MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ARCHITECTURE, CIVIL ENGINEERING AND DESIGN
COMPUTER TECHNOLOGIES OF AIRPORT CONSTRUCTION AND RECONSTRUCTION DEPARTMENT

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Head of the Department

______ O.I. Lapenko

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BACHELOR THESIS

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SPECIALTY 192 «BUILDING AND CIVIL ENGINEERING»

Educational and professional program: «Industrial and civil engineering»

Theme: Apartment building in Kremenchuk

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Design rule check: ______ O. Rodchenko

Kyiv 2022

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ АРХІТЕКТУРИ, БУДІВНИЦТВА ТА ДИЗАЙНУ
КАФЕДРА КОМП'ЮТЕРНИХ ТЕХНОЛОГІЙ БУДІВНИЦТВА ТА РЕКОНСТРУКЦІЇ АЕРОПОРТІВ

ДОПУСТИТИ ДО ЗАХИСТУ

Завідувач випускової кафедри

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"08" _____06_____ 2022 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ БАКАЛАВРА
ЗА СПЕЦІАЛЬНІСТЮ 192 «БУДІВНИЦТВО ТА ЦИВІЛЬНА ІНЖЕНЕРІЯ»
ОСВІТНЬО-ПРОФЕСІЙНА ПРОГРАМА
«ПРОМИСЛОВЕ І ЦИВІЛЬНЕ БУДІВНИЦТВО»

Тема: «Житловий будинок у м. Кременчук»

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НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет архітектури, будівництва та дизайну
Кафедра комп'ютерних технологій будівництва та реконструкції аеропортів
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ЗАТВЕРДЖУЮ
Завідувач кафедри
О.Г. Лапенко
« 13 » / 04 2022 р.

ЗАВДАННЯ
на виконання дипломної роботи

МОХАМЕД Ая Зінебалдін Абдельхафез Алі
(П.І.Б. випускника)

1. Тема роботи «Житловий будинок у м. Кременчук»
затверджена наказом ректора від «13» квітня 2022р. № 379/ст.

2. Термін виконання роботи: з «23» травня 2022р. по «19» червня 2022р.

3. Вихідні дані роботи: план та переріз спортивно-оздоровчого комплексу, навантаження відповідно до ДБН В.1.2-2:2006 «Навантаження та впливи».

4. Зміст пояснювальної записки:
Вступ, аналітичний огляд, архітектурно-планувальна частина, розрахунково-конструктивна частина, технологічно-організаційна частина, висновки, список використаних джерел.

5. Перелік обов'язкового ілюстративного матеріалу: таблиці, рисунки, діаграми, графіки не менше 4-х креслень та 4-х слайдів:

- фасади, план типового поверху, експлікації
- креслення конструкції, специфікації елементів
- технологічно-організаційні схеми виконання основних будівельних процесів

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1.	Аналітичний огляд	13.05.22-14.05.22	
2.	Архітектурно-будівельний розділ	16.05.22-20.05.22	
3.	Розрахунково-конструктивний розділ	23.05.22-02.06.22	
4.	Технологічно-організаційна частина	03.06.22-04.06.22	
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8. Дата видачі завдання: «13» травня 2022 р.

Керівник дипломної роботи: ______________ Горб О.Г.

Завдання прийняв до виконання: ______________ МОХАМЕД Ая

Content

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Ch.	Sh.	№ doc.	Signature	Data			
Developer	*Mohamed Aya*				*Apartment building in Kremenchuk*	Let.	Sheet	Sheets
Supervisor	*Horb O.*							
						National Aviation University		
N. Control								
Approved	*Lapenko O.*							

1. Introduction

1.1. Reasons for the object reconstruction

The main goal of this project is to build an apartment building in Kremenchuk. This city is located in the central part of Ukraine, in the middle reaches of the Dnieper River, on its left and right banks, 113 km southwest of Poltava and 292 km southeast of Kyiv.

An Apartment is also known as multi-story building; it is a building that supports two or more floors above ground and where three or more residences are contained within one floor. The height or number of floors in a building has no restrictions as a multi-story building may contain more than two, although as the building gets taller there are more things that have to be considered as chances of failure and error can easily be made if constructed.

An apartment building can also be a part of an apartment complex, flat complex, block of flats, tower block, a high-rise building and many more especially if it is bought too rent out apartments for residents. To provide appropriate housing within the local region or to meet the housing needs of an expanding community, some towns incorporate multiple multi-story apartment buildings.

Steel or reinforced concrete can be used to construct an apartment building structure. The fundamental building shape is usually chosen, or at least heavily influenced, by other members of the design team. It is frequently determined by site boundaries, whether physical or legislative, such as planning restrictions. The engineer should double-check for any project-specific requirements before turning this simple shape into a design. In any case, we must test soil compression and wind direction before beginning the construction of an apartment building. The following are some of the steps that are taken in Apartment Building Construction:

1.2. Design of Building Components

1) design of the formwork;

2) design of the staircase;

3) deep beams;

4) slabs.

Excavation, foundation and layout:

- excavation is the process of digging trenches in the ground to build foundations and basements;
- the excavation level at the escape site is 220 mm;
- excavation is done by JCB on an hourly basis;
- after the excavation, the surface is leveled;
- layout is done on the PCC poured over the leveled surface;
- the steel for the column and foundation (raft) is then set out according to the blueprints.

The steps involved in column casting are as follows:

- column layout is done on the raft;
- starter layout is done;
- the column ties and link bars are supplied in accordance with the column reinforcement drawings and general specifications.
- main bar displacement should be provided with L bar;
- plumb of formwork should be checked;
- height of cast should be calculated accurately;
- avoid caps as much as possible.

1.3 Things which should be reconsidered

1. The layout should be double-checked;

2. Look for any differences in the placement of the column between architectural and structural drawings.

3. Check the integrity of temporary structures placed near the excavated land after excavation;

4. Before constructing raft reinforcement, a shuttering wall, primarily made of bricks, should be constructed and filled with soil on the other side.

5. Inspect the direction of the raft's chair bars.

Project Description

The Apartment building that was planned to be built is on the typical side of things. 9 story building that have around 15 separate apartments per floor. Some of the amenities included are multi-functional installations, an elevator, a heating system and a parking space that can be used by residents and also for temporary parking usage. There are basement and security room.

Some of the detailed parts of the construction measurements are:

- The stairs connect all of the floors.
- Supporting columns measuring 300x300 mm.
- Pylons - 300x1600.
- External walls- foam blocks 200 mm thick.
- Internal walls 160 mm thick.
- Partitions – 80 mm.
- The bottom position of the first bottom is taken at 1280 mm above the planning mark of the construction point.
- The veranda position mark is-0.830 mm.
- All apartments bathrooms, halls and corridors, have natural light through the windows.
- The windows are accepted in standard sizes (OS-15-12).

The height of a room accepted is:

- Typical floor- 3000 mm;
- Basement - 1950 mm.
- First floor- 3000 mm;

Table 1.1. Measurement of rooms

The name of the room	Area, m2
Room	12.5
Room	10.3

Hall	17.2
Kitchen	8.0
Bath	2.5
Toilet	1.4
Balcony	2.6
Corridor	6.2
Corridor	4.7
Residential	40.0
General	69.7
Tambour	2.0
Security room	2.0
Garbage collection	3.7
Toilet	1.0
Elevator hall	12.9

1.4 Characteristics of the area and construction site

The apartment building is located in Kremenchuk.. The Annual Average temperature in kremenchuk:

During summer :

- Highest: 27°C
- Lowest: 13.7°C

During spring :

- Highest: 14.7°C
- Lowest: 3.7°C

During Autumn:

- Highest: 17°C
- Lowest: 6°C

During winter:

- Highest: 0.8°C
- Lowest: -6°C

The foundation of the house is shallow foundation with a monolithic reinforced concrete which hence requires a vertical and horizontal coating of waterproofing materials. It is the most applicable according to its soil composition and will support the long life and stagnant stand of the building.

Overall, the house is a properly planned and economically well executed.

2. Architectural and construction chapter

2.1 Master Plan

This project is all about the construction of an 9-storey Apartment Building in Kremenchuk. The area where the construction of the building is planned is in an empty plot of land where no buildings needs to be demolished, located in the Central part of the city. The total area of the site when designing the construction of a residential building is taken as a rectangle. The maximum area of the plot is 930 m^2. The sources of energy resources to which the building under construction can be connected and which can be used in the construction process are at a distance of 0.5 km.

Each floor has a corridor, elevator, stairways and 15 different apartments.

2.2 Constructive solution

The foundation of the apartment building

- Basement walls – monolithic:
  - Internal – 160 mm
  - External – 300 mm
- Exterior walls - foam blocks
  - Internals wall from the foam blocks – 160 mm
  - Partition – 80 mm
- Measurement per steps:
  - Height – 150 mm
  - Width – 300 mm
- Stairwell:
  - Width – 1300 mm

- For the interfloor overlappings, the bearing design we used reinforced concrete plates.
- Stairs are individual coverings made of reinforced concrete slabs, which are laid on reinforced concrete supports on the reinforced concrete mortar with subsequent facing.
- 2 layers of welded roofing material
- Horizontal waterproofing is made of cement-sand mortar M150 composition 1:2 with sealing impurities (liquid glass, sodium aluminate) or two layers of waterproofing material "Technoelast".
- Vertical waterproofing is performed by coating twice with two layers of Bitumen rubber mastic on the primer primer.
- Pavement around the building:
  - 0.15 m of gravel and sandy compacted soil for paving
  - Waterproof
  - Transverse slope that is 1m wide.
- Electrification - from the external network, voltage 380/220 V.
- Lighting - incandescent lamps.
- Communication devices - broadcasting network, collective television antenna, telephony, Internet.
- Elevators - two cargo and passenger, with a loading capacity of 500 kg.
- Savage – from the household to the city network; gutter - internal
- Garbage can - with a camera on the 1st floor, with a replaceable container
- Kitchen equipment - electric stove (380 V)
- Ventilation in the house is accepted natural supply and exhaust. Separate exhaust ducts with a cross section of 350 x 1020 mm are arranged near the internal self-supporting walls along the axes 4-8, from the kitchen, bathroom, toilet.
- Natural ventilation by window is also possible in the corridors.

- Hot water supply from a separate boiler, the estimated pressure at the base of the risers is around 57m.
- Temperature of the heat carrier is between 150-170 *C.
- Heating - water central, single-pipe system with upper branching, dead-end, with convectors using the "Comfort-20" option with steel radiators PCT-2 for design.
- Water supply for drinking and daily use.
- Fire from the external network, the calculated pressure at the base of the risers is 53 m and with fire extinguishing 60.5 m.

2.3. Exterior, interior design and materials

Exterior design:

- The facades of the structure are decorated with decorative plaster.
- Veranda covering - porcelain.
- Stuffing of window and door openings – wooden frames with double-glazed windows.

Interior designing and materials

Ceiling and wall materials

- The walls in living apartments, hallways, halls, are decorated with wallpaper, in apartments with high moisture (heating room, kitchen work face bathrooms).
- The walls are decorated with tiles made in ceramic, in common areas (elevator halls, entranceway).
- All surfaces are pre-plastered and painted.
- The ceiling is pre-plastered with water-emulsion paint on top.

Floor Materials

- In all the living areas the floors is finished with laminate.
- In areas with high level of humidity like the bathrooms, kitchen, elevator halls and the entryway - ceramic.
- Sound insulation.

