-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
____________O.I. Lapenko
“_____” _____________ 2022

BACHELOR THESIS

(EXPLANATORY NOTE)

SPECIALTY 192 «BUILDING AND CIVIL ENGINEERING»

Educational and professional program: «Industrial and civil engineering»

Theme: Individual residential building in Kyiv

Performed by: student FACD group 406, Tarasenko Ania Mykolayivna

Thesis Advisor: associate professor Kostyra Natalia Oleksandrivna

Design rule check:_______________________________________O. Rodchenko

Kyiv 2022

NATIONAL AVIATION UNIVERSITY

Faculty of Architecture, Construction and Design

Department of Computer Technologies of Airport Construction and Reconstruction

Specialty: 192 "Construction and Civil Engineering"

Educational and professional program: "Industrial and Civil Engineering"

APPROVE

Head of Department

____________O.I. Lapenko

“_____” _____________ 2022

TASKS

for the implementation of diploma work

Tarasenko Ania Mykolayivna

1. Topic of work «Individual residential building in Kyiv» approved by the order of the rector from «__» _____________ 2022 y. №_______.

2. Term of work: from з __ _________ 2022 y. to __ _________ 2022 y.

3. Initial work data:

- Type of building: Two-storey individual residential building;
- City of construction: Kyiv
- Loading according to DBN "Loads and impacts"
- 1st climatic region according to DSTU-N B B.1.1-27: 2010 "CONSTRUCTION CLIMATOLOGY".

4. The content of the explanatory note: analitical rewiew, architectural part, structural part, bases and foundation.

5. List of required illustrative material: tables, figures, diagrams, graphs.

6. Calendar plan-graph

№	Tasks	Deadline	Head's signature
1.	Analytical review	20.05.2022	
2.	Architectural part	20.05.2022	
3.	Structural part	31.05.2022	
4.	Bases and foundation	09.06.2022	
5.	Calendar plan-graph of execution of Diploma	31.05.22	
6.	Making an explanatory note	09.06.2022	

7. Date of issue of the task:

Head of diploma work:_________________________________ Kostyra N.O.

The task was accepted:_________________________________Tarasenko A.M.

CONTENT

Introduction

The subject of my diploma project «Individual residential building in Kyiv».

Creating a house of this type is relevant to show new methods of design solutions, e.g. green roofing, the great advantage of which is the reduction of precipitation coming to the sewer systems, as well as the protection of the waterproofing membrane.

Vegetation helps to neutralize the harmful effects of sunlight and rain on the waterproofing membrane, which protects it and increases its service life.
And it is also important to focus on the topic of heating houses.
At the moment, our country refused to supply gas from the aggressor country, so to save this fossil fuel, it is better to design a warm floor that requires much less gas, and also retains heat in the room for much longer.
The roof is made of non-combustible materials, guarantees fire resistance and prevents the spread of fire, and does not emit any harmful or hazardous substances when heated and exposed to flames, which is a timely advantage against getting combustible particles from guns and missiles at this time of war.

CHAPTER 1

ANALITICAL REVIEW

1. Analytical review

Residential buildings are designed for permanent or temporary living of people with the provision of human needs. Functional processes implemented in housing cover various aspects of human life and social activity: life, rest, sleep, cooking and eating, hygiene, family communication, education, self-education, leisure, etc.

Individual residential buildings in the State classifier of buildings and Constructions DK 018-2000 are considered in the section "Houses residential" and divided into groups: single-family houses (group 111) and two or more apartments (group 112).

Single-family buildings (group 111, class 1110) include detached residential buildings of manor type (urban, out-of-town, rural), villas, cottages, houses for forestry personnel, summer houses for temporary accommodation, garden houses, as well as - twined or blocked houses with separate apartments that have their own entrance from the street.

The class of single-family buildings (1110) is divided into subclasses:

- 1110.1 Single-apartment buildings of mass construction;

- 1110.2 Cottages and single-apartment houses of increased comfort;

- 1110.3 Houses of manor type;

- 1110.4 Cottages and garden houses.

Class of houses with two or more apartments (group 112) includes houses with two apartments (subclass 1121) and houses with three or more apartments (subclass 1122).

The class of houses with two apartments (subclass 1121) covers separated, twined or interlocked houses with two apartments and is divided into:

- 1121.1 Two-apartment buildings of mass construction;

- 1121.2 Cottages and two-apartment houses of increased comfort.

Class of houses with three or more apartments (1122), includes in particular:

- 1122.1 Multi-apartment buildings of mass construction;

- 1122.2 Apartment buildings of increased comfort, individual.

