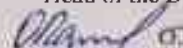MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ARCHITECTURE, CIVIL ENGINEERING AND DESIGN
COMPUTER TECHNOLOGIES OF AIRPORT CONSTRUCTION AND
RECONSTRUCTION DEPARTMENT

TO ADMIT TO GUARD

Head of the Department

О.] Lapenko

" _ø_ " _/ 06_ 2022

BACHELOR THESIS

(EXPLANATORY NOTE)

SPECIALTY 192 «BUILDING AND CIVIL ENGINEERING»

Educational and professional program: «Industrial and civil engineering»

Theme: <u>Sports and recreation complex in Rivne</u>

Performed by: <u>Soliman Anas Z.</u>

Thesis Advisor: <u>Oleksandr Horb</u>

Design rule check: <u>O. Rodchenko</u>

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

_____ О.І. Лапенко

" 1 " 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: «Спортивно-оздоровчий комплекс у м. Рівне»

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Київ 2022

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Спеціальність: 192 «Будівництво та цивільна інженерія»
Освітньо-професійна програма: «Промислове і цивільне будівництво»
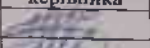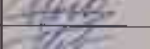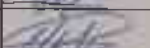
ЗАТВЕРДЖУЮ
Завідувач кафедри
О.І. Лапенко
« *13* » /*01* 2022 р.

ЗАВДАННЯ
на виконання дипломної роботи

СОЛІМАН Анас Зінелабедін Мавад
(П.І.Б. випускника)
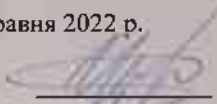
1. Тема роботи «Спортивно-оздоровчий комплекс у м. Рівне»
затверджена наказом ректора від «13» квітня 2022р. № 379/ст.

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-конструктивий розділ	23.05.22-02.06.22	
4.	Технологічно-організаційна частина	03.06.22-04.06.22	
5.	Вступ. Висновки. Список використаних джерел.	06.06.22-07.06.22	
6.	Підготовка доповіді та презентації	08.06.22-11.06.22	
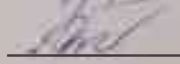
8. Дата видачі завдання: «13» травня 2022 р.

Керівник дипломної роботи: _____ Горб О.Г.

Завдання прийняв до виконання: _____ СОЛІМАН Анас

Content

Ch.	Sh.	№ doc.	Signature	Data		Let.	Sheet	Sheets
					EN 406-BA			
Developer		*Soliman Anas*			*Sports and recreation complex in Rivne*			
Supervisor		*Horb O.*						
N. Control						*National Aviation University*		
Approved		*Lapenko O.*						

1. Introduction

1.1. Reasons for the object reconstruction

Construction is one of the most important branches of material production and the national economy as a whole. The construction industry is aimed at creating new and modernizing existing funds for industrial and non-industrial purposes - ready-to-operate buildings, structures, structures, their complexes, as well as improving the industry structure, location and creation of new enterprises, integrated economic development not only individual regions. but also the country as a whole, the implementation of long-term urban planning programs, etc.

The construction complex of Ukraine is undergoing a process of reform in accordance with the requirements of market economy development. In modern conditions it is especially important to increase the efficiency of the created production potential, mobilize all opportunities aimed at increasing labor productivity, improving the structure of production, forming a holistic sectoral management system focused on overcoming the decline in construction production and meeting the social needs of the industry. The main strategic goal of the state policy of construction complex management is the formation of socially oriented investment and construction market, which ensures the competitiveness of construction products, transformation in the technological structure of production, flexible adaptation of production to demand, high perception of investment and construction activities. information and other innovations.

Currently, the industrialization of the construction industry is widely used standard, ie the most modern, easy to operate and profitable in construction projects and building structures to provide housing, cultural and leisure facilities, public and sports facilities, etc. Container delivery of building materials of full factory readiness is developing. Installation of prefabricated structures, aggregate concrete technology, etc. are widely used.

Construction provides an opportunity to create a strong base for solving numerous tasks to further improve the welfare of the population. Market relations make special demands on product quality as one of the main factors influencing the efficiency and profitability of the completed construction project and ensure its reliability and durability.

The quality of erected buildings and structures is determined by the quality of development of design and estimate documentation, materials and products, construction and installation work. Control over the impact of construction production on the environment is intensifying (emissions of gas and dusty substances into the atmosphere; acid, petroleum products, waste products - solutions, dyes, solvents, etc.; development of large land areas that cause soil erosion, etc.).

Therefore, modern conditions of design of construction sites, organization and technology of construction work require designers and direct contractors to have knowledge of construction technologies, regulatory information, state building codes of Ukraine and regulations in the field of construction.

Construction as a branch of material production includes design and survey, research, construction and installation organizations, enterprises of the construction industry, the production of building materials and transport.

Various branches of the national economy are involved in this sphere, which provide construction with metal and metal structures, cement, timber, construction machinery, vehicles, fuel, energy resources. In the process of creating fixed assets, which are construction products of construction companies, involved labor resources (workers and employees of construction companies), means of labor (tools) and objects of labor (materials). Interacting with each other, the main elements of the construction process create the final construction products in kind (buildings, structures, objects) and in monetary terms.

Cost reduction in architecture and construction is carried out by rational volume-planning solutions of buildings, the right choice of building and

finishing materials, improvement of construction methods. The main economic reserve in urban planning is to increase the efficiency of land use.

In the diploma the main attention is paid to the solution of economic and technological problem of construction of a modern building, which would simultaneously meet the requirements for heat protection and seismic resistance under the condition of the use of available local materials.

1.2. Characteristics of the area and construction site

The construction site is located in the central part of Rivne in the area of mixed housing. In the northeast, the site faces Peace Avenue, on the other hand it is limited by existing buildings.

The city of Rivne is in the first temperature zone, the average temperature of the coldest five days is -23 ° C; the temperature of the coldest day - 26 ˚C; average monthly relative humidity of the coldest month - 85%; average monthly relative humidity of the hottest month - 73%; wind area - III; the standard weight of snow cover per 1 m2 of horizontal surface is 1.4 kPa (139 kg / m^2); normative depth of soil freezing - 70 cm; seismicity - 6 points on the MSK-64 scale according to DBN B.1.1-12: 2014.

The entrance to the construction site is along the avenue, which facilitates the convenient delivery of materials to the construction site.

The relief of the construction site is flat, fluctuations of relative marks are insignificant. The absolute elevation of the site is 245.00 m.

There is no surface water at the site. Ground waters are found at a depth of 2 m from the ground surface. With respect to concrete on any type of cement, water is not aggressive.

According to engineering and technical surveys, the site is represented by gravel soils with sandy filler, overlain by dusty sands and a vegetative layer.

Local building materials include: gravel, sand, crushed stone, brick, all mortars.

The disadvantage is the tightness of the site, which does not allow optimal placement of mechanisms and materials required for the work.

1.3. Feasibility analysis of the volumetric-planning solution

According to the climatic conditions of the region the panel, frame-panel and brick buildings are mainly erected. The perspective solutions from the point of view of satisfaction of reliability, economical efficiency, technological effectiveness, architectural expressiveness include frame systems with application of prestressed structures, including the subsequent tensioning of slabs at the stage of installation.

In earthquake-resistant buildings, two types of flooring are widely used - solid and hollow. At the same time, the support of floor slabs on brick walls should be at least 120 mm.

When selecting the types of concretes for grouting, the requirements of their minimum shrinkage should be followed. Otherwise, through cracks will occur in the contact areas during the operation of the objects. As a result, the stiffness of the horizontal diaphragm in its plane can significantly decrease.

As the variants of volumetric-planning decisions can be given the following:

Walling options:

- brick walls although more often used in our region, but it has been proven that it is not appropriate, due to their high thermal conductivity, but you can use insulation, laid inside the wall, or attached to the outside; as the projected building - frame, the thickness of the brickwork can be made minimal;

- monolithic reinforced concrete wall with cavities filled with loose material of low thermal conductivity can also be a variant of the wall envelope. When erecting monolithic walls, the main attention should be paid to the manufacture of good-quality formwork, its reliable fixing and easy relocation in the process of concreting.

Foundation options:

- tape, working like a beam on a resilient base;

- pillar foundations for columns.

1.4. Selection of basic construction materials, products and structures

The following construction materials are used to erect the building:

- foundation blocks and monolithic concrete are used as foundations;

- external and internal bearing walls are made of clay bricks on cement-sand mortar;

- exterior walls are insulated with efficient insulation;

- partitions - brick, 120 mm thick;

- ceilings and coverings are made of reinforced concrete hollow-core slabs;

- window and door openings are covered with reinforced concrete lintels;

- stairwells - of precast reinforced concrete elements;

- staircase guards - metal with wooden handrails;

- the roof is designed flat, using new materials and installation technologies;

- windows - metal-plastic, double-glazed;

- doors - wooden and metal-plastic;

- flooring: self-leveling floors with cement screed, ceramic tiles; hydro-insulation - ruberoid;

- external finishing is performed plastering with cement mortar on the plastic mesh, followed by application of latex matte paint;

- for internal finishing is performed plastering with cement mortar; subsequently used oil paint and ceramic tiles.

2. Architectural and construction chapter

2.1. Master Plan

The scheme adopted in the project landscaping and landscaping of the site provides a favorable environment. The area located in front of the main

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entrance to the building has a surface of asphalt concrete preparation.

The area also provides elements of landscaping: grass seeding, shrubs, trees, on the side of the main street - flower beds, in the courtyard - a frame for climbing plants and flowers.
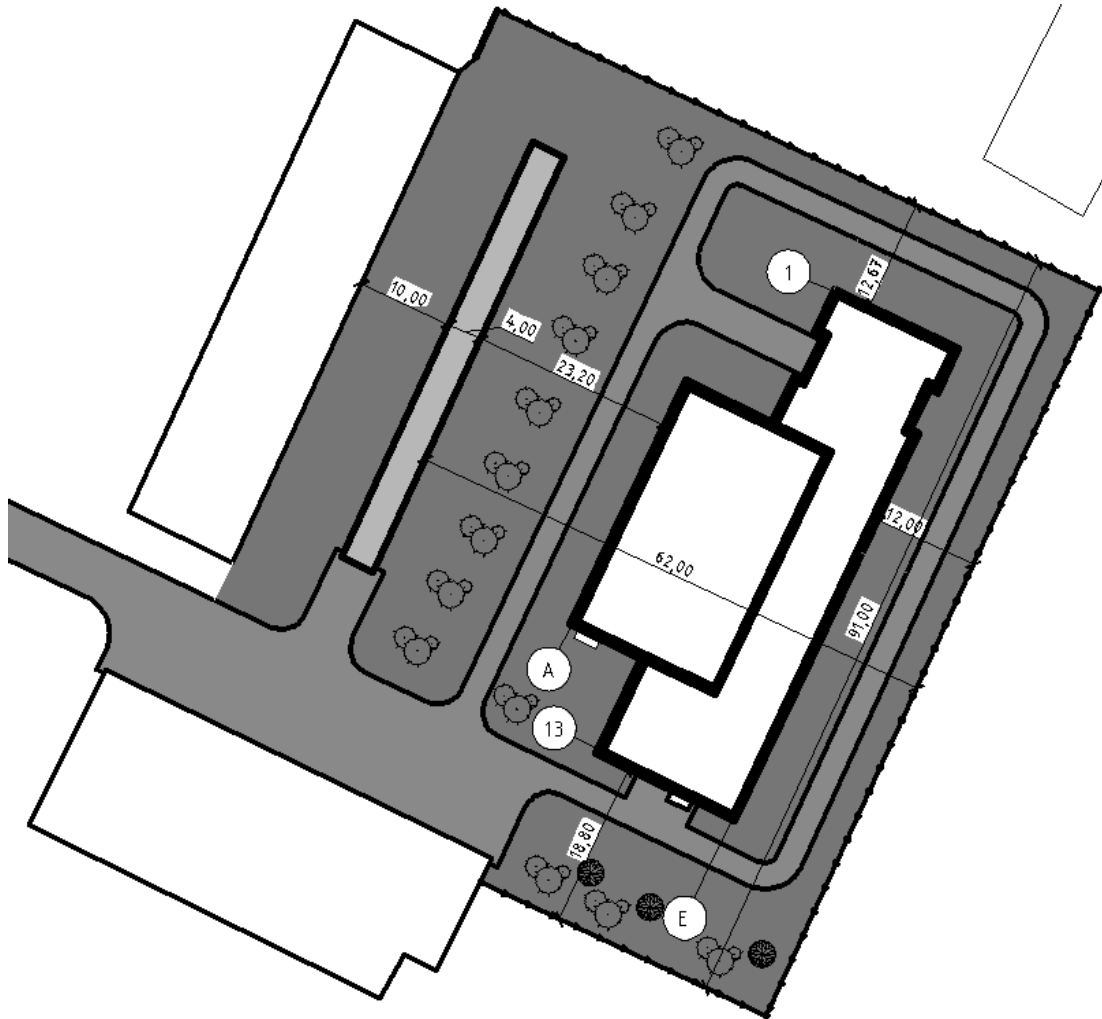
Fig. 2.1 Master Plan

Table 2.1. Technical and economic indicators of the master plan

№	Name	Unit	Number
1	Site Area	m^2	7017
2	Building area	m^2	1318
3	Driveway area	m^2	742
4	Sidewalk area	m^2	674
5	Landscaping area	m^2	4283

2.2. Space-planning and constructive solution

The building of the sports complex is one-storey with a basement, multi-level, with the protruding volume of the sports hall. The sports complex is designed for training sessions in sports games (badminton, basketball, volleyball), there is a room for individual strength training and the composition of the premises for shooting sports (shooting gallery). The simultaneous maximum capacity of the complex is 24 people per shift.

The location of the premises allows for the movement of people engaged in the following sequence: an entrance hall with a checkroom for outerwear, locker rooms (male and female with showers and toilets) and a gym.

A second exit is provided in the building.

In the joints of the walls in the masonry reinforcement grids are laid cross-section longitudinal reinforcement of a total area of not less than 1 cm^2, length 1.5 m through 700 mm in height.

Foundations. The following options for foundations may be considered:

a) single piles with a small cross-section, since the house is two-storey and loads from it are small, which can be made directly at the construction site, having the necessary materials for this: concrete, reinforcement, formwork, concrete vibratory compactor; when cutting down the head in the pile, leave the releases of reinforcement, which are then welded to the columns reinforcement;

b) strip foundation is the least labor-intensive, yet the easiest and most economical type of foundation. However, this type of foundation is not suitable for weak soils;

c) the solid foundation with the floors on the ground with a strip in the place of resting of the enclosing wall, the rest of it serves as a floor and is about 8 cm thick. Such a foundation has to be built on the gravel layer of about 50 cm. It is better to eliminate the cold bridge on the perimeter with the effective insulation. This type of foundation is best suited in our case.

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Exterior walls. The outer walls of the building are designed of red brick M-100 with the insulation of mineral wool boards and lined with polymer panels.

Partition walls are most often made of brick, plaster and wood:

a) brick and cinder-block partitions are put, as a rule, in brick and stone houses on a solid base. Red, silicate or raw bricks are used. Usually the thickness of brick partitions - ½ brick, but it can be more. To give rigidity to such partitions through every 5-6 rows of masonry laid two bars of wire reinforcement thickness of 3-4 mm;

b) gypsum plasterboard.

Ceilings are designed as:

a) precast reinforced concrete of slabs PK-60-15-8T, laid on a precast reinforced concrete transom, but this will be very expensive;

b) monolithic reinforced concrete poured into the formwork installed on the beams, as which you can use a metal beam, such as I-beam or two channels, cross-section which is set by calculations.

Roofing. Rolling.

Blind area - concrete coating thickness of 15 mm on rubble base thickness of 100 mm; width 1.0 m.

Windows - with double glazing. The material of the windows - five-chamber metalplstik. Window plastic construction is environmentally friendly and resistant to atmospheric influence and ultraviolet.

Doors. Internal and external doors are blank. Made of five-chamber metal plastic. External doors are reinforced. For exterior doors, boxes are arranged with thresholds. Door leaf is hung on the hinges (awnings), allowing removal of the open wide door leaf from the hinges - to repair or replace the door leaf.

The floors are poured on the ground of monolithic concrete C12/15 (M100) reinforced with mesh reinforcement of A400 class. Floor covering is made of ceramic tiles.

Heating and hot water supply is designed from the main heating networks. The radiators serve as heating devices.

Water supply. Cold water supply is projected from the intra quarterly water supply manifold with two inputs.

Domestic sewage fecal and rain is performed gravity intradoor with tie-in wells intra quarter sewerage.

Power supply is performed from the urban substation.

Table 2.2. Explanation of the premises

Room number	Names	Square, m^2	Room category
1	Administration	10,46	
2	Administration	10,99	
3	Staff bathroom	13,15	
4	Methodical room	27,03	
5	Tambour	10,20	
6	Men's Cloakroom	26,21	
7	Men's shower room	7,43	
8	Women's shower room	7,43	
9	Women's dressing room	26,21	
10	Instructor's room	11,52	
11	Doctor's room	10,23	
12	Room for cleaning equipment	2,85	
13	Waiting room	12,51	
14	Lobby Hall	42,71	
15	Dressing Room	9,12	
16	Utility room	20,98	
17	Corridor	5,85	
18	Gym	513,89	
19	Inventory	17,51	
20	Electric switchboard	17,51	
21	Ventilation chamber	36,59	
22	Strength training room	53,38	
23	Sports and household equipment pantry	19,46	
24	Classroom	45,04	

Table 2.3. Specification of the openings fillings elements

Pos. brand	Designation	Name	Quantity
Windows			
W1	Individual	1680x1500 (h) mm	14
W2	Individual	900x1500 (h) mm	2
W3	Individual	2180x1500 (h) mm	3
W4	Individual	3000x30000 (h) mm	5
Doors			
D1		DG 21-10	15
D2		DG 21-7	5
D3	DSTU B V.2.6 - 15:2011	DG 21-9	4
D4		DN 21-12	2
D5		DN 21-20	2
D6		DN 21-15	1

2.3. Thermal calculation

Thermal calculation of the enclosure

Determine the value of degree-days of the heating period

$$ГСОП = (t_в - t_{отпер}) \times z_{отпер};$$

where $t_в = 20^oС$ – indoor air temperature;

$t_{отпер} = 9.5^oС$ – average temperature of the heating period;

$z_{отпер} = 226$ days – heating period duration;

$ГСОП = (20 + 9.5) \times 226 = 6667^oС \times$ days.

We find the value of the heat transfer resistance of the enclosing structures:

$R_{отр} = 3.2 м^2 \cdot {}^oС/Wt$
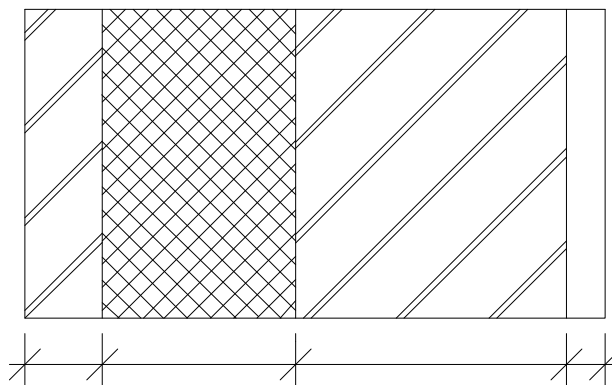
Fig. 2.2. Wall construction

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Table 2.4. Wall construction properties

Name	γ_0, kg/m³	δ, m	λ, Wt/(m*°C)	R, m²°C/Wt
1. Polymer board		0.03	0.008	0.027
2. Insulator - mineral wool board	13	0.15	0.12	3.33
3. masonry	1800	0.7	0.38	0.543
4. cement-sand mortar	1800	0.76	0.02	0.026

Determine the heat transfer resistance of the outer wall:

$$R_0 = 1/\alpha_6 + \delta_1/\lambda_1 + \delta_2/\lambda_2 + \delta_3/\lambda_3 + \delta_4/\lambda_4 + 1/\alpha_{_H};$$

where $\alpha_6 = 8.7\,\text{Wt/(m²°C)}$ – heat transfer coefficient of the internal surface of the enclosing structure; $\alpha_{_H} = 23$ Wt/(m²°C) – heat transfer coefficient of the outer surface of the enclosing structure.

$$R_0 = 3{,}17 \text{ m}^2 \cdot °\text{C/Wt} > R^{\text{тр}}_0 = 3{,}08 \text{ m}^2 {}_* °\text{C/Wt}$$

Therefore, the condition of resistance to heat transfer is satisfied.

Thermal calculation of the cover

Determine the value of degree-days of the heating period

$$\textit{ГСОП} = 6341.4\,°\text{C} \times \text{days.}$$

We find the value of the heat transfer resistance of the enclosing

structures: $R_{omp} = 4.75 \text{м}^2 \cdot °\text{C/Wt}$

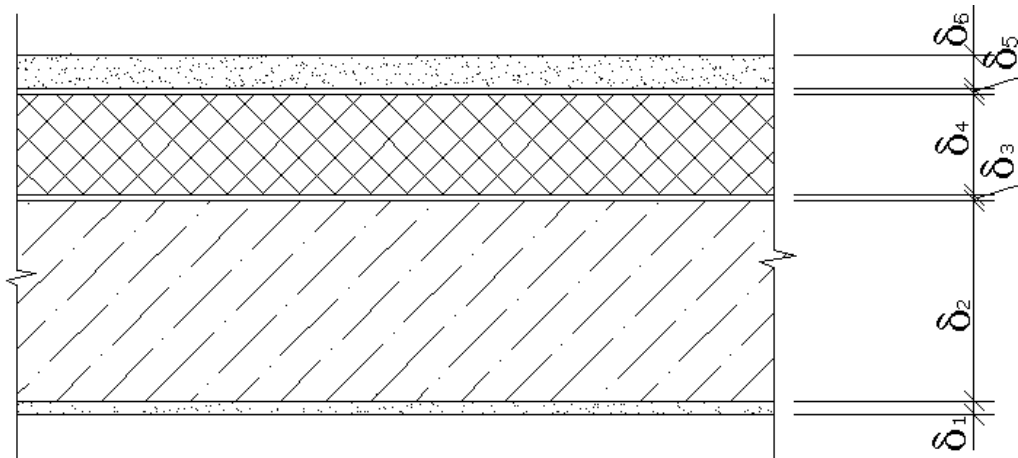Fig. 2.2. Attic floor design

Table 2.5. Attic floor properties

Name	γ_0, kg/m³	δ, m	λ, Wt/(m*°C)	R, m²°C/Wt
1. timber	500	0.14	0.12	3.33
2. mineral wool slabs	80	0.15	0.38	0.543
3. cement-sand mortar	1600	0.22	0.02	0.026

Determine the heat transfer resistance of the attic floor:

$$R_0 = 1/\alpha_e + \delta_1/\lambda_1 + \delta_2/\lambda_2 + \delta_3/\lambda_3 + \delta_4/\lambda_4 + 1/\alpha_\text{н};$$

where $\alpha_e = 8.7\,\text{Wt/(m²°C)}$ – heat transfer coefficient of the internal surface of the enclosing structure; $\alpha_\text{н} = 23\,\text{Wt/(m²°C)}$ – heat transfer coefficient of the outer surface of the enclosing structure.

$$R_0 = 0.115 + 0.286 + 4.59 + 0.029 + 0.0435 = 4.91 \,(\text{m}^2 \times °\text{C/Wt})$$

$$R_0 = 4.91\,(\text{м}^2 \times °\text{C/Вт}) > R_{omp.} = 4.75\,(\text{m}^2 \times °\text{C/Wt})$$

3. Calculation of roof slabs

Calculated load per 1 m with a slab width of 1.5 m, taking into account the reliability factor for the intended use of the building γ_n=0,95:

constant q=4,543*1,5*0,95=6,474 kN/m - see table 3.1.

full q+v=5,453*1,5*0,95=7,770 kN/m - see table 3.1.

temporary v=0,91*1,5*0,95=1,297 kN/m - see table 3.1.

Normative load on 1 m:

constant q=3,956*1,5*0,95=5,637 kN/m - see table 3.1.

full q+v=4,656*1,5*0,95=6,635 - kN/m - see table 3.1.

Since the designed building has an attic roof, the impact of snow loads on the coating will not.

Forces from design and normative loads.

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To determine the design span of the plate, we pre-determine the dimensions of the cross-section of the beam: h=(1/12)*ℓ=(1/12)*300=25 cm, b=20 cm.

When resting on the wall on the top the calculated span:

$\ell_o=\ell – b/2=6 – 0,2/2=5,9$ m.

From the design load

$M=(q+v)*\ell_o^2/8=7,770*5,9^2/8=33,81$ kN*m.

$Q=(q+v)*\ell_o/2=7,770*5,9/2=22,92$ kN.

From the standard load

$M=(q+v)*\ell_o^2/8=6,635*5,9^2/8=28,87$ kN*m.

$Q=(q+v)*\ell_o/2=6,635*5,9/2= 19,57$ kN.

Table 3.1 Collection of deck loads

Type of load	Normative load, kN/m²	Reliability coefficient of load, γ_f	Design load, kN/m²
Constant: cement-sand screed $\delta=0,05$ m, $\gamma=1800$ kg/m³	0,9	1,3	1,17
insulation (mineral wool) $\delta=0,20$ m, $\gamma=13$ kg/m³	0,026	1,3	0,034
vapor barrier $\delta=0,005$ m, $\gamma=600$ kg/m³	0,03	1,3	0,039
reinforced concrete slab	3	1,1	3,3
Total	**3,956**		**4,543**
Temporary: load from the attic room	0,7	1,3	0,91
Total	**4,656**		**5,453**

Determining the dimensions of the plate cross-section

The section height of the multihollow (7 circular cavities with a diameter of 15.9 cm) prestressed slab h=22 cm;

working height of the section ho=h - a=22 - 3=19 cm.

Dimensions: the thickness of the upper and lower shelves

(22 - 15.9)*0.5 = 3.05 cm.

Width of the ribs: middle - 3.6 cm; extreme - 6.55 cm.
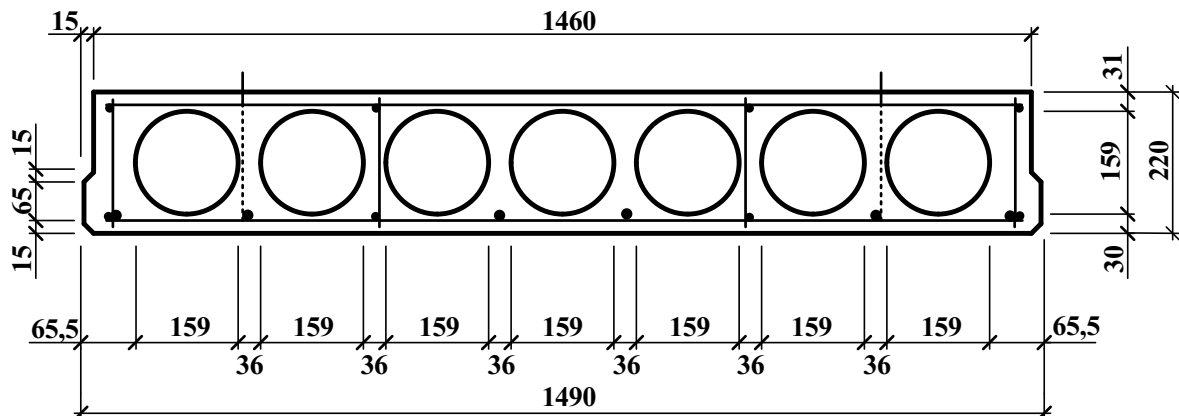
Fig. 3.1. Cross-section of a hollow-core slab

In the calculations for the limit states of the first group the calculated thickness of the compressed flange of a T-beam section h_f'=3,1 cm;

attitude h_f'/h=3,1/22=0,14>0,1, the entire width of the shelf b_f'=146 cm is taken into account;

calculated rib width b=146 – 7*15,9=34,7 cm.

Concrete and reinforcement strength characteristics

Multi-core prestressed slab is reinforced with rod reinforcement of A500C class with mechanical tension on the stops of the forms.

The crack resistance of the slab has the requirements of the 3rd category.

Concrete of heavy class C16/20:

R_{bn}=15 MPa – normative resistance of concrete to axial compression.

$R_{b,ser}$=15 MPa – design resistance of concrete to compression for the II group of limiting states

R_b=11,5 MPa – design resistance of concrete to compression for the I group of limiting states.

R_{bt}=0,9 MPa – design tensile strength of concrete for the I group of limiting states.

R_{btn}=1,4 MPa – standard tensile strength of concrete.

$R_{bt,ser}$=1,4 MPa – design tensile strength of concrete for the II group of limiting states.

E_b=27000 MPa – concrete modulus of elasticity.

γ_{b2}=0,9 – concrete condition factor.

Transfer strength of concrete R_{bp} is set so that during compression the stress ratio $\sigma_{bp}/R_{bp} \leq 0,75$.

Armature class A500C:

R_{sn}=540 MPa – standard tensile strength.

$R_{s,ser}$=540 MPa – design tensile strength for the II group of limiting states.

R_s=450 MPa – design tensile strength of the reinforcement for group I of the limit states.

E_s=180000 MPa – modulus of reinforcement elasticity.

The prestressing of the reinforcement is assumed to be σ_{sp}=0,7*R_{sn}=0,7*540=378 MPa

We check if the condition is fulfilled: $\sigma_{sp}+p \leq R_{s,ser}$, where with the mechanical method of tensioning the reinforcement p=0,05*σ_{sp}=0,05*378=18,9 MPa

378+18,9 ≤ 540

396,9 ≤ 540, the condition is satisfied

Calculate the limit deviation of the prestressing according to the formula:

$$\Delta\gamma_{sp} = 0,5 * \frac{p}{\sigma_{sp}} * (1 + \frac{1}{\sqrt{n_p}}) = 0,5 * \frac{18,9}{378} * (1 + \frac{1}{\sqrt{6}}) = 0,0352$$

where n_p – the number of stressed bars of the slab

The tensioning accuracy factor with a favorable effect of prestressing is found by the formula:

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$\gamma_{sp}=1 - \Delta\gamma_{sp}=1 - 0{,}0352=0{,}9648$.

When checking for crack formation in the upper zone of the plate during compression, take:

$\gamma_{sp}=1+\Delta\gamma_{sp}=1+0{,}0352=1{,}0352$.

Prestressing taking into account the tensioning accuracy:

$\sigma_{sp}=0{,}9648*378=364{,}69$ MPa.

Calculation of slab strength along the section normal to the longitudinal axis

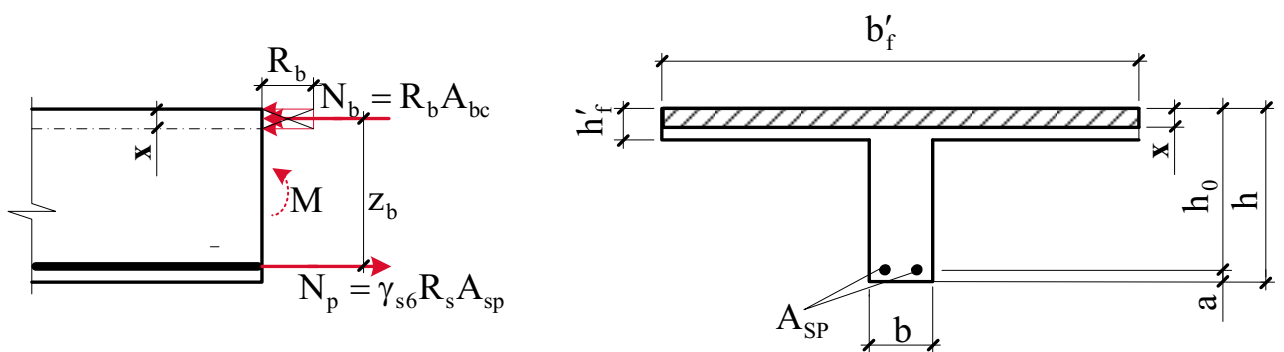T-section with a flange in the compressed area. M=33,81 kN*m

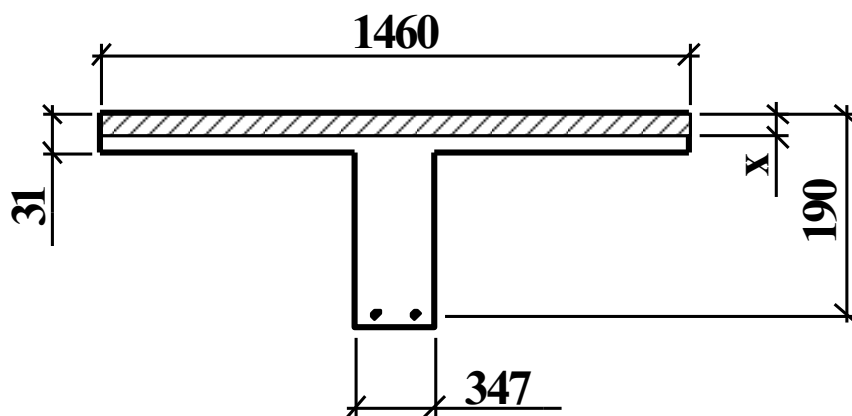Fig. 3.2. Force diagram for calculating the strength of the normal section

Fig. 3.3. Cross-section of the hollow-core slab

$$\alpha_m = \frac{M}{R_b * b_f' * h_0^2} = \frac{3381000}{0{,}9*11{,}5*146*19^2*100} = 0{,}062 .$$

$\xi=0{,}065$; $\zeta=0{,}967$

x=ξ*h$_o$=0,065*19=1,235 cm < 3 cm – neutral axis passes within the compressed shelf

The characteristics of the compressed zone are determined by the formula:

ω=α – 0,008*R$_b$=0,85 – 0,008*0,9*11,5=0,767.

where α=0,85 – coefficient taken for heavy concrete

Calculate the limit height of the compressed zone by the formula:

$$\xi_R = \frac{\omega}{1+\dfrac{\sigma_{sR}}{\sigma_{sc,u}}*\left(1-\dfrac{\omega}{1,1}\right)},$$

where σ$_{sR}$=R$_s$ – σ$_{sp}$=450 – 364,69=86,31 MPa;

σ$_{sc,u}$=500 MPa.

$$\xi_R = \frac{\omega}{1+\dfrac{\sigma_{sR}}{\sigma_{sc,u}}*\left(1-\dfrac{\omega}{1,1}\right)} = \frac{0,767}{1+\dfrac{86,31}{500}*\left(1-\dfrac{0,767}{1,1}\right)} = 0,729 \;.$$

The coefficient of operating conditions, taking into account the resistance of the prestressed reinforcement above the conditional yield strength, is accepted for valves of class A500C equal to 1.

Calculate the cross-sectional area of the stretched reinforcement according to the formula:

$$A_{sp} = \frac{M}{R_s*\zeta*h_0} = \frac{3381000}{450*0,967*19*100} = 4,09 \; см^2 \;.$$

We accept 6 rods ∅ 10 mm A500C with A$_{sp}$=4,71 cm^2.

Calculation of the strength of the plate on the section inclined to the longitudinal axis

Q=22,92 kN.

Influence of compression force P=97,32 kN:

φ$_n$=0,1*N/R$_{bt}$*b*h=0,1*97320/0,9*34,7*19*(100)=0,16<0,5

Check whether the transverse reinforcement is required by calculation.

Condition:

$Q_{max} \le 2{,}5 * R_{bt} * b * h \Rightarrow 920*10^3 \le 2{,}5*0{,}9*0{,}9*34{,}7*19*(100)$;

$22{,}92*10^3 \le 133{,}51*10^3$ – is performed.

At $q_1 = q + v/2 = 6{,}474 + 1{,}297/2 = 7{,}123$ kN/m $= 71{,}23$ N/cm and because by the formula:

$q_1 \le 0{,}16 * \varphi_{b4} * (1+\varphi_n) * R_{bt} * b$,

where $\varphi_{b4} = 1{,}5$ – for heavy concrete,

$0{,}16*1{,}5*(1+0{,}03)*0{,}9*0{,}9*34{,}7*(100) = 694{,}81$ Н/см $> 71{,}23$ N/cm,

therefore, we accept $c = 2{,}5 * h_o = 2{,}5*19 = 47{,}5$ cm.

Another condition:

$Q = Q_{max} - q_1 * c = 22{,}92*10^3 - 71{,}23*47{,}5 = 19{,}54$ kN;

$Q \le \varphi_{b4} * (1+\varphi_n) * R_{bt} * b * h_o^2 / c$;

$19{,}54*10^3 \le 1{,}5*(1+0{,}03)*0{,}9*0{,}9*34{,}7*19^2*(100)/47{,}5$;

$19{,}54*10^3 \le 33*10^3$ – the condition is satisfied.

Consequently, the calculation does not require transverse reinforcement.

On the supporting sections of length $\ell/4$ we install the reinforcement structurally, $\varnothing$ 4 mm A240C with a step $s = h/2 = 22/2 = 11$ cm, take a step $s = 10$ cm; in the middle part of the span transverse reinforcement is not used.
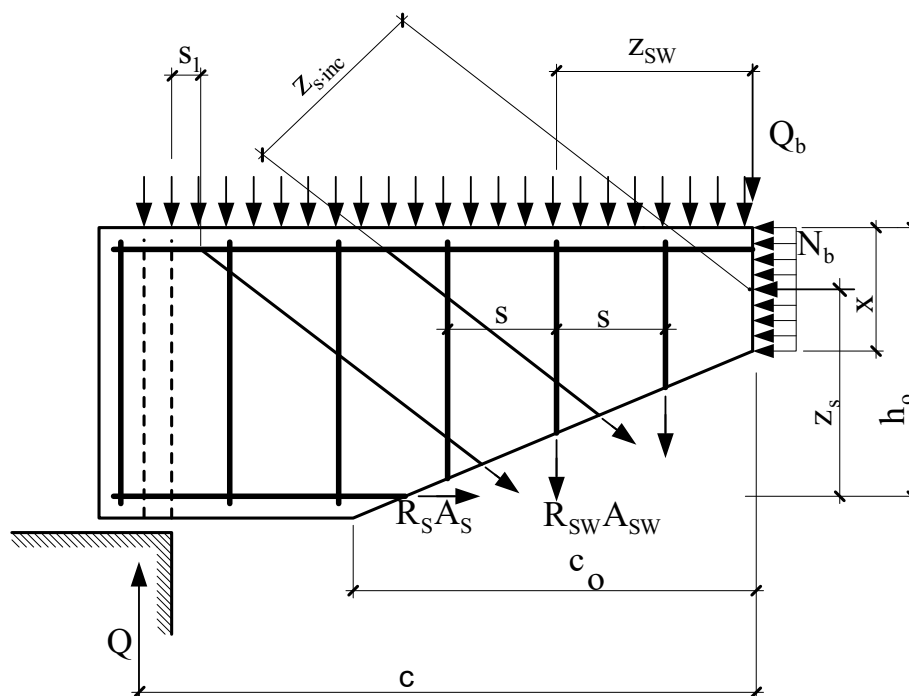
Fig. 3.4. Calculation diagram of forces in the inclined section

Geometric characteristics of the reduced section

We replace the circular outline of the voids with an equivalent square one with side h=0.9*d=0.9*15.9=14.31 cm. The thickness of the shelves of the equivalent section $h_f'=h_f=(22 - 14,31)*0,5=3,85$ cm.

The width of the rib 146 - 7*14.31=45.83 cm.

The width of the voids 146 - 45,83=100,17 cm.

Ratio of elastic modulus $\alpha=E_s/E_b=180000/27000=6,667$.

The area of the reduced section is found by the formula:

$A_{red}=A+\alpha*A_{sp}=146*22 – 100,17*14,31+6,667*1,13=1786,1$ cm^2.

where A – cross-sectional area of concrete minus the cross-sectional area of channels and grooves, cm^2.
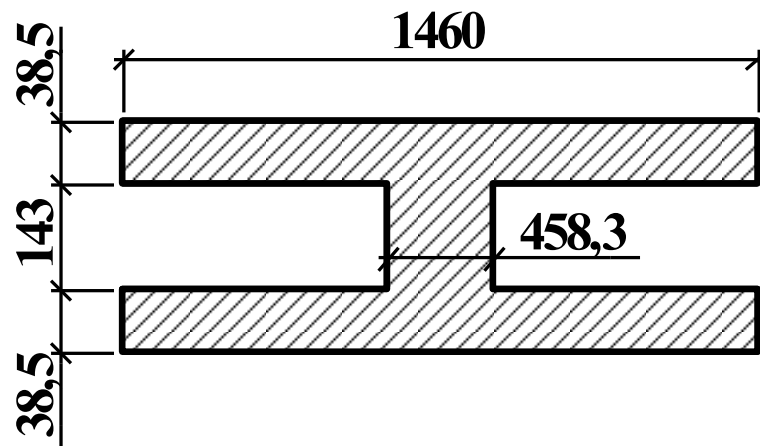
Fig. 3.5. Cross-section of the hollow-core slab

Distance from the bottom edge to the center of gravity of the reduced section:

$y_o=0,5*h=0,5*22=11$ cm.

The moment of inertia of the symmetrical section by the formula:

$I_{red}=\sum[I_i+A_i*(y_o – y)^2]=146*22^3/12 – 100,17*14,31^3/12=154012$ cm^4.

Moment of resistance of the section along the lower and upper zone:

$W_{red}=W'_{red}=I_{red}/y_o=154012/11=14001$ cm^3.

The distance from the core point farthest from the stretched zone (upper) to the center of gravity of the section is found by the formula:

$r = \varphi_n * (W_{red} / A_{red}) = 0,85 * (14001/1786,1) = 6,66$ cm;

the same, the farthest from the stretched zone (bottom) $r_{inf} = 6,66$ cm,

where $\varphi_n = 1,6 - \sigma_{bp}/R_{b,ser} = 1,6 - 0,75 = 0,85$.

The ratio of the stress in the concrete from the standard loads and compression forces to the design resistance of the concrete for the limit states of the second group tentatively take equal to 0.75.

Elastoplastic moment of resistance in the tensile zone according to the formula:

$W_{pl} = \gamma * W_{red} = 1,5 * 14001 = 21001,5$ cm^3,

here $\gamma = 1,5$ – for an I-beam section at $2 < b_f^{'}/b = b_f/b = 146/45,83 = 3,19 < 6$.

Elastoplastic moment of resistance along the tensile zone in the manufacturing and compression stages: $W_{pl}^{'} = 21001,5$ cm^3.

Reinforcement prestressing losses

1. Stress relaxation losses in rod reinforcement with mechanical tensioning method: $\sigma_1 = 0,1 * \sigma_{sp} - 20 = 0,1 * 378 - 20 = 17,8$ MPa.

2. Losses from temperature difference between tensioned fittings and stops: $\sigma_2 = 0$.

3. Losses from deformation of anchors located at tensioning devices:

$\sigma_3 = (\Delta \ell / \ell) * E_s = (2/6000) * 180000 = 60$ MPa.

4. Losses from reinforcement friction against the walls of channels or the surface of concrete structures: $\sigma_4 = 0$.

5. Losses from deformation of steel mold in the manufacture of prestressed reinforced concrete structures: $\sigma_5 = 30$ MPa.

6. Losses from rapid creep of concrete during natural curing.

Compression force:

$P_1 = A_{sp} * (\sigma_{sp} - \sigma_1 - \sigma_3 - \sigma_5) = 4,71 * (378 - 17,8 - 60 - 30) * *100 = 127,26$ kN.

The eccentricity of this force with respect to the center of gravity of the section:

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$e_{op}=y_o/2 – a=11 – 3=8$ cm.

Tension in concrete under compression according to the formula:

$\sigma_{bp}=P_1/A_{red}+P_1*e_{op}*y_o/I_{red}=(127260/1786,1+127260*8*22/154012)/100=2,17$MPa.

We set the value of transfer strength of concrete from the condition $\sigma_{bp}/R_{bp}\leq0,75$; $R_{bp}=2,17/0,75=2,89$ MPa$<0,5*C16/20=10$ MPa, accept $R_{bp}=10$MPa, then the relation $\sigma_{bp}/R_{bp}=2,17/10=0,217$.

Calculate the compressive stresses in the concrete at the center of gravity of the area of stressed reinforcement from the compression force (without taking into account the moment from the weight of the slab):

$\sigma_{bp}=P_1/A_{red}+P_1*e^2_{op}/I_{red}=(127260/1786,1+127260*8^2/154012)/100 = 1,24$ MPa.

Rapid creep losses at $\sigma_{bp}/R_{bp}=1,24/10=0,124$ and at

$\alpha=0,25+0,025*R_{bp}=0,25+0,025*10=0,5<0,8$

$\sigma_6=40*\sigma_{bp}/R_{bp}=40*0,124=4,96$ MPa.

First Losses $\sigma_{los1}=\sigma_1+\sigma_3+\sigma_5+\sigma_6=17,8+60+30+4,96=112,76$ MPa.

7. Stress relaxation losses of rod reinforcement $\sigma_7=0$.

8. Concrete shrinkage losses $\sigma_8=40$ MPa.

9. Creep losses in concrete $\sigma_9=150*\alpha*\sigma_{bp}/R_{bp}=150*1*0,124=18,6$ MPa

$\alpha=1$ – coefficient, taken for naturally-cured concrete,

σ_{bp}/R_{bp} – are found taking into account the first losses:

$P_1=A_{sp}*(\sigma_{sp}–\sigma_{los1})=4,71*(378 – 112,76)=124,93$ kN.

$\sigma_{bp}=(127260/1786,1+127260*8^2/154012)/100=1,24$ MPa.

$\sigma_{bp}/R_{bp}=1,24/10=0,124$

10. Losses from concrete buckling under coils of spiral or ring reinforcement $\sigma_{10}=0$.

11. Losses from deformation of compression of joints between blocks (for structures consisting of blocks) $\sigma_{11}=0$.

Second losses $\sigma_{los2}=\sigma_8+\sigma_9=40+18,6=58,6$ MPa.

Total losses $\sigma_{los}= \sigma_{los1}+\sigma_{los2}=112,76+58,6=171,36$ MPa.

Compression force including total losses:

$P_2 = A_{sp}*(\sigma_{sp} - \sigma_{los}) = 4,71*(378 - 171,36)*100 = 97,32$ kN.

Calculation of the formation of cracks normal to the longitudinal axis

It is performed to find out the necessity of checking the crack opening. In this case, for the elements whose crack resistance requirements are of the 3rd category, take the value of reliability coefficients of loading f=1; M=28.87 kN*m. According to the formula: $M \leq M_{crc}$.

We calculate the moment of crack formation using the approximate method of core moments by the formula:

$M_{crc} = R_{bt,ser}*W_{pl} + M_{rp} = 1,4*21001,5*(100) + 1284040 = 4224250$ H*cm =42,24 kN*m.

here the core moment of the compression force is found by the formula at $\gamma_{sp} = 0,9$:

$M_{rp} = P_2*(e_{op} + r) = 0,9*97320*(8 + 6,66) = 1284040$ N*cm.

As M=28,87 kN*m, cracks are not formed in the tensile zone, so there is no need to calculate their opening.

Calculation of plate deflection

Limit deflection $f = \ell/200 = 590/200 = 2,95$ cm.

Calculate the parameters necessary to determine the deflection of the plate. The replacement moment is equal to the bending moment from a constant load M=28,87 kN*m. The total longitudinal force is equal to the precompression force including all losses and at $\gamma_{sp}=1$: $N_{tot} = P_2 = 97,32$ kN.

eccentricity $e_{tot} = M/N_{tot} = 2887000/97320 = 29,67$ cm,

coefficient $\varphi_\ell = 0,8$ – under prolonged load action.

$$\varphi_m = \frac{R_{bt,ser}*W_{pl}}{M - M_{rp}} = \frac{1,4*21001,5*(100)}{2887000 - 1284040} = 1,83 > 1,$$

consequently, we take $\varphi_m = 1$.

The coefficient characterizing the uneven deformation of the tensile reinforcement, determined by the formula:

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$\psi_s = 1,25 - \varphi_\ell = 1,25 - 0,8 = 0,45 < 1.$
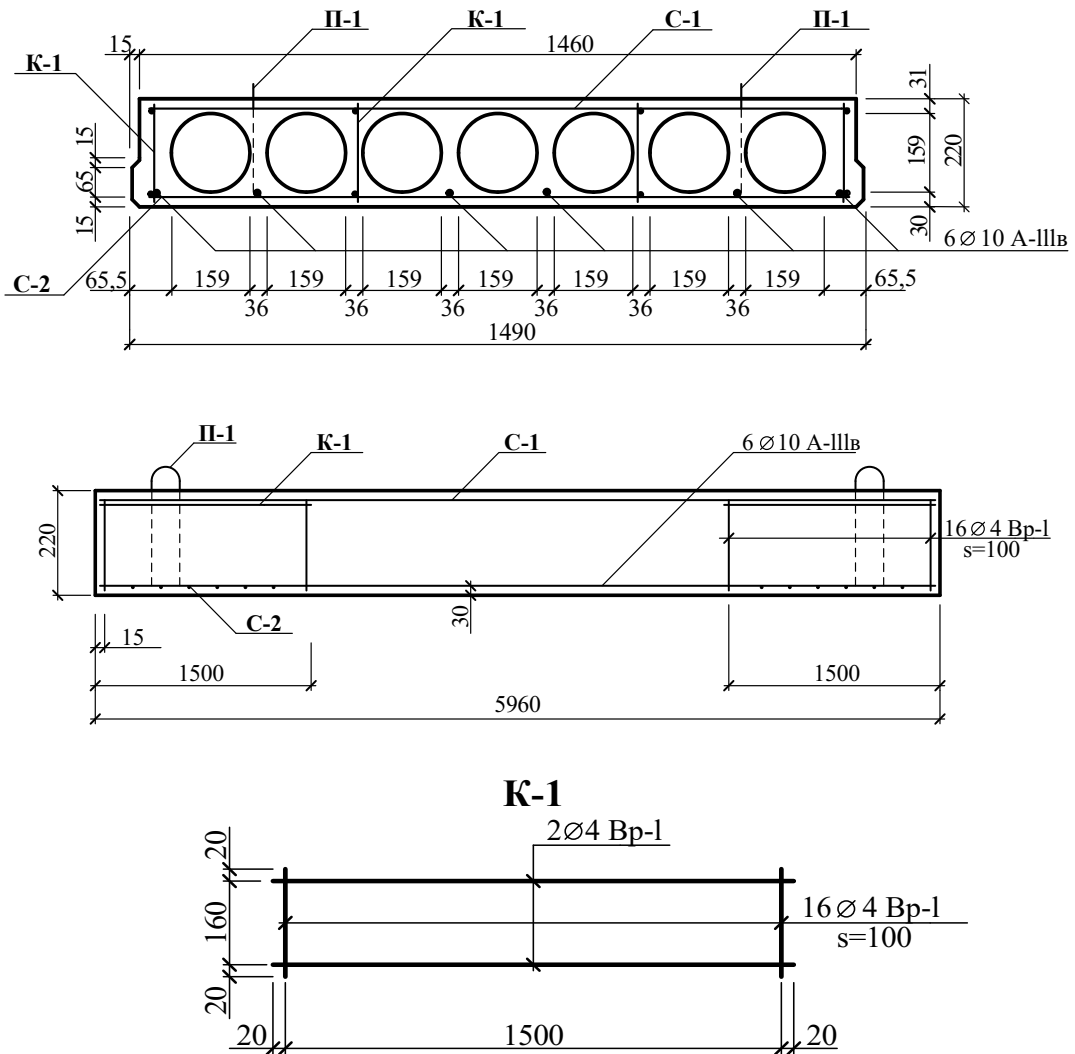
Fig. 3.6. Reinforcing the hollow slab

Calculate the curvature of the axis in bending according to the formula:

$$\frac{1}{r} = \frac{M}{h_o * z_1} * \left(\frac{\psi_s}{E_s * A_{sp}} + \frac{\psi_b}{\nu * E_b * A_b} \right) - \frac{N_{tot} * \psi_s}{h_o * E_s * A_{sp}} = \frac{2887000}{19 * 17,075 * (100)} *$$

$$* \left(\frac{0,45}{180000 * 1,13} + \frac{0,9}{0,15 * 27000 * 562,1} \right) - \frac{97320 * 0,45}{19 * 180000 * 1,13 * (100)} = 9,79 * 10^{-5} \text{ м}^{-1}$$

Here $\psi_b = 0,9$; $\nu = 0,15$ – in the case of prolonged exposure to stresses;

$z_1 \approx h_0 - 0,5 * h'_s = 190 - 0,5 * 38,5 = 17,075$ cm.

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$A_b=(\varphi_f+\xi)*b*h_o=b_f^{'}*h_f^{'}=146*3{,}85=562{,}1$ cm^2

Calculate the deflection according to the formula:

$f=(5/48)*\ell_o^2*(1/r)=(5/48)*590^2*9{,}79*10^{-5}=2{,}86$ cm $< 2{,}95$ cm, condition is satisfied

4. Basics and foundations
4.1. Evaluation of engineering and geological conditions
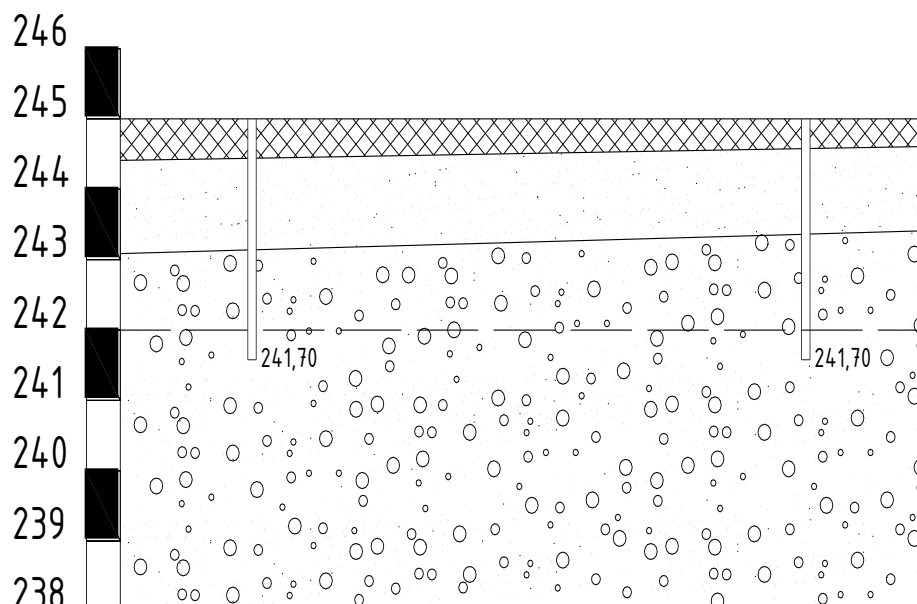
Fig. 4.1. Geological section

Designing foundations and foundations begins with the study and general evaluation of the entire strata and its individual layers. The assessment is made on the basis of geological maps, sections, columns, which are given in the reports on engineering and geological surveys.

According to the engineering and geological section, the building is located on a site that has a quiet topography.

The soils have a layered overlaying with a steady bedding of layers. The upper vegetative layer covers the site with thickness up to 0.5 m.

Below in the interval from 0,5 to 2m there is dusty sand.

From the depth of 2 m, pebble-like soil with sandy filler is located.

Pebble soil is a bearing layer.

Groundwater is found at the depth of 3 m.

The normative depth of seasonal freezing for the city of Rivne is 0.7 m.

4.2. Justification of possible foundation options and their analysis, choosing the most rational solution

Based on the assessment of the engineering-geological conditions, analysis of the loads on the foundation and the work of the above-ground structures we develop sketches of possible options of foundations and foundation structures. The basis for the development of foundation options is the study of analogues available for application in the given soil conditions, design documentation of the constructed facilities. For specific engineering-geological conditions it is advisable to plant the object on possible different variants of foundations (natural and artificial) and foundations. A more detailed study selects the most acceptable of them, taking into account: geological conditions, the method of work production and the capabilities of construction organizations, construction and materials that can be purchased by the customer.

In this diploma project, we can accept the following options:

- strip monolithic foundation;

- a pillar monolithic foundation;

- a pile foundation - made of reinforced concrete piles, tied with a monolithic reinforced concrete stringer;

- monolithic reinforced concrete slab;

- bored foundation, and others.

The strip foundation is the least time-consuming and, at the same time, the simplest and most economical type of foundation.

Pile foundation is used to construct buildings on weak soils. A rather labor-intensive and expensive type of foundation.

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The monolithic slab option is more labor-intensive and requires an unreasonable excess of construction costs. Thus, in the final analysis we will take the variants of strip and column foundations, as the most economical and least labor-intensive.

The basic principle of designing strip foundations for buildings is that the strip foundations of all walls are combined into a single system and form a sufficiently rigid horizontal frame, redistributing the uneven deformations of the foundation.

In the case of columnar foundations, the frame is formed of foundation beams, which are rigidly connected to each other on the supports to ensure joint operation.

The building - with a basement, so the depth of the foundation is taken for design considerations, the height of the basement footing - 2.70 m.

4.3. Calculation of foundations for a bearing wall

Depth of the foundation $h = 2.7$ m, the foundation's height $h_f = 1.5$ m, the load at the level of the top of the foundation $N_o = 120.8$ kN/m. The calculated resistance of the foundation soil $R_O = 600$ kPa - pebble soil with sandy aggregate.

Approximate dimensions of the foundation will be found in

assuming that it is centrally compressed.

The width of the foundation's footing base according to the formula, assuming $\gamma_{mt} = 20$ kN/m^2.

$F = b \cdot 1 = No/(R_0 - \gamma_{mt}h) = 120,8/(600-20\cdot1,5) = 0,21$ m.

Consider the effect of foundation depth and width on the value of design pressure.

For foundations composed of coarse clastic soils $k_1 = 0,125$; $k_2 = 0,25$.

$R = Ro[1+k_1(b-b_1)/b_1]\cdot((h+h_1)/2h_1) = 600[1+0,125(0,23-1)/1]\cdot((1,3+1,5)/2\cdot1,5) = 506,1$ kPa.

Based on the design pressure, we again determine the width of the foundation: $F = 120,8/(506,1-20\cdot1,5) = 0,27$ kPa.

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Table 4.1. Load on the foundation

Type of load	Normative loads		Load factor, γ_f	Design loads per unit area, kN/m²
	per unit area, kN/m²	from the cargo area, kN		
Constant loads				
Ceramsite	0.119	1,071	1.2	1,28
Cement-sand screed	0,045	0,4	1.1	0,44
Reinforced concrete truss	7,2	7,2	1.1	7,92
Brick wall 640 mm	12,6	12,6	1.1	13,86
Floor slabs	3	18	1.1	19,8
From the concrete floor on the slab	3,75	33,75	1,3	43,87
Foundation blocks	4,95	4,95	1.1	5,44
Total	–	77,97	–	92,61
Temporary loads				
Per 1 $м^2$ of roof projection from snow	1.070	9,63	1.6	15,4
including long-acting	0.321	2,9	1.6	4,6
Short-term per 1 $м^2$ of attic floor	0.7	6,3	1.3	8,2
Total	–	18,83	–	28,2
Full load		96,8		120,8

Let's choose foundation blocks FBS 24.6.6 width b = 0.6 m for design considerations.

For gravelly soils we find $\varphi_n=43°$ and $c_n=0{,}002$ MPa. Then for $\varphi_{II}=43°$ we find the dimensionless coefficients $M\gamma=3{,}12$; $Mq=13{,}46$ and $Mc=13{,}37$.

Determine the ratio $L/H=36/9=4$ and find the value of working conditions coefficients $\gamma_{C1} =1{,}4$ and $\gamma_{C2} = 1{,}2$. Since the calculated characteristics of φ_{II} and c_{II} are obtained from the table data, i.e. indirectly, we accept the value of the coefficient $k=1.1$.

Determine the specific weight of the bearing layer soil

$\gamma_{II} = 10\times1810=0{,}0181$ MN/m³

and the soil above the base of the foundation,

$\gamma'_{II} = 10\cdot1810 = 0{,}018 MH/м^3.$

Find the design resistance of the foundation soil:

$$R = \frac{\gamma_{c1}\gamma_{c2}}{\kappa}\left[M_{\gamma}\kappa_z b_{\gamma II} + M_q d_I \gamma'_{II} + \left(M_q -1\right)d_b\gamma'_{II} + M_c c_{II}\right]$$

$$R = \frac{1{,}4\cdot1{,}2}{1{,}1}(3{,}12\cdot1\cdot0{,}8\cdot0{,}0181+13{,}46\cdot1{,}3\cdot0{,}0181+13{,}37\cdot0{,}002)=$$

$0{,}594 MПa = 594 кПa.$

Since R=594 kPa, found according to the given soil characteristics, turned out to be greater than R=506.1 kPa, found according to R_o, the foundation width can be reduced. But since the width of the walls is 640 mm, this should not be done for structural reasons.

$P_{cp}=(120{,}8+20\cdot2\cdot0{,}8)/0{,}8=191$ kPa.

Condition $P_{cp}\leq R$ is fulfilled because 191<594.

According to the formula:

$$T = \left(qd + \gamma'_{II}d^2/2\right)\cdot tg^2\left(45° - \varphi/2\right)$$

determine the equilibrium active pressure of the soil on 1 m of the foundation wall: $T = 0.02$

Find the reduced height of the soil layer and the distance from the base of the foundation to the point of application of the equilibrium active ground pressure:

$$h_{np} = \frac{q}{\gamma'_{II}} = \quad 0{,}01/0{,}0181 = 0{,}552\,m$$

$$a_0 = \frac{d}{3} \cdot \frac{d + 3h_{np}}{d + 2h_{np}} = \frac{1{,}5}{3} \cdot \frac{1{,}5 + 3 \cdot 0{,}552}{1{,}5 + 2 \cdot 0{,}552} = 0{,}6\,м$$

Moment with respect to the center of gravity of the foundation's bedrock from the result of the equilibrium of active ground pressure:

$M_т = 0{,}02 \cdot 1{,}1 = 0{,}022$ MN·m.

The weight of 1 m of the foundation wall can be found using the data

$$Gф = 10\frac{1580}{2{,}38} + 10 \cdot 3\frac{1630}{2{,}38} + 10 = 0{,}027$$

Weight of the ground at the foundation's edge:

$Gгр = 0{,}0181 \cdot 0{,}05 \cdot 1{,}0 \cdot 1{,}0 \cdot 2 = 0{,}00181$ MN.

Moment relative to the center of gravity of the foundation's footing from the weight of the soil at its edge:

$M_{гр} = 0{,}00181(0{,}3/2 + 0{,}3) = 0{,}0008$ MN·m.

Determine the edge stresses under the foundation subtype:

$$P\max = \frac{N'}{bl} + \frac{N'6e}{b^2 l} = \frac{0.11 + 0.027 + 0.00181}{0.6 \cdot 1.2} + \frac{(0.0091 + 0.027 - 0.0008)6}{0{,}6 \cdot 1.2^2} =$$

$0.44\,МПа$

$$P\min = \frac{0.11 + 0.027 + 0.00181}{0.6 \cdot 1.2} - \frac{(0.0091 + 0.027 - 0.0008)6}{0{,}61 \cdot 1.2^2} =$$

$0.05\,МПа$

Condition $P_{max} = 0.44$ *MPa* < 1.2·0,795 = 0,95

$P_{min} > 0$ is satisfied, so we take foundation blocks FBS 24.6.6 b = 0.6 m, l = 2.4 m, h = 0.6 m.

Stresses in the ground beneath the base of the foundation at the wall edge from the standard loads:

$$P = \frac{0.97 + 0.027 + 0.00181}{0.6 \cdot 1.2} + \frac{(0.0091 + 0.02 - 0.0008)6}{0.6 \cdot 1.2^2}\frac{0{,}35}{1{,}2} = 0.25\,MPa$$

Bending moment at the face of the wall from the standard loads:

$$M = 1(1,2 - 0,35)^2 \frac{2 \cdot 0,214 + 0,25}{6} = 0,08 MH \cdot \text{м}$$

$$\text{n} = \frac{\dfrac{E_S}{E_B}}{} = 210000/27000 = 7.78$$

μ= 0.57 / 100·30 = 0.00019 = 0.019 %

$$\text{Wpl} = [0.292 + 0.75(\gamma_1 + 2\mu_1 \cdot n)]bh^2 =$$

[0.292+0.75(0+2·0.00019·7.78)]0.6·0.3 = 0.05 m^3

Find the value of the design tensile strength of concrete in the calculation of the second group of limiting states R_{btn} = l,6 MPa and determine the cracking moment of the foundation section:

$$M_{crc} = R_{bt,ser} \cdot W_{pl} = 1,6 \cdot 0,05 = 0,08 \ MN \ m.$$

We check if the condition is fulfilled:

$$M \leq M_{crc}$$

0,008= 0,08 MN m.

The condition is fulfilled, therefore, cracks in the foundation body do not arise.

5. Construction technology

5.1. Earthworks

Design and performance of excavation work is carried out with the use of a standard technological map of the complex mechanized process for excavation, and its binding to a given object with the specification of the scope of work. The excavated soil is removed from the construction site and used for backfilling or vertical leveling of newly built facilities. This complex mechanized process consists of preparatory and main operations.

The preparatory operations include:

- the construction of temporary roads for the transportation of soil;

- cutting the topsoil and turf layer;

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- leveling of the construction site;

- loading of the vegetative soil with an excavator into dump trucks and its transportation to a dumping site.

The main operations include:

- excavation of the excavation up to the design marks with an excavator and sweeping of the ground with a sweeper;

- transportation of the excavated soil by dump trucks beyond the construction site;

- manual excavation in areas with a large number of benches.

Cutting of the topsoil is performed using DZ-28 bulldozer on the basis of T-130.1.G-1 tractor after tying and dividing the site for the building with fixing points on the ground with wooden stakes or steel pins and proper leveling of the surface. The developed topsoil is loaded with an excavator EO-3322A with a backhoe and a 0.5 m^3 bucket in KamAZ-5511 dump-trucks and is taken out of the construction site to be used for landscaping. The thickness of the topsoil is 24 cm.

Planning provides for subsequent excavation of the site so as not to cause repeated digging and overburden.

At the underfilled sections of the planned area is carried out layer-by-layer compaction of the backfilled soil with a pneumatic wheeled roller type DU-31.

After the preparatory period, the breakdown of the main axes of the building and drawing up an executive diagram, an excavation must be made.

Due to the large volume of earthworks the excavation is excavated by EO-3322A backhoe with a 0.5 m3 bucket and loading the ground in dump trucks KamAZ-5511 with the carrying capacity of 10 tons.

The excavators are equipped with a stripping device which allows excavating the pit to the design marks with a slight deviation (up to 5 cm).

The technological process of reclamation by a scraper is as follows. From each work camp excavator works out the excavation in a usual way with

underdrawal of ground to the design mark at 15 - 20 cm. Stripping of the excavation foundation is performed by means of sharp cutting edge of the blade by removing the ground by layers of 5 - 10 cm in thickness.

Due to the complexity of the foundations' shape, on the excavation sections with a large number of ledges up to 1.2 m long one can excavate the foundation pit manually.

To control the depth of excavation, it is recommended to equip the excavator with an electron-hydrostatic depth gauge.

5.2. Technological map for the installation of the building frame and brickwork

Prefabricated reinforced concrete structures and parts shall be manufactured according to standard working drawings in accordance with the current DSTU, standards and catalogs. All reinforced concrete structures shall be released from the factories with the specified strength.

Before the start of installation of structures at each stage, it is necessary to:

- complete the installation of the precast elements of the floor below with the arrangement of permanent fasteners;

- make an executive diagram of the location of the elements of the erected structures and hand them over under the act;

- transfer the main breakdown axes to the floor;

- determine the mounting horizon.

Slinging of the elements shall provide their lifting and supplying to the place of installation in the position corresponding to the designed one. The slinging scheme shall be determined by the project.

Lifting of the elements shall be performed in two steps: firstly to the height of 20 - 30 cm (in this position the correctness of slinging, reliability of the grips, strength of mounting straps, etc. is checked), after that further lifting of the element is performed. Lifting and moving of the element should be done

smoothly, without jerking, swinging, rotating, pushing or striking against previously installed elements.

The element shall be led to the place of installation from the outside of the building, in this case the crane arm must not pass over the working place of the installers. Installation should be carried out in such a way that the furthest structures from the crane are installed first, and then all the rest in sequence.

Installation shall be performed on a layer of mortar. It is not permitted to place the mortar, which has already begun to set, into the joints. The elements, displaced from the mortar bed during the curing period, shall be cleaned from the stiffened mortar and reinstalled on the fresh mortar.

It is not allowed to release the installed element from the hook of the crane until it is securely fixed either temporarily or permanently. Installed elements may only be released from temporary fastenings after they have been permanently fastened. Before permanent fastenings are made, the correct position of the assembled structures and the embedded parts to be connected must be checked. Caulking of joints and joints of precast elements (including corrosion protection of steel embedded parts, caulking and sealing of joints) shall be made after checking the correct installation of structures, acceptance of welded and other types of connections between them.

Laying of floor panels

Before the start of work, all structures of the lower floors must be assembled and finally secured and the floor panels arranged in the crane area. The work is performed by a team consisting of three persons: the 5th category assembler - one, the 4th category assembler - one, the 2nd category assembler - one. Perform operations on laying the floor panels in the following order:

Cleaning the panel and checking its dimensions

The installer inspects the panel, checks the presence of embedded parts and the condition of mounting hinges. With light blows of the hammer chisel, he cleans the panel of concrete and dirt.

Preparation of Mortar Bed

The installer cleans the place of panel laying using a hammer-chisel, and the installer takes the mortar from the box with a shovel and makes a mortar bed, smoothing the mortar with a trowel.

Slinging and delivery of the panel to the place of laying

The erector takes the sling supplied by the crane driver, hooks it in turn for the mounting loops of the panel, and gives a command to the crane driver to tension the sling ties. After making sure that the slings are secure, the installer leaves at a safe distance, and the crane driver by his signal lifts and moves the panel to the place of laying.

Panel installation

The installers, while standing on the previously laid panel, receive the panel at a distance of 30 cm from the ceiling and orient it over the place of laying. The crane driver, at the signal of the erector, lowers the panel onto the mortar bed. The straps remain taut.

Alignment and unalignment of the panel

Installers level the correctness of the panel installation height, correcting noticed deviations by changing the thickness of the mortar bed. In case of displacement of the panel in the plan installers straighten it with crowbars. Then, at the command of the installer the crane driver loosens the tension of the sling and the installers unstring the panel.

Installing the staircases

Before the beginning of the work it is necessary to lay the staircases, as well as to check the working order of the mounting accessories. The work is performed by a team consisting of three people: 5th category installer - 1, 4th category installer - 1, rigger 2nd category - 1. Stairway laying operations shall be performed in the following order:

Preparing the supporting surface

Installers carry and lay out tools in convenient places for work. Then they clean off the accumulation of mortar and debris and moisten the support surfaces of the platforms with a sledgehammer, steel broom and broom.

Preparing the stairway for slinging

The rigger performs an external inspection of the staircase and checks the strength of the mounting hinges. If necessary, they are cleaned of dirt, rust, and concrete buildup with a steel brush and hammer.

Slinging the ladder and transporting it to the place of laying

The rigger slings the ladder, departs from it on 4-5 m and gives a command to the crane driver to raise the ladder by 20-30 cm. After ensuring that the slinging is secure he signals to the crane driver to transfer the ladder to the place of laying.

Making a bed of mortar

Installers arrange the bed from mortar, spreading it with shovels on the places where the march is laid and smoothing it out with trowels.

Receiving and laying of staircase

The crane driver at the command of the installer submits a flight of stairs to the place of laying. Installers accept it at distance of 20-30 cm from the bearing surfaces, unfold and lower it on the prepared bed from a mortar at first the bottom part of the march and then the top.

Alignment of a ladder march

Fitters with tensioned sling produce crowbar alignment of the march in plan, achieving a tight adjacency to the wall unit of the stairwell. Horizontality of the steps they check the level.

Unbuckling the staircase

At the installer's command the crane driver loosens the straps, and the installers de-string the staircase.

The limit deviations of the positions of the elements in the structures in acceptance with respect to the axes or reference marks must not exceed the values given in the table. No further construction and installation work shall be allowed until the certificate of acceptance of the erected structures of the entire structure or its individual parts is drawn up.

The masonry walls and prefabricated elements shall be installed in segments. The bricklaying of the walls shall be performed by a bricklaying crew.

The following preparatory work shall be carried out prior to the start of bricklaying

- Construction materials, inventory devices and tools shall be delivered and stored;

- access roads, temporary roads and storage areas shall be arranged;

- all zero cycle erection works shall be completed.

Bricklaying with the use of a standard kit is carried out by "two" and "three" units.

Work in the "two-man" unit is distributed as follows. The leading mason of the 4th grade stretches and rearranges the mooring, performs masonry yard rows, checks the laid masonry and partially puts brush. Bricklayer 3-th category helps the leading bricklayer to install the mooring, delivers bricks and mortar on the wall, and in his spare time helps to conduct masonry bond. After completing masonry first layer on the first seating crew masons go to the second seating, and installers on the first seating. This is the sequence of work involved in the construction of all the floors in a building. The laying of the partitions is performed by the "two-person" team simultaneously on the whole section. While the Grade 3 bricklayer on one of the partitions prepares mortar, the Grade 4 bricklayer on the other partition arranges bricks. The masons then swap places and continue laying the partitions in the same sequence. Link "two" performs the same masonry walls.

In the link "three" mason of the 4th grade lays out yard rows and checks the correctness of masonry. During masonry, he moves along the front of work after the mason of the 2nd category, which feeds and lays bricks, feeds and spreads mortar. The stonemason of the 3rd category lays out the brickwork. Masonry inner and outer quoins are performed in the same order, but carried out

in opposite directions. A mason of the 4th grade with a stonemason of the 3rd grade moves the pier.

The main characteristics of bricks:

- type - ordinary clay plastic pressing;

- dimensions: 250 x 120 x 65 mm;

- brick grade: 75-150;

- volume weight - 1600-1900 kg/m^3.

The composition of the cement-lime mortar brand 75 by volume:

- cement (grade 600) - 1;

- lime mortar - 0.4;

- sand - 4.5.

Table 5.1. Standard kit for a complete masonry team of 24 people

Name of the mechanism, tool, fixture.	Unit	Number	Service life, months
The unit for the reception of commercial mortar	pcs.	1	36
Dural rule 2-meter	pcs.	6	12
Trowel	pcs.	24	6
Fork gripper for bricks	pcs.	1	24
Water tank	pcs.	1	24
Articulated panel scaffolds	pcs.	16	24
Fixture for mounting staircases	pcs.	2	36
Suspension beam holder	pcs.	16	24
Scaffold for gypsum concrete partitions	pcs.	40	24

Pyramids	pcs.	6	36
Traverse with lifting capacity of 4 tons	pcs.	1	12
Paving grid for masonry	pcs.	8	12
Wrapping	pcs.	20	12
600 g plummet	pcs.	5	36
Mortar shovel	pcs.	12	6
Assembly scrap	pcs.	2	24
Scrap iron	pcs.	2	24
Sledgehammer weight 2 kg.	pcs.	2	36
Metal meter	pcs.	3	12
Tape measure PC-20	pcs.	2	24
Construction level	pcs.	2	24
Carpenter's axe	pcs.	2	24
Plummet 1000 g	pcs.	5	36
Hacksaw	pcs.	2	24

Acceptance of the work performed on the erection of masonry structures shall be performed prior to plastering their surfaces.

Intermediate acceptance with the registration of the acts on the hidden works shall be subject to the following completed works and completed structural elements:

- foundation grounds, foundation depth, foundation dimensions and the quality of their masonry;

- masonry waterproofing;

- reinforcement laid in masonry structures, steel embedded parts and their corrosion protection;

- anchoring of purlins, beams, slabs on walls and columns, and compliance with the project of their embedding in the masonry;

- fastening of cornices;

- partitioning work and deviations, and other hidden works.

Acts of hidden work shall be made by representatives of the construction company and technical supervision. The acceptance of masonry structures shall be accompanied by the works log.

When accepting the completed work on the construction of masonry structures, the following shall be checked:

- correctness of the dressing, thickness and filling of joints, as well as horizontal rows and verticality of the corners of masonry;

- correctness of the installation of smoke and ventilation ducts in the walls;

- availability and correctness of the embedded parts installation - bonds, anchors, etc.;

- the quality of the surfaces of the facade walls made of bricks without plastering; compliance with the color, the required dressing, pattern and joints;

quality of the facade surfaces clad with ceramic, concrete and other types of stones and slabs.

When accepting masonry structures performed in seismic areas, intermediate acceptance with drawing up acts on hidden work shall be subject to the performed work on the device

- the reinforcement belt at the level of the foundation top;

- on-floor anti-seismic belts;

- anchoring of thin walls and partitions to the permanent walls, framing and floor slabs

- reinforcing masonry walls with inclusions of monolithic and prefabricated reinforced concrete elements in the masonry;

- anchoring the elements protruding above the attic floor;

- anti-seismic joints, as well as other types of anti-seismic reinforcement of masonry structures, provided by the project and hidden in the process of work.

The quality of materials, semi-finished products and factory-made products used in masonry structures shall be established by certificates and passports of manufacturers, as well as by data of control laboratory tests performed by construction companies.

Table 5.2. Maximum allowable deviations in masonry

Permissible deviations	Deviation value, mm
1. Deviations from the design dimensions:	
a) по толщине	+8
b) according to the cutoff and floor marks	10
c) across the width of the partitions	-10
d) in the width of the openings	+10
e) on the offset of the axes of adjacent window openings	15
f) on offsets of structural axes	8
2. Deviations of surfaces and corners of masonry from the vertical:	
a) for one floor	8
b) for the whole building	20
3. Deviations of masonry rows from the horizontal:	
a) per 10 m wall length	10
4. Irregularities on the vertical surface of the masonry, when laying 2 m rail:	
a) plastered	8
b) unplastered	5

5.3. Subject warehouses and temporary roads

The construction site is free of buildings and structures, hence there will be no cost for their demolition. The construction site is located in a residential area with existing access roads and communications. In the process of preparing the site for construction work it will only be necessary to connect the water supply from existing networks.

At the construction site organized warehouses for storing construction materials. They consist of:

- outdoor warehouses designed to store mass construction materials, parts and structures (sand, crushed stone, precast concrete structures), which are not spoiled by atmospheric precipitation;

- half-closed warehouses (sheds) for materials that require protection from direct sun and precipitation (wooden products, joinery, roofing materials, tarpaulin, roofing felt, etc.);

- closed warehouses for storage of expensive and perishable materials in the open air (cement, lime, dye, gypsum, nails, work clothes, etc.).

Areas of outdoor warehouses are calculated in detail, on the basis of actual sizes of the stored materials of the normative specific load on the base of the warehouse with the observance of safety rules. Also, at the design of warehouses calculated standards of warehousing per 1 m2 of storage area with regard to passages and passageways are used. Squares of storage have a slope of 2-5o for drainage. Binding of the warehouse is carried out along temporary roads.

The area of purchased warehouses calculates on the basis of a three-day stock of materials.

Stocking rate for:

- bricks, crushed stone, sand, slag, precast concrete, insulation, for road transport distances up to 24 km - 5-10 days;

- cement, lime, glass, roll materials, window and door units, steel structures - 8-10 days.

For the construction use constructed and temporary roads, which are placed depending on the adopted scheme of motor traffic. Roads on the site - natural ground.

Table 5.1. Temporary roads

Name	Indicator, m
1. Width:	
lanes	3,5
roadways	3,5
2. The smallest radius of curves in the plan	12,0
road and storage area;	1,0
road and craneway;	2,5
road and site fencing.	1,5

5.4. Safety measures of basic technological processes

Before starting work in conditions of occupational risk, it is necessary to identify hazardous areas for people, in which hazardous factors associated or not associated with the nature of work are or may be in constant operation.

Areas of permanent occupational hazards include:

- locations in the vicinity of uninsulated live parts of electrical installations;

- locations in the vicinity of unfenced drops of 1.3 m or more in height;

- places, where the maximum permissible concentrations of harmful substances in the air of the working area may be exceeded.

Areas of potentially hazardous production factors shall include:

- areas in the vicinity of the building (structure) under construction;

- areas of movement of machines, equipment or their parts, working

bodies;

- areas above which cargo is moved by cranes.

Places of temporary or permanent location of workers shall be located outside the hazardous areas.

At the boundaries of zones of permanent hazardous production factors, protective fencing shall be installed, and the zones of potentially hazardous production factors - signal fencing and safety signs.

Production areas and areas of work in settlements or on the territory of the organization must be fenced to prevent access by unauthorized persons.

The design of protective fencing shall meet the following requirements:

- the height of fencing of the production areas shall be not less than 1.6 m, and the height of fencing of the work areas shall be not less than 1.2;

- fences adjacent to places of mass passage of people must be at least 2 m high and be equipped with a continuous protective canopy;

- the visor must be able to withstand the action of the snow load and load from falling single small objects;

- fences must have no openings, except for gates and wickets, controlled during working hours and locked after its completion.

The places of passage of people within the hazardous areas must have protective fencing. Entrances to buildings (structures) under construction shall be protected from above by a canopy at least 2 m wide from the wall of the building. The angle formed between the canopy and the wall above the entrance shall be 70-75°.

When carrying out work in enclosed areas, at height, underground, measures shall be provided to enable evacuation of people in case of fire or accident.

At the entrance to the production area it is necessary to install a scheme of roads and driveways within the construction site with indication of places of storage of materials and structures, places of turning of vehicles, fire water supply facilities, etc.

In the production areas, work sites and workplaces, workers shall be provided with potable water, the quality of which shall comply with sanitary requirements.

Construction sites, work areas and workplaces, passageways and approaches to them shall be illuminated in accordance with the requirements of state standards at night. Lighting of enclosed spaces shall comply with the requirements of building codes and regulations.

Lighting shall be uniform, without the glare effect of lighting fixtures on workers. No work in unlit places is allowed.

Workplaces and passages to them, located on the floors, coatings at a height of more than 1.3 m and a distance of less than 2 m from the boundary of the height difference shall be protected by protective or safety fences, and at a distance of more than 2 m - by warning fences.

The aisles at the working places and to the working places shall meet the following requirements:

the width of the single passages to the working places and to the working places shall be not less than 0.6 m, and the height of such passages in light - not less than 1.8 m;

When performing work at heights, hazardous areas shall be provided below the work site

For the passage of the workers who perform work on the roof with a slope of 20°, as well as on the roof cover, not designed for loads from the weight of workers, it is necessary to arrange ramps of at least 0.3 m wide with cross bars for feet support. Gangways must be secured for the duration of work.

Storage sites must be protected from surface water. It is prohibited to store materials, products on the bulk unconsolidated soils.

Materials, products, structures and equipment when stored at the construction site and work sites shall be stacked as follows:

- bricks in packages on pallets - in no more than two tiers, in containers - in one tier, without containers - not more than 1.7 m high

- floor slabs - in a stack no higher than 2.5 m on pads and with gaskets;

- cross girders - in a stack up to 2 m high on pads and with spacers;

- timber - in a stack the height of which during normal stacking shall not exceed half the stack width, and during stacking in cages - not more than the stack width;

- small-grade metal - in a stack no higher than 1.5 meters;

- glass in boxes and rolls - vertically in 1 row on a pallet;

- pipes with a diameter of up to 300 mm - in a stack up to 3 m high on pads and with gaskets with end stops;

Between the stacks (racks) in warehouses should be provided aisles of width of at least 1 m and driveways, the width of which depends on the dimensions of vehicles and loading/unloading mechanisms serving the warehouse.

It is not allowed to lean (lean) materials and products against fences, trees and elements of temporary and permanent structures.

Wiring of temporary power grids with a voltage of up to 1000 V used for power supply to construction facilities shall be made with insulated wires or cables on supports or structures designed for mechanical strength when wires and cables are laid on them, at a height above ground level, decking of not less than, m:

- 3.5 - above passageways;

- 6.0 - above the passages;

- 2.5 - above the workplace.

General lighting fixtures with a voltage of 127 V and 220 V shall be installed at a height of at least 2.5 m from the ground, floor and decking.

Switches, circuit breakers and other electrical switching devices used outdoors or in wet shops shall be protected.

All electrical starting devices shall be placed so as to exclude the possibility of starting machines, mechanisms and equipment by unauthorized persons. It is prohibited to switch on several current collectors with one starting

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device.

Switchboards and circuit breakers shall have locking devices.

When placing mobile machines in the production area, the work manager must determine the working area of the machine and the boundaries of the danger zone created by it before starting work. This must ensure that the working area as well as the working areas are visible from the operator's position. In cases where the operator of the machine does not have sufficient visibility, he must be assigned a signaler.

All persons connected with the machine must be made aware of the significance of the signals during its operation and travel. Dangerous areas, which arise or may arise during operation of the machine, must be marked with safety signs and (or) warning notices.

When placing and operating machinery, vehicles, measures must be taken to prevent them from toppling or spontaneous movement under the action of wind, slope or ground subsidence.

When operating machines with moving tools, it is necessary to prevent access of people to the danger zone, the boundary of which is at least 5 m from the limit position of the tool, if the manufacturer's instructions do not contain any other increased requirements.

Instruction on fire safety

The construction manager shall be personally responsible for fire safety, timely implementation of fire protection measures, organization of fire guards, provision of fire extinguishing equipment, organization and work of voluntary fire brigades.

Persons responsible for fire safety shall:

2.1 Establish the smoking, firing and other fire hazardous works regime, the procedure for cleaning, removing and disposing of combustible waste.

2.2 To acquaint the employees with the fire safety of each type of work, as well as substances, materials, structures and equipment used at the enterprise.

Linear engineering and technical personnel responsible for fire safety

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shall:

3.1 Ensure that all workers, employees and persons involved in the construction site comply with the established fire safety regulations in the entrusted areas of work;

3.2 Carry out the fire prevention measures provided by the rules in a timely and qualitative manner. 3.3.

3.3 To check the fire safety condition of the work places every day at the end of work. The detected and eliminated defects shall be registered in a special log. Not to allow the presence of workers, employees and other persons who have finished work, in the household and auxiliary rooms in the evening and at night.

3.4 Persons guilty of violating the fire safety rules and requirements shall be liable in accordance with the labor, administrative, criminal or civil law depending on the nature of the violations and consequences. 4.

4. The work places shall be kept clean at all times, and the waste shall be removed daily from the places of work to specially designated places. 5.

5. It is forbidden to make bonfires on the territory. 6.

6. It shall be prohibited to store flammable liquids in open containers. Flammable liquids shall be poured or dispensed only into hermetically sealed metal containers with pumps, through a copper mesh. Do not pour liquids with buckets or with a siphon.

7. Fire containers from - under flammable liquids should be stored on a specially designated area remote from the places of operation of the nearest buildings by at least 30 meters.

8. Premises and working areas where work is performed with combustible substances emitting explosive vapors shall be equipped with natural or forced inflowing and exhaust ventilation.

9. Only the persons trained according to the Fire Safety Minimum program and instructed in fire safety measures before starting work are allowed to work with combustible substances and materials.

10. Fire points shall be set up in the most fire-hazardous areas, at large amounts of welding work, as well as during work at heights.

11. After welding and other hot work, the person responsible for these jobs shall remove gas cylinders from the workshop to specially allotted places, and switch off the electric and gas welding equipment.

12. When operating electrical installations shall be prohibited:

- to use cables and wires with damaged or lost protective properties of the insulation;

- use non-standard heating devices for heating and drying;

- leaving isolated ends of electric wires and cables energized;

- allow electrical wires to come into contact with metal structures

- leave live electrical appliances and electrical equipment unattended;

- use defective sockets, light boxes and switches;

- tie up and twist electric wires, as well as pull wires and light fixtures on electric wires

- use rollers, switches, plug sockets to hang clothing and other objects;

- wrapping electric lamps in paper or other combustible materials;

- use radio and telephone wires for electrical networks;

- use uncalibrated fuses or homemade fuses as electrical protection, or disconnect electrical protection devices.

13. Lighting projectors on the territory of the construction site should be installed, as a rule, on separate poles. It is prohibited to install on roofs made of combustible materials and on buildings with polymer insulation in the enclosing structures.

14. The following fire safety requirements must be observed during the construction and installation of temporary metal stoves: the height of the legs of metal furnaces without linings shall be not less than 0,2 m. Floors made of combustible materials under the stoves must be insulated with one row of bricks laid flat on the clay mortar, or asbestos cardboard 12 thick covered with roofing steel. Metal furnaces shall be installed at a distance of not less than 1m from

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constructions made of combustible materials and not less than 0.7m from constructions protected from fire; when installing metal stoves without legs or temporary brick stoves on a wooden floor, the floor under the stove must be made of four rows of bricks laid flat on clay mortar, and the two lower rows of brickwork may be made with cavities. In front of the firebox there should be nailed to the floor a sheet of roofing steel 0,7x0,5 m in size or a brick floor of the same size in one row on the mortar. Metal chimneys shall not be laid through ceilings made of combustible or hardly combustible materials. When a metal chimney is led out through a window, a substitute sheet of roofing iron of at least 3 diameters of the chimney should be inserted in the chimney through the window. The end of the chimney shall be led behind the wall by at least 0.7 m and finished with an upward-directed branch pipe of at least 0.5 m in height.

15. It is prohibited to store fuel near the ceiling openings of the oven.

16. The furnaces shall be heated under the constant supervision of the stoker.

17. It is forbidden to kindle furnaces with kerosene, gasoline and other flammable liquids, to use firewood longer than the size of the fuel box, to heat furnaces with open doors, to heat coal, coke or gas furnaces not adapted for this purpose.

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