- Waterproofing

3. Calculation of constructions

3.1 Reinforced concrete slab

Calculation of prefabricated reinforced concrete floor slab with round cavities

1. Initial data for design

Pre-stressed panel with round cavities with cavities 1.6 m wide is made of concrete class C32/40.

Prestressed fittings - made of K-7 steel.

For buildings with responsibility class CC2. And the reliability factor for the purpose of structures construct equal 1,1.

Table 3.1. Characteristics of materials

Concrete C 32/40				The fittings are tense class K-7 (K1400)			
f_{ck}	f_{cd}	f_{ctk}	E_{cm}	f_{pk}	$f_{p0,1k}$	E_p	ε_{uk}
29	22	2,1	$36 \cdot 10^3$	1470	1335	$18 \cdot 10^4$	0,014

Non-stressed fittings C240			
	f_{yd}	f_{ywd}	E_s
C240	225	170	$2{,}1 \cdot 10^5$

f_{pk} - the characteristic value of the tensile strength of the reinforcement;

$f_{p0,1k}$ – the characteristic value of the conditional yield strength of 0.1%;

E_p – modulus of elasticity of fittings;

E_{uk} – ultimate relative deformation of the elongation of the reinforcement

Estimated value of tensile strength of stressed reinforcement K-7

F_{pd} – determined by the formula (according to DSTU BD.2.6-156: 2010):

$$f_{pd} = \frac{f_{p0,1k}}{\gamma_s} = \frac{1335}{1{,}2} = 1112{,}5 MPa$$

Where - reliability factor for fittings, taken in accordance with table.2.1 DBN B.2.6-98: 2009.

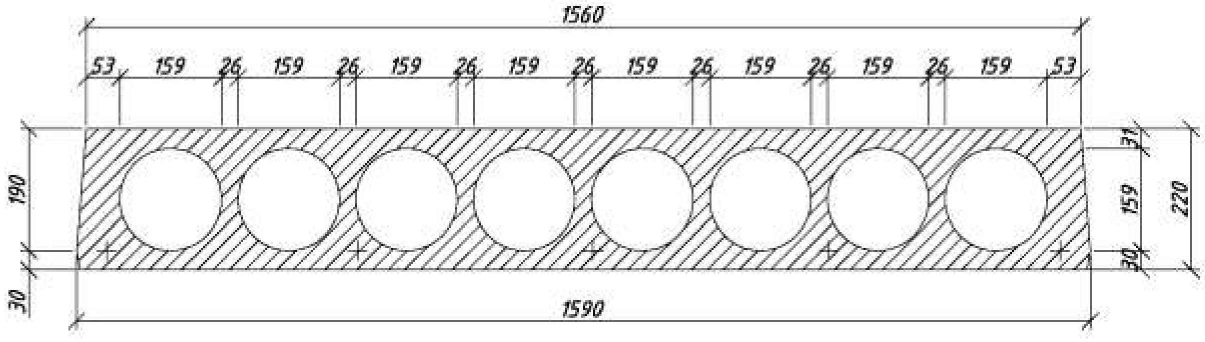

Fig.3.1 Cross-sectional dimensions and panel reinforcement scheme

Let's set the dimensions of the cross section of the crossbar. According to the recommendations for bending elements we take:

$h = \left(\frac{1}{8} \ldots \frac{1}{15}\right) l = \left(\frac{1}{8} \ldots \frac{1}{15}\right) 700 = 87{,}5 - 46{,}6\ cm$, h= 70 cm

$b = (0{,}3 \ldots 0{,}5)h = (0{,}3 \ldots 0{,}5)70 = 21 - 35 см$ b=20 cm

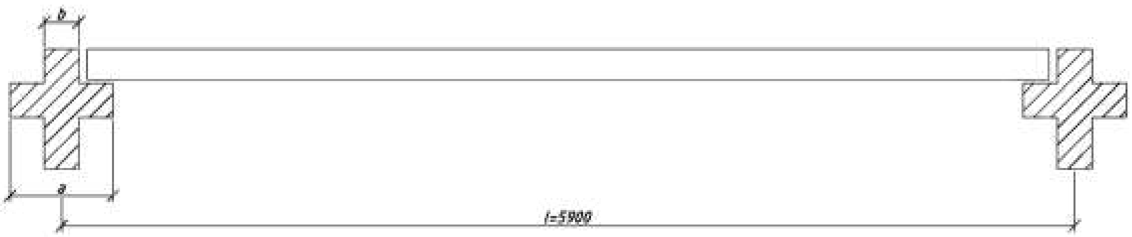

Fig.3.2 For this case, when the panels rest on the shelves of the crossbars, the estimated span: $l_0 = l - a + c = 590 - 40 + 10 = 560 см$,

where l - the distance between the axes of the crossbars, l=5,9m

a – the width of the lower shelf of the bolt;

c – depth of lying in a wall or leaning of a shelf on a crossbar, c=10-12cm.

The load transferred to the floor panel consists of permanent (own weight of the panel, floor) and temporary (useful), which is given in the design.

Full design load per meter of the panel with a nominal width of 1.6 m at $\gamma_f > 1{,}0$:

$P = p.16 = 30{,}382.1{,}6 = 48{,}611\ kN/m$

Where 1.6 is the nominal width of the panel.

Constant and long-term load per meter of the panel with a nominal width of 1.6 m at $\gamma_f = 1{,}0$

$$P_{n,1} = (G_n + v_n).16 = (4{,}4 + 0).1{,}6 = 7{,}04\ kN/m$$

from full load at $\gamma_f > 1$

$$M = P \cdot l_0^2 / 8 = 48{,}611 \cdot 5{,}6^2 / 8 = 190{,}55 kN/m$$

$$V_{Ed} = P \cdot l_0 / 2 = 48{,}611 \cdot 5{,}6 / 2 = 136{,}111 kN$$

from constant and long loading at $\gamma_f = 1$

$$M_l = P_{n,1} \cdot l_0^2 / 8 = 7{,}04 \cdot 5{,}6^2 / 8 = 27{,}597 kNm$$

Table 3.2. Efforts from design loads

Type of load	Load at $\gamma_f = 1$ & $\gamma_f = 1{,}1$, kN/m^2	γ_f	Load at $\gamma_f > 1$ & $\gamma_f = 1{,}1$, kN/m^2
Permanent 1. Tiled floor , 70 mm $G = G_1 \cdot \gamma_f \cdot \gamma_n$, $G_1 = 1{,}4KN$	1,4	1,3	2,002
2. Weight of 1m^2 of the floor panel $G = G_2 \cdot \gamma_f \cdot \gamma_n$, $G_2 = 3{,}0\ KN$	3,0	1,1	3,63
Total	$G_n = 4{,}4kN$		$G = 5{,}632kN$
Temporary Variable load υ at $\gamma_f = 1{,}0$	22,5	1,0	24,75
Total	$P_n = 25{,}9\ kN$		$P = 30{,}382kN$

from full load at $\gamma_f = 1$

$$M = P_{n,2} \cdot l_0^2 / 8 = 43{,}04 \cdot 5{,}6^2 / 8 = 168{,}717 kNm$$

from the action of the payload per meter of the panel with a nominal width of 1.6 m:

$$M_1 = \frac{Q_n \cdot l^2}{8} = \frac{4{,}4 \cdot 5{,}6^2}{8} = 17{,}248 kN/m$$

from the action of constant and long-term load per meter of the panel with a nominal width of 1.6 m:

$$M_2 = \frac{(G_n + Q) \cdot l^2}{8} = \frac{(22{,}5 + 0) \cdot 5{,}6^2}{2} = 88{,}2 kN/m$$

Working height of section

$$d = h - a = 220 - 30 = 190mm,$$

where a - is the protective layer of concrete;

For calculation we accept an I-beam section. Based on the premise that the neutral axis passes within the shelf, we take the width of the shelf equal to the actual width of the panel $b_{eff} = 1560mm$

In this case, the condition must be met

$$\frac{h_f}{h} = \frac{30}{220} = 0{,}136 > 0{,}1,$$

Where h_f - shelf height:

$$h_f = \frac{h - D}{2} = \frac{220 - 159}{2} = 30{,}5mm;$$

D – The diameter of the cavity, taken 159 mm.

I-beam rib width

$$b_w = b_f - 8\,.D = 1560 - 8.159 = 288mm$$

where 8 – the number of cavities of the panel.

<u>Calculation of normal cross sections by moment</u>

1) Estimated case for the T-section

Checking the position of the neutral axis Mf is determined without taking into account A'_s

$$M_f = b_{eff}\,.h_f\,.f_{cd}\left(d - 0{,}5h_f\right) = 1560.30{,}5.22(190 - 0{,}5.30{,}5) = 182{,}921.10^6 H.mm = 182{,}921 kN$$

Since, $M_f = 182{,}921 KNm < M = 190{,}555 KNm$, then the cross section is calculated as a T-section from the shelf in the compressed area $b_{eff} = 1560mm$

2) Moment M_2

$M_2 = (b_{eff} - b_w) M_f / b_{eff} = (1{,}56 - 0{,}3)182{,}921 / 1{,}56 = 147{,}744 kN/m$

3) Moment M_1

$M_1 = M - M_2 = 190{,}555 - 147{,}744 = 42{,}811 kN/m$

4) Coefficient α_m

$\alpha_m = M_1 / b_w d^2 f_{cd} = 42{,}811 \cdot 10^6 / 300 \cdot 190^2 \cdot 22 = 0{,}1797$

5) For table 1 at $\alpha_m = 0{,}1797,\ \xi = 0{,}25,\ \zeta = 0{,}9$

6) $\xi < \xi_R = 0{,}711$

7) The required area of the stressed *reinforcement*

$$A_p = M_1 / f_{pd} d\zeta + M_2 /(d - 0{,}5h_f) f_{pd} = \frac{42{,}811 \cdot 10^6}{1112{,}5 \cdot 190 \cdot 0{,}9} + \frac{147{,}744 \cdot 10^6}{(190 - 0{,}5 \cdot 30{,}5) \cdot 1112{,}5} = 985{,}003 mm^2$$

We accept Ø18K-7 area $A_p = 1272 mm^2$

Calculation of cross sections

1) Check of necessity of settlement transverse reinforcement

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{190}} = 2{,}02 < [2d] = [380]$$

$$\rho = \frac{A_{s1}}{b_w \cdot d} = \frac{1272}{1560 \cdot 190} = 0{,}0043 < [0{,}02]$$

2) $$V_{Rd.C} = \left[C_{Rd.C} k (100 \rho_1 f_{ck})^{\frac{1}{3}} + k_1 \sigma_{cp} \right] b_w d == \left[\left(\frac{0{,}18}{1{,}5} \right) 2{,}02 (100 \cdot 0{,}0042 \cdot 29)^{\frac{1}{3}} + 0{,}15 \cdot 4{,}63 \right] \cdot$$

$$\cdot 1560 \cdot 190 = 371158 H = 371{,}158 kN$$

$$\sigma_{cp} = \frac{P}{A_c} = \frac{821{,}452 \cdot 10^3}{177312} = 4{,}63 МПа > 0{,}2 f_{cd} = 4{,}4 MPa$$

3) *Since* $V_{Rd.C} = 371{,}158 кH > V_{Ed} = 136{,}111 kN,$ then the calculated transverse reinforcement is not required. We accept constructively armature Ø6A240C a step of 200 mm.

Geometric characteristics of the cross section of the plate

Let's specify the previously accepted I-beam section, replacing round cavities with equivalent squares with the party $h_1 = 0{,}9 \cdot 159 = 143 мм,$ then the thickness of the shelves of the I-beam

$$h_f = \frac{h-h_1}{2} = \frac{220-143}{2} = 38{,}5mm \approx 38mm$$

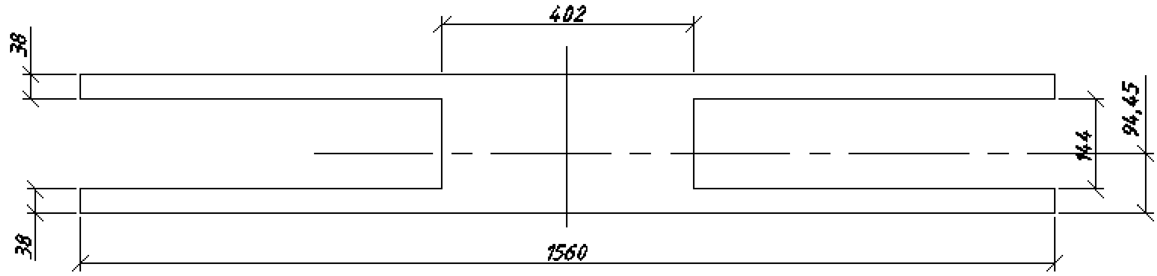

Fig 3.3. Estimated equivalent cross section

Thickness of the I-beam ribs

$$b_w = b_f - 8h_1 = 1560 - 8\cdot 144 = 408mm$$

Geometric characteristics of the given section:

1) The area of the equivalent section of the panel

$$A_c = \sum_{i=1}^{n} A_{bi} = 2b_{eff}h_f + b_w\left(h-2h_f\right) = 2\cdot 1560\cdot 38 + 408\cdot\left(220-2\cdot 38\right) = 177312mm^2$$

2) The cross-sectional area of the longitudinal reinforcement 5Ø18K-7, 5Ø3A240SI - longitudinal grids of the upper shelf - $A_s' = 35mm^2$

$$A_s = \sum_{i=1}^{n} A_{pi} + \sum_{i=1}^{n} A_s' = 1272 + 35 = 1307mm^2$$

3) As $0{,}008A_c = 0{,}008\cdot 177312 = 1418{,}5\text{мм}^2 > A_s = 1307mm^2$, then the geometrical characteristics of the reduced section are determined without taking into account the fittings. $A_{red} = A_c = 177312mm^2$

4) Calculate the static moment of the reduced section relative to the lower face of the plate

$$S_{red} = b_{eff}\cdot h_f\,(h-\frac{h_f}{2}) + b_w\left(h-2h_f\right)\frac{h-2h_f}{2} + b_{eff}h_f\,\frac{h_f}{2} = 1560\cdot 38\left(220-\frac{38}{2}\right)+$$
$$+408\left(220-2\cdot 38\right)\frac{220-2\cdot 38}{2} + 1560\cdot 38\cdot\frac{38}{2} = 17271744mm^2$$

5) The distance from the axis passing through the center of gravity of the reduced section to the lower face of the plate

$$y_0 = \frac{S_{red}}{A_{red}} = \frac{17271744}{177312} = 94{,}45mm$$

6) The moment of inertia of the reduced section relative to the center of gravity

$$I_{red} = \frac{b_{eff}(h_f)^3}{12} + b_{eff}h_f\left(h - y_0 - \frac{h_f}{2}\right)^2 + \frac{b_w(h-2h_f)^3}{12} + b_w(h-2h_f)\cdot\left(y_0 - \frac{h-2h_f}{2}\right)^2 + \frac{b_{eff}(h_f)^3}{12} +$$

$$+ b_{eff}h_f\left(y_0 - \frac{h_f}{2}\right)^2 = \frac{1560\cdot 38^2}{12} + 1560\cdot 38\left(220 - 94{,}45 - \frac{38}{2}\right)^2 + \frac{408(220-2\cdot 38)^3}{12} + 408(220-2\cdot 38)\cdot$$

$$\cdot\left(94{,}45 - \frac{220-2\cdot 38}{2}\right)^2 + \frac{1560\cdot 38^3}{12} + 1560\cdot 38\left(94{,}45 - \frac{38}{2}\right)^2 = 1148{,}92\cdot 10^6\,mm^4$$

7) The moment of resistance of the section relative to the lower face

$$W_{red} = \frac{I_{red}}{y_0} = \frac{1148{,}92\cdot 10^6}{94{,}45} = 12164{,}31\cdot 10^3\,mm^3$$

8) The same with respect to the upper face

$$W_{red} = \frac{I_{red}}{h - y_0} = \frac{1148{,}92\cdot 10^6}{220 - 94{,}45} = 9151{,}09\cdot 10^3\,mm^3$$

9) The radius of the core section

$$r = \frac{W}{A_c} = \frac{9151090}{177312} = 51{,}61\,mm$$

<u>Determination of initial forces of reinforcement tension and level of compression of concrete</u>

1) Initial stresses $\sigma_{p.\max}$ in tensioned fittings A_p:

$0{,}3f_{p0,1k} \le \sigma_{p.\max} \le 0{,}8f_{pk}$ *(або* $\le 0{,}9f_{p0,1k}$*);*

We accept: $\sigma_{p.\max} = 0{,}75f_{p0,1k} = 0{,}75\cdot 1335 = 1001{,}25\,MPa$

2) Initial reinforcement tension force:

$$P_{\max} = A_p\cdot\sigma_{p.\max} = 1272\cdot 1001{,}25 = 1273{,}59\,kN$$

3) Stress in concrete at the level of CT reinforcement A_p:

$$\Delta\sigma_c = \frac{P}{A_c} \pm \frac{P\cdot e_{op}}{I}\cdot y_0 \mp \frac{M_i}{I}\cdot y_0 = \frac{1273{,}59\cdot 10^3}{177312} + \frac{1273{,}59\cdot 10^3\cdot 64{,}45}{1148{,}92\cdot 10^6}\cdot 94{,}45 -$$

$$- \frac{27{,}597\cdot 10^3}{1148{,}92\cdot 10^6}\cdot 94{,}45 = 13{,}93\,MPa$$

$$e_{op} = y_0 - c = 94{,}45 - 30 = 64{,}45\,mm;$$

Mi - the moment of its own weight at $\gamma_f = 1$

$$M_i = \frac{G_n\cdot l_0^2}{8} = \frac{4{,}4\cdot 1{,}6\cdot\cdot 5{,}6^2}{8} = 27{,}597\,kNm,$$

Where 1.6 is the nominal width of the panel.

Calculation of losses

A. Instant losses:

1) The cost of deformation of the forms with non-simultaneous tension of the rods:

$$\Delta P_3 = A_p \cdot 30 = 1272 \cdot 30 = 38160H = 38{,}16\kappa H$$

2) Losses due to instantaneous (elastic) deformation of concrete structure:

$$f = \frac{(n-1)}{2n} = \frac{(5-1)}{2 \cdot 5} = 0{,}4$$

$$\Delta P_{el} = A_p E_p \sum \left[\frac{f \cdot \Delta\sigma_c(t)}{E_{cm}(t)} \right] = 1272 \cdot 18 \cdot 10^4 \left[\frac{0{,}4 \cdot 13{,}94}{36 \cdot 10^3} \right] = 35463H = 35{,}463kN$$

3) Temperature losses during heat treatment of structures:

$$\Delta P_e = 0{,}5 A_p E_p \alpha_i \Delta t = 0{,}5 \cdot 1272 \cdot 18 \cdot 10^4 \cdot 1 \cdot 10^{-5} \cdot 65 = 74412H = 74{,}412kN$$

4) Losses from short-term relaxation of stresses in the valve:

- With the mechanical method of tension

$$\Delta P_r = A_p \left(0{,}22 \frac{\sigma_{p.\max}}{f_{p0,1k}} - 0{,}1 \right) \sigma_{p.\max} = 1272 \cdot \left(0{,}22 \frac{1001{,}25}{1335} - 0{,}1 \right) 1001{,}25 = 82783H = 82{,}783kN$$

5) Initial tension taking into account short-term losses

At $\sum \Delta P_i = 38{,}16 + 35{,}463 + 74{,}412 + 82{,}783 = 230{,}818kN$

$$P_{01} = P_{\max} - \sum \Delta P_i = 1273{,}59 - 230{,}818 = 1042{,}772kN$$

B. Long-term costs:

$$\Delta\sigma_{pr} = \beta_f \frac{P_{01} - \Delta P_3}{A_p} = 0{,}04 \frac{1042{,}772 \cdot 10^3 - 38{,}16 \cdot 10^3}{1272} = 32{,}790MPa$$

$$\sigma_{cp} = \frac{P_0}{A_c} + \frac{P_0 \cdot e_{op}^2 - M_{cp} e_{op}}{I_c} = \frac{1273590}{177312} + \frac{1273590 \cdot 64{,}45^2 - 27{,}597 \cdot 10^6 \cdot 64{,}45}{1148{,}92 \cdot 10^6} = 10{,}239MPa$$

$$\varepsilon_{cs} = \frac{0{,}4}{1\text{м}} = 0{,}0004$$

$\varphi(t, t_0) = \varphi(t, \infty)$. For table. At humidity $W = (40....75)\%$ for C32 / 40 concrete the maximum creep coefficient $\varphi(t, \infty) = 2{,}0$.

$$\Delta P_{c+s+r} = A_p \Delta\sigma_{p,c+s+r} = A_p \frac{\varepsilon_{cs} E_p + 0{,}8\Delta\sigma_{pr} + \frac{E_p}{E_{cm}}\varphi(t,t_0)\sigma_{c,QP}}{1 + \frac{E_p A_p}{E_{cm} A_c}\left(1 + \frac{A_c}{I_c} Z_{cp}{}^2\right)[1 + 0{,}8\varphi(t,t_0)]} =$$

$$= 1272 \frac{0{,}0004 \cdot 18 \cdot 10^4 + 0{,}8 \cdot 32{,}790 + \frac{18 \cdot 10^4}{36 \cdot 10^3} \cdot 2{,}0 \cdot 10{,}239}{1 + \frac{18 \cdot 10^4 \cdot 1272}{36 \cdot 10^3 \cdot 177312}\left(1 + \frac{177312}{1148{,}92 \cdot 10^6} \cdot 64{,}45^2\right)[1 + 0{,}8 \cdot 2{,}0]} = 221320H = 221{,}32kN$$

Tension effort taking into account all losses

At $\sum \Delta P_i = 38{,}16 + 35{,}463 + 74{,}412 + 82{,}783 = 230{,}818kN$

$\sum P_{02} = P_{\max} - \sum \Delta P_i - \Delta P_{csr} = 1273{,}59 - 230{,}818 - 221{,}32 = 821{,}452kN$

Check of crack resistance of the stretched zone

Cracks in the sections of normal to the longitudinal axis of the bending elements are absent if the condition is satisfied:

$$M_{cr} \geq M$$

$$M_{cr} = W \cdot f_{ctk} + P_{02}(e_{op,2} + r) = 9151{,}09 \cdot 10^3 \cdot 2{,}1 + 821{,}452 \cdot 10^3 (64{,}45 + 51{,}61) = 114{,}555kN/M$$

$M_{cr} = 120{,}607кНм \geq M = 88{,}2kN/m$ - Cracks are not formed.