In addition, residential buildings include dormitories (1130.1-1130.3), boarding schools (1130.4, 1130.5), shelters (1130.6) - and other houses for collective residence (1130.9). The main classification feature of housing is the type of communication residential cell with a plot. On this basis, distinguish between manor and multi-storey residential buildings. Individual residential buildings correspond to the concept homestead. Modern architectural typology divides homesteads by number of apartments on single-apartment and apartment (Fig.1.1).

Manor houses

Single-apartment **Apartment**

Two-apartment

Four apartment

Blocked Row

Cober

Terrace

Fig.1.1. Classification of manor houses by the number of apartments

Single-family residential buildings are designed for single-family settlement and are located separately on the site. Apartment manor houses consist of several blocked residential cells of single-family settlement . According to the type of blocking, they are divided into: two-apartment (twin, pair-block), blocked (linear, etc.), four-apartment, cobblestone and terrace (Fig.1.2).

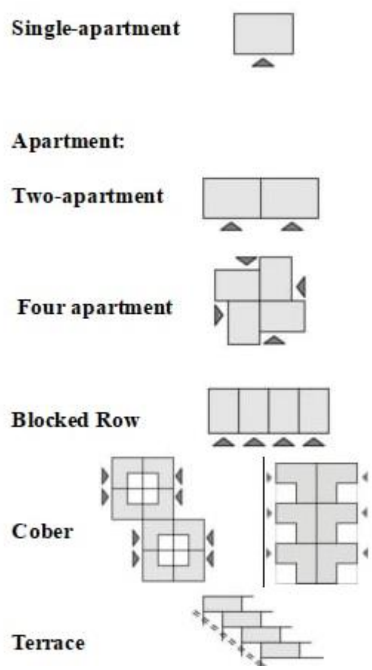


Fig. 1.2. Schemes of blocking residential houses

Two-apartment buildings are blocked on one common side, row blocked - one common side for end blocks and two common sides for row blocks, four-apartment buildings - two. A feature of coaster houses is the blocking of two or three sides between each other and the formation of an inner courtyard of 30-60 m^2, which can be designed for each cell separately, or combined for several blocked houses.

Terrace houses are designed for construction on the terrace. Terrace type building allows you to block residential buildings both horizontally and vertically. For horizontal locking, you can use the above solutions, and vertical locking makes it possible to implement the functions of the infield due to the device of the terrace.

Various blocking solutions allow to achieve a high density of development while maintaining the comfort of living. Individual buildings are 1-2 storeys, sometimes - 3 storeys. According to the volume-planning structure, individual residential buildings are designed as one level (1 storey) and in several levels: 2 or more storey; with level drops. According to the specifics of the use of internal space, mansard and attic houses are distinguished. In the basement and basement floors of the house arrange premises for economic purposes.

Separately located individual houses allow you to apply effective volume and planning solutions that contribute to increasing energy efficiency. At the same time, such houses usually have worse compactness than blocked houses. Also, separately located individual residential buildings are characterized by a more variable location on the site, there are more opportunities for the organization of the site to create a favorable microclimate landscape means and the location of technological equipment for the use of alternative energy sources.

The improvement of energy efficiency contributes to the blocking of buildings, due to the improvement of their compactness and reduction of heat loss due to external fencing structures.

The most favorable types of houses in terms of energy saving - blocked, among which the most common are two-apartment and row. Blocked four-apartment and coaster houses are options for dense building, are compact, but have disadvantages - limiting the orientation of individual apartments, deterioration of visual comfort, etc.

Terrace blocked houses are an effective means of creating dense buildings in complex terrain. To accommodate energy-efficient terrace houses, the orientation of the sloping surface of the plot to the south is necessary. The terrace houses provides for the use of flat roofs of apartments, located below the terrace, using the technology of the operation of the roof.

Thus, housing design taking into account the features of the type of house plays an important role in achieving significant energy efficiency indicators, since the type of volume-planning solution significantly affects its energy efficiency.

Classification by quantitative indicators of energy used

Functional, volumetric-planning, design and technological characteristics of the designed building are complex related to its energy efficiency. In the world practice, a number of definitions of the characteristics of buildings have been formed depending on the amount of energy used in it:

- "House with low energy" -year heat consumption up to 70 kW hour/m^2;

- Zero net energy (ZNE) building, net-zero energy building (NZEB), net zero building (NZB) - a house with zero energy balance during the year, which can be achieved by seasonal accumulation and redistribution of energy by various architectural, constructive and engineering methods. The zero annual balance during the year is determined by calculating the amount of energy received and spent, or CO2 emissions, or the cost of energy received and used;

- "The house is energy autonomous" - in which energy needs are ensured throughout the year by energy obtained and accumulated in it through the use of volume planning solutions and the use of engineering equipment. Such houses do not provide connection to external power supply networks, that is, its energy autonomy is achieved;

- "House of plus energy" - a house in which energy is obtained more than the building needs during the year. For this purpose, a complex of engineering equipment can be used, in particular, solar collectors, heat pumps, wind turbines, etc.

In the international practice of construction and operation of energy-efficient buildings, there is an opportunity to evaluate energy efficiency in combination with a general environmental assessment. Several standards and certification systems (Fig.1.3) are used for this and different countries of the world: BREEAM, LEED, HQE, DGNB and others.

BREEAM	Building Research Establishment Environmental Assessment method	
LEED -	Leadership in Energy and Environmental Design	
HQE	Haute Qualité Environnementale (High Quality Environmental standard)	
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen”	

Fig. 1.3. Signs of environmental certification systems

BREEAM (engl.Building Research Establishment Environmental Assessment Method) is a method of ecological certification of houses. Developed by the British company BRE Global, BREEAM determines standards for sustainable design and construction, as well as makes it possible to compare different buildings by their environmental impact. BREEAM is believed to be distinguished by stricter evaluation criteria; BREEAM is easier to adapt to local features.

LEED (engl. The Leadership in Energy&Environmental Design). Guide in energy and environmental design is the rating system of certification of "Green buildings" (Green building). This system is developed by the American Council on Green Houses (eco-houses) - United States Green Building Council (USGBC) as a building standard for determining energy efficiency and environmental friendliness of projects and buildings .

HQE - (Haute Qualité Environnementale), High Quality Environmental Standard - ecological certification system in France. The system determines the impact on the environment through the assessment of the harmony of the relationship of the house to the environment, the integrated choice of building materials and technologies, the prevention of inconvenience during construction, minimizing energy, water, reducing the amount of garbage, reducing the needs for maintenance and repair of the house. At the same time, the quality of the premises microclimate is evaluated: temperature and humidity comfort, acoustic and visual comfort, air and water quality.

DGNB - (Deutsche Gesellschaft für Nachhaltiges Bauen) is a German system of ecological certification of houses with a thorough assessment of more than 50 factors that cover environmental, economic indicators, socio-cultural aspects, technological and functional processes. The quality level is determined by the estimates of Gold (Gold), Silber (Silver) and Bronze (Bronze) .

Energy certification or certification is also used to determine and fix energy costs in the house. In European countries, the energy certificate is a necessary document for the maintenance of the house as a real estate object and a mandatory part of the project documentation for new construction. DBN has been B.2.6-31:2016 in Ukraine since 2017 "THERMAL INSULATION OF BUILDINGS" regulates the determination of the energy efficiency indicator of the house and the procedure for drawing up an energy passport .

Classification by type of use of alternative and renewable energy sources

Classification of energy-efficient houses is adopted in accordance with the types of alternative energy sources used in them. Alternative energy sources are renewable energy sources, which include solar, wind, geothermal, wave and tidal energy, hydropower, biomass energy, gas from organic waste, sewerage gas wastewater treatment plants, biogas, and secondary energy resources, which include blast and coke oven gases, methane degassing gas of coal deposits, transformation of discharge energy potential of technological processes. Accordingly, by the type of renewable energy that used in the house, they can be classified into:

- helioenergoactive;

- wind energy-active;

- energy active using low-voltage thermal hydro- and geothermal energy;

- bioenergy.

According to the degree of replacement in the energy balance of the house with energy from alternative energy sources from non-renewable sources, the houses differ:

- low energy activity - replacement up to 10%;

- average energy activity - from 10 - 60%;

- high energy activity - 60 -100%;

- energetically autonomous houses 100%;

- excessive energy activity > 100%.

Buildings of low energy activity include houses of outdated housing stock.

Houses of medium energy activity are modern residential buildings with separate solutions for active and passive use of solar or other types of alternative energy sources.

Houses of high energy activity include houses in which the use of different types of alternative energy sources plays a significant role in energy supply. In energetically autonomous houses, energy is fully supplied by energy from alternative sources (for example, solar irradiation energy, wind power, etc.). Houses of excess energy activity, thanks to the maximum use of alternative and renewable energy sources, produce more energy than they need for their functioning.

To determine the feasibility of using alternative sources, it is necessary to know the nature of the resource and its technical economic potential.

Solar energy

The Sun's energy is one of the most important sources of energy on Earth. Solar energy can be converted into mechanical, electrical and thermal energy, affecting chemical processes and physical phenomena.

Solar installations (solar collectors thermal, photovoltaic) are widely used in heating and cooling systems of buildings, hot water, power supply. Solar collector systems are effective throughout Ukraine, but maximum efficiency is observed when using them in the southern and eastern regions. It is known that the average annual amount of total energy of solar radiation, which arrives annually on the territory of Ukraine, is from 1070 kWhour/m^2 in the northern part of Ukraine and more than 1400 kWhour/m2 and above in the Crimea. Regions with the greatest potential of solar energy in Ukraine are Odessa, Kherson, Donetsk, Mykolaiv, Zakarpattya, and Crimea (Fig.1.4, 1.5).

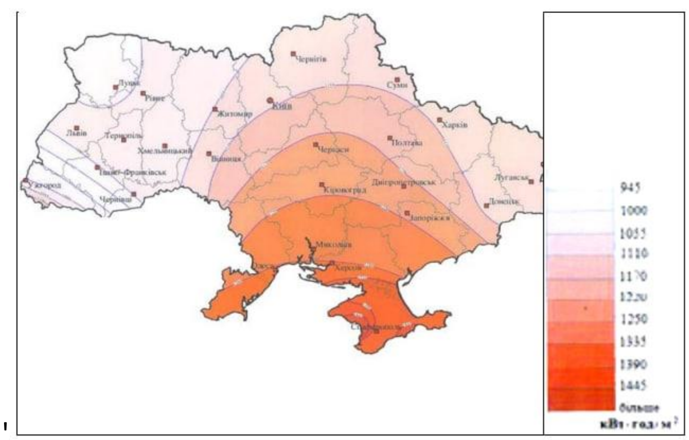


Fig.1.4. Distribution of specific solar radiation in Ukraine during the year

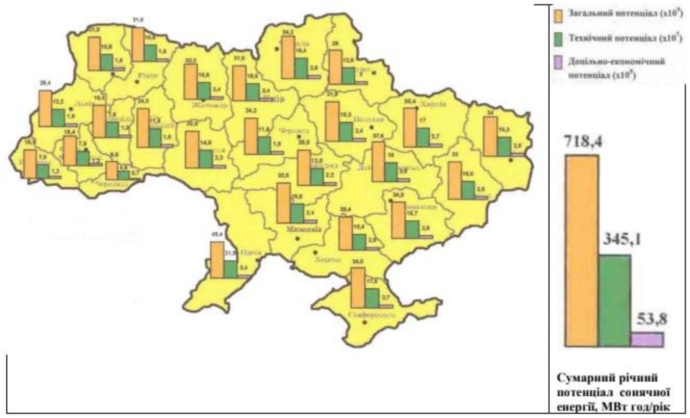


Fig.1.5. Potential of solar radiation in Ukraine

Wind power

The kinetic energy of the wind generated by moving air can be converted into other forms of energy - in particular, mechanical or electrical. The most common modern installations for obtaining such energy are wind turbines. According to the research of the Institute of Renewable Energy of the National Academy of Sciences of Ukraine, the greatest potential for the use of wind energy in the territory of Ukraine is observed in Odessa, Kherson, Donetsk, Transcarpathian region, as well as in the Crimea (Fig.1.6).

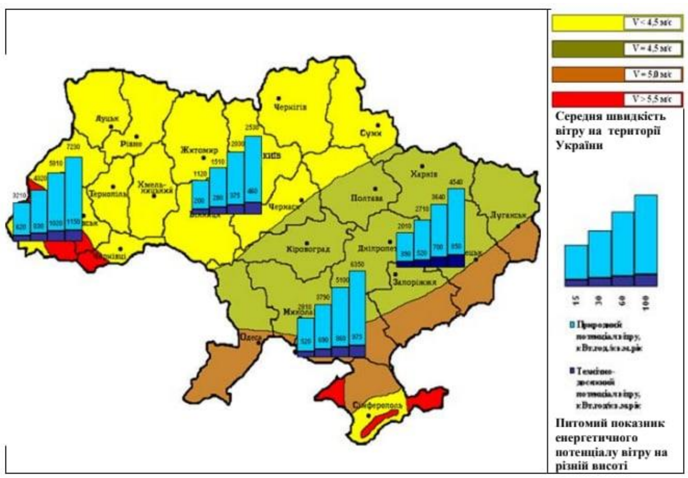


Fig.1.6. Potential of wind energy in Ukraine

Geothermal energy

Geothermal energy is used as subsoil heat, hydrothermal water, steam and hydrothermal sources, which are the result of energy flow from the Earth's core. Energy from geothermal sources is used to obtain heat or to transform geothermal thermal and electric power stations into electricity. Chernihiv, Poltava, Kharkiv, Luhansk and Sumy regions have the potential to use geothermal energy in Ukraine. The estimated economic and expedient energy potential of the use of thermal waters of Ukraine is up to 8.4 million tons/year (Fig.1.7).

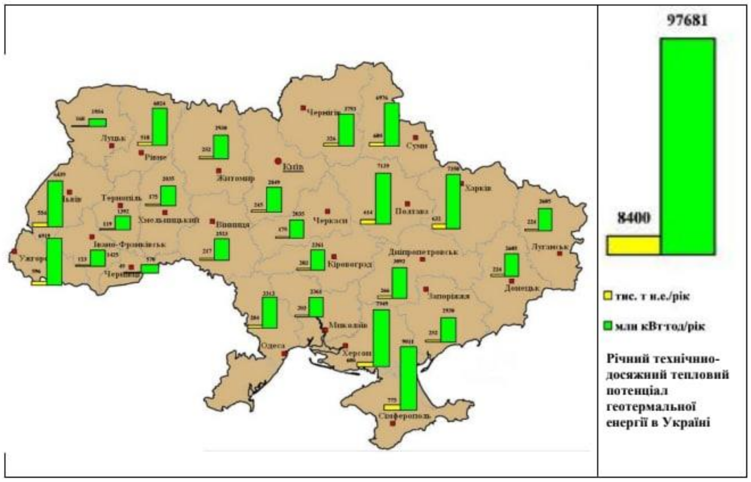


Fig.1.7. Potential of geothermal energy in Ukraine

Low-voltage thermal energy.

The source of low-voltage thermal energy is the environment, it is the soil, sea, lake and river water, groundwater that can accumulate the heat of solar radiation; warm external and exhaust air; recycled industrial heat; heat from drainage networks. On the territory of Ukraine, it is possible to obtain the amount of energy equivalent to 12.6 million tons o.e. (OE - oil equivalent) (tabl.1,1.2) through the use of low-voltage energy. A device that allows you to obtain energy from low-voltage sources is a heat pump, which is recommended to be used in combination with other engineering devices using alternative and renewable sources.

For example, I will take Kyiv and Chernihivska regions.

Table 1.1.

Energy potential of the upper soil layer in Ukraine

#	Regions	Technically achievable thermal potential of the upper layer of soil (thousand tons o.e/year)
1	Kyiv	700
2	Chernihivska	119
TOTAL		819

Table 1.2.

Energy potential of air in Ukraine

#	Regions	Technically achievable air thermal potential (thousand tons o.e/year)
1	Kyiv	861
2	Chernihivska	112
TOTAL		973

Bioenergy involves obtaining energy from biomass - a renewable substance of biological origin. The most common way to process biomass is to produce biogas. Biogas is obtained from organic raw materials using complex processes of biological decomposition of organic substances in anaerobic conditions (without air access) under the influence of a special group of bacteria. As a result of this process, biogas and fertilizers are formed. The process is carried out in special bioreactors methanthenes, biogas in gas holders is stored. Biogas production is associated with the processing and recycling of livestock waste, poultry, crop production, food, alcohol industry, municipal waste.

According to the State Agency for Energy Efficiency and Energy Saving of Ukraine, the annual potential of biogas in Ukraine is 3.2 billion cubic meters and its use is promising throughout Ukraine. The use of biogas makes it possible to obtain thermal and electrical energy, which is used for energy supply of housing and other needs. The type of energy that is provided to be used in the house affects the choice of its location, the use of volume-planning, design solutions using the appropriate engineering equipment.

Classification using specific volumetric planning solutions

In the practice of designing energy-efficient houses, directions have been formed that combine the characteristics of environmental friendliness and energy efficiency, at the same time various solutions for improving energy efficiency are used. By characteristic features, they can be distributed by volume-planning solutions, according to the applied technologies of erection and operation. According to planning solutions, they can be divided into "solar," recessed and atrial houses.

"Solar" house is a house in which solar energy is used to provide energy.

Recessed house - using the reception of partial depth into the soil, which plays the role of a massive accumulator of thermal energy of solar irradiation.

Atrium house - using atrium space to improve energy efficiency of the house (as a climate buffer between the external and internal environments, as a system of passive solar heating, etc.).

According to the technologies used in the construction and operation can be determined:

- mobile (dynamic, transformative) - houses that can be moved to another place, which can change their position in space, orientation on the sides of the world, have moving elements (tracking solar collector, sun protