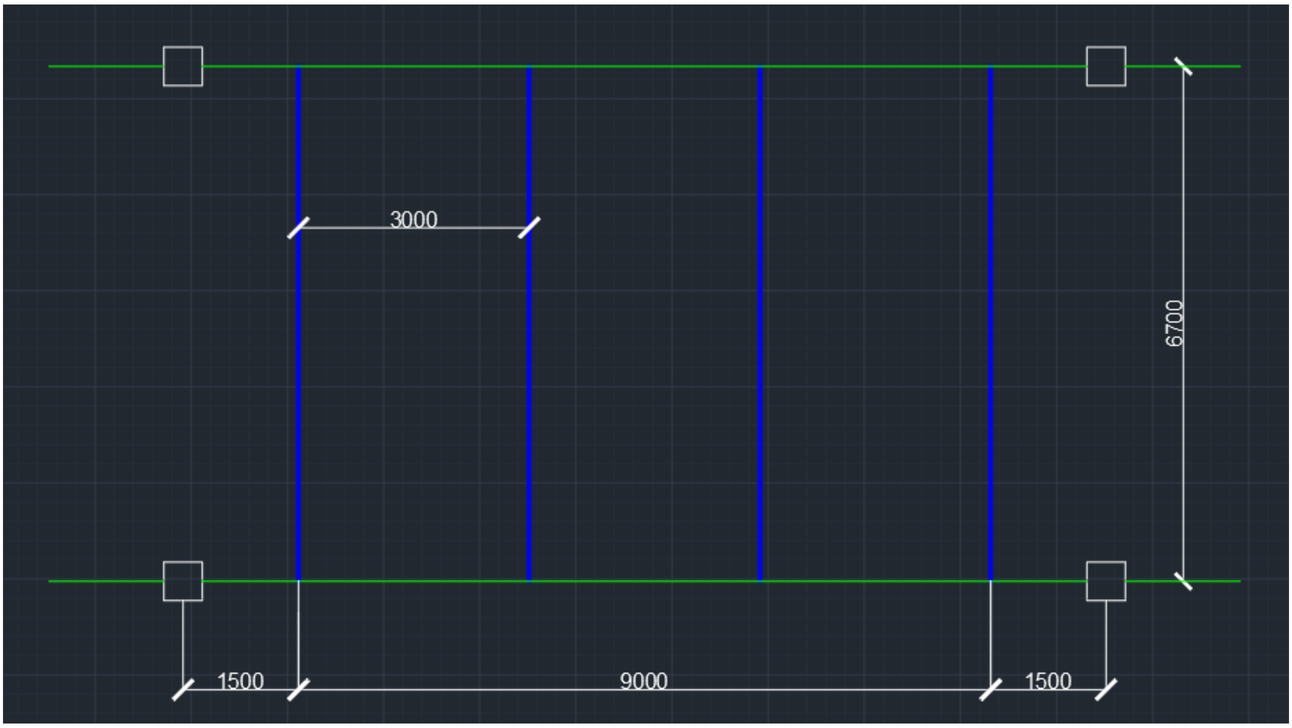
Assume step of the first beam when the length of the main beam is divided by 4 parts.

$$A = 12/4 = 3\ m$$

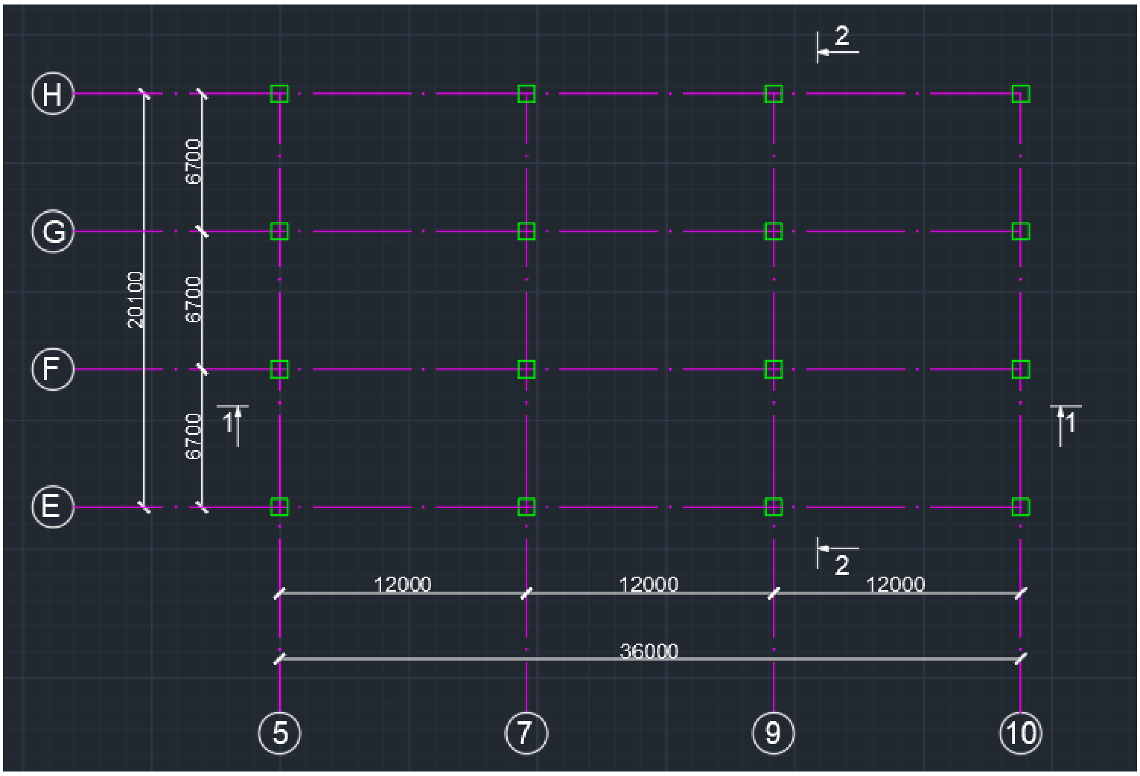
$$3000 * 3 = 9000\ mm$$

$$12000 - 9000 = 3000 \text{ mm}$$

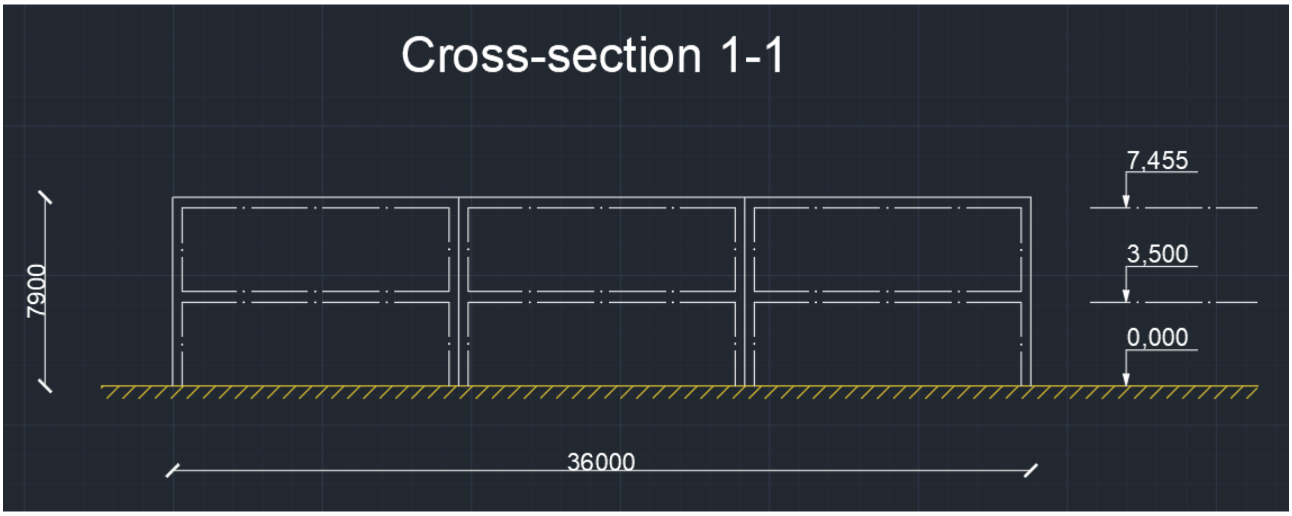
$$3000/2 = 1500 \text{ mm}$$

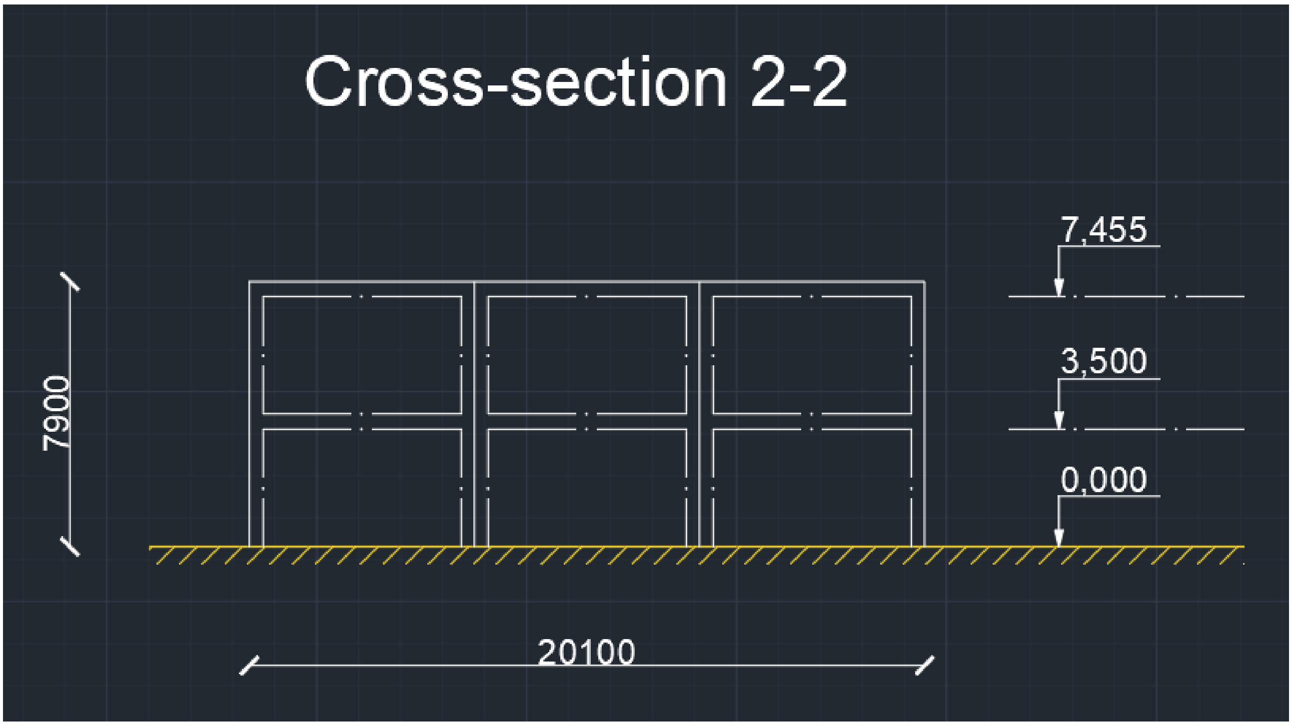


Scheme of I-beams placement



Scheme of I-beams placement between columns in axis E-H





Cross sections 1-1 and 2-2 with markings of heights

3.2.2. Calculation of service rating load and limit rating load

Service rating load o weight of the floor covering and the platform is considered by the formula

$$g_m = \sum t_i \rho_i \gamma_n / 100 \text{, [kN/m}^2\text{]}$$

Limit rating load

$$g_l = \sum t_i \rho_i \gamma_n \gamma_f / 100 \text{, [kN/m}^2\text{]}$$

where t_i - the thickness of the i-layer of the floor covering in mm;

ρ_i - the density of the i-layer in kg/m^3;

γ_n, γ_f - coefficients of reliability on usage and load(load factor) respectively;

We assume $\gamma_n = 0.95$, the II class of the building that have important value;

γ_f - is assumed in accord with the Building Code «Навантаження і впливи» for dead load(table 5.1), for temporary load (6.7)

Table 3.1

Collection of loads per 1 m^2 of linear foundation under external walls:

№	Layer	Density, ρ	Thickness of layer, mm	q, kN/m^2
1	Rolled linoleum	1600	10	0,152
2	Concrete screed C8/10	1800	30	0,513
3	Basalt wool plate	150	100	0,143
4	Concrete C12/15	2400	80	1,824
5	Corrugated sheet H60-845-0,9	7850	0,9	0,67

$$q = \frac{0,01 \cdot 1600 \cdot 0,95}{100} = 0,152\ kN/m^2$$

$$q_1 = q \cdot y_f = 0,152 \cdot 1,1 = 0,167\ kN/m^2$$

$$q = \frac{0,03 \cdot 1800 \cdot 0,95}{100} = 0,513\ kN/m^2$$

$$q_1 = q \cdot y_f = 0,513 \cdot 1,1 = 0,564\ kN/m^2$$

$$q = \frac{0,1 \cdot 150 \cdot 0,95}{100} = 0,143\ kN/m^2$$

$$q_1 = q \cdot y_f = 0,143 \cdot 1,1 = 0,167\ kN/m^2$$

$$q = \frac{0,08 \cdot 2400 \cdot 0,95}{100} = 1,824\ kN/m^2$$

$$q_1 = q \cdot y_f = 1,824 \cdot 1,1 = 2\ kN/m^2$$

$$q = \frac{0,009 \cdot 7850 \cdot 0,95}{100} = 0,67 \frac{kN}{m^2}$$

$$q_1 = q \cdot y_f = 0,67 \cdot 1,1 = 0,737 \frac{kN}{m^2}$$

$$\sum q = 3,302\ kN/m^2; \qquad \sum q_1 = 3,625\ kN/m^2$$

The service rating load is necessary for calculate members of beam cage by the second group of limit state. Is determined by the formula:

- for platform opened for examination

$$g_e = g_{n1} + \gamma_n p_n$$

where p_n is the service temporary load taken from task;

$$g_e = 3,302 + 5 \cdot 0,95 = 8,052\ kN/m^2$$

The limit rating load necessary for calculate members of beams` cage by the I group of limit state is determined by the formula

$g_m = g_1 + p_n\gamma_n\gamma_f$

($\gamma_f = 1.3$ if $p_n < 2.0kN/m^2$, $\gamma_f = 1.2$ if $p_n \geq 2.0kN/m^2$)

$$g_m = 3{,}302 + 5\ \cdot 1{,}2\ \cdot 0{,}95 = 9{,}002\ kN/m^2$$

The overall dimensions of beams` cage in plan equals 3Lx3B,

where L=12m, and B=6.7m.

We have to design two-piece column with welding joints and load-bearing beams.

The grade of steel is assumed in terms of location of site and design temperature of the in accord with Building Code B.2.6 -198:2014 $t \geq -30$ degrees of Celsius.

- for beam and column from section steel C245 and more;
- for main beam made from sheet steel C245 and more;
- for braces between columns C235 and more.

Answers:

$$g_e = 3{,}302 + 5\ \cdot 0{,}95 = 8{,}052\ kN/m^2$$

$$g_m = 3{,}302 + 5\ \cdot 1{,}2\ \cdot 0{,}95 = 9{,}002\ kN/m^2$$

3.2.3. Calculation of the metal platform and designing the first beam

Calculation of the "Normal type of beam cage with reinforced concrete platform"

The thickness of reinforced concrete platform is defined in terms of service rating load and span of the platform.

Table 3.2

Thickness of the reinforced concrete platform, cm

Design span of the r.c. platform, m	Service rating load, kN/m^2			
	15-20	21-25	26-30	31-35
1,5-2,0	10	12	12	14
2,1-2,5	12	12	14	16
2,6-3,0	14	14	16	18

$g_e = 8{,}05\ \mathrm{kN}/m^2$

l_p = a = 3 m

$t_p = 14\ cm = 140\ mm$

II CALCULATION AND DESIGN THE FIRST BEAM OF THE WORKING PLATFORM

1. Determination limit value n_0 - is a ratio of span to the limit deflection.

Let`s calculate limit deflection and value n_0 for beams of cage that is opened for examination

The height of the platform space:

H = 7,5 m; h_{str} = 0,5 m

h = H - h_{str} = 7,5 – 0,5 = 7 m > 6 m

Main beam has span l_i = 12 m

l_1 = 6 m $\qquad f_{u1} = \frac{600}{200} = 3\ cm$

l_2 = 24 m $\qquad f_{u2} = \frac{2400}{250} = 9{,}6\ cm$

$f_{ui} = 3 + \frac{9{,}6-3}{24-6}$·(12-6) = 5,2 cm

$n_{oi} = \frac{1200}{5{,}2} = 230{,}77$

The first beam has the span l_i = 6,7 m

l_1 = 6 m $\qquad f_{u1} = \frac{600}{200} = 3\ cm$

l_2 = 24 m $\qquad f_{u2} = \frac{2400}{250} = 9{,}6\ cm$

$f_{ui} = 3 + \frac{9{,}6-3}{24-6}$·(6,7-6) = 3,25 cm

$n_{oi} = \frac{670}{3{,}25} = 206{,}15$

2. Determination of limit value of design resistance of steel by yield point (opt R_y)

Determination limit value of design resistance for the first beam and second beam. Calculation the limit value of design resistance of steel with a view to expenditure of materials may be found from the condition that the moment of resistance of the beam in terms of strength equals to moment of resistance of beam in terms of rigid.

Limit value of design resistance for simple first beam from all variants of beam cage is calculated by the formula:

$$opt\ R_y = 492 \cdot y_f \sqrt[3]{\frac{g_e \cdot a}{n_{0FB}^2 \cdot t_{wFB}}}$$

y_f — average overload factor, $y_f = \frac{g_m}{g_e}$;

a, d — spacing between first beam and secondary beam respectively;

t_w – the thickness of web of the first beam

$t_{wFB} = 0{,}005 - 0{,}007\ m$

g_e – service rating load;

g_m – limit rating load;

Calculation:

$$y_f = \frac{9{,}002}{8{,}052} = 1{,}118;$$

First beam (reinforced concrete):

$$opt\ R_y = 492 \cdot 1{,}118 \sqrt[3]{\frac{8{,}052 \cdot 3}{206{,}15^2 \cdot 0{,}006}} = 250{,}72\ MPa$$

The grade of steel is chosen according to Building Code (table Г.2) by thickness of the flange:

$t_f = 5 - 10\ mm$ – for first beam;

The design resistance of steel should be equal or less than optimum value.

Assume:

For the first beam C275 $R_y = 260\ MPa$;

3. Determination of linear density of beams

For first beam: $q_{l.FB} = 608 \cdot l \cdot \sqrt{\frac{g_m \cdot a}{R_y \cdot 10^3}}$;

1. For first beam: $q_{l.FB} = 608 \cdot 6{,}7 \cdot \sqrt{\frac{9 \cdot 3}{260 \cdot 10^3}} = 41{,}51\ kg/m$;

$$M = \frac{q \cdot l^2}{8} = \frac{41{,}51 \cdot 6{,}7^2}{8} = 232{,}92\ kNm$$

Determination of service and design loading acting on beams with taking into account dead weight of beams

Let`s specify service and design load acting on beams with dead weight of beams

Service load $q_e = g_{n1} \cdot a + \left[\frac{(t_p - t)\cdot\rho\cdot a + q_1}{100} + P_n \cdot a\right] \cdot y_n;$

Design load $q_m = g_1 \cdot a + \left[\frac{(t_p - t)\cdot\rho\cdot a\cdot y_f + q_1\cdot 1{,}05}{100} + P_n \cdot a \cdot 1{,}2\right] \cdot y_n;$

where g_{n1} , g_1 $-$ service and limit rating loads from table №1;

t_p , t $-$ thickness of the platform that is calculated and is assumed respectively;

y_f $-$ for reinforced concrete platform 1.1;

For reinforced concrete platform ρ = 2500 kg/m^3;

Calculation:

For the first beam:

$g_{n1} = 3{,}302\ kN/m^2;$ $g_1 = 3{,}625\ kN/m^2;$

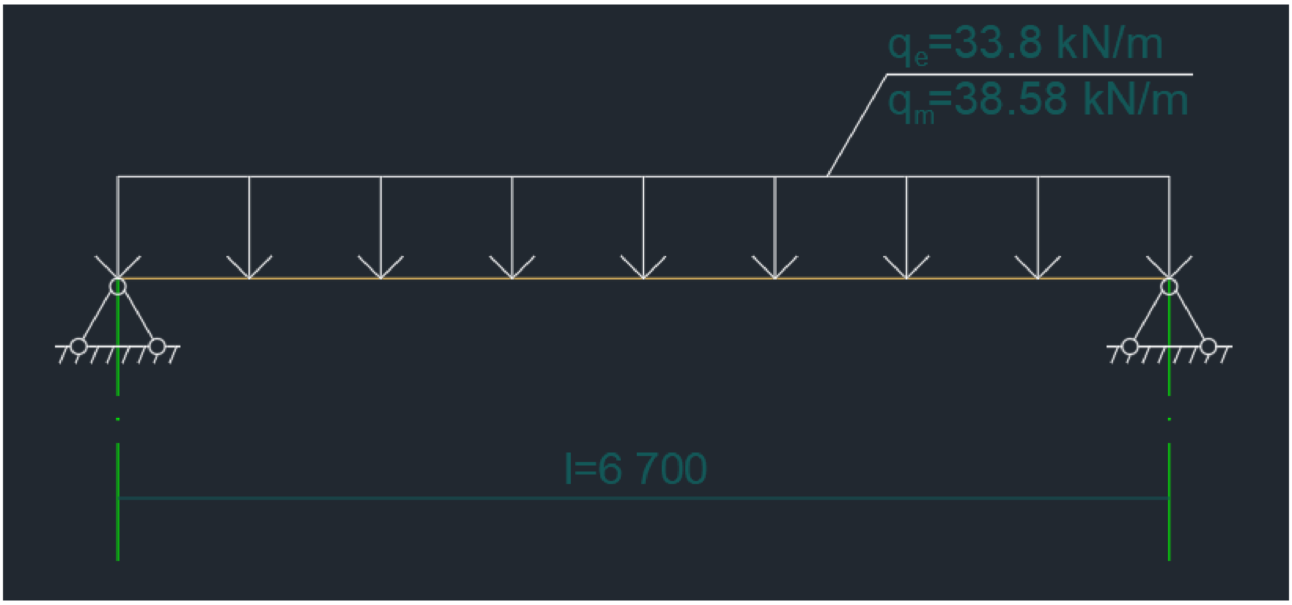
$P_n = 5\ kN/m^2;$ $t_p = 14\ mm;$

$$q_e = 3{,}302 \cdot 3 + \left[\frac{(0{,}14 - 0{,}01) \cdot 2500 \cdot 3 + 41{,}51}{100} + 5 \cdot 3\right] \cdot 0{,}95 = 33{,}8\ kN/m$$

$$q_m = 3{,}625 \cdot 3 + \left[\frac{(0{,}14 - 0{,}01)\cdot 2500\cdot 3\cdot 1{,}1 + 41{,}51\cdot 1{,}05}{100} + 5 \cdot 3 \cdot 1{,}2\right] \cdot 0{,}95 = 38{,}58\ kN/m$$

$$W_x = \frac{M}{R_y} = \frac{232{,}92}{260} = 0{,}93$$

Assume I-beam 40Б2.



Scheme of loads

3.2.4. Comparison of variants

Main parameters are:

1. Expenditure of materials;
2. Cost of assembled construction;
3. Labour capacity of manufacture and assembly of construction;
4. The cost of 1t of the platform from base steel C235 with thickness until 8mm is taken as relative currency unit.

The cost of 1 m^3; of reinforced concrete platform is assumed as 60% from the cost of 1t of the metal platform. The expenditure of materials and cost of the constructions are determined per 1m^2 of the platform`s plan. Labour capacity is estimated qualitative in terms of types and quantity of beams. The cost of beams is dependent on grade of steel, cross-section and design resistance of material. This influence takes into account with help coefficient k_1.

For metal platform $t \le 8mm,$ k_1=1.0; $t > 8mm,$ k_1=0.94;

For reinforced concrete platform k_1=0.6(60%);

For beams with parallel flanges k_1=1.07;

1. Expenditure of materials

Mass of steel:

Variant I: for platform $g_p = t_p \cdot p = 0{,}014 \cdot 2{,}5 = 0{,}035\ t/m^2$

for first beam $g_{FB} = \frac{q_1}{a} = \frac{0{,}035}{3} = 0{,}012\ t/m^2$

Total: 0,047 t/m^2;

Volume of the reinforced concrete platform is 0,12 m^3/m^2

The influence grade of steel on its cost is characterized by the coefficient K_2

$$K_2 = \frac{0{,}0037R_y + 0{,}2773}{0{,}0037R_{y(235)} + 0{,}2773};$$

First beam (R_y=260MPa)

$$K_2 = \frac{0{,}0037 \cdot 260 + 0{,}2773}{0{,}0037 \cdot 230 + 0{,}2773} = 1{,}098;$$

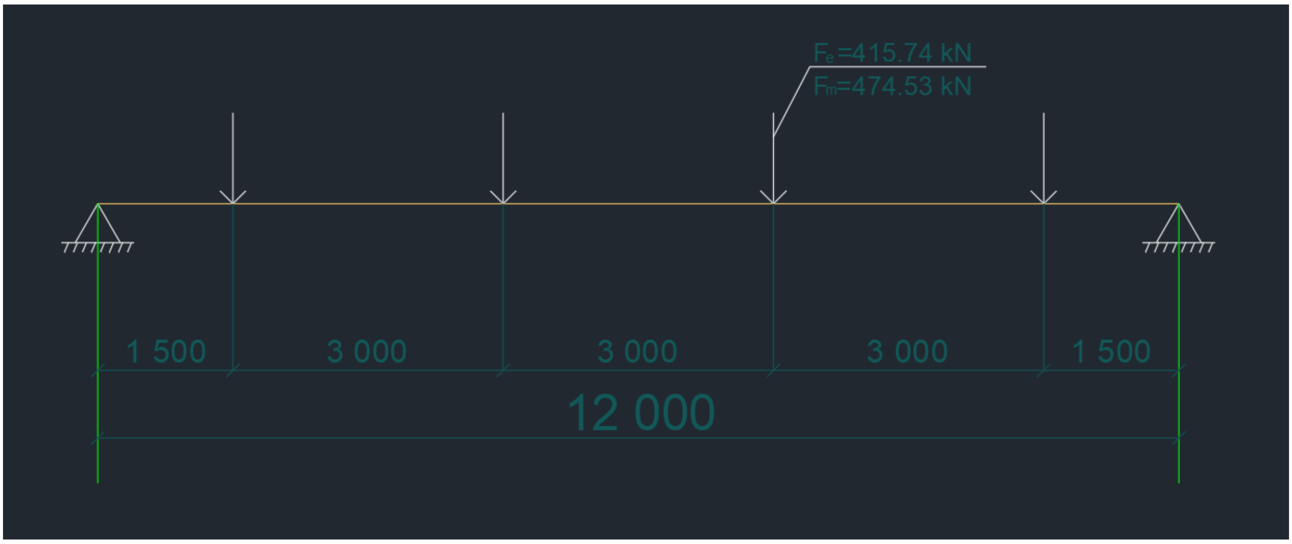
3.2.5. Calculation and design of the main beam

The main beam is a simple beam with hinged support. Rating load acting on the beam is determined by the formula

$$F_m = 2V_{m(3)} \cdot K_{dw};$$

K_{dw} - coefficient that takes into account dead weight of main beam, is ranged from 1.02…1.03;

V_m - shearing force on bearings of the first beam when we design normal type of beam cage, $V_m = \frac{q_m \cdot l}{2};$



Sign scheme of loading main beam

$$V_m = \frac{38{,}58 \cdot 12}{2} = 231{,}48\ kN$$

$$F_m = 2 \cdot 213{,}48 \cdot 1{,}025 = 474{,}53\ kN$$

If number of concentrated load is more than 5 we can to change it on evenly distributed load

$$q_m = \frac{F_m}{a} = \frac{474{,}53}{3} = 158{,}18\ kN/m$$

Maximum value of bending moment in the middle of the span

$$M_{max} = \frac{q_m \cdot l^2}{8} = \frac{158{,}18 \cdot 12^2}{8} = 2847{,}24\ kN \cdot m$$

$$Q_{max} = \frac{q_m \cdot l}{2} = \frac{158{,}18 \cdot 12}{2} = 949{,}08\ kN$$

Service rating load

$$V_e = \frac{q_e \cdot l}{2} = \frac{33{,}8 \cdot 12}{2} = 202{,}8\ kN$$

$$F_e = 2V_{e(3)} \cdot K_{dw} = 2 \cdot 202{,}8 \cdot 1{,}025 = 415{,}74\ kN$$

Average overload factor

$$y_f = \frac{F_m}{F_e} = \frac{474{,}53}{415{,}74} = 1{,}14$$

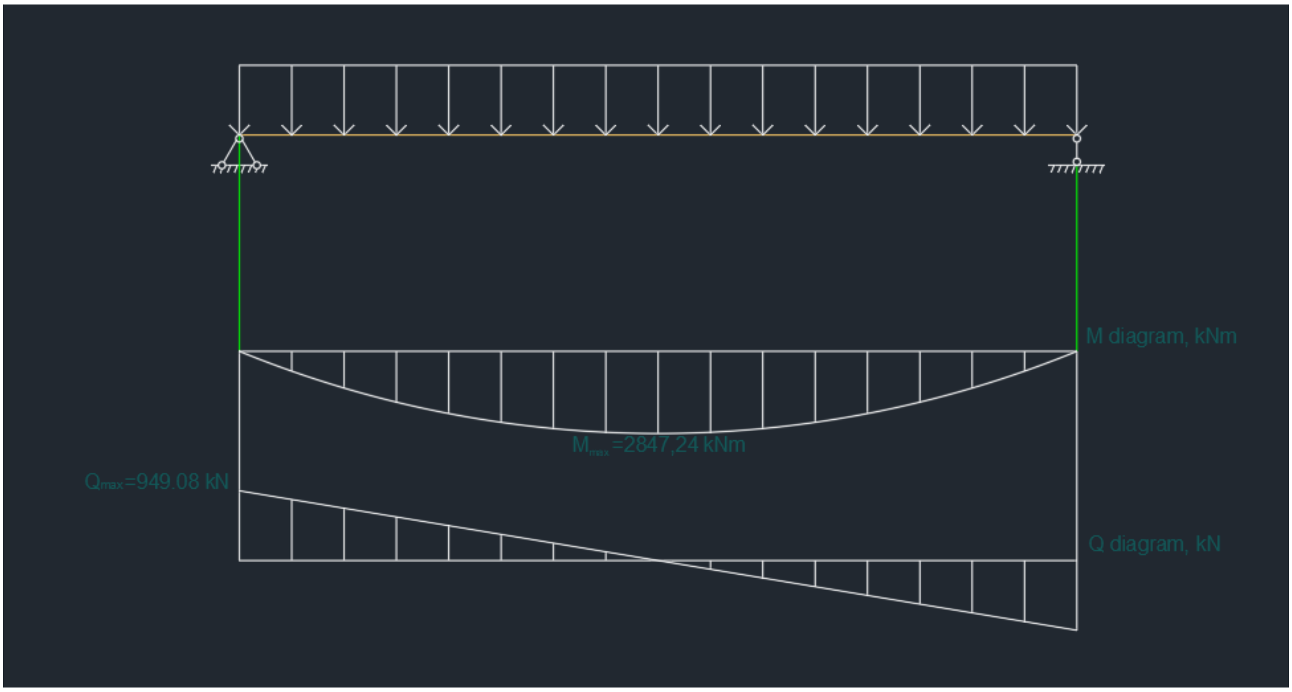


Diagram of bending moments and shearing force

The minimum height of a beam is determined from the condition of the optimal one from the stand point of the amount of material required. The determination of the most advantageous cross-section of the beam consists of the finding the minimum area A of the section for the given moment of resistance $W = \dfrac{M}{R_y}$ and in the most efficient distribution of this section area between the web and flanges that dependent on the height h and thickness of the web t_w

$$A = A_w + 2A_f;$$

Let`s find limit value of design resistance R_y for main beam

$$\max R_y = 5655 \cdot (\frac{M \cdot \lambda_w}{\gamma_c})^{1/4} \cdot (\frac{\gamma_f}{n_0 \cdot l \cdot K_{ch} \cdot K_q})^{3/4};$$

At first let`s assume the web slenderness ratio $\lambda_w = \dfrac{h_w}{t_w};$

In practice the web slenderness ratio depends on span of main beam

$$l = 12m \rightarrow \Lambda_w = 120;$$

$\gamma_c -$ coefficient on reliability of conditions of working, $\gamma_c = 1.0;$

$K_{ch} -$ coefficient that takes into account change of cross-sectional characteristics, $K_{ch} = 1.02;$

$K_q -$ coefficient that considers influence of deformation from shearing force $K_q = 1.068;$

$$maxR_y = 5655 \cdot (\frac{2847{,}24 \cdot 120}{1})^{1/4} \cdot (\frac{1{,}05}{230{,}77 \cdot 12 \cdot 1{,}02 \cdot 1{,}068})^{3/4} = 348{,}68\ MPa$$

The grade of steel is chosen for the sheet steel with thickness of flange

$t_f = 11 - 20mm \Rightarrow l \le 15m;$

$t_f > 20mm \Rightarrow l > 15m;$

Assume for main beam grade of steel C375 $R_y = 345\ MPa$

Let`s design the beam`s cross-section. Necessary moment of resistance of the beam

$$W = \frac{M}{R_y \cdot y_c} = \frac{2847{,}24 \cdot 10^3}{345 \cdot 1} = 8252{,}87\ cm^3$$

$$A = 2{,}512 \cdot \sqrt[3]{\frac{W^2}{\Lambda_w}} = 2{,}512 \cdot \sqrt[3]{\frac{68109856{,}06}{120}} = 207{,}98\ cm^2$$

$$opt\ h = 0{,}77 \cdot \sqrt{A \cdot \Lambda_w} = 0{,}77 \cdot \sqrt{207{,}98 \cdot 120} = 121{,}65\ cm$$

$$h_w \approx 0{,}97 opt\ h = 0{,}97 \cdot 121{,}65 = 117{,}99\ cm$$

Assume $h_w = 120\ cm$

$$t_w = \frac{h_w}{\lambda_w} = \frac{120}{120} = 1\ cm$$

Assume $t_w = 10\ mm$

If web is supported by transverse stiffeners the thickness of web should be more or equal next condition

$$t_w \geq \frac{h_w}{6} \cdot \sqrt{\frac{R_y}{E}};$$

$$1 \geq \frac{120}{6} \cdot \sqrt{\frac{345}{2{,}06 \cdot 10^5}} = 0{,}73$$

the condition is provided.

The ratio $\frac{A_f}{A_w} = \beta$ is characterize with help coefficient β and when we calculate main beam under the elastic range $\beta = 0.5;$

$\beta = 0.394$ if we calculate main beam with allowance elastic-plastic deformation and zone of pure bending;

Area of flange

$A_f = h_w \cdot t_w \cdot opt\beta;$ $\quad A_f = 120 \cdot 1 \cdot 0{,}394 = 47{,}28\ cm^2$

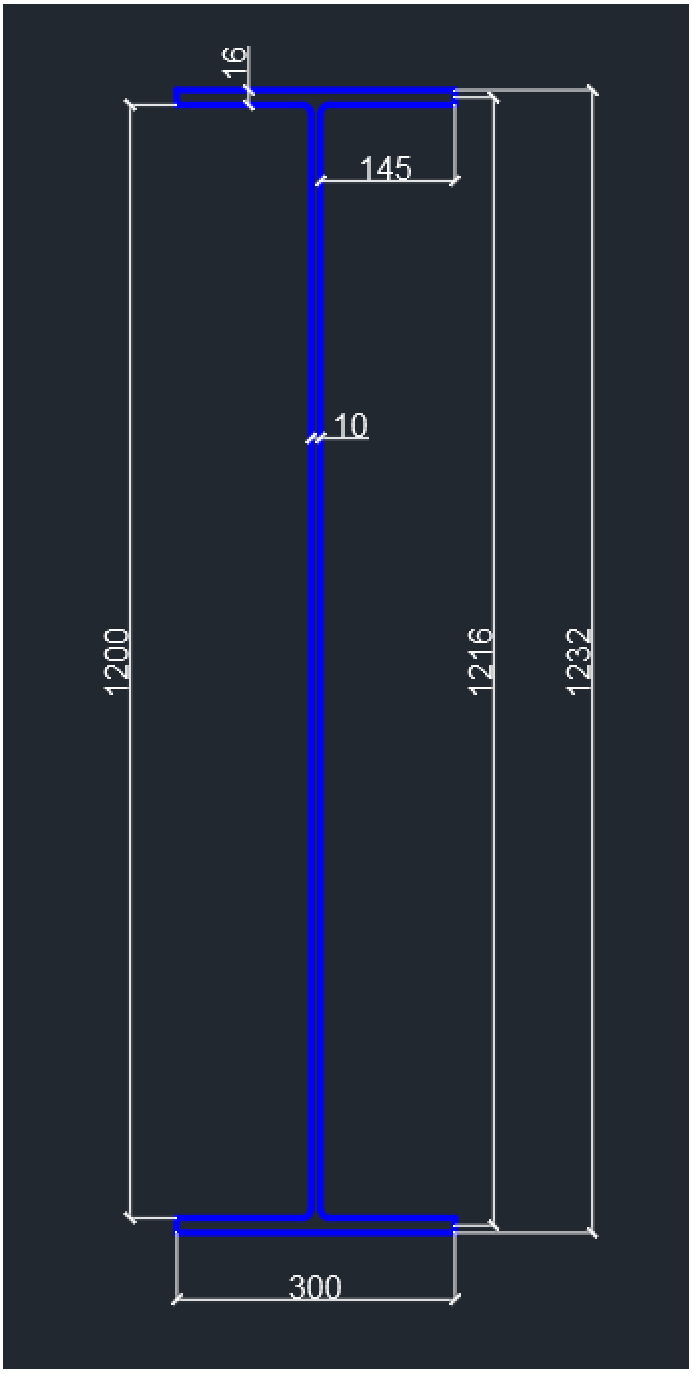
Assume $b_f \cdot (\frac{1}{3} \dots \frac{1}{5}) opt\ h = 15{,}76 \dots 9{,}45\ cm$

For flanges assume general purpose steel GOST 82-70 with $\beta_f = 300\ mm$ and thickness of the flange

$$t_f = \frac{A_f}{b_f} = \frac{47{,}28}{30} = 1{,}57\ cm$$

Assume main beam:

– 300x16mm for flange; – 1200x10 mm for web.



Cross-section of main beam

Checks on the flange for stability

$$\frac{0.5(b_f - t_w)}{t_f} \le 0.11\frac{h_f}{t_w};$$

$$\frac{0{,}5(30-1)}{1{,}6} = 9{,}06 < 0{,}11\frac{121{,}6}{1} = 13{,}38$$

The stability of the flange is provided.

Checks on stresses in the beam

Let`s calculate moment of gyration and moment of resistance under the elastic range

$$I_x = \frac{t_w \cdot h_w^3}{12} + 2A_f \cdot (\frac{h_f}{2})^2 = \frac{t_w \cdot h_w^3}{12} + A_f \frac{h_f^2}{2} = \frac{1 \cdot 120^3}{12} + 47{,}28 \frac{121{,}6^2}{2} = 493554{,}28\ cm^4$$

$$W_x = \frac{I_x \cdot 2}{h} = \frac{2 \cdot 493554{,}28}{123{,}2} = 8012{,}25\ cm^3$$

Plastic moment of resistance of the beam equals

$$W_{xpl} = 2\left(\frac{h_w^2}{8} \cdot t_w + \frac{1}{2} A_f \cdot h_f\right) = 2\left(\frac{120^2}{8} \cdot 1 + \frac{1}{2} 47{,}28 \cdot 121{,}6\right) = 9349{,}25\ cm^3$$

The coefficient

$$C_1 = C = \frac{W_{xpl}}{W_x} = \frac{9349{,}25}{8012{,}25} = 1{,}17;$$

Moment of resistance under the plastic range with zone of pure bending

$$W_{x`pl} = \frac{W_x + W_{xpl}}{2} = \frac{8012{,}25 + 9349{,}25}{2} = 8680{,}75\ cm^3$$

Maximal normal stresses distributed through cross-section

$$max\sigma = \frac{M}{W_{x`pl}} = \frac{2847{,}24 \cdot 10^3}{8680{,}75} = 327{,}99\ MPa < R_y \cdot y_c = 345 \cdot 1 = 345\ MPa$$

The strength is not provided on

$$\frac{345 - 327{,}99}{345} \cdot 100\% = 4{,}93\%$$

Checks on beam deflection

$$q_e = \frac{F_e}{a} = \frac{415{,}74}{3} = 138{,}58\ kN/m$$

$$f = \frac{5}{384} \cdot \frac{138{,}58 \cdot 12^4 \cdot 10^2}{2{,}06 \cdot 493554{,}28} \cdot 1{,}02 \cdot 1{,}068 = 4{,}0\ cm < 7{,}68\ cm$$

The stiffness is provided.

3.2.6. Change the cross-section of the main beam

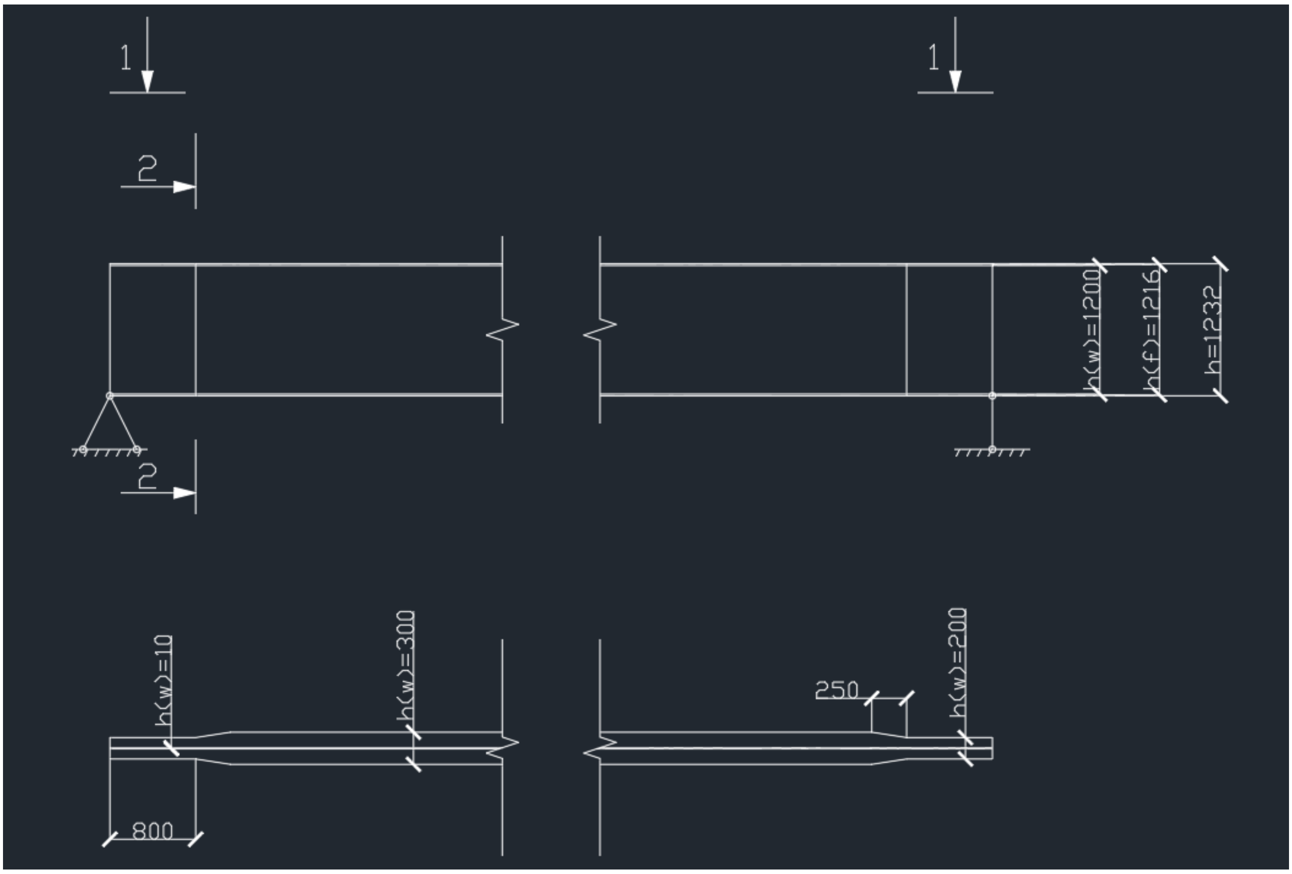
If the span of the main beam less than 30m you can to design only one change from one side of the axis. The width of flanges is changed on the distance that equals to 1/6 of the span from the bearings in case if load evenly distributed throughout the span. The calculation of reduction cross-sectional dimensions is performed in range of elastic deformations. The width of reduced flange should be more than

$b_{f1} \geq 180mm;$

$b_{f1} \geq 180mm + t_w;$ - if the first beams are supported over main beam;

$b_{f1} \geq \frac{h}{10};$

$b_{f1} \geq 0.5b_f;$



Scheme to the change of cross-section

The butt joint of flanges is coincided with place where first beam is supported by the main beam. The strength of butt joint should be provided. Assume reduce width of flanges.

$$b_{f1} = 200\ mm > 180\ mm;$$

$$b_{f1} = 200\ mm > \frac{h_w}{10} = \frac{1200}{10} = 120\ mm;$$

$$b_{f1} = 200\ mm > 0{,}5b_f = 0{,}5 \cdot 300 = 150\ mm;$$

Let`s calculate geometric characteristics of changed cross-section I_x, W_x, A.

$$I_x = \frac{1 \cdot 120^3}{12} + \frac{20 \cdot 1{,}6 \cdot 121{,}6^2}{2} = 380584{,}96\ cm^4;$$

$$A_{f1} = 20 \cdot 1{,}6 = 32\ cm^2;$$

$$W_{x1} = \frac{2 \cdot 380584{,}96}{123{,}2} = 6178{,}33\ cm^3$$

Butt joints are done with backing strip and visual control of quality of the welds $l_w = b_{f1}$; $R_{wy} = 0.85R_y$;

Limit bending moment that can be taken by cross-section is calculated by the formula

$$M_1 = W_{x1} \cdot 0{,}85R_y \cdot y_c = 6178{,}33 \cdot 0{,}85 \cdot 345 \cdot 1 \cdot 10^{-3} = 1811{,}79\ kNm;$$

Distance from the bearing to the butt joint equals to:

$$x_1 = \frac{V_m}{q_m} - \sqrt{\left(\frac{V_m}{q_m}\right)^2 - \frac{2M_1}{q_m}} = \frac{2314{,}8}{158{,}18} - \sqrt{\left(\frac{2314{,}8}{158{,}18}\right)^2 - \frac{2 \cdot 1811{,}79}{158{,}18}} = 0{,}8\ m;$$

where V_m — shearing force on bearings equals 2314,8 kN;

q_m — limit rating evenly distributed load acting on the main beam, $q_m = 158{,}18\ kN$;

This distance is not coincide with the step of the first beam.

It is known the maximum normal and tangential stresses take place in the web where cross-section is changed. Summary stresses are checked up by the formula:

$$\sigma_{sum} = \sqrt{\sigma_1^2 + 3\tau_1^2} \leqslant 1{,}15R_y \cdot y_c;$$

$\sigma_1 = \sigma_x \frac{h_w}{h}$; $\sigma_{sum} = \frac{M_1}{W_1}$;

$$\sigma_1 = \frac{1811{,}79 \cdot 10^3}{6178{,}33} \cdot \frac{1200}{1232} = 285{,}62\ MPa;$$

$$\tau_1 = \frac{Q_x \cdot S_{f1}}{I_1 \cdot t_w};$$

where Q_x – shearing force on distance x from the bearing;

S_{f1} – statical moment of reduced flange due to axis x;

$$Q_x = Q_{max} - q_m \cdot x = 2314{,}8 - 158{,}18 \cdot 0{,}8 = 2188{,}26\ kN$$

$$S_{f1} = b_{f1} \cdot t_f \frac{h_w + t_f}{2} = 20 \cdot 1{,}6 \frac{120 + 1{,}6}{2} = 1945{,}6\ cm^3;$$

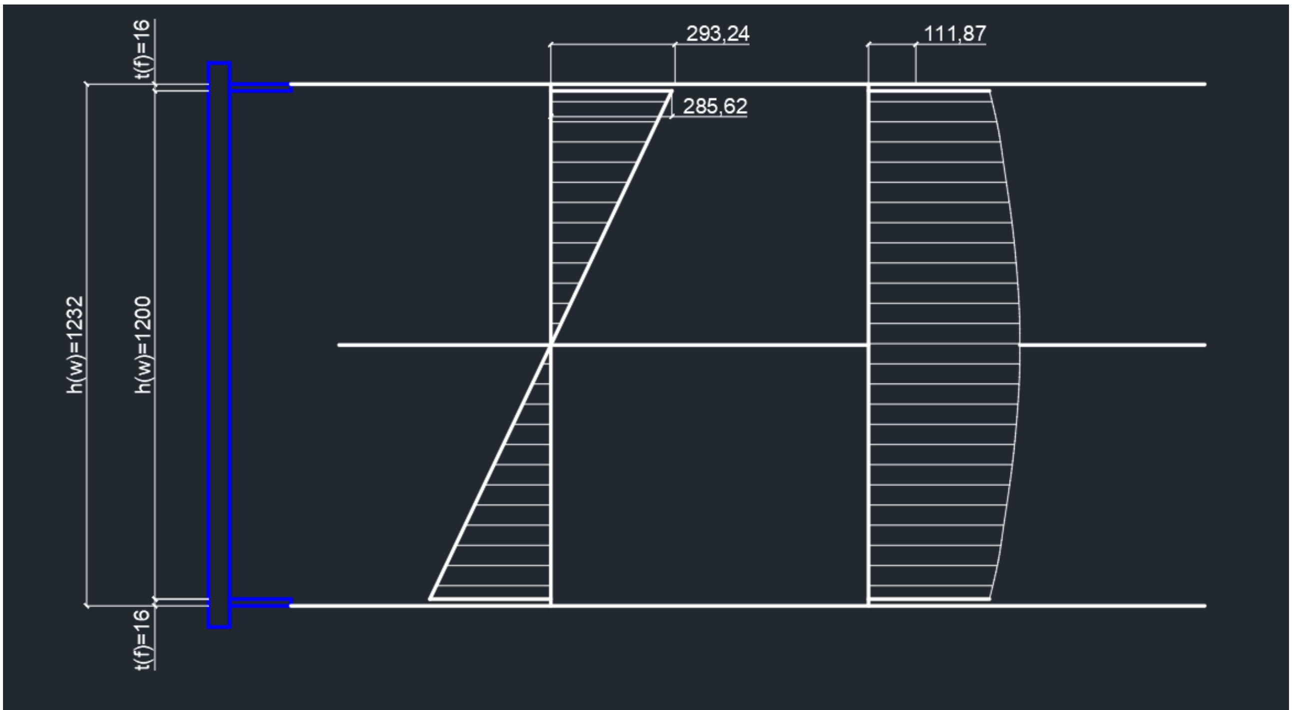
Tangential stresses in most loaded point

$$\tau_1 = \frac{2188{,}26 \cdot 1945{,}6 \cdot 10}{380584{,}96 \cdot 1} = 111{,}87\ MPa$$

Summary stresses

$$\sigma_{sum} = \sqrt{285{,}62^2 + 3 \cdot 111{,}87^2} = 345{,}14\ MPa \leqslant 1{,}15 \cdot 345 \cdot 1 = 396{,}75\ MPa;$$

Conclusion: the strength is provided.



Cross-section 2-2

3.2.7. Arrangement of the stiffeners and checks the local stability of the beams web

Checks for local stability of beams web may be performed on the assumption when tangential stresses are equal to

$$\tau_{cr} = 10.3\frac{R_s}{\lambda_w^2};$$

From condition $\tau_{cr} = R_s$;

$$\bar{\lambda}_w = \frac{h_w}{t_w}\sqrt{\frac{R_y}{E}} = \frac{120}{1,6}\sqrt{\frac{345}{2,06 \cdot 10^5}} = 3,07;$$

This value of conditional flexibility of web is characterize that web cannot lose its stability before waste of strength.

The web of beam is strengthened by stiffeners in the next cases:

1. If moving load is absent on flanges and conditional flexibility more than 3.2;
2. If moving load is present and conditional flexibility more than 2.2;

The dimensions of the stiffeners is taken in accord with Building Code

$b_{st} > \frac{h_w}{30} + 40mm$ - width;

$t_s > 2b_{st}\sqrt{\frac{R_y}{E}}$ - thickness;

In zone of development plastic deformation σ_{loc} doesn`t allow.

The 1st point web works on the assumption on plastic behavior.

The 2nd point web works on the assumption of elastic behavior.

Normal stresses $\sigma_1 = \frac{M_{\max}}{c_1 \cdot W}$ $\quad c_1 = \frac{W_{pl}}{W}$;

c_1 - coefficient that takes into account plastic deformations.

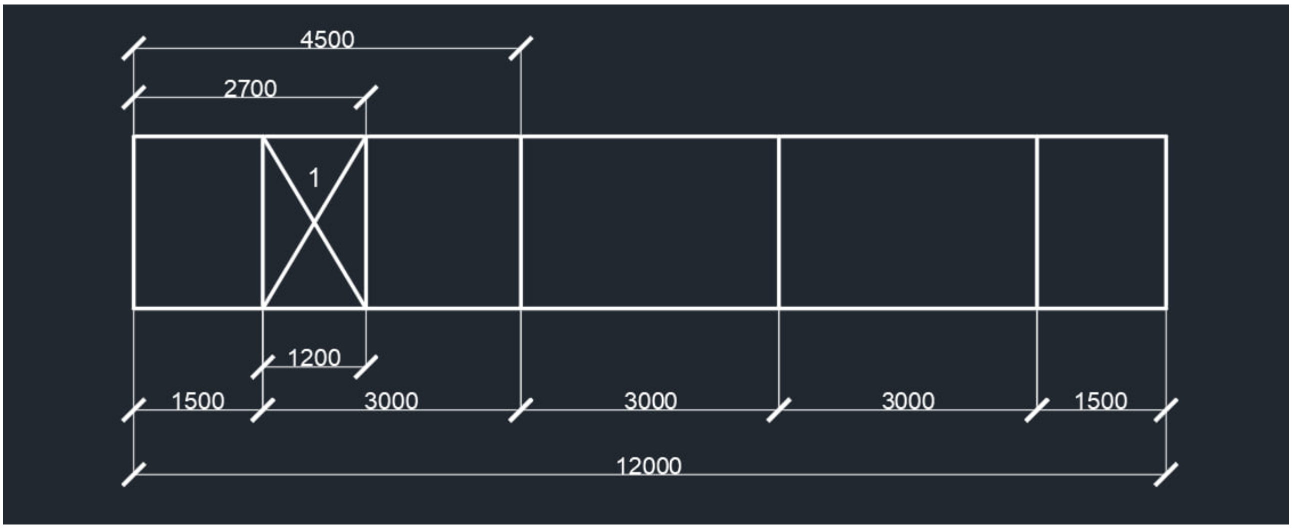
$\sigma_2 = \frac{M_x}{W} \cdot \frac{h_w}{h}$, where $M_x = \frac{q \cdot x(l-x)}{2}$;

if $\sigma_1 = \sigma_2$ and $l_{pl} = L - 2x$

$l_{pl} = L\sqrt{1-\frac{h}{c_1 \cdot h_w}}$;

The distance between stiffeners should be less or equal

$a_{st} \le 2h_{ef}$ if $\lambda_w > 3.2$ and $a_{st} \le 2.5h_{ef}$ if $\lambda_w \le 3.2$



Scheme to the arrangement of stiffeners

$$\bar{\lambda}_w = \frac{h_w}{t_w}\sqrt{\frac{R_y}{E}} = \frac{120}{1,6}\sqrt{\frac{345}{2,06 \cdot 10^5}} = 3,07 \le 3,2;$$

$$b_{st} = 120\,mm > \frac{1200}{30} + 40 = 44\,mm$$

The thickness of the stiffener

$$t_{st} = 10\,mm > 2b_{st}\sqrt{\frac{R_y}{E}} = 2 \cdot 120\sqrt{\frac{345}{2,06 \cdot 10^5}} = 9,82\,mm;$$

The stiffeners are arranged with spacing:

$a = 3\,m < 2,6h_w = 2,6 \cdot 1,2 = 3.12\,m;$

Let`s check up the local stability of the plate №2 where cross-section was changed.

The length of plate $a > h_{ef} = 1.9$

Assume $a_1 = h_w$

The distance from bearings to the point 1 equals 2.1m.

Bending moment

$$M_2 = \frac{q_m x_2(l - x_2)}{2} = \frac{158{,}18 \cdot 2{,}1(12 - 2{,}1)}{2} = 1644{,}28\ kNm;$$

$$Q = Q_{max} - q_m \cdot x_2 = 2314{,}8 - 158{,}18 \cdot 2{,}1 = 1982{,}62\ kN$$

$$\sigma = \frac{M_2}{W} \cdot \frac{h_w}{h} = \frac{1644{,}28}{6178{,}33} \cdot \frac{1{,}20}{1{,}232} \cdot 10^3 = 259{,}2\ MPa;$$

W - moment of resistance of changed cross-section.

Tangential stresses

$$\tau = \frac{Q}{t \cdot h} = \frac{1982{,}62 \cdot 10}{120 \cdot 1} = 165{,}22\ MPa;$$

Let`s calculate critical stresses in accord with formula 9.40 from Building Code

$$\sigma_{cr} = \frac{C_{cr} \cdot R_y}{\lambda_w^2};$$

Coefficient C_{cr} is taken from table 9.2 of Building Code and depends on δ

$$\delta = \beta \frac{b_f}{h_{ef}} \left(\frac{t_f}{t} \right)^3,$$ where

β - from table 9.3 depends on type of supporting platform.

If we have continuous platform

$\beta \Rightarrow \propto, \qquad \delta \geq 30, \qquad C_{cr} = 35.5$

$$\sigma_{cr} = \frac{35{,}5 \cdot 345}{3{,}07^2} = 1299{,}48\ MPa;$$

$$\tau_{cr} = 10.3 \cdot (1 + \frac{0.76}{\mu^2}) \frac{R_s}{\overline{\lambda}_{ef}^2};$$

$$h_{ef} = h_w;$$

$$\mu = \frac{a}{h_{ef}} = \frac{3}{1{,}2} = 2{,}5;$$

$$\lambda_{ef} = \frac{d}{t_w}\sqrt{\frac{R_y}{E}} = \frac{120}{1}\sqrt{\frac{345}{2{,}06 \cdot 10^5}} = 4{,}91;$$

where $d = h_w$ less side of plate.

$$\tau_{cr} = 10{,}3 \cdot \left(1 + \frac{0{,}76}{2{,}5^2}\right) \cdot \frac{120}{4{,}91^2} = 57{,}49\ MPa;$$

$$\sqrt{\left(\frac{\sigma}{\sigma_{cr}}\right)^2 + \left(\frac{\tau}{\tau_{cr}}\right)^2} \le \gamma_c,$$ where $\gamma_c = 1$ from table 5.1 of Building Code.

$$\sqrt{(\frac{259{,}2}{1299{,}48})^2 + (\frac{57{,}49}{165{,}22})^2} = 0{,}26 < y_c = 1;$$

Conclusion: the stability of web is provided.

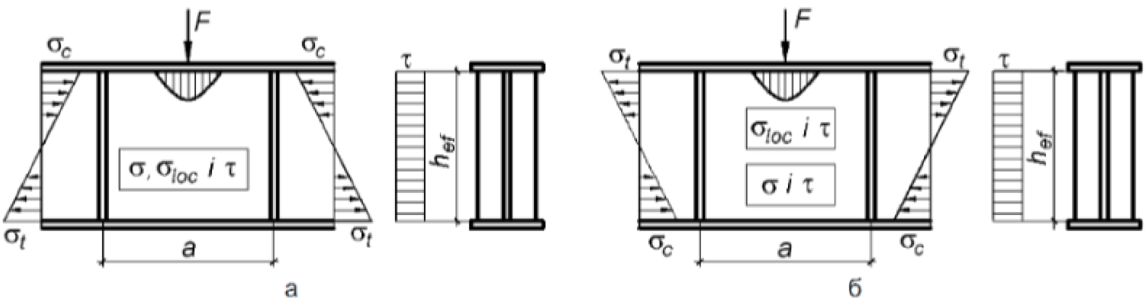
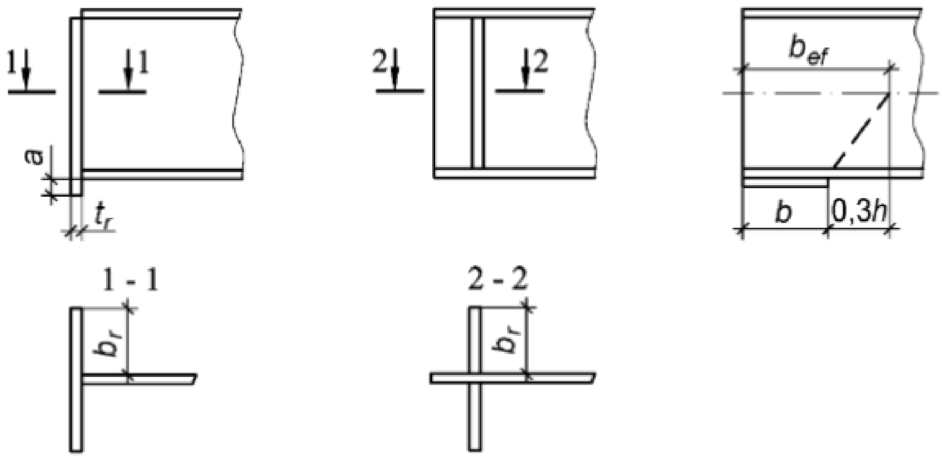


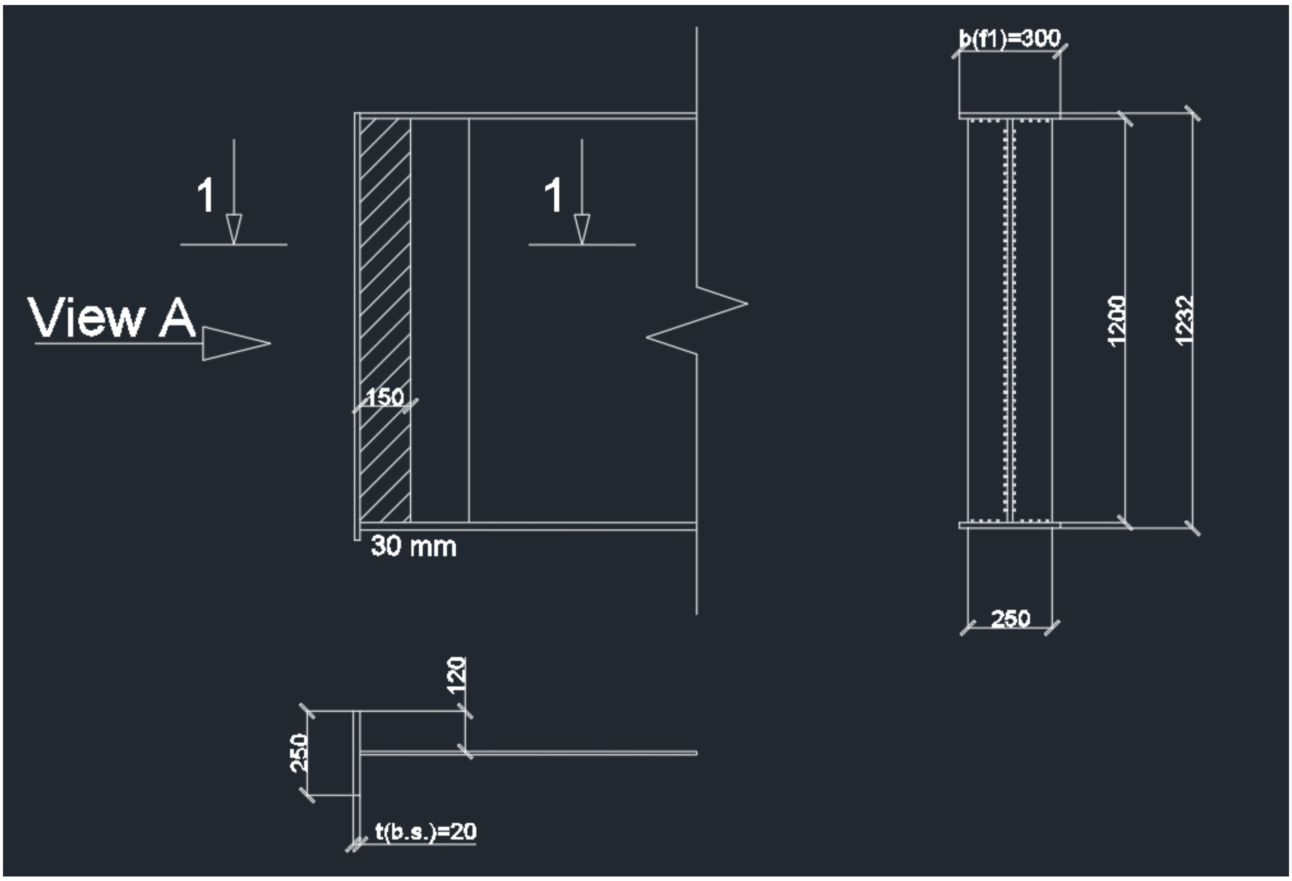
Diagram of the section of the beam reinforced with transverse stiffeners

3.2.8. Calculation of bearing part of main beam

Calculation of geometrical characteristics and flexibility of bearing part of beam and definition of buckling factor



Scheme of beam's bearing part: a) – with milled bearing stiffener; b) – with bearing stiffener removed from the end of the beam; c) – without bearing stiffener



The thickness of bearing stiffener is ranged from 12 to 20mm and the width equals or more 180mm. Assume the width of bearing stiffener 250mm.

$$t_{b.s.} = \frac{V_b \cdot 10}{b_{b.s.} \cdot R_p} = \frac{2314{,}8 \cdot 10}{25 \cdot 480} = 1{,}93\ cm;$$

Assume $t_{b.s.} = 20\ mm$

The lower part of bearing stiffener assume $d < 1.5 \cdot t_{b.s.} = 1.5 \cdot 20 = 30\ mm$

Let`s determine the width of bearing part of web.

$$C = 0{,}65 t_w \sqrt{\frac{E}{R_y}} = 0{,}65 \cdot 1 \sqrt{\frac{2{,}06 \cdot 10^5}{345}} = 15{,}88\ cm;$$

$$I_{xb.s.} = \frac{t_{b.s.} \cdot b_{b.s.}^3}{12} = \frac{2 \cdot 25^3}{12} = 2604{,}17\ cm^4;$$

Effective area of bearing stiffener plus part of the web that taking into account in calculation

The length of the part of web is calculated by the formula

$$A_{ef} = b_{b.s.} \cdot t_{b.s.} + c \cdot t_w = 25 \cdot 2 + 15 \cdot 1 = 65\ cm^2$$

$$i_x = \sqrt{\frac{I_x}{A_{ef}}} = \sqrt{\frac{2604{,}17}{65}} = 6{,}33\ cm;$$

$$\lambda_x = \frac{l_{ef}}{i_x} = \frac{120}{6{,}33} = 18{,}96 \rightarrow \varphi = 0{,}983$$

$$\lambda = \lambda_x \sqrt{\frac{R_y}{E}} = 18{,}96 \sqrt{\frac{345}{2{,}06 \cdot 10^5}} = 0{,}76$$

$\lambda = 0{,}6 \rightarrow \varphi = 986$ $\qquad\qquad$ $\lambda = 0{,}8 \rightarrow \varphi = 967$

$$\frac{986 - 967}{0{,}2} = 95 \cdot 0{,}03 = 2{,}88$$

$$986 - 2{,}88 = 983{,}12 \approx 983$$

$$\varphi = 983$$

Checks up the stability is calculated by the formula

$$\sigma = \frac{N}{A_{ef} \cdot \varphi} = \frac{2314{,}8 \cdot 10}{65 \cdot 0{,}983} = 343{,}28\ MPa < R_y y_c = 362{,}28 \cdot 1{,}15 = 396{,}75\ MPa;$$

The stability of bearing stiffener is provided

Checks up the local stability of bearing stiffener by the formula

$\frac{b_{ef}}{t_{b.s.}} \le (0.36 + 0.1\lambda)\sqrt{\frac{E}{R_y}}$, where $\lambda = 0{,}76$;

$$b_{ef} = \frac{b_{b.s.} - t_w}{2} = \frac{25 - 1}{2} = 12$$

$$\frac{12}{2} = 6 < (0{,}36 + 0{,}1 \cdot 0{,}76)\sqrt{\frac{2{,}06 \cdot 10^5}{345}} = 29{,}81;$$

The local stability of bearing stiffener is provided. For connection bearing stiffener to the web of beam we use semiautomatic welding.

Diameter of welding wire assume from 1.4 to 2mm and the leg of fillet weld $k_f = 3 - 8\,mm$ in accord with table 16.1 from Building Code. ($k_f = 6\,mm$);

From table 16.2 $\beta_f = 0{,}9$; $\beta_z = 1{,}05$;

$R_{wf} = 202{,}5\,MPa$;

$R_{wz} = 0{,}45R_{un} = 0{,}45 \cdot 490 = 220{,}5\,MPa$;

For C375 $R_{un} = 490\,MPa$;

Design cross-section is cross-section on metal of fillet weld because of

$R_{wf} \cdot \beta_f < R_{wz} \cdot \beta_z$;

Calculation necessary leg of fillet weld

$$k_{fnec} = \frac{1}{\beta_f}\sqrt{\frac{V \cdot 10}{85 \cdot n \cdot R_{wf} \cdot y_{wf} \cdot y_c}} = \frac{1}{0{,}9}\sqrt{\frac{2314{,}8 \cdot 10}{85 \cdot 2 \cdot 220{,}5 \cdot 1 \cdot 1}} = 0{,}87\,cm;$$

where V - bearing forces;

n – number of fillet welds;

Assume $\beta_f = 0{,}9$; $\beta_z = 1{,}05$;

Assume $k_{fnec} = 10\,mm$;

$$R_{wf} \cdot \beta_f < R_{wz} \cdot \beta_z = 182{,}25 < 231{,}53$$

3.2.9. The calculation of fillet welds which connecting web with flanges (welds of flanges).

The fillet welds which connected web to flanges assume two-sided and choose for their welds automatic welding "in boat". Welding wire is taking С$_в$-08ГА d=1.4…2mm from table Д.1 of Building Code.

Minimal leg of fillet weld according table 16.1 equals 6 mm (web – 10 mm, flanges – 16 mm $R_{un} = 490\ Mpa,\ R_y = 345\ Mpa,\ C375$).

Checks up the strength of welds if $k_f = 6\ mm$. Coefficients $\beta_f = 0.9\ \ \beta_z = 0.9$

$R_{wf} = 200\ Mpa$ - table Д.2 $R_{wz} = R_{un} \cdot 0{,}45 = 490 \cdot 0{,}45 = 220{,}5\ MPa$.

Rating cross-section $\beta_f R_{wf} < \beta_z R_{wz}$ is cross-section of fillet weld. Maximum value of shearing force on the bearings equals.

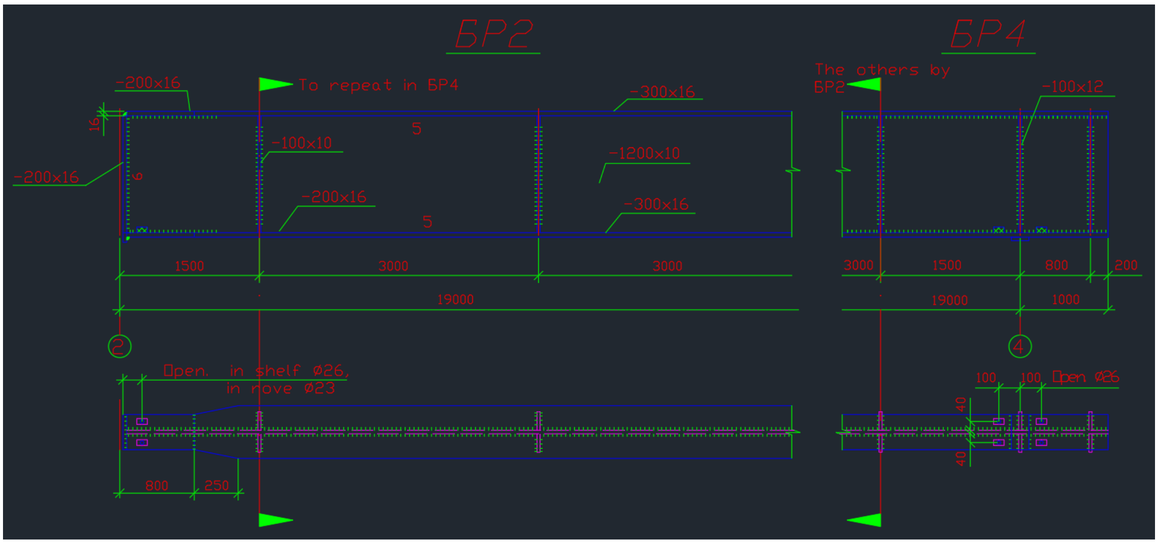
The shearing force T (in all alloys) avoid mutual removing flanges and web. T is shearing force per m and is calculated in accord with formula

$$T = \frac{Q \cdot S}{I} = \frac{2314{,}8 \cdot 30 \cdot 1{,}6 \cdot 0{,}5(120 + 1{,}6)}{380584{,}96} = 17{,}75\ kN/cm$$

Checks up the strength of weld $2\beta_f k_f R_{wf} \geq T$;

$$\frac{2 \cdot 0{,}9 \cdot 0{,}6 \cdot 200}{10} = 21{,}6\frac{kN}{cm} > T = 17{,}75\frac{kN}{cm}$$

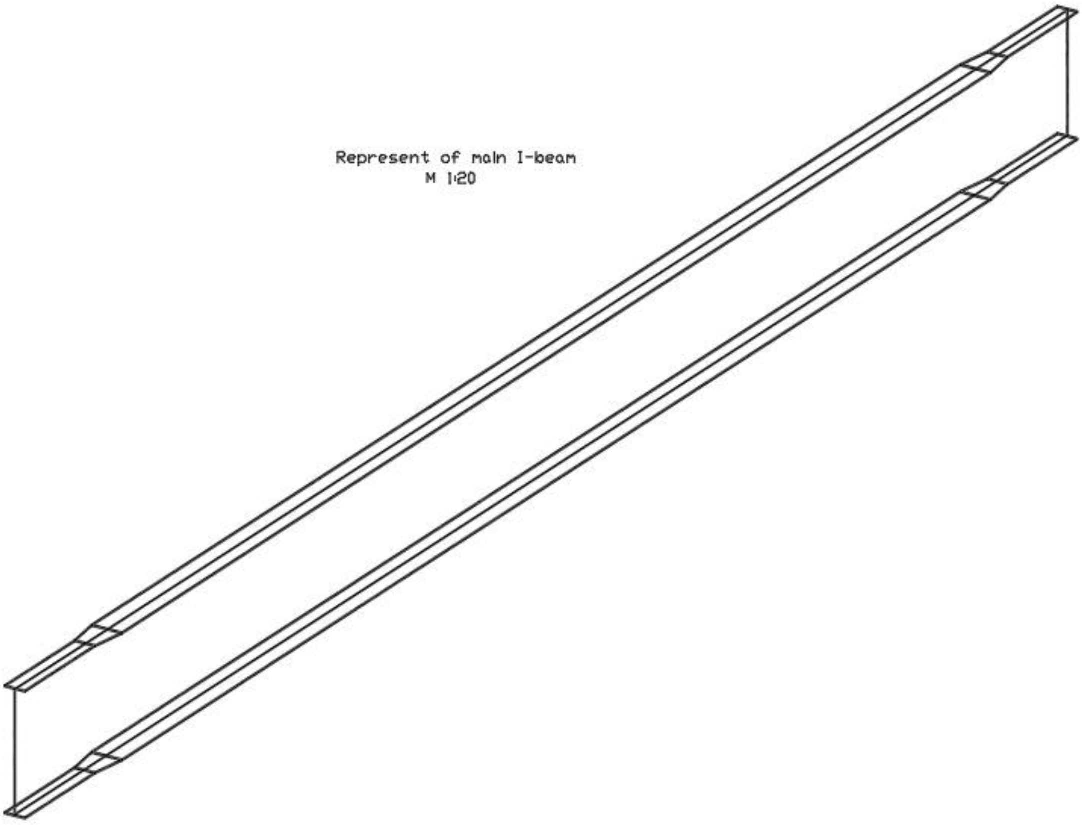
Conclusion: the strength of welds is provided.



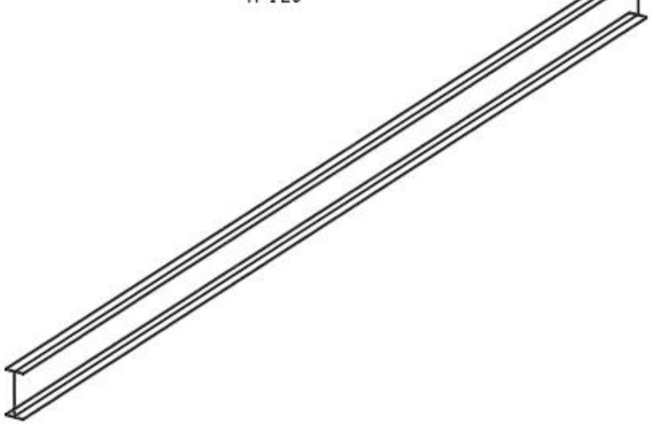
Design of I-beam section

Final view of main and first beams

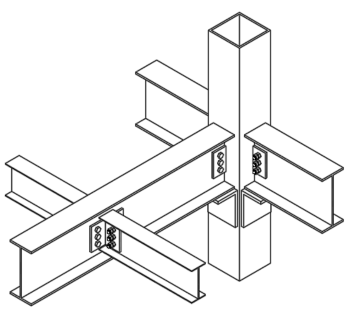
Represent of main I-beam
M 1:20



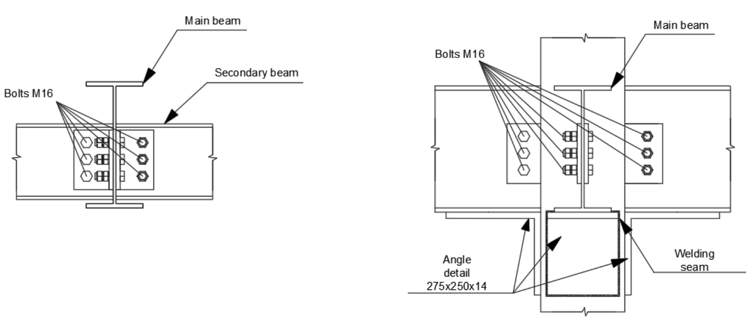
Represent of first I-beam
M 1:20

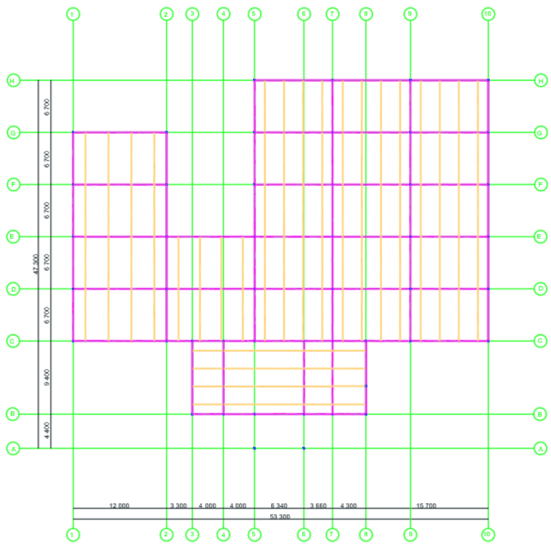


Represent of I-beam joint
M 1:10

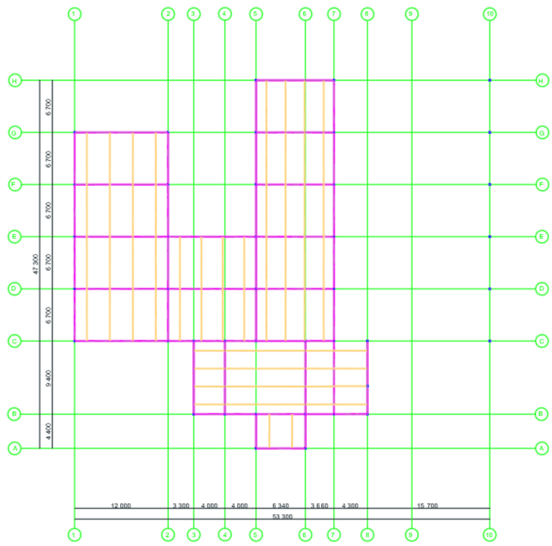


I-beams joint
M 1:5

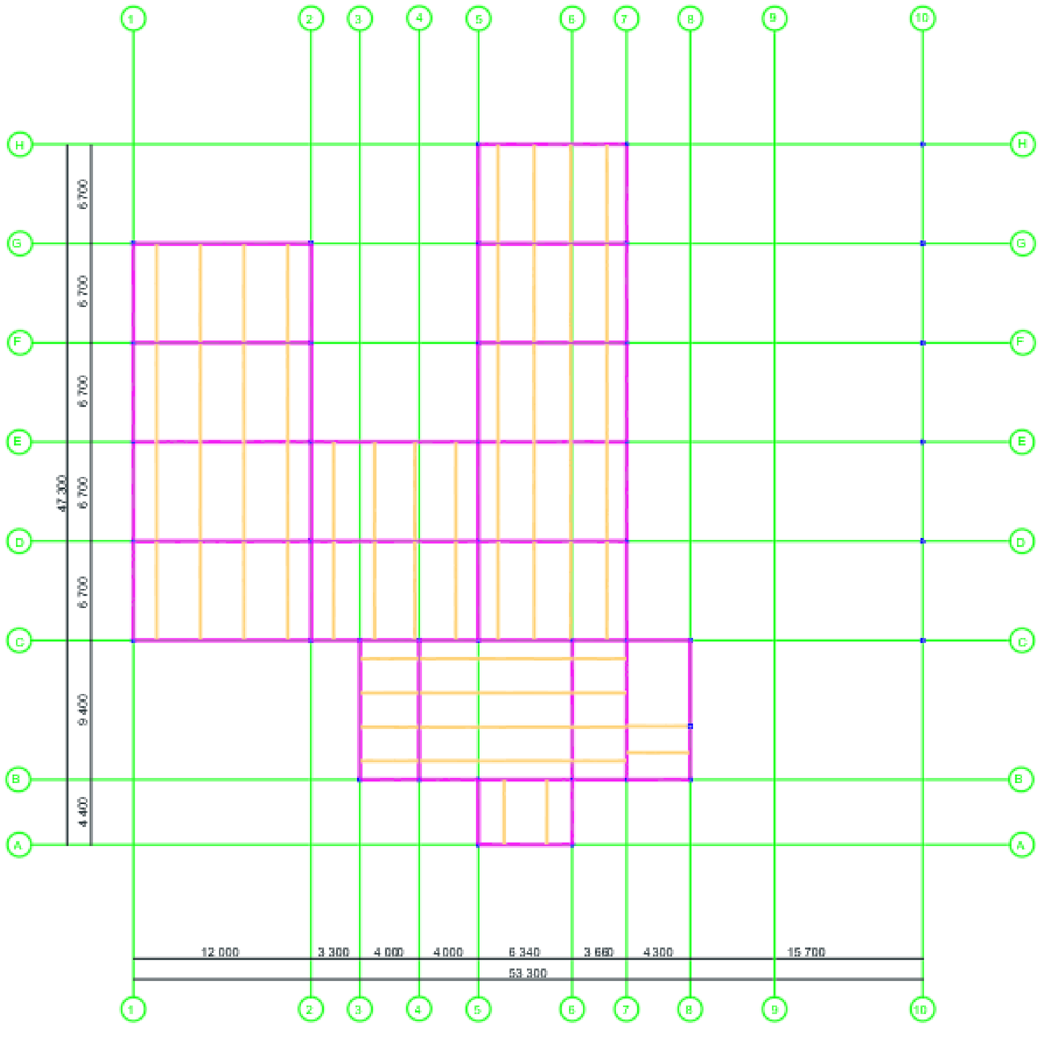




Plan of I-beams of basement

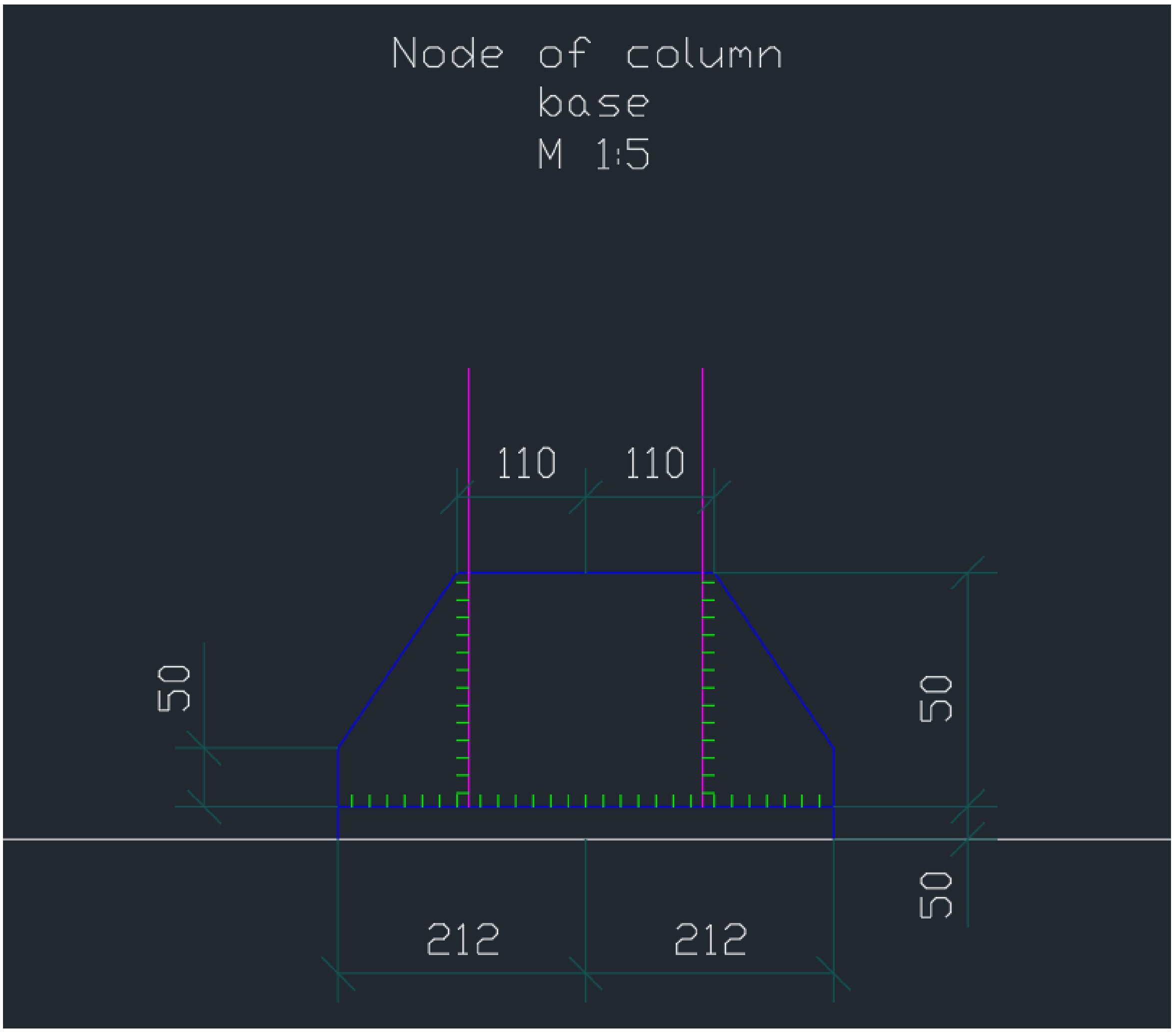


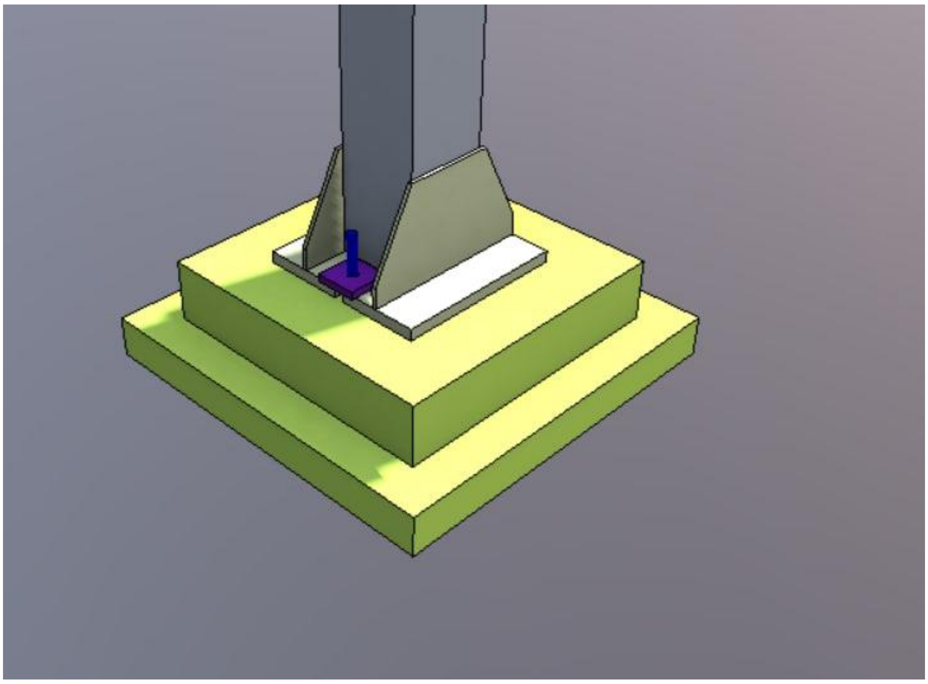
Plan of I-beams of 1-st floor



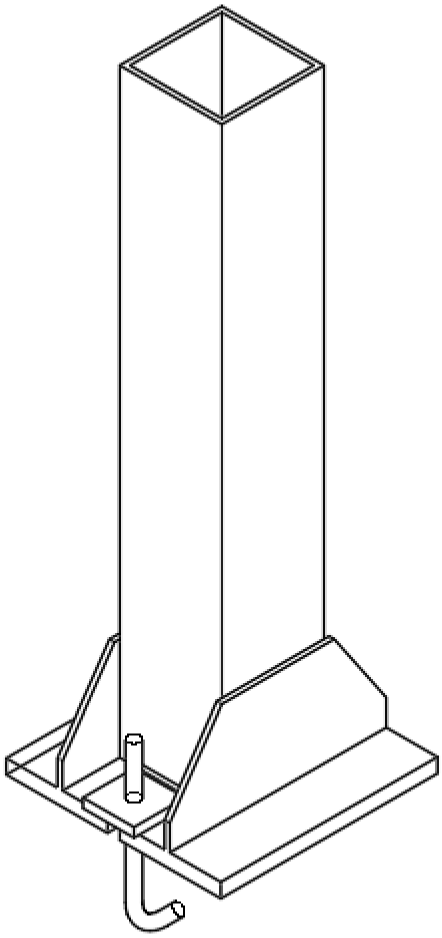
Plan of I-beams of 2-nd floor

3.3. Base of the column





3D view of the base of column



After installing the column in the base, the formwork is poured with concrete, forming a ready structural element. After that, I-beams and other structural elements can be installed.

3.4. Calculation of the foundation

The dimensions of the foundations for the columns are taken depending on the cross-section of the column: (a = b = 200 mm)

Calculations:

1. First plate of the foundation:

$$l_1 = \mathrm{a} + 0{,}15 \cdot 2 = 0{,}2 + 0{,}3 = 0{,}5 \text{ m};$$

where a – thickness of the column, a $= 0{,}2$ m.

2. Second plate of the foundation:

$$l_2 = l_1 + 0{,}3 \cdot 2 = 0{,}5 + 0{,}6 = 1{,}1 \text{ m};$$

3. Third plate of the foundation:

$$l_3 = l_2 + 0{,}3 \cdot 2 = 1{,}1 + 0{,}6 = 1{,}7 \text{ m};$$

l_3 must be aliquot to 3, so assume $l_3 = 1{,}8\ m\ \vdots\ 3$.

Assume dimensions of first plate of the foundation – 0,5 x 0,5 m;

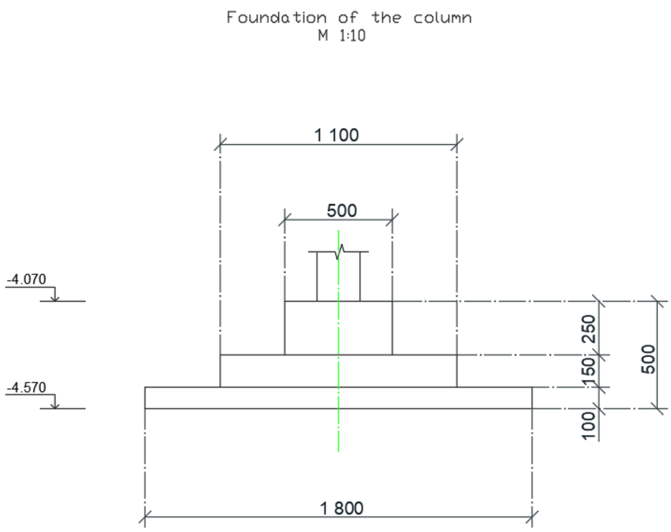
second plate – 1,1 x 1,1 m;

third plate – 1,8 x 1,8 m.

The height of first plate assume 0,25 m;

second plate – 0,15 m;

third plate – 0,1 m, which in total gives us the height of the foundation = 0,5 m.



Calculation by bearing capacity

To start the calculation, you need to find the total loads that are applied to the edge of the foundation**:**

$$N_{\text{p}} = (Q \cdot 2 \cdot y) \cdot 2 = 949{,}08 \cdot 2 \cdot 1{,}01 \cdot 2 = 3824{,}28\ kN$$

Since the condition is not fulfilled, we continue to calculate the foundation as eccentrically loaded.

Calculated base resistance $R = 280\ kPa$; $M = 0\ kNm$.

The thickness of the base below the base of the foundation is divided into layers:

$$h_{\text{i}} = 0{,}4b = 0{,}4 \cdot 1{,}8 = 0{,}72\ m$$

Vertical stress from the own weight of the soil at the level of the base of the foundation: $\sigma_{zg,0} = 18{,}1\ kPa = 0{,}018\ MPa$.

According to table 9.4 "To the calculation of the settlement of the foundation" if $\sigma_{zg,0} = 0{,}018\ MPa, \quad \rightarrow \quad \sigma_{zp} = 0{,}128\ MPa$;

$$p = \sigma_{zp} + \sigma_{zg,0} = 0{,}128 + 0{,}018 = 0{,}146\ MPa$$

where $\sigma_{zp} -$ additional vertical stresses below the sole;

$\sigma_{zg,0} -$ vertical stresses from the self-weight of the soil.

Foundation depth $d_n = 4{,}57\ m$, top edge on mark 4,07 m, so:

$H = 4{,}57 - 4{,}07 = 0{,}5\ m -$ the height of the column foundation.

We check the correctness of determining the dimensions of the sole of the foundation under the column under the condition: $P_{avg} \leq R$.

$$P_{max}^{min} = \frac{N_{\text{p}}}{A} \mp \frac{M}{W}$$

$$A = b \cdot l = 1{,}8 \cdot 1{,}8 = 3{,}24\ m^2$$

$$W = b \cdot l^2/6 = \frac{1{,}8 \cdot 1{,}8^2}{6} = 0{,}972\ m^3$$

$$P_{min} = \frac{N_{\text{p}}}{A} - \frac{M}{W} = \frac{3{,}83}{3{,}24} - \frac{0}{0{,}972} = 1.182\ MPa$$

$$=$$

$$P_{max} = \frac{N_{\text{p}}}{A} + \frac{M}{W} = \frac{3{,}83}{3{,}24} + \frac{0}{0{,}972} = 1{,}182\ MPa$$

$$P_{avg} < R$$

$$1182\ kPa > 280\ kPa$$

The conditions are not met, so the accepted dimensions of the foundation sole are incorrect. Therefore, it is necessary to change the dimensions of the sole of the foundation:

$$\frac{N_{\text{p}}}{A} = \frac{3824}{280} = 13{,}66\ m$$

$$a = b = \sqrt{13{,}66} = 3{,}7\ m$$

The minimum length of the base of the foundation is 3,7 m, but we accept 3,9 m, according to 3,9 ⋮ 3.

$$h_{\text{i}} = 0{,}4b = 0{,}4 \cdot 3{,}9 = 1{,}56\ m$$

$$P_{max}^{min} = \frac{N_{\text{p}}}{A} \mp \frac{M}{W}$$

$$A = b \cdot l = 3{,}9 \cdot 3{,}9 = 15{,}21\ m^2$$

$$W = b \cdot l^2/6 = \frac{3{,}9 \cdot 3{,}9^2}{6} = 9{,}89\ m^3$$

$$P_{avg} = \frac{N_{\text{p}}}{A} - \frac{M}{W} = \frac{3{,}83}{15{,}21} \mp \frac{0}{9{,}89} = 0{,}252\ MPa$$

$$P_{avg} < R$$

$$252\ kPa < 280\ kPa$$

The conditions are met, so the accepted dimensions of the foundation sole are correct.

Let`s recalculate dimensions of the foundation plates.

Calculations:

1. If calculated lower plate of foundation equals 3,7 m, so:

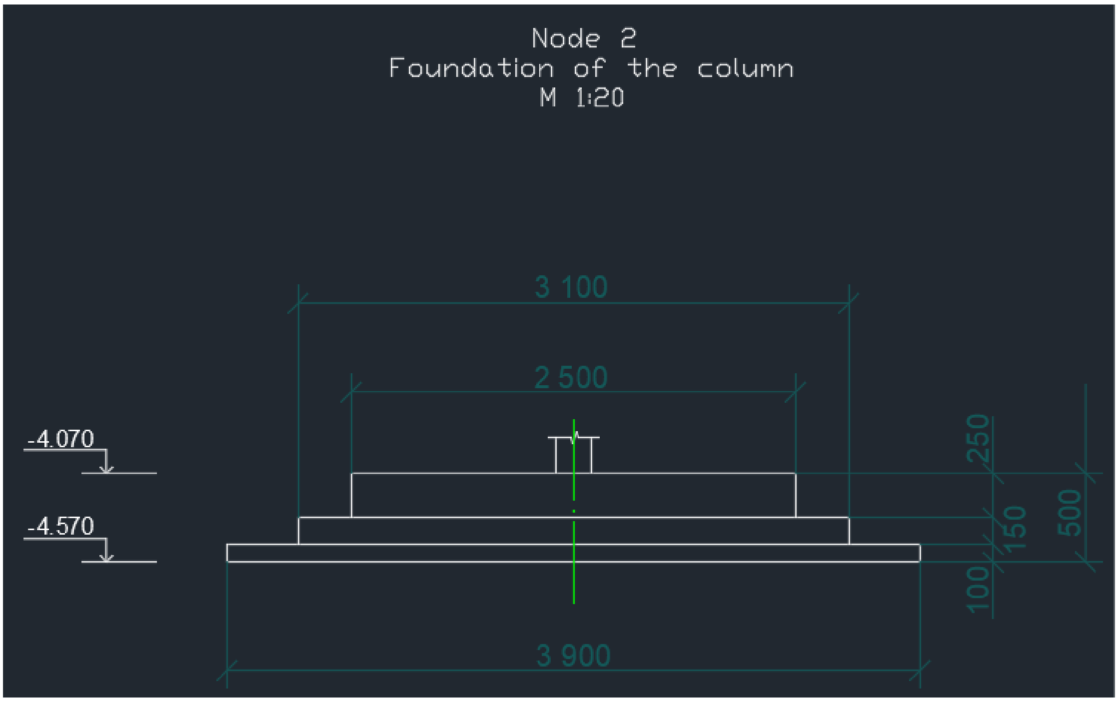
$$l_3 = 3{,}7\ m$$

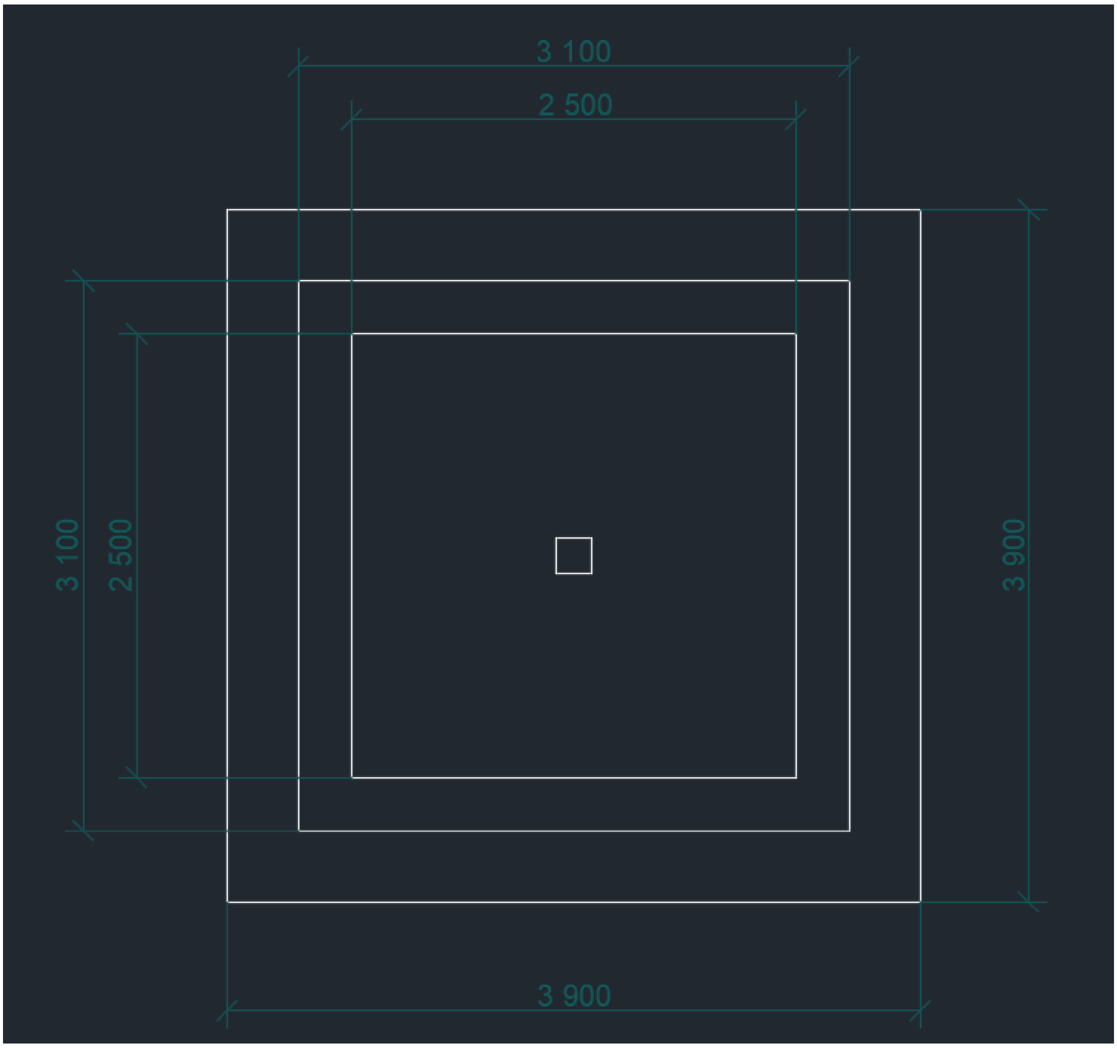
$$l_2 = l_3 - 0{,}3 \cdot 2 = 3{,}7 - 0{,}6 = 3{,}1 \text{ m};$$

2. Upper plate of the foundation:

$$l_1 = l_2 - 0{,}3 \cdot 2 = 3{,}1 - 0{,}6 = 2{,}5 \text{ m};$$

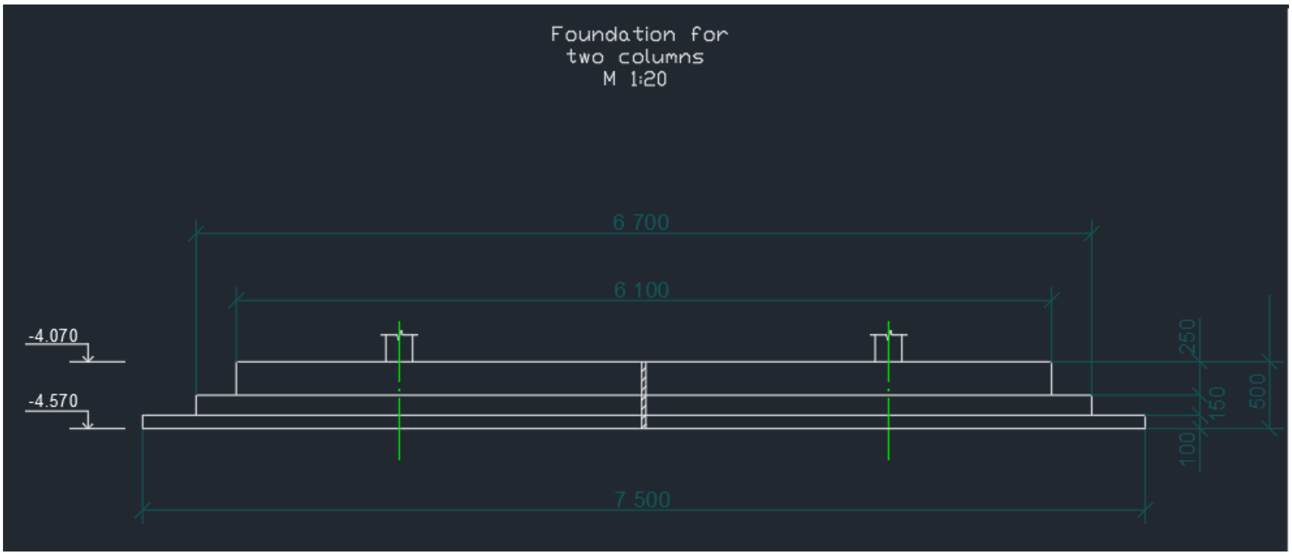
So we have column foundation of this parameters:

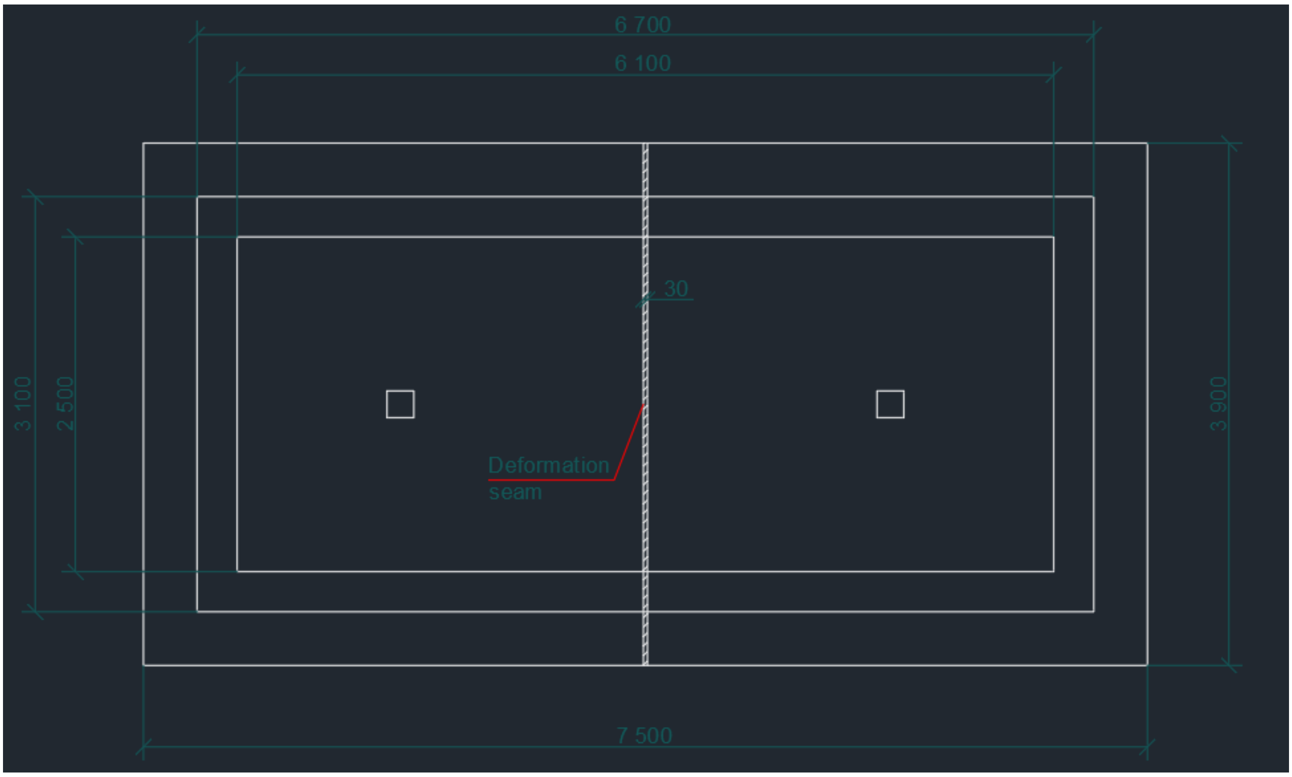




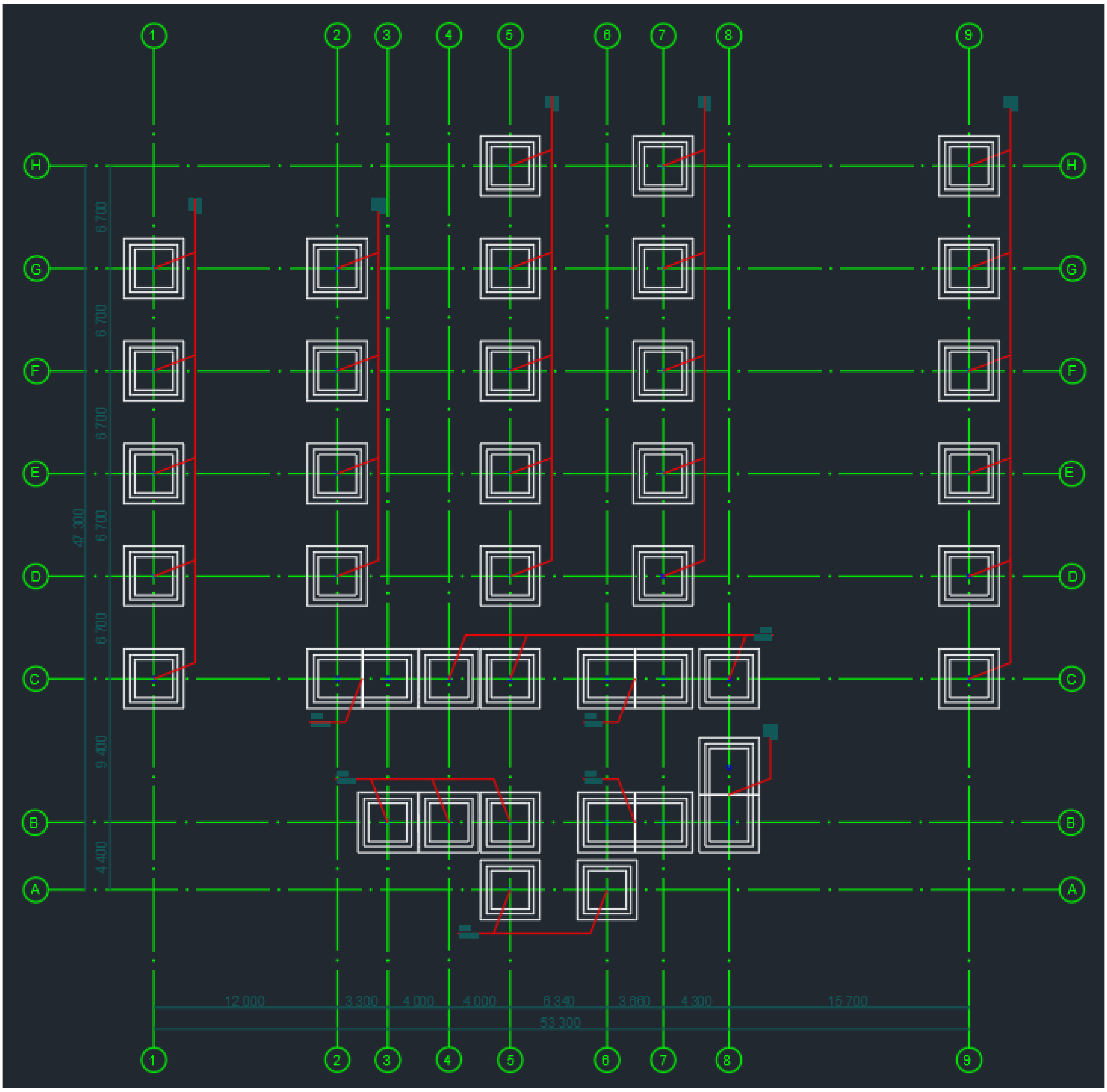
Foundation for one column

But we also have situations when 2 columns are too close to each other and their foundations have to intersect. In this case, you need to connect 2 foundations together and make a deformation seam in the center as in the drawings:



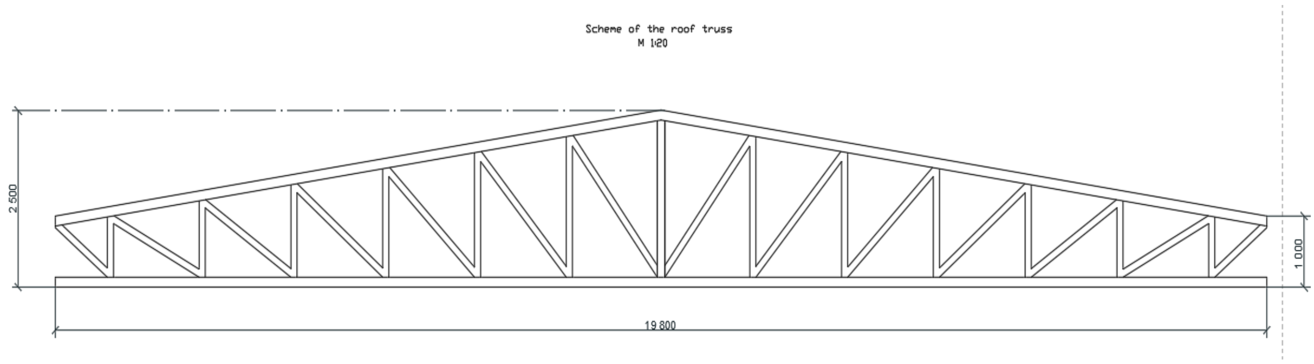


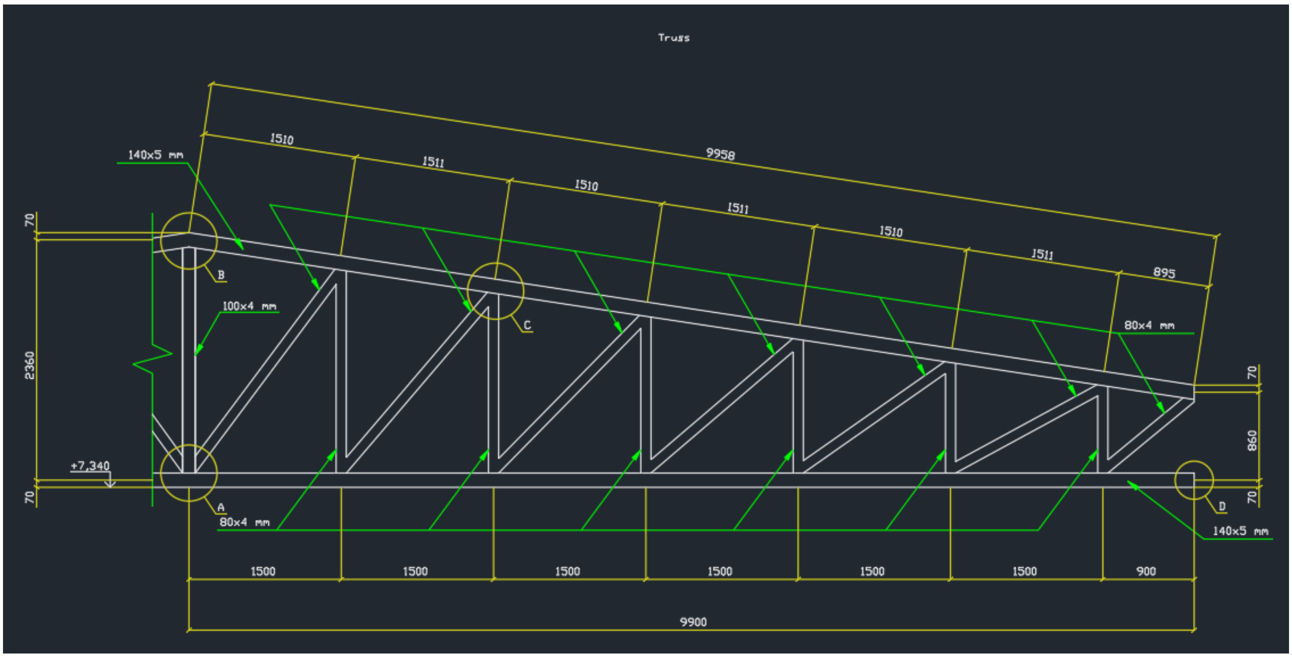
The dimensions of the bottom slab of the double foundation were also rounded to a multiple of 3. There are three double foundations on the plan with the larger side of 7500 mm, and one with the side of 7200 mm.



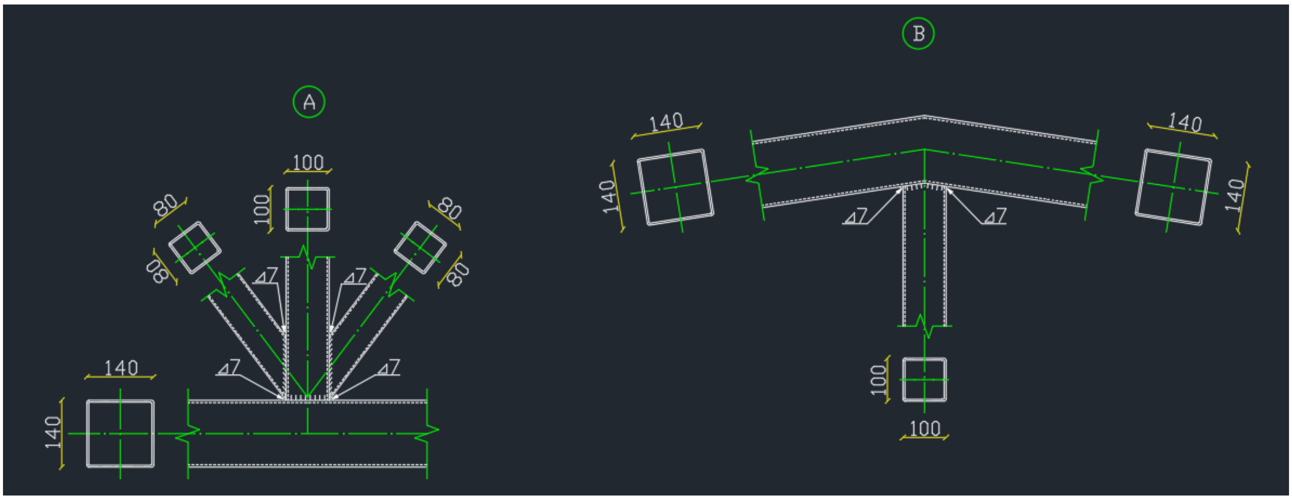
Plan of the column foundations at level -4,570

3.5. Designing of the truss

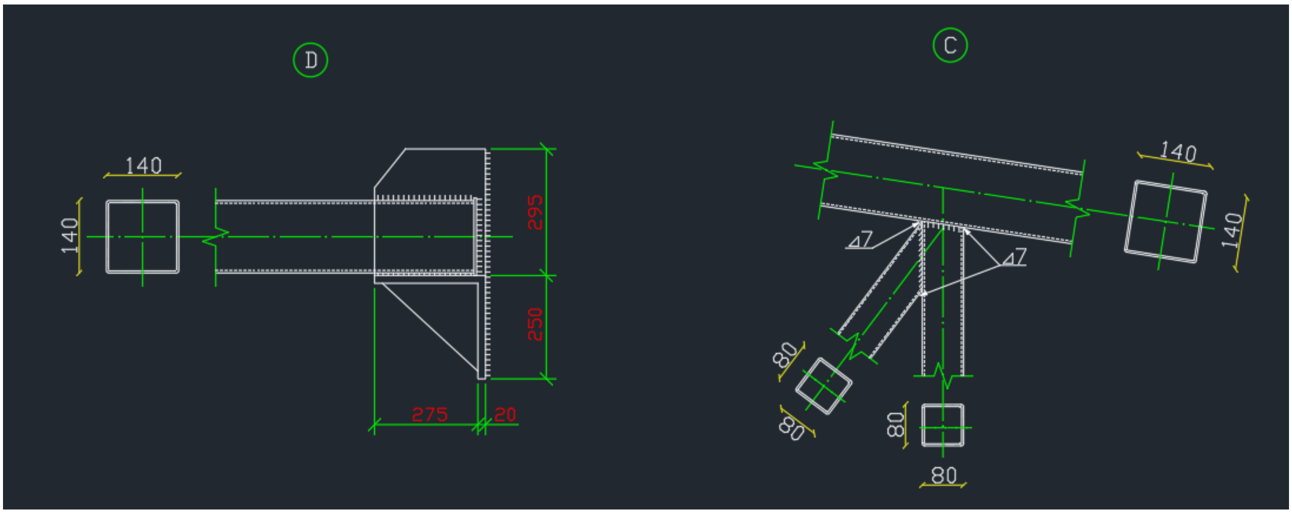


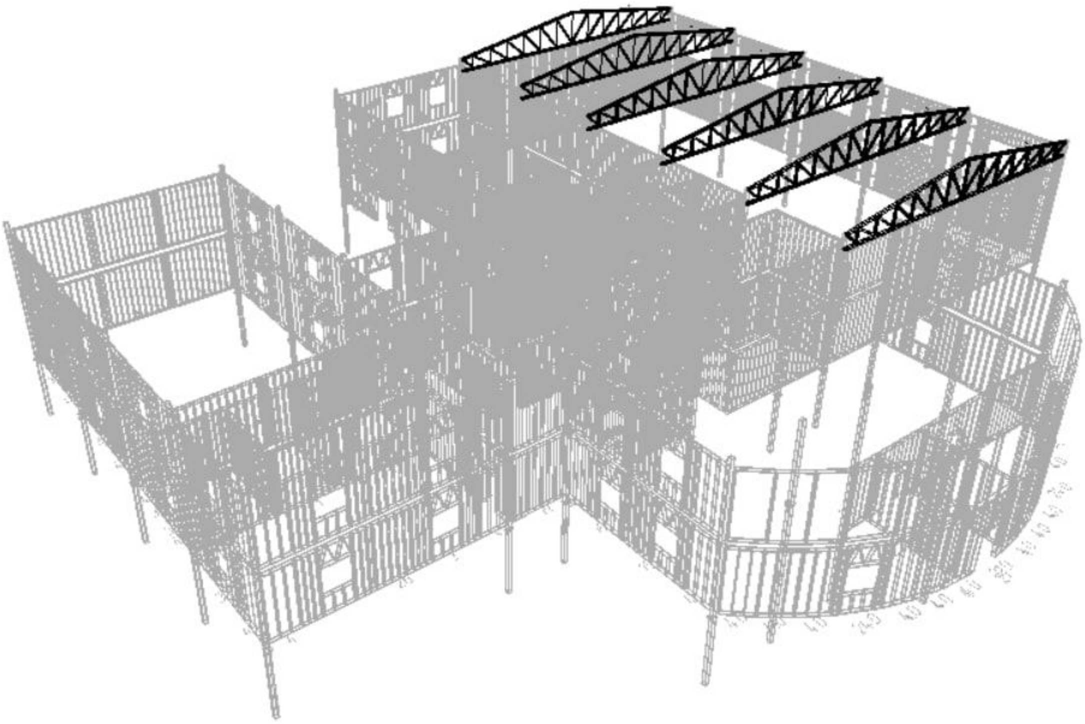


Nodes of the truss



Nodes of the truss





3D view of placement of the trusses

Table 3.3

Specification for assembly units of truss						
Num	Units	Cross-section	Length, m	Weight, kg	Total weight, kg	Steel grade
1.	1	140x140x5 mm	19,8	409,66	409,66	A400C
2.	2	140x140x5 mm	10,0	206,9	413,8	A400C
3.	1	100x100x4 mm	2,23	26,16	26,16	A400C
4.	2	80x80x4 mm	2,0	18,44	36,88	A400C
5.	2	80x80x4 mm	1,78	16,41	32,82	A400C
6.	2	80x80x4 mm	1,55	14,29	28,58	A400C
7.	2	80x80x4 mm	1,33	12,26	24,52	A400C
8.	2	80x80x4 mm	1,1	10,14	20,28	A400C
9.	2	80x80x4 mm	0,87	8,02	16,04	A400C
10.	2	80x80x4 mm	2,32	21,39	42,78	A400C
11.	2	80x80x4 mm	2,16	19,0	38,0	A400C
12.	2	80x80x4 mm	2,0	18,44	36,88	A400C
13.	2	80x80x4 mm	1,84	16,97	33,94	A400C
14.	2	80x80x4 mm	1,7	15,68	31,36	A400C
15.	2	80x80x4 mm	1,6	14,75	29,5	A400C
16.	2	80x80x4 mm	1,1	10,14	20,28	A400C
					1269,14	

CHAPTER 4
Technological card and labor protection

4.1. Technological card

The construction process of this school includes the installation of heavy and bulky structures. This can only happen with the help of a cargo crane, which is selected according to parameters such as the maximum weight of the lifting object and the maximum height to which it needs to be lifted.

In my case, this structure has a steel truss, the weight of which reaches 1.5 tons, and the lifting height is 10 m. So, on of the best variants of the crane will be KC-55713-1 on the chassis of KAMAZ-65115.

Here you can see side view of this crane:

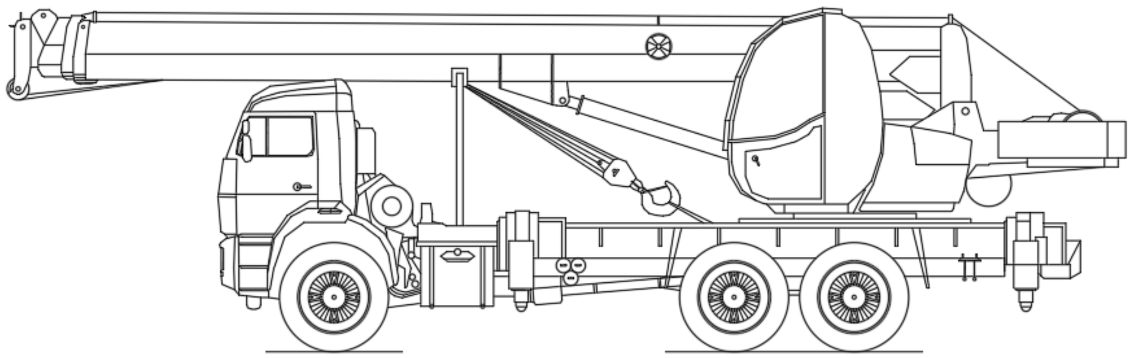


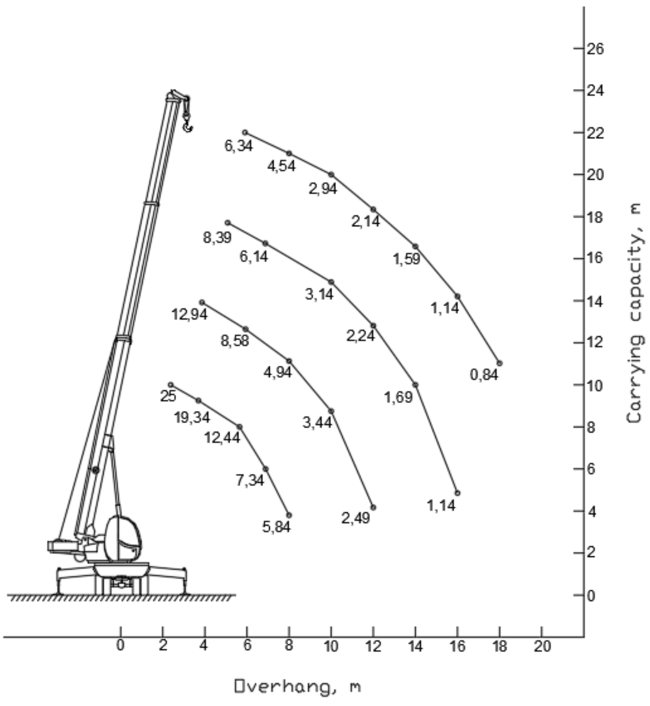
Table 4.1

Technical characteristics of the crane KC-55713-1

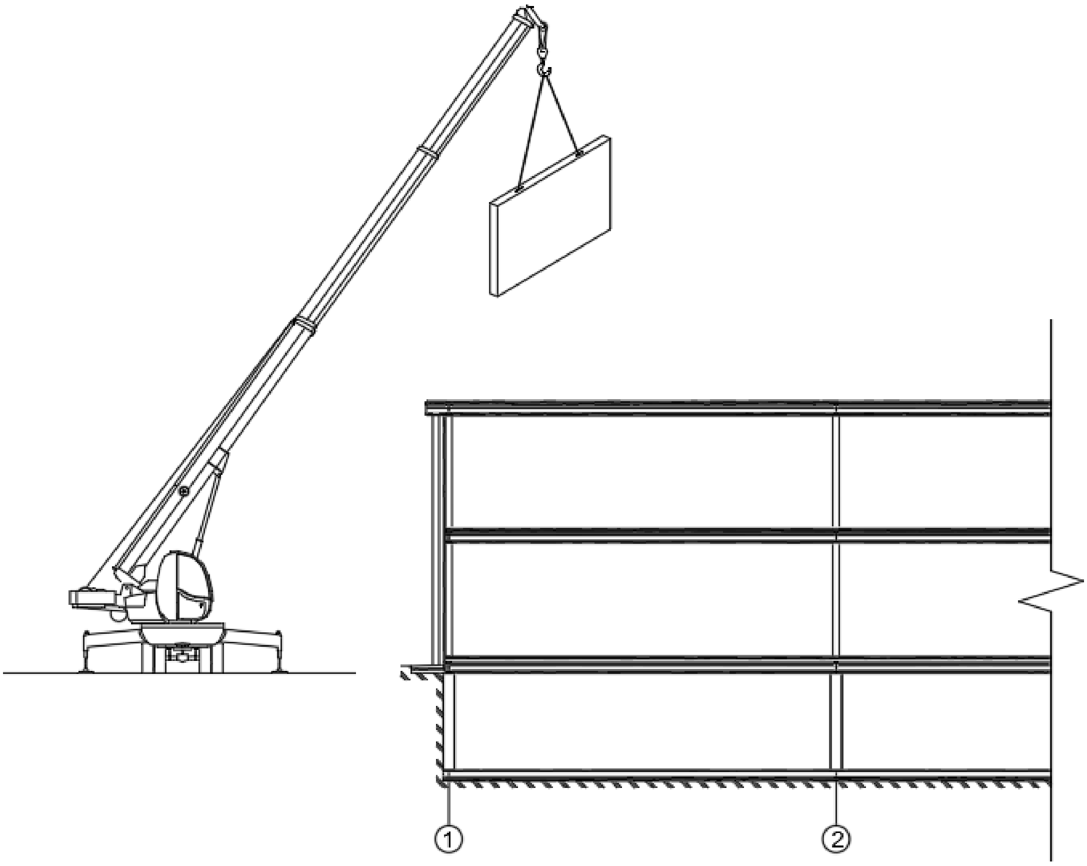
Parameter	Value
Load capacity	25 t
Load moment	80 t·m
Hang length	9,7 – 22,0 m
Hang profile	rectangular
Crane operating area	240, 360
Maximum hook drop depth	24 m
Maximum hook height	21,9 m

Nominal lifting speed	6 m/min
Maximum lifting speed	40 m/min
Turntable rotation speed	up to 2,5 rounds/min
Safety device	ОГМ-240
Maximum load for telescoping hang	4,34 t
Base vehicle chassis	KAMAZ-65115
Wheel formula	6 x 4
Chassis base	3,69 + 1,32 m
Transport speed	60 km/h
Crane dimensions in transport position	12,0 x 2,55 x 3,6 m
Crane weight in minimum configuration	20,5 t
Load on the first axle	4,5 t
Load on the rear platform	16,0 t

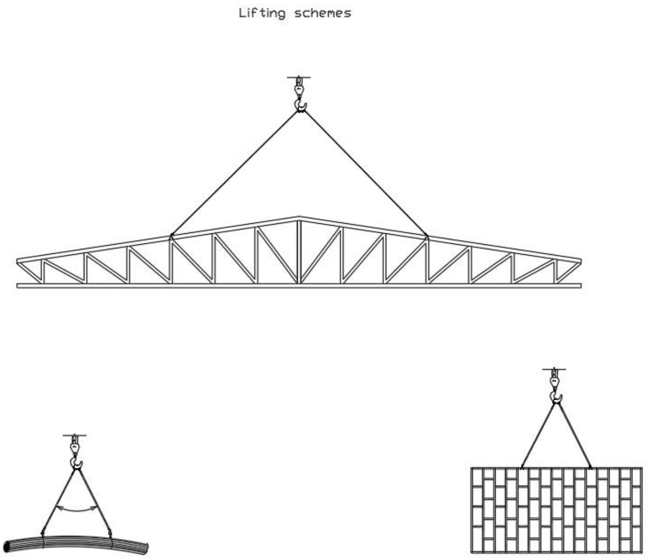
Installation characteristics
of the crane KC-55713-1



This is scheme of load characteristics characteristics of the crane. That is, the parameters at which the crane can lift a certain weight. For example, with a lifting height of 10 m and an overhang of 14 m, the crane can lift a load of no more than 1.69 tons.

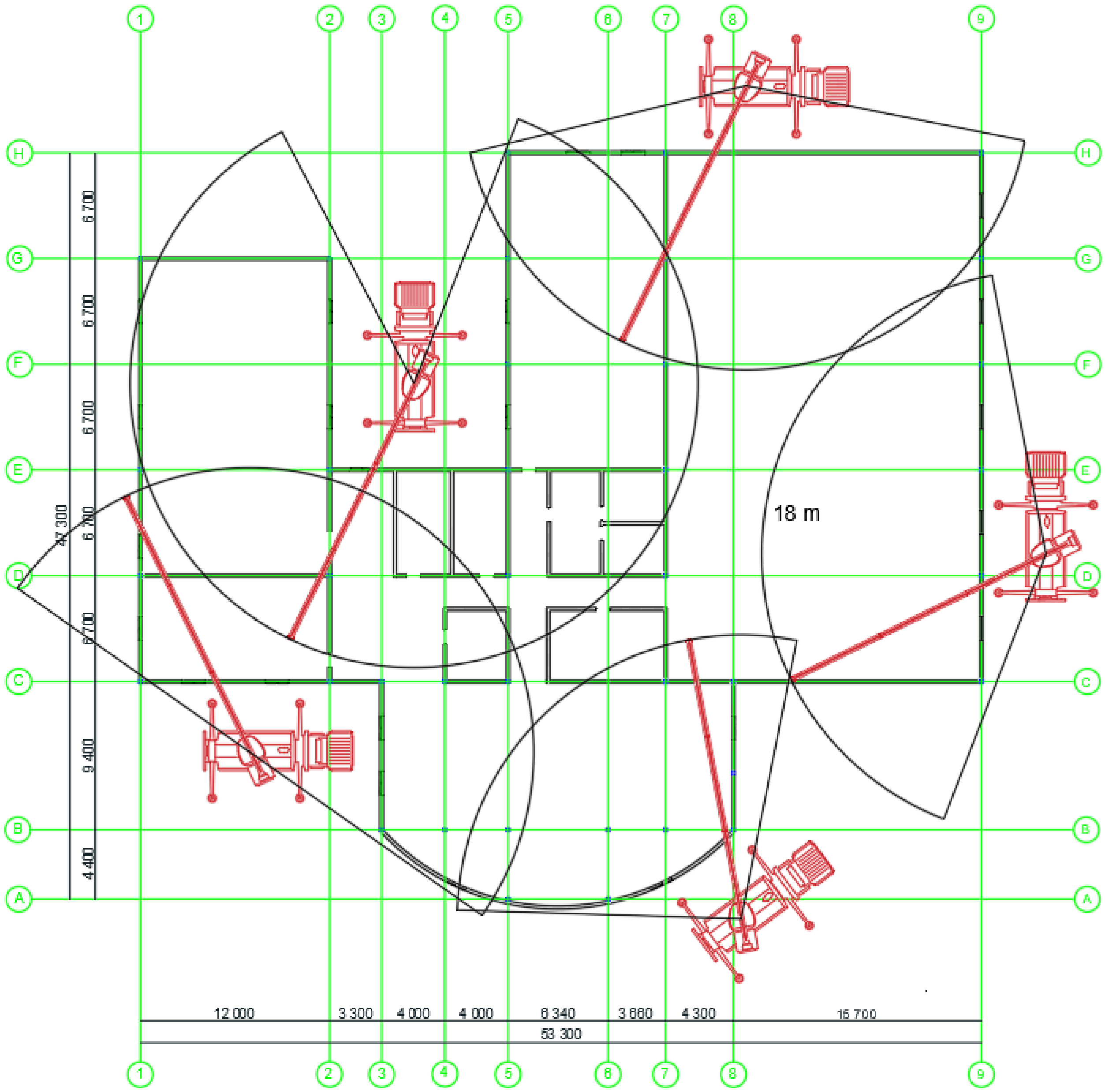


Example of lifting a wall panel



The crane should lift roof trusses, I-beams, wall panels, columns, reinforcing bars, metal profile sheets, pre-fabricated concrete element and others.

Some examples of lifting schemes are shown next to it.



Plan of the placement and operating area of the cranes

due to building plan

4.2. Labor protection

4.2.1. Safety instruction

Table 4.2

Safety instruction

1.	All work on the construction site should be carried out in accordance with the requirements of DBN A.3.2-2-2009 "Labor protection and industrial safety in construction".
2.	Construction and installation work should be carried out after written permission from the chief engineer of the construction organization.
3.	Before the start of construction, a technical-engineer worker responsible for the safe movement of cargo with the help of cranes must be appointed.
4.	Do not allow people to work without overalls, shoes and personal protective equipment.
5.	Helmets are mandatory for everyone present at the construction site.
6.	Do not use faulty, unsuitable load-bearing and unmarked load-lifting elements.
7.	It is forbidden for people to be in the operating area of the crane.
8.	Before work, check the presence of fuses on the lifting devices.
9.	Slings and traverses should be inspected after each shift.
10.	During the welding of metal structures, ground the welded structures and elements of the welding apparatus.
11.	It is forbidden to carry out electrical welding work during rain without a cover over the workplace.
12.	Staying on structural elements during their lifting or moving is prohibited.
13.	Unfastening structures should be carried out only after they are securely fixed.
14.	It is forbidden to carry out work at height and to operate the crane at a wind speed of more than 15 m/s.
15.	Keep a height allowance of 0.5...1 m for safe installation of structures.

16.	To apply lubricants with a pneumatic sprayer, workers need to have individual protective equipment: glasses, respirators, tarpaulin suits and boots.
17.	It is forbidden to stay on the formwork of people who are not related to the performance of the specified works.
18.	It is forbidden to place on the formwork materials and equipment that are not related to direct work.
19.	The condition of the formwork and other fastenings must be constantly monitored.
20.	Workplaces at a height of more than 1.3 meters should be surrounded by a temporary fence.
21.	The width of the passages to the workplaces should be at least 0.6 m, and the height at least 1.8 m.
22.	It is forbidden to carry out work in poorly lit places.
23.	The reinforcement must be folded in specially designated places for this purpose. The edges of reinforcement should be covered with shields.

4.2.2. Labor protection measures

1) Wearing protective helmets is mandatory for all persons present at the construction site.

2) When formwork and reinforcement are moving by cranes to the workplace, protective pallets, containers and load-catching devices that exclude the fall of the load at rising must be used.

3) Dangerous areas must be marked with safety signs and inscriptions established form.

4) Protective and signaling fences and warning signs must be installed on the borders of dangerous zones or other dangerous factors.

5) It is forbidden to place on the formwork materials and equipment that are not related to direct work.

6) It is forbidden to stay on the formwork of people who are not related to the performance of the specified works.

7) It is forbidden to move the vibrating device by the current-carrying hoses during its use. When moving the vibrating device from one place to another, it must be turned off.

8) It is forbidden to carry out work at height and to operate the crane at a wind speed of more than 15 m/s.

9) Removal of the formwork is carried out only with the permission of the supervisor/manufacturer.

4.2.3. Briefings on labor protection issues

According to the nature and timing of training on labor protection issues are divided into:

- introductory;

- primary;

- repeated;

- unscheduled;

- targeted.

Introductory briefing is held:

- with all newly hired employees (permanent or temporary), regardless of education, work experience in this profession or positions;
- with employees who are on a business trip at the enterprise and take a direct part in the production process, with drivers vehicles entering the territory of the

enterprise for the first time, pupils, trainees and students who came to the enterprise for passing industrial practice;

- with students in educational institutions before the start of labor and professional training in laboratories, workshops, landfills, etc.

Initial briefing is held at workplace before starting work:

- with employees hired (permanently or temporarily) at the enterprise;
- with an employee who is transferred from one production shop to another;
- with an employee who will perform a new job for him;
- with a seconded employee who directly participates in the production process at this enterprise;
- with a student or trainee who has arrived for industrial practice, before he performs new types of work; before studying each topic during labor and professional training in educational institutions in laboratories, classes, workshops, at the stations, during the implementation extracurricular learning in groups and sections, etc.

Repeated briefing is carried out on workplace with all employees: on jobs with increased danger - once a quarter, and other jobs - once every six months.
Re-instruction is carried out individually or with a group employees who perform the same type of work, according to the primary program instruction in full.

Unscheduled briefing is held with by employees at the workplace or in occupational safety offices:

- when new or revised normative acts are put into effect labor protection, as well as when making changes and additions to them;
- when changing the technological process, changing or upgrading the equipment, devices and tools, raw materials, materials and other factors that affect labor protection;
- in case of violation by an employee or student regulatory acts on labor protection, which may lead to or have led to injuries, accidents or poisoning;

- at the request of employees of the state labor protection supervision body higher economic organization or state executive power in case if an employee, student or apprentice is found to be ignorant of safe methods, labor practices or normative acts on labor protection;
- with a break in work of more than 30 calendar days - for work with high risk, and for the rest of the works - more than 60 days.

Unscheduled briefing is carried out individually or with a group employees, common by profession, the scope and content of instruction are determined in each individual case, depending on the circumstances that caused the need its implementation.

Targeted instruction is held with employees:

- when performing one-time works that are not directly related to work responsibilities by specialty (loading, unloading, one-time work outside the workshop or enterprise);
- when liquidating an accident, natural disaster;
- when carrying out works for which a permit-admission order is drawn up, for permits and others documents;
- on company tours;
- when organizing mass events with students and pupils (excursions, hikes, sports events, etc.).

4.2.4. Air parameters inside the working area

A set of indicators of the production environment form a microclimate. Such parameters as:

- air temperature, °C;
- relative humidity, %;
- speed of air movement, m/s;
- heat radiation intensity, W/m2 (kcal/m2·h);
- barometric pressure, mm Hg.

Air humidity has a significant effect on a person's well-being and performance. Air humidity can be absolute and relative.

Absolute humidity is the amount of moisture (g) contained in m3 of air at a given temperature (g/m3).

Relative humidity is the percentage ratio of the absolute amount of water vapor in the air to their maximum possible amount at a given temperature.

In production, the specified indicators act on a person in total, mutually strengthening or weakening each other. For example, increasing the speed of air movement increases the effect of low temperature and, conversely, weakens the effect of high temperature on the human body. An increase in the value of humidity worsens the well-being of a person both at low and at high temperature. Thus, the combination of meteorological parameters of the production environment can be favorable or unfavorable for human well-being.

If the ambient temperature rises to 25 °C and higher, and the relative humidity is more than 75%, then the heat exchange of a person with the environment is disturbed, and the body temperature rises. Thermoregulation occurs by 95% evaporation. Overheating increases the flow of blood to the peripheral blood vessels. Due to the expansion of blood vessels, the amount of blood and heat transfer increase. Under such parameters, a person loses 5-8 liters of fluid and 50-80 g of salts per shift, that is, the water-salt and vitamin exchange in the human body is disturbed, weakness, headache, tinnitus, nausea occur. Breathing and pulse become more frequent, blood pressure rises and then falls. In severe cases, heat stroke occurs, which is classified as an accident. Seizures may also occur; if a person loses 20% of water, death occurs.

Working at low temperatures can lead to hypothermia of the human body. Peripheral blood vessels narrow, blood flow to them and heat transfer decreases. Frostbite is also classified as an accident.

According to the norms, there are permissible and optimal meteorological conditions at the workplace.

Permissible are the parameters of the microclimate that, with a long-term and systematic effect on a person, can cause transient, and those that quickly normalize, changes in the body's thermal state, which are accompanied by the stress of thermoregulation mechanisms, but do not go beyond physiological adaptations. At the same time, there is no damage or impairment of health, but uncomfortable heat sensations, deterioration of well-being and reduced work capacity may be observed.

The microclimate parameters are called **optimal**, which, with long-term and systematic action on a person, ensure the preservation of the normal thermal state of the body without stressing the mechanisms of thermoregulation. They provide a feeling of thermal comfort and create conditions for a high level of human performance.

The optimal combination of metrological conditions of the production environment is called comfort.

4.2.5. Categories of difficulty of work

All works will be divided into three categories according to the degree of difficulty: easy, medium and heavy.

Easy physical work (category I) includes activities with energy consumption up to 150 kcal/h (175 W). Light physical work is divided into category Ia and 1b.

Category Ia includes work that is carried out while sitting and is accompanied by slight physical exertion, with energy consumption of 90-120 kcal/h (105-140 W).

Category Ib includes work that is carried out while sitting, standing or is associated with walking and is accompanied by some physical exertion, with energy consumption of 121-150 kcal/h (141-175 W).

Types of activities with energy consumption in the range of 151-250 kcal/h (176-290 W) belong to the average difficulty of physical work (category II). Physical works of medium difficulty are divided into categories IIa and IIb.

Category IIa includes jobs associated with constant walking, moving small (up to 1 kg) products or objects in a sitting or standing position and which require a certain physical effort, with energy consumption from 151 to 200 kcal/h (176-232 W) .

Category IIb includes work related to walking, moving and carrying loads up to 10 kg and which are accompanied by moderate physical stress, with energy consumption of 201-250 kcal/h (233-290 W).

Heavy physical work (category III) includes activities with an energy expenditure of 251-300 kcal/h (291-349 W). Category III includes work related to constant movement, movement and transfer of significant (above 10 kg) loads and which require great physical effort.

4.2.6. Danger of electric current

Electric burn is the most widespread electric trauma. Current burn is contra-distinguished in networks with voltage not above 2 kWt, which caused by passing through the body tissue current with strength not more than 1 A, and arc burn, which arises from electric arc temperature, that may reach more than 3500 °C. Arc arises at accidental short current in plants with voltage not more than 6 kV, and also in networks higher than 10 kV at man approach to current conducting parts, which are found them under voltage.

At first help assignment for victim from influence of electric current it is necessary to execute such operations: to absolve from source of current; immediately to bring on ambulance; quickly to define a victim state and to provide rest to him, flow of crisp air, heat; in lack of breathing and pulse - to do artificial breathing and external heart massage.

When a number of persons, who gives help, is equal to two or more, then one of them must make a heart massage to victim (to press by open palm on thorax), second must make artificial breathing (it is necessary to make 10-12 inhales in a minute). Pressing must be taken once in a second with interruptions on 2 s after each four - six pressings. If help is lend by one man, then after two - three inhales it must be taken four – six pressings for heart massage.

4.2.7. Fire Security

The instruction on fire safety during construction and installation work (hereinafter referred to as the Instruction) was developed on the basis of the legislation of Ukraine on labor protection in accordance with the requirements of the Law of Ukraine "On Fire Safety", the Rules of Fire Safety in Ukraine (NAPB A.01.001-2004), establishes general fire safety requirements during the construction, reconstruction and repair of buildings and structures, as well as the operation of temporary structures and buildings and is a regulatory act within the enterprise.

The requirements of this Instruction must be taken into account during the development of construction organization projects and work execution projects. Persons who have violated the requirements of this instruction bear personal responsibility in accordance with the procedure established by law: disciplinary, material, administrative or criminal - depending on the consequences caused by the violation.

DUTIES AND ACTIONS OF EMPLOYEES IN THE EVENT OF A FIRE

1. In case of detection of a fire (signs of burning), each employee must: - immediately notify the fire and rescue service by phone "01", indicating the address, number of floors, place of fire, presence of people, as well as their surname; — take measures to evacuate people, extinguish the fire using existing fire extinguishers and other fire extinguishing means; — notify the contractor about the occurrence of a fire.
2. The manager, the official who was notified about the fire, must: — check whether the fire and rescue service has been called; — turn off (if necessary) current receivers; — check whether people have been notified about the fire; — in the event of a threat to people's lives, to immediately organize their evacuation, to remove from the danger zone all persons not connected with the elimination of the fire; — ensure compliance with labor protection requirements by employees participating in firefighting; — organize a

meeting of the fire and rescue service units, provide them with assistance during the localization and liquidation of the fire.

3. After the arrival of the fire and rescue service units, ensure their unhindered access to the place of fire.
4. If there are victims, it is necessary to provide first (pre-medical) aid, call an ambulance or take measures to transport them to the nearest medical facility.

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20. Metinvestholding

APPENDIX 1

Drawings