Determination of deflections

1) Definition $\left(\frac{1}{r}\right)_1$ - curvature from short-term action of only short-term load without taking into account the forces of pre-compression P.

Modulus of elasticity $E_c = E_{cm} = 36 \cdot 10^3 MPa$

$$\left(\frac{1}{r}\right)_1 = \frac{M_1}{E_c \cdot I_c} = \frac{17{,}248 \cdot 10^6}{36 \cdot 10^3 \cdot 1148{,}92 \cdot 10^6} = 4{,}17 \cdot 10^{-7} mm^{-1}$$

2) Definition $\left(\frac{1}{r}\right)_2$ - curvature from long action of constant and long loading without taking into account forces of preliminary compression by armature A_p.

Modulus of elasticity

$$E_c = E_{eff} = \frac{E_{cm}}{1 + \varphi(\infty)} = \frac{36 \cdot 10^3}{1 + 2{,}0} = 12 \cdot 10^3 MPa$$

$$\left(\frac{1}{r}\right)_2 = \frac{M_2}{E_c \cdot I_c} = \frac{88{,}2 \cdot 10^6}{12 \cdot 10^3 \cdot 1148{,}92 \cdot 10^6} = 6{,}40 \cdot 10^{-6}\, мм^{-1}$$

3) Definition $\left(\frac{1}{r}\right)_3$ - curvature due to bending of the element from the short-term action of the force P02 from the pre-tension of the valve A_p, as well as bending caused by shrinkage and creep of concrete under the influence of force P_{02}.

$$M_3 = P_{02} \cdot e_{op} = 821{,}452 \cdot 0{,}06445 = 52{,}943 kN/m$$

Modulus of elasticity $E_c = E_{cm} = 36 \cdot 10^3\, MPa$.

The curvature due to the bending of the element from the short-term action of force P_{02}:

$$\left(\frac{1}{r}\right)_3 = \frac{M_3}{E_c \cdot I_c} = \frac{52{,}943 \cdot 10^6}{36 \cdot 10^3 \cdot 1148{,}92 \cdot 10^6} = 1{,}28 \cdot 10^{-6}\, mm^{-1}$$

The curvature due to the bending of the element from the short-term action of force P_{02}:

$$\left(\frac{1}{r}\right)_{cs} = \varepsilon_{cs} \cdot \alpha_e \frac{S}{L_0} = 0{,}0004 \cdot 5{,}83 \cdot \frac{17271744}{5600} = 7{,}19 mm^{-1}$$

Where ε_{cs} - free relative shrinkage deformations

$$\varepsilon_{cs} = \frac{0{,}4}{1м} = 0{,}0004$$

$$\alpha_e = \frac{E_s}{E_{cm}} = \frac{2{,}1 \cdot 10^5}{36 \cdot 10^3} = 5{,}83$$

4) The complete curvature of the axis of the element

$$\frac{1}{r} = \left(\frac{1}{r}\right)_1 + \left(\frac{1}{r}\right)_2 - \left(\frac{1}{r}\right)_3 = 4{,}17 \cdot 10^{-7} + 6{,}4 \cdot 10^{-6} - 1{,}28 \cdot 10^{-6} = 5{,}537 \cdot 10^{-6}\, mm^{-1}$$

5) Deflection of the panel at $M_{cr} > M$

$$f = K_m \cdot \frac{1}{r} \cdot L_0^2 = \frac{5}{48} \cdot 5{,}537 \cdot 10^{-6} \cdot 5600^2 = 18{,}09 mm$$

Where $K_m = \frac{5}{48}$ – coefficient that depends on the shape of the diagram of moments.

$$f = 18{,}09 мм < f_u = \frac{1}{250} L_p = \frac{1}{250} \cdot 5600 = 22{,}4 mm$$

The rigidity requirements are met.

Deflection control without direct calculations

1) Reference percentage of reinforcement

$$\rho_0 = \sqrt{f_{ck}} \cdot 10^{-3} = \sqrt{29} \cdot 10^{-3} = 0{,}0054$$

2) The actual percentage of reinforcement

$$\rho = \frac{A_p}{b \cdot d} = \frac{1272}{1560 \cdot 190} = 0{,}0043$$

3) If $\rho < \rho_0$ the limiting span / altitude ratio is determined by the formula

$$\frac{1}{d} = K\left[11 + 1{,}5\sqrt{f_{ck}}\frac{\rho_0}{\rho} + 3{,}2\sqrt{f_{ck}}\left(\frac{\rho_0}{\rho} - 1\right)^{\frac{3}{2}}\right] =$$

$$= 1 \cdot \left[11 + 1{,}5\sqrt{29} \cdot 10^{-3}\frac{0{,}0054}{0{,}0043} + 3{,}2\sqrt{29} \cdot 10^{-3}\left(\frac{0{,}0054}{0{,}0043} - 1\right)^{\frac{3}{2}}\right] = 11{,}002 < [20]$$

Where K is a factor that takes into account different design schemes. Take the table. For hinged plate K=1,0.

Conclusion:

$l / d = 11{,}002 < [20]$ - Deflections n exceed the allowable; the calculation of deflections for this case cannot be performed.

3.2 Reinforced concrete column

Table 3.2.Load collection

Name	Regulatory load, KN / m2	γfm	γp	Estimated load, *KN / m2*
Reinforced c / p stack – 50 mm	0.9	1,3	1,1	1,287
Expanded clay – 100 mm, p = 1200 g / m3	2.4	1,3	1,1	3,432
Vapor barrier	0.05	1,3	1,1	0,0715
Reinforced plate – 180 mm	4.5	1,1	1,1	5,445
Snow	1.72	1,4	1,1	2,6488
TOTAL				*12,88*

Overlapping

Name	Regulatory load, kN / m2	γfm	γp	Estimated load, kN / m2
Laminate – 10 mm	0,06	1,2	1,1	0,0792
Lining under a laminate – 4 mm	0,024	1,2	1,1	0,0317
Sound insulation – 16 mm, p = 700 g / m3	0,112	1,3	1,1	0,1602
Reinforced plate – 180 mm	4,5	1,1	1,1	5,445
Temporary load	1,5	1,2	1,1	1,98
TOTAL				7,696

Column on the 2nd floor

q = 0.3x0.3x34.8x25 = 78.3 kN

G = (12.88 + 7.696x10) x2.9x1.75 + 78.3 = 534.39 kN

Concrete class C35/45: $.f_{ck} = 32MPa\,, f_{ck} = 25MPa$

Fittings class A500C: $f_{yk} = 500C, f_{yd} = 435MPa, f_{ywd} = 25MPa$

Estimated effort in the upper section: $N = -456{,}19\ KN$

Estimated effort in the lower section: $N = -534{,}49\ KN$

The height of the column is: *H =3,0m*

Determination of the area of the longitudinal reinforcement of the eccentrically compressed section of 300x300 mm of the column, reinforcement is carried out using symmetrical reinforcement.

Column flexibility:

$$\lambda = \frac{L_0}{i} = \frac{0{,}5 \cdot 300}{11{,}547} = 12{,}99;$$

$$i = \sqrt{\frac{a^2}{12}} = \sqrt{\frac{30^2}{12}} = 8{,}66cm;$$

$$N = -534{,}49\ KN$$

$$\lambda_{\lim} = \frac{20 \cdot A \cdot B \cdot C}{\sqrt{n}} = \frac{20 \cdot 0{,}7 \cdot 1{,}1 \cdot 1{,}7}{\sqrt{0{,}21}} = 57{,}13;$$

A=0,7; B=1,1; C=1,7.

$$n = \frac{N_{Ed}}{f_{cd} \cdot A_c} = \frac{481 \cdot 10^3}{25 \cdot 300^2} = 0{,}21;$$

$\lambda_{\lim} = 57{,}13 > \lambda = 12{,}99$ - The column is rigid;

$$\frac{N}{b \cdot h \cdot f_{ck}} = \frac{534.49 \cdot 10^3}{300 \cdot 300 \cdot 32} = 0{,}186;$$

At graphic calculation of the necessary area of armature we accept $\rho = 0{,}2$.

$$\sum A_s = \frac{\rho \cdot b \cdot h \cdot f_{ck}}{f_{yk}} = \frac{0{,}2 \cdot 300 \cdot 300 \cdot 32}{500} = 1152 mm^2.$$

We accept symmetrically located fittings 2∅28A500C, where

$A_s = 1232 mm^2$

We accept cross armature with a step of 200 mm.

3.3 Foundation

Calculation of the foundations of shallow foundation.

Determine the depth of laying the base of the foundation.

From geological conditions d1 = h1 + 0.4 = 0.8 + 0.4 = 1.2 m

From climatic conditions: the normative depth of freezing for the city of Kremenchuk is 1.2 m.

Given the design of the floor and the room temperature t = 150 C, we determine that Kh = 0.6 m.

$$d_{min} \geq d_f + (0.2 \ldots 0.4m) = 0{,}72 + 0{,}4 = 1{,}12m$$

Estimated depth of freezing df = Kh x dfn = 1.2 x 0.6 = 0.72 m.

According to design requirements

a) without a basement

$$d_{min} \geq 0.5m$$

b) with a basement

$$d_{min} = d_b + 0.5 = 0.8 + 0.5 = 1.3m$$

$$d_b = H_{under.} - 1.1 = 0.8\ m$$

Given the data obtained, we take the depth of laying the foundation:

a)d=1.3 m

b) d=1.3 m

Determine the dimensions of the base of the foundation

Section 1-1 (column without basement)

Determine the preliminary width of the base of the foundation

$$b=\sqrt{\frac{N}{R_0-\gamma_0 d}}$$

$$b=\sqrt{\frac{393.15}{221-20\cdot 1.3}}=1.4m$$

We specify the calculated resistance of the soil at the level of the sole foundation b = 1.4 m

$$R=\frac{\gamma_{c1}\cdot\gamma_{c2}}{k}\left[M_{\gamma}\cdot k_z\cdot в\cdot\gamma_{II}+M_q\cdot d_1\cdot\gamma_{II}^{/}+(M_q-1)\cdot d_в\cdot\gamma_{II}^{/}+M_c\cdot c_{II}\right]$$

γ_{c1} - 1.1 m according to the table for plastic sand

γ_{c2} - 1.1 m

k-1.0 reliability factor

$d_в = 0$;

M_{γ} - 0.61 ; M_q - 3.44 ; M_c - 6.04; c_{II} - 0.12 ;

$$\gamma_{II}^{/}=\frac{\sum h_i\cdot y_i}{\sum h_i}=\frac{0.3\cdot 15.69+0.5\cdot 16{,}48+18{,}44\cdot 0{,}5}{1{,}3}=17{,}04кN/m^3$$

γ_{II} - 16,48 кN

$$R_1=\frac{1.1.1}{1.1}[0{,}61.1.1{,}4.16{,}48+3{,}44.1{,}3.17{,}04+(3{,}44-1).0.17{,}04+6{,}04.0{,}12]=100{,}097KPa$$

$$b=\sqrt{\frac{393{,}15}{100{,}097-20\cdot 1.3}}=2{,}3м$$

$$\frac{|b_1-b_0|}{b_0}\cdot 100\%=\frac{|2{,}3-1{,}4|}{1{,}4}\cdot 100\%=64\%>5\%$$

$$\frac{|R_1-R_0|}{R_0}\cdot 100\%=\frac{|100.097-221|}{221}\cdot 100\%=54\%>5\%$$

Since the conditions are not met, we specify the calculated soil resistance at the level of the sole

$$R_1 = \frac{1.1.1}{1.1}[0{,}61.2.3{,}4.16{,}48 + 3{,}44.1{,}3.17{,}04 + (3{,}44 - 1).0.17{,}04 + 6{,}04.0{,}12] = 110{,}049KPa$$

$$b_2 = \sqrt{\frac{393{,}15}{110.049 - 20 \cdot 1.3}} = 2{,}16m$$

$$\frac{|b_2 - b_1|}{b_1} \cdot 100\% = \frac{|2.16 - 2.3|}{2.3} \cdot 100\% = 6\% > 5\%$$

$$\frac{|R_2 - R_1|}{R_1} \cdot 100\% = \frac{|110.049 - 100.097|}{100.097} \cdot 100\% = 9\% > 5\%$$

Since the conditions are not met, we specify the calculated soil resistance at the level of the sole

$$R_1 = \frac{1.1.1}{1.1}[0{,}61.1.2{,}16.16{,}48 + 3{,}44.1{,}3.17{,}04 + (3{,}44 - 1).0.17{,}04 + 6{,}04.0{,}12] = 108{,}49KPa$$

$$b_3 = \sqrt{\frac{393{,}15}{108{,}49 - 20 \cdot 1.3}} = 2{,}18m$$

$$\frac{|b_3 - b_2|}{b_{21}} \cdot 100\% = \frac{|2.18 - 2.16|}{2.16} \cdot 100\% = 0{,}92\% < 5\%$$

$$\frac{|R_3 - R_2|}{R_2} \cdot 100\% = \frac{|108.49 - 110.49|}{110.49} \cdot 100\% = 1.4\% < 5\%$$

The condition is fulfilled and therefore we finally accept the width of the foundation cushion b = 2.2 m

Audit:

$$\sigma_{mt} = \frac{\sum N}{A} \le R$$

$$\sum N = 393{,}15 + 125{,}84 = 518{,}99KN$$

$$A = 2{,}2 \times 2{,}2 = 4{,}84$$

$$\sigma_{mt} = \frac{\sum N}{A} = \frac{518{,}99}{4{,}84} = 107{,}22 < R = 108{,}49kPa$$

$$b = \sqrt{\frac{1042{,}649}{221 - 20 \cdot 1.3}} = 2{,}3m$$

We specify the calculated resistance of the soil at the level of the sole foundation b = 2.3 m

$$R = \frac{\gamma_{c1} \cdot \gamma_{c2}}{k}\left[M_{\gamma} \cdot k_z \cdot в \cdot \gamma_{II} + M_q \cdot d_1 \cdot \gamma_{II}^{/} + (M_q - 1) \cdot d_в \cdot \gamma_{II}^{/} + M_c \cdot c_{II}\right]$$

γ_{c1} - 1.1 m according to the table for plastic sand

γ_{c2} - 1.1 m

k-1.0 reliability factor

$d_в = 0{,}8$;

M_{γ} - 0.61 ; M_q - 3.44 ; M_c - 6.04; c_{II} - 0.12 ;

$$\gamma_{II}^{/} = \frac{\sum h_i \cdot y_i}{\sum h_i} = \frac{0.3 \cdot 15.69 + 0.5 \cdot 16{,}48 + 18{,}44 \cdot 0{,}5}{1{,}3} = 17{,}04 kN/m^3$$

γ_{II} - 16,48 кN

$$R_1 = \frac{1.1.1}{1.1}[0{,}61.1.2{,}3.6{,}48 + 3{,}44.1{,}3.17{,}04 + (3{,}44 - 1).0.17{,}04 + 6{,}04.0{,}12] = 146{,}635KPa$$

$$b = \sqrt{\frac{1042{,}649}{146{,}635 - 20 \cdot 1.3}} = 2{,}93m$$

$$\frac{|b_1 - b_0|}{b_0} \cdot 100\% = \frac{|2{,}93 - 2{,}3|}{2{,}3} \cdot 100\% = 27\% > 5\%$$

$$\frac{|R_1 - R_0|}{R_0} \cdot 100\% = \frac{|146{,}635 - 221|}{221} \cdot 100\% = 33\% > 5\%$$

Since the conditions are not met, we specify the calculated soil resistance at the level of the sole.

$$R_1 = \frac{1.1.1}{1.1}[0{,}61.1.2{,}93.16{,}48 + 3{,}44.1{,}3.17{,}04 + (3{,}44 - 1).0.17{,}04 + 6{,}04.0{,}12] = 153{,}598KPa$$

$$b_2 = \sqrt{\frac{1042{,}649}{153{,}598 - 20 \cdot 1.3}} = 2{,}85m$$

$$\frac{|b_2 - b_1|}{b_1} \cdot 100\% = \frac{|2.85 - 2.93|}{2.93} \cdot 100\% = 2{,}7\% < 5\%$$

$$\frac{|R_2 - R_1|}{R_1} \cdot 100\% = \frac{|153.598 - 146.635|}{146.635} \cdot 100\% = 4.7\% < 5\%$$

The condition is fulfilled and therefore we finally accept the width of the foundation cushion b = 2.9 m

Audit:

$$\sigma_{mt} = \frac{\sum N}{A} \le R$$

$$\sum N = 1042{,}649 + 218{,}66 = 1261{,}309KN$$

$$A = 2{,}9 \times 2{,}9 = 8.41$$

$$\sigma_{mt} = \frac{\sum N}{A} = \frac{1261.309}{8.41} = 149.97 < R = 153.598кПа$$

Determine the length of the pile

L=0.05+0.5+2+0.6+2.9+1.8+1=8.85m

We accept: L = 9 m; d = 620 mm

Determine the bearing capacity of the pile

$$\mathrm{F_d} = \gamma_c(\gamma_{cr} \cdot \mathrm{R} \cdot \mathrm{A} + \mathrm{u}\sum \gamma_{cf} \cdot \mathrm{f_i} \cdot \mathrm{h_i}) = 1(1 \cdot 138.042 \cdot 0.301 + 1.9468 \cdot 215.912) = 461.887$$

$\gamma_{cr} = 1$

$\gamma_{cf} = 1$

$\mathrm{A} = \pi \mathrm{R}^2 = 3.14 \cdot 0.310^2 = 0.301$

$\mathrm{u} = \mathrm{Rd} = 3.14 \cdot 0.62 = 1.9468$

For sand we define R:

$$\mathrm{R} = 0.75\alpha_4(\alpha_1 \cdot \gamma_1^{I} \cdot \mathrm{d} + \alpha_2 \cdot \alpha_3 \cdot \gamma_I \cdot \mathrm{h}) = 0.75 \cdot 0.29(17.3 \cdot 18.73 \cdot 0.62 + 32.8 \cdot 0.614 \cdot 18.73 \cdot 1.15) = 138.042$$

Determination of the estimated load on the piles

$$N_p = \frac{F_d}{\gamma_{od}} = \frac{461.887}{1.4} = 329.91$$

$\gamma_{od} = 1.4$

Section 1-1 (column without basement)

Load acting on the cross section

$N_I = 1.2 \cdot N_n = 1.2 \cdot 393.15 = 471.78$

Determining the number of piles

$$n = \frac{N_I}{N_p} = \frac{471.78}{329.91} = 1.43$$

We accept 2 piles

Find the minimum distance between the piles

$l_{min} = 1 + d = 1 + 0.62 = 1.62m$

Section 2-2 (column with basement)

Load acting on the cross section

$N_I = 1.2 \cdot N_n = 1.2 \cdot 1042.649 = 1251.17$

Determining the number of piles

$$n = \frac{N_I}{N_p} = \frac{1251.17}{329.91} = 3.79$$

We accept 4 piles

Find the minimum distance between the piles

$l_{min} = 1 + d = 1 + 0.62 = 1.62m$

<u>Checks of pile foundations</u>

Section 1-1

$$N_{cep} = \frac{\sum N}{n} \le N_p$$

$$\sum N = 471{,}72 + 11{,}275 = 483{,}055 KN$$

$$N_{cep} = \frac{\sum N}{n} = \frac{483.055}{2} = 241.52 \le N_p = 329.91$$

Section 2-2

$$N_{cep} = \frac{\sum N}{n} \le N_p$$

$\sum N = 1251{,}17 + 11{,}275 = 1262{,}445KN$

$$N_{cep} = \frac{\sum N}{n} = \frac{1262.445}{4} = 315.61 \leq N_p = 329.91$$

The subsidence of the foundations is not deep

b = 2.2 m; d = 1.3 m; the average pressure under the sole of the foundation is P = 107.22 kPa.

Draw up a calculation scheme to determine the subsidence and break the thickness of the soil from the base of the foundation into elementary layers

h_i = 0.4 x 2.2 = 0.88 m

Determine the stress from the own weight of the soil at characteristic points:

On the sole of the first layer

$$\sigma_{zg.1} = \gamma_1 . h_1 = 15{,}996 .\ 0{,}3 = 4{,}7\text{KPa}$$

On the sole of the second layer

$\sigma_{zg.2} = \sigma_{zg.1} + \gamma_2 . h_2 = 4{,}7 + 16{,}48 .\ 0{,}5 = 12{,}94\ \text{KPa}$

At the level of the base of the foundation

$\sigma_{zg.0} = \sigma_{zg.2} + \gamma_3 . h_3^I = 12{,}94 + 18{,}44 .\ 0{,}5 = 22{,}16\ \text{KPa}$

At the groundwater level

$\sigma_{zg.3} = \sigma_{zg.2} + \gamma_3 . h_3^I = 12{,}94 + 18{,}44 .\ 1{,}5 = 40{,}6\text{KPa}$

On the sole of the third layer

$\sigma_{zg.3}^{II} = \sigma_{zg.3}^{I} + \gamma_{sb3} . h_w = 40{,}6 + 18{,}44 .\ 0{,}6 = 51{,}664\text{KPa}$

$\sigma_{zg.3} = \sigma_{zg.3}^{II} + \gamma_w . h_w = 51{,}664 + 18{,}44 .\ 0{,}6 = 62{,}72\text{KPa}$

On the sole of the fourth layer

$\sigma_{zg.4} = \sigma_{zg.3} + \gamma_4 . h_w = 51{,}664 + 18{,}73 . 2{,}9 = 105{,}98\text{KPa}$

On the sole of the fifth layer

$\sigma_{zg.5} = \sigma_{zg.4} + \gamma_5 . h_5 = 105{,}981 + 19{,}84 . 1{,}8 = 141{,}63\text{KPa}$

On the sole of the sixth layer

$\sigma_{zg.6} = \sigma_{zg.5} + \gamma_6 . h_6 = 141{,}639 + 19{,}32 . 2{,}4 = 188{,}007\text{KPa}$

Determine the additional pressure on the basis of:

$\sigma_{zp.0} = p - \sigma_{zg.0} = 107{,}22 - 22{,}16 = 85{,}06\text{KPa}$

Determine the additional pressure on the base at each point is given in the table.

Deformations of each layer are determined by the formula: $S_i = \frac{\sigma_{zp.cep.i} \cdot h_i}{E_i} \cdot \beta$

β - without a dimensional factor equal to 0.8

Table 3.3. Calculation of the subsidence of the foundations

№	Depth of point	2z/b	α_i	$\sigma_{zg.i}$	$\sigma_{zp.i}$	$\sigma_{zp.cepi}$	E_i kPa	h_i, cm	Sedimentation of the layer
0	0	0	1,0	22.16	85,06	17,012	10000	0	0
1	0,9	0,8	0,8		68,048	20,418	10000	90	0,14
2	1,5	1,3	1,3	40,6	47,63	9,41	10000	60	0,045
3	1,8	1,6	1,6		38,22	13,05	10000	30	0,03
4	2,4	2,1	2,1	51,664	25,17	12,18	28000	30	0,02
5	3,3	3	3		12,99	2,87	28000	60	0,02
6	4,2	3,8	3,8	79,2	10,12	2,98	28000	90	0,026
7	5,1	4,6	4,6		7,14	1,28	28000	90	0,018
8	5,6	5,09	5,09	105,98	5,86	0,42	28000	50	
9	5,9	5,3	5,3		5,44				
						Total subsidence			0,299

We compare the calculated subsidence with the average limit value for an industrial building $S = 0{,}299 \leq S_u = 10$

The lower limit of the compressible zone:

$\sigma_{zp} = 10{,}12 kPa < 0{,}2\sigma_{zg} = 0{,}2 \,.\, 51{,}664 = 10{,}33$ KPa

4. Construction Technology

This project is all about the construction of an 11-storey Apartment Building in Kremenchuk.

Construction conditions are accepted according to the section "Fundamentals and foundations".

The area where the construction of the building is planned is in an empty plot of land where no buildings needs to be demolished, located in the Central part of the city. The total area of the site when designing the construction of a residential building is taken as a rectangle. The maximum area of the plot is 930 m2. The sources of energy resources to which the building under construction can be connected and which can be used in the construction process are at a distance of 0.5 km.

We accept the following distribution of volumes of works on the organizations erecting object: BMU-1 carries out general construction works, including erects underground parts of the building; BMU-2 carries out finishing works; BMU-3 performs specialized work (electrical, plumbing, installation of equipment.

4.1 Determining the scope of construction and installation work

№ p/p	Name of construction processes and works	Unit of measurement	Regulatory source	Amount	
				Total	On one floor
1	Preparatory work	people/day	Aggregate indicator	34,7	-
2	Soil development	1000 m3 of soil	DBN D.2.2-1-99 gr. 16-17	0,688	-
3	Laying the foundations of shallow foundations:				
3.1	Assembly and disassembly of formwork	100 m3 of concrete in practice	*DSTU B D.2.2-1: 2008*	4,42	-
3.2	Reinforcement works	t	DSTU B D.2.2-2: 2008	2,194	-
3.3	Laying concrete	100 m3 of concrete in practice	DSTU B D.2.2-3: 2008	4,42	-

№ p/p	Name of construction processes and works	Unit of measurem ent	Regulatory source	Amount	
				Total	On one floor
3.4	Assembly and disassembly of formwork	100 m3 of concrete in practice	*DSTU B D.2.2-1: 2008*	4,42	-
4	Backfill	*1000 $м^3$ soil*	*DBN D.2.2-1-99 gr. 28-29*	0,138	-
5	Arrangement of vertical structures on the floor (columns, stairwells, elevator shafts, etc.):			79,2	7,2
5.1	Assembly and disassembly of formwork	100 m3 of concrete in practice	DSTU B D.2.2-1: 2008	-	0,07
5.2	Reinforcement works	t	DSTU B D.2.2-2: 2008	-	2,8
5.3	Laying concrete	100 m3 of concrete in practice	DSTU B D.2.2-3: 2008	-	0,07
6	Floor arrangement on the floor:	M2		3749	312, 4
6.1	Assembly and disassembly of formwork	100 m3 of concrete in practice	DSTU B D.2.2-1: 2008	-	0,56
6.2	Reinforcement works	t	DSTU B D.2.2-2: 2008	-	31,8
6.3	Laying concrete	100 m3 of concrete in practice	DSTU B D.2.2-3: 2008	-	0,56

№ p/p	Name of construction processes and works	Unit of measurement	Regulatory source	Amount	
				Total	On one floor
7	Foam masonry of external walls	1 m3 of masonry	DBN D.2.2-8-99	-	30,64
8	Foam-block laying of inter-apartment and intra-apartment partitions	100 m2 of partitions [excluding openings]	gr.6,15	-	0,147
9	Installation and dismantling of external forests	100 m2 of vertical projection	DBN D.2.2-8-99	-	0,160
10	Insulation of external walls	100 m2 of surface	gr.7	0,257	-
11	Facade plastering	100 m2 of plastered surface		2,575	-
12	Decorative plaster and	100 m2 of surface	DBN D.2.2-8-99	2,575	-
13	dispersion painting of a facade	100 m2 slot	gr.43	2,57	0,23
14	Filling of metal-plastic window openings	100 m2 slot	DBN D.2.2-15-99	52,52	4,78
15	Filling of external and internal doorways	100 m2 of plastered surface	gr.51	-	0,147
16	Plastering of inter-apartment and intra-apartment partitions	100 m2	DBN D.2.2-15-99	-	3,12
17	Arrangement of a basis	100 m2 of	gr.184	-	1,87

№ p/p	Name of construction processes and works	Unit of measurement	Regulatory source	Amount	
				Total	On one floor
	under floors	coverage			
18	Arrangement of parquet floors	100 m2 of coverage	DBN D.2.2-10-99	-	0,94
19	Arrangement of linoleum floor coverings	100 m2 of coverage	gr.20	-	0,31
20	Arrangement of floors from a ceramic tile	100 m2 facade	DBN D.2.2-10-99	2,575	-
21	Painting of facades from cradles	100 m2 of surface to be painted	gr.27-29	-	0,11
22	Painting with silicate solutions of internal walls	100 m2 of surface to be painted	DBN D.2.2-15-99	-	3,12
23	Whitewashing of ceilings	100 m2 of surface	gr.60, 61	-	0,17
24	Wallpapering the walls	100 m2 of facing surface	DBN D.2.2-11-99	-	0,06
25	Exterior and interior wall cladding	man-days	gr. 11	44,99	-
26	Electrical work	man-days	DBN D.2.2-11-99	78,1	-
27	Plumbing work	man-days	gr. 34, 35	74,98	-
28	Installation of equipment	man-days	DBN D.2.2-11-99	56,23	-
29	Adjustment works	m2	gr. 36	312,4	
29.1	Roof arrangement:	100 m2 of insulated coating	DBN D.2.2-11-99	3,124	-

№ p/p	Name of construction processes and works	Unit of measurement	Regulatory source	Amount	
				Total	On one floor
29.2	Laying insulation	100 m2 of roof	gr. 27	3,124	-
30	Arrangement of a rolled flat roof.		DBN D.2.2-15-99		
30.1	Paving arrangement:	1 m3 layer	gr. 161	76,6	-
30.2	Arrangement of a crushed stone basis	100 m2 of coverage	DBN D.2.2-15-99	0,76	-
31	Installation of asphalt-cement screed	10 days	-	3	-

The standard duration of construction is 9 months - 198 days.

Preparatory work - 1 month - 22 days.

Installation of equipment and commissioning - 1 month - 22 days.

4.2. Choice of bulldozer, excavator and crane.

Cut the vegetation layer with a DZ-27 bulldozer on the basis of a T-130 tractor with transverse holes equal to the width of the bulldozer blade (3.2 m).

The development of the soil in the pit should be carried out by cross-end excavation, excavator EO-4121A, equipped with a return shovel with unloading of soil into dump trucks installed on the same level with the excavator.

The crane is selected according to the load capacity and height of the building.

The concrete hopper has the maximum weight. When filled with concrete, the mass is 6 tons. The height of the building is 38.4 m. So we accept the tower crane KB-504

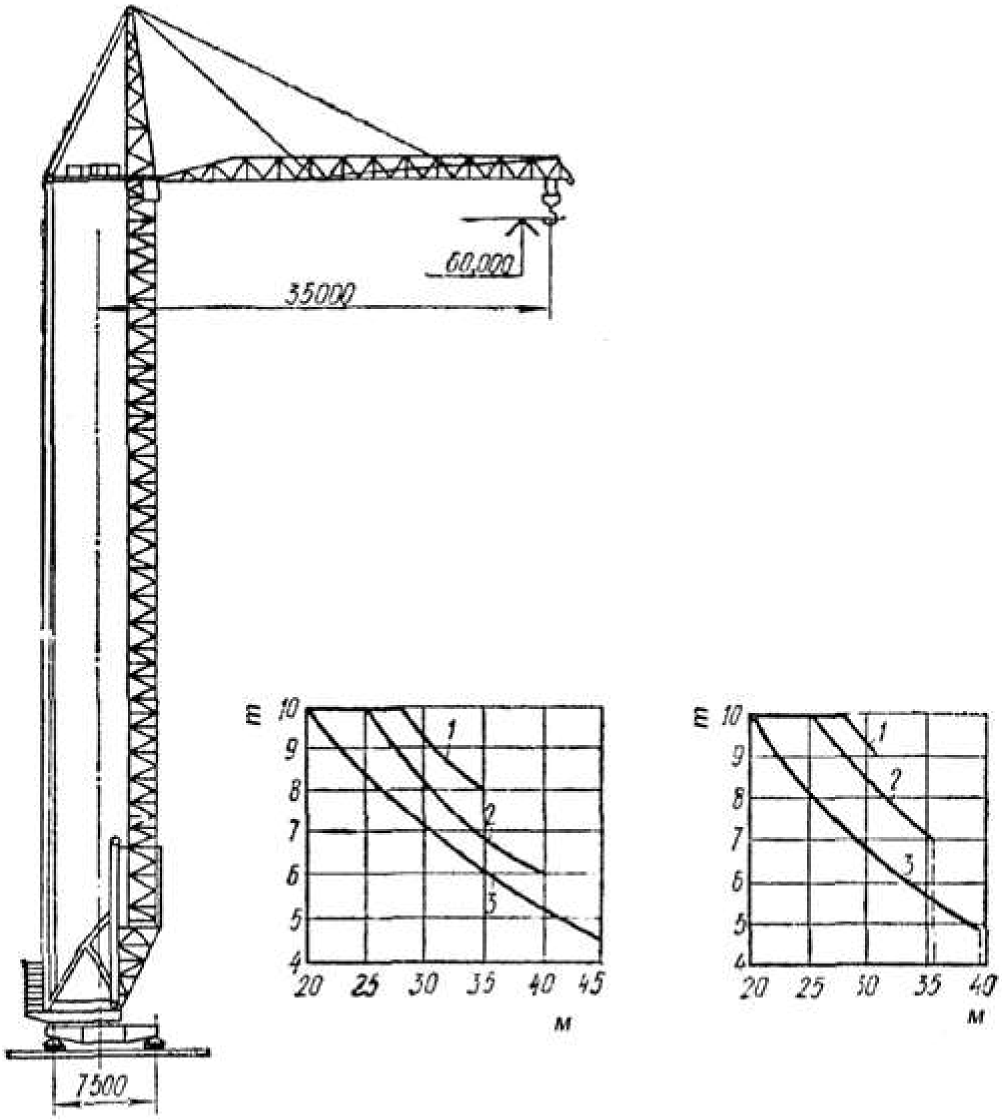

Fig.4.1 General view and load-height characteristics of the crane KB-504:

a - horizontal arrow; b - with an inclined arrow;

1, 2, 3 - maximum boom departure at, respectively, 35, 40 and 45 m

4.3. Basic decisions on the organization and technology of construction

Monolithic structures of the building frame are made using inventory metal formwork. Vertical constructions of floors are executed with use of a metal panel board timbering. The variety of sizes of boards gives the chance to pick up a timbering optimally for any objects: height of boards 0,6; 1.2; 2.5; 3.0, width from 0.3 to 2.4 m.

Overlapping - with the use of telescopic risers.

Construction of vertical structures of the floor (columns, stiffening diaphragms, stiffening cores, etc.) begins after gaining sufficient strength of the floor of the previous floor. This period of time depends largely on the ambient temperature and quality of concrete, namely the presence of various additives in concrete. It is accepted at the level of 70% of the planned period of gaining the design strength of the concrete floor below the floor, ie (28 × 0.7) 19 ÷ 20 days. In order to increase the load-bearing capacity of the floor under construction, as well as the possibility of reducing the overall construction time of the house, do not remove the formwork from the two floors below the floor under construction. This allows you to start work on the construction of vertical structures of the floor before the floor will gain 70% of the planned period of gaining the design strength of the floor concrete. Based on the generalization of construction practice, this period of time between the end of laying concrete in the floor and the beginning of work on the construction of vertical floor structures (installation of reinforcement, formwork and concreting structures) is 6 ÷ 8 days.

After concreting the vertical structures of the floor, in 3 ÷ 5 days the formwork is removed from them and the construction of the floor formwork and the installation of reinforcing mesh on the floor begin.

After gaining intermediate strength of vertical structures begins lying concrete in the floor. Based on the generalization of construction practice, this period of time is taken at the level of 30% of the planned period of gaining the design strength of concrete vertical structures of the floor. When performing the project, it is taken equal to (28 x 0.3) 7 ÷ 8 days.

As evidenced by the practice of construction, during the calendar month, as a rule, monolithic structures are built on two floors of a single-section frame-monolithic residential building.

Laying the walls in height requires a change in the level of the workplace of masons. In this regard, use special inventory scaffolding. When erecting buildings up to 40 m high, riser (tubular) scaffolding can be used.

Pin forests are a popular and widespread type of tubular scaffolding. This design differs in high reliability, simplicity of installation and high reliability.

These scaffoldings are intended for finishing works, a brick and stone lying on objects of average height. They are attached to the wall with "plugs" and rest on "shoes", while the flooring is assembled from wooden boards to lighten the overall weight. Elements of a design are joined with each other by means of pins (which are soldered to bearing support) and lugs. The rise of workers is carried out on the stairs provided with stag handrails. The stability of pin scaffolds, in addition to the method of fastening the elements, is achieved by installing diagonal braces, as well as by alternating the level of the racks.

An important advantage of the design is the ability to combine with elements of clamp scaffolding, to work on buildings with a complex structure. These forests, like others, are grounded, provided with a protective net and lightning rod.

However, it should be remembered that the production of such forests is the most time-consuming: the cost of thick-walled support pipes and welds are reflected in the cost of the forests themselves. At the same time, the lack of bolts and other fasteners in the structure make this type of scaffolding one of the easiest to install.

Lifting of building materials for the construction of floor structures that are not load-bearing structures of the building (apartment walls, partitions, windows, doors, etc.) can be carried out as cranes, on specially installed outriggers, and specially installed additional lifts.

Remote platforms in the construction of monolithic houses are installed in the slot of the house. The function of this equipment is a reception or otherwise unloading platform for construction cargo: bricks, buckets with mortar, gypsum concrete blocks and other materials.

The platform is established on a necessary floor by means of the tower crane, for fastening use struts in a floor and their ceiling in a set goes 4 pieces, at the expense of it the platform is reliably fixed.

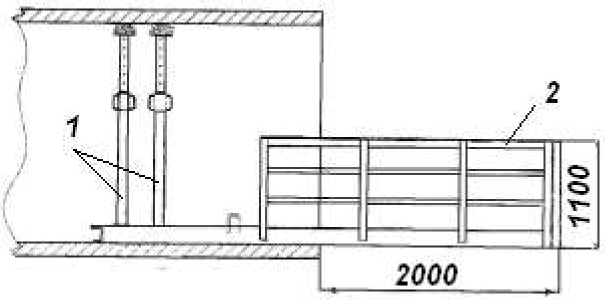

Fig.4.2 General appearance and dimensions of the remote area
1 - Struts, 2 - removable fence.

Table 4.2. Technical characteristics of remote platforms

Mark	К-1	К-1.4	К-1.3
Load capacity, kg	1200	2500	2500
Workplace, m	1,5×2,0	2,49×2,17	2,49×2,17
Overall dimensions, m	3,3×2,3×1,3	4,65×2,3×1,4	4,8×2,3×1,4
Weight, kg	500	950	1000
Note	wooden planking	wooden planking	metal planking

The elevator is cargo, construction, added: loading capacity - from 1000 - to 3000 kg, height of rise from 8 - to 100 meters, the size of a cargo platform - from 1500x1500 mm - to 3000x3000 mm the size of a protection - from 1000 mm - to 2800 mm the lift is mounted stationary and attached to the erected parts of the frame of the house.

The supply of building materials, moving them to the place of further performance of works for the arrangement of structures on the floor (construction of partitions and walls), is carried out in the period caused by the process of hardening of the concrete laid in the structure. In this case, the floor on which the supply of building materials is carried out, should be below 4 - 5 floors on which the construction of the frame of the house. In addition, during this period can be partially performed work on the arrangement of structures on the floor. When designing the schedule of construction and installation works, the scope of these works (construction of building structures on the floor) are taken without taking into account the possible implementation of their earlier.

Additional elevators are installed to lift people, their dimensions in the plan are conditionally accepted 1.25 m × 1.6 m or installed freight ones are used.

Transportation of structures to the construction site is carried out directly from the supplier.

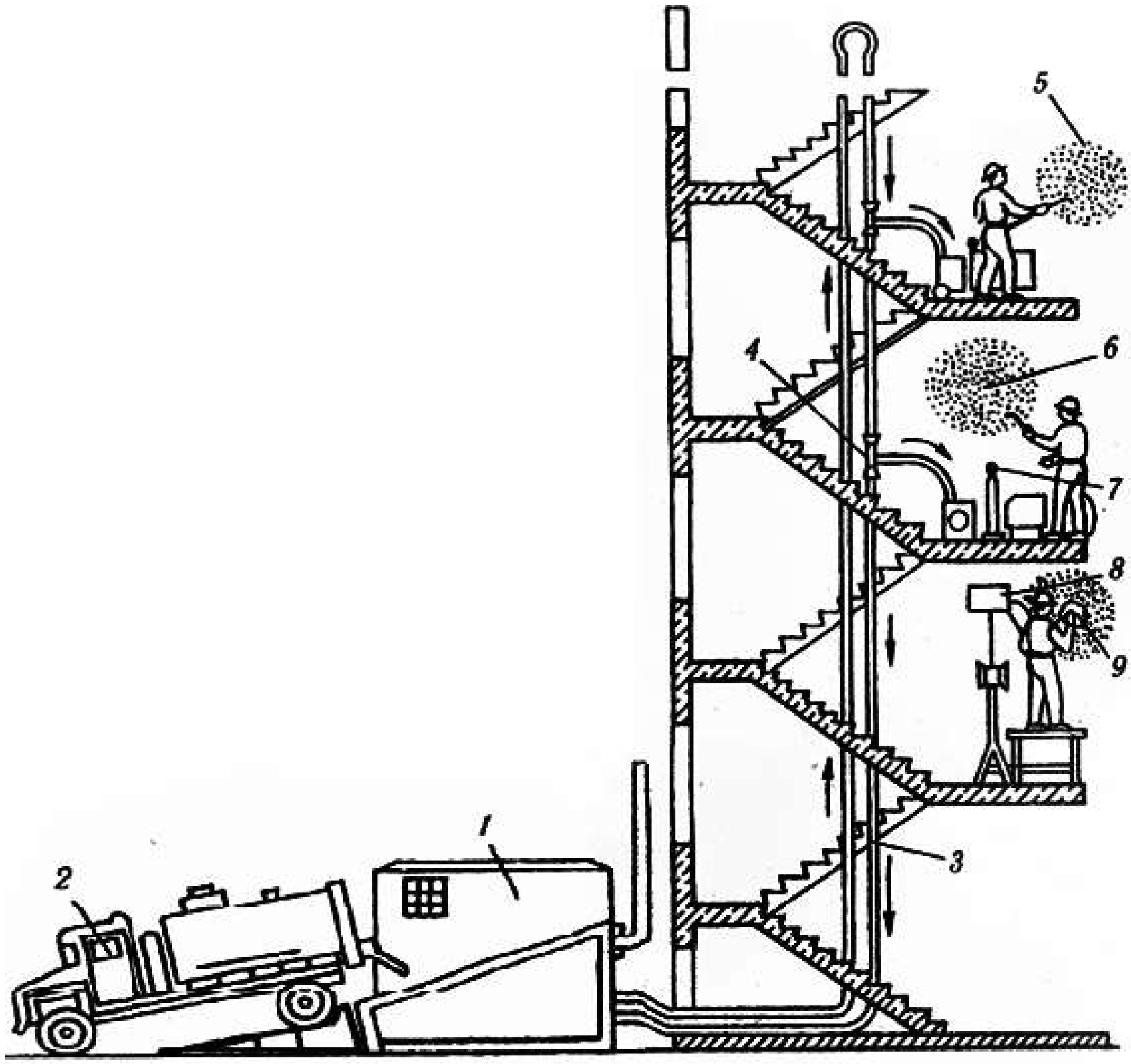

Fig. 4.3 Scheme of complex mechanization of plaster robots

1 - plaster station for receiving the solution and transporting it to the floors; 2 - mortar truck; 3 - main ring mortar pipeline; 5 - application of spray and soil; 6 - applying the cover; 7 - mortar pump installation; 8 - current frequency converter; 9 - mashing of the cover.

The bunker for concrete (a bucket for concrete, the bunker "glass") vertical is widely used in monolithic construction for storage and giving of various concrete mixes. The mixture is loaded into the hopper, and then (usually by crane) is transported to the place of filling the monolith.

Table 4.3. Technical characteristics

Model, kg	Load capacity, kg	Volume, m.cub	Dimensions, cm (LxWxH)	Weight, kg
BN-0.5	960	0,5	122x113x135	72
BN-1.0	2 500	1,0	160x140x173	280
BN-1.8	4 500	1,8	164x164x249	360

5. Labour and Environmental protection

5.1 The Safety in a working environment:

1. There should be at least two entrances and exits to the construction site and the enclosed areas within it (exception - construction of facilities in the conditions of compacted buildings). The gate width for autos must be at least 4.5 m, and for rail transport, it must be at least 4.9 m. (if there are no other restrictions, the width of the gate for road transport can be assigned according to a simplified scheme - the width of the vehicle plus 1, 5 m).

2. If at all possible, highways and pathways should be built outside of hazard zones. They should be fitted with a signal fence, warning signs, and road signs regarding entering the risk zone if they are located in an area where commodities are moved by crane.

Ring roads should be used to create highways; if necessary, loop detours or turning areas of at least 12 × 12 m should be given (for example, on dead-end roads).

For free access to buildings and locations of storage of materials, structures, and equipment, the maximum distance between indoor roads and buildings should not exceed 25 meters.

Motorway pavements should have a roadway width of 3.5 m for one-way traffic and 6.0 m for two-way traffic; transit roads should have 4.5 and 8.0 m, respectively.

Rounding radii of on-site highways must be at least 12 meters (in design); during transportation of large structures, they must be at least 30 meters.

If the building's width exceeds 18 m, passages shall be given on two longitudinal sides; if the width exceeds 100 m, passages should be provided on all sides.

3. Sanitary and industrial facilities, worker recreation spaces, highways, and pedestrian roadways should be positioned outside of risk zones, and at least 50 meters away from things that release dust, toxic fumes, or gases.

4. Entrances to household premises from railway lines should be placed at least 7.0 meters from the house's outer wall, taking into consideration the placement of the complete railway track.

5. The construction site and work areas must be fenced in accordance with GOST 23407, as well as the object's characteristics and the peculiarities of the construction and installation activity.

6. To protect workers from being exposed to harmful production factors, toxic substances in the work environment, and so on, it is necessary to:

•identify areas of work where harmful production factors may emerge owing to technology and working conditions;

•provide, if necessary, special measures for the treatment of hazardous effluents and emissions, as well as the preservation of hazardous and harmful substances; •provide the necessary protection measures when using devices that contain radioactive isotopes and are sources of ionizing radiation, as well as when using lasers.

7. To prevent structures, products, or materials from falling from a height while being moved by crane, or in the event of a loss of stability during installation or storage, the design must state:

•containerization and packaging methods for the transportation of artificial and bulk materials, concrete, and mortar, in accordance with the type of the cargo being transported and the ease with which it may be delivered to the job site;

• Load-grabbing devices (cargo slings, traverses, mounting grips) - in accordance with the weight and dimensions of the moving cargo, slinging and installation conditions;

• Slinging methods, supplying elements during storage and installation in the de sign or close to the design position;

• Devices (pyramids, cassettes) for stable storage of structural elements;

• Product, material, and equipment storage order and methods;

8. The necessity for protective floors (decks), strong canopies, and barriers to be arranged on one vertical during construction and installation activities.

•reduction of climbing works owing to the use of conveyor or larger assembly, large-block or crane-free installation method; priority layout of permanent fencing structures (walls, fences of balconies and openings, etc.) in order to prevent workers from falling from a height

• establishing the location and ways of fastening safety ropes and seat belts in accordance with the design and spatial planning solutions of the facility under construction, as well as the standards of occupational safety;

Furthermore, the activities should identify:

• paving means suited to conduct a specific type of work or activity;

• Means of promoting individuals to positions.

9. To protect workers from dangerous electric current exposure, provide:

• temporary electrical installations, route selection and voltage determination of temporary power and lighting electrical networks, methods of fencing live parts and placement of distribution systems and devices;

• Grounding of metal parts of electrical equipment that may be accidentally energized;

• Protective measures when performing work in high-risk and especial situations.

10. It is necessary to provide:

• determination of types of machines, their location, and mode of operation in accordance with technology and construction conditions during the performance of works with the application of cars, mechanisms, or equipment in PVR;

• Measures to prevent the impact of harmful and dangerous factors on the driver and other employees;

• use of technical measures to limit the machine's movement or angle of rotation, as well as means of communication between the driver and other staff (sound signaling, radio, and telephone communication) during machine operation and inspection in confined spaces;

• Particular conditions for installing the machine in the area of the collapse prism, on loose soil, or on special buildings are identified on the budget plan.

11. Slinging structure methods must prevent the moving weight from slipping.

Sling calculations are made in compliance with the "Rules of crane construction and safe operation" (NPAOP 0.00-1.01).

12. When creating fire safety measures for construction and installation projects, it is required to adhere to DBN B. 1.1-7-2002 and 1.2-7-2008 regulations.

13. Work in vertical walls without fastenings in excavations is defined in item 10.2.4 of these regulations.

Fasteners should be installed if you need to work in deeper excavations or in the presence of constrained production circumstances in water-saturated soils.

Excavation arrangements with a depth of 3.0 m or more should be made in line with the design of fastening (calculation of fasteners is noted in the explanatory note).

14. It is required to take precautions to ensure invariability of position and communication preservation during excavation works if communications are crossed. The method of soil development should be agreed upon with the body that manages these communications in this circumstance.

15. Lifting equipment and vehicles should be placed near the excavations' unfortified slopes in accordance with NPAOP 0.00-1.01 criteria (Table 7).

16. If buildings and structures are being constructed (reconstructed) in dangerous areas near places where goods are moved by cranes, buildings under construction may become public or industrial buildings and structures, transportation or pedestrian roads, and other possible places for people, it is necessary to take precautions to avoid hazardous areas, in particular:

a) Near the places of movement of cargo by crane:

• Tower cranes must be equipped with additional means to limit the area of their work in order to avoid the emergence of dangerous areas in places where people are;

• the speed of rotation of the crane boom towards the boundary of the working area must be limited to a minimum at a distance of less than 7 m from the transported load to the zone boundary;

• Goods movement within a distance of less than 7 meters from the boundaries of risky regions should be done with the use of safety or safety equipment that prevent the load from falling;

b) On plots near buildings under construction (reconstructed):

• The working area of the crane must be limited so that the moving load does not go beyond the contours of the house in the location of the protective screen;

• The working area of the crane must be limited so that the moving load does not go beyond the contours of the house in the location of the protective screen.

Construction machinery should be located to allow enough space for inspection and maneuverability of the working area, as long as a safe distance is kept from loose excavation, cargo stacks, and equipment.

Workplaces should be built on stable and strong structures, with the location of dangerous regions taken into consideration.

They must be provided with collective protective equipment, appropriate technological equipment, minor mechanization equipment, mechanized tools, and safe work devices.

17. Workplaces and passages to them with a height of 1.3 m or higher, and a distance of less than 2 m from the height difference's limit, should be secured by protective fences, as per GOST 12.4.059.

If such barriers cannot be erected, work at height should be done while wearing a safety belt (GOST 12.4.089).

18. During the aboveground portion of the house's development, fences must meet the following requirements:

• Reusability;

• Ease of installation and disassembly;

• Reliability of the fence's node of fastening to parts of building designs

Instead of a protective fence, a signal fence (GOST 23407) with safety signs should be installed at workplaces at a distance of 2 m or more from the limit of the difference in height (GOST 12.4.026).

To get to high-rise offices, you'll need to set up stairwells and transitional bridges.

The routes to the workspaces must be no less than 0.6 m wide, and the passages in the lumen must be no less than 1.8 m high.

Stairs with an inclination of more than 20 degrees should be surrounded by a fence.

When organizing paving means, standard inventory constructions should be used.

Atypical paving agents should only be used if they are made according to a design that has been approved in the prescribed way.

5.2 Occupational health and safety in the building industry (DBN A.3.2-2-2009)

1. When performing construction work, the employer must provide sanitary facilities (dressing rooms, showers, washrooms, clothes and shoe dryers, heating rooms, eating and recreation, women's personal hygiene, toilets, etc.) as well as drinking water and medical care to employees in accordance with current regulations and the collective agreement (agreement).

2. Internal highways on construction sites must meet DBN A.3.1-5 criteria and be provided with suitable road signs governing vehicle and construction machinery movement in accordance with Ukraine's Road Rules: Vehicles near work sites must not travel faster than 10 km/h on straight portions and 5 km/h on curves.

3. It is required to utilize passenger or freight elevators (elevators) to lift and lower personnel to workplaces during the construction of buildings and structures with a height or depth of 25 m or more, which are operated in accordance with NPAOP 0.00-1.02, NPAOP 0.00-1.36.

4. The floor formwork must be enclosed around the perimeter. Shields must be used to cover all openings in the formwork's working floor.

5. The lag of stairway installation shall not exceed one story during the development of measures on the organization and technology of erection of frame-monolithic, monolithic structures and constructions.

6. Scaffolding near vehicle passage shall be guarded with wheel bars at a distance of not less than 0.6 meters from vehicle dimensions.

7. 16 In the case of masonry, the space between the building's wall and the scaffolding's working level, which is built near it, should not exceed 50 mm, and in the case of finishing and repair work, 150 mm.

The space between the insulating surface and the working flooring should not exceed two insulation thicknesses plus 50 mm when doing thermal insulation work. If no repair is done, the clearances bigger than 50 mm must be closed within the detachable parts.

8. Measures must be taken to prevent the impact of the following dangerous and harmful production factors on workers during the preparation, supply, laying, and care of concrete, as well as the preparation, installation, and dismantling of formwork (hereinafter referred to as "during concrete work":

- elevated temperature of the valve (during the work on the preliminary thermal stress of the valve);
- noise and vibration, insufficient illumination of the workplace;
- adverse weather conditions;
- moving machines and objects moving by them;
- collapse of elements of building structures and formwork;
- elevated temperature of the valve (during the work on the preliminary thermal stress of the valve);

9. For the erection of vertical elements of buildings and structures, formwork must be tightly fastened on the working horizon. The formwork must be provided with parts (platforms, ladders, and so on) that allow employees to be safely lifted to job marks.

10. Unless the PVR specifies otherwise, the distance between the lower edge of the hopper and the previously laid concrete or the surface on which the concrete is laid should not exceed 1.0 m when pouring concrete from the hopper.

11. With the authorization of the supervisor, disassemble the formwork after the concrete has reached strength of at least 70%, as stated by the structure's design documentation.

12. The construction of stairways and platforms for buildings (structures), as well as freight and passenger lifts (elevators), must be completed concurrently with the construction of the house's structures. On mounted stairways, fences must be placed right away.

13. It is prohibited to carry out installation work at height in open areas with wind speeds of 15 m/s or greater, ice, thunderstorms, or fog that makes visibility within the front of the works difficult.

14. When working with solutions containing chemical additives, personal protective equipment (rubber gloves, protective ointments, goggles) should be used according to the manufacturer's instructions, considering the composition of the substances used.

15. No more than 3/4 of the volume of a bituminous copper can be filled. The filler that goes into the boiler ought to be completely dry. Ice and snow should not be allowed to enter the boiler.

16. Workers must be on both sides of the wall when dragging the cable through the holes in the walls. The distance between the wall and the workers' hands in their most extreme position must be at least 1 m.

17. It is important to provide for the implementation of the following measures in the design-technological and design-estimate documents in order to comply with the requirements of the legislation on environmental protection and the population in the construction process:

- construction and installation work in territories with a limited regime of economic activity (protected areas, protected objects, etc.) are allowed to be carried out only in accordance with the requirements of state ecological and sanitary-hygienic examinations;
- construction of temporary highways and other access roads must be carried out in such a way as to avoid and prevent damage to agricultural lands, trees, and shrubs;
- control of dust generation and air pollution;
- prevention of lower horizon groundwater pollution during building works, artificial soil consolidation;
- execution of a set of solid and liquid waste utilization and disposal procedures;
- only carry out works on reclamation and change of existing relief (creation of ponds and reservoirs, destruction of ravines, beams, swamps, and spent quarries) in the presence of project documentation agreed in a specific order;

- disinfect industrial and domestic effluents in accordance with the Rules of acceptance of wastewater from enterprises into municipal and departmental sewerage systems of Ukrainian settlements.

18. Discharge of wastewater, as well as untreated domestic or industrial effluents generated on or near the construction site, is forbidden during construction and installation operations, in line with SanPiN 2.1.5-980 and SanPiN 4630.

Destruction of woody and shrubby vegetation on the construction site if it is not provided in the design documentation (destroyed trees and shrubs must be compensated by planting similar vegetation after construction).

Waste and garbage storage in residential areas without the use of special devices. Violations of these standards are directly the responsibility of the supervisor.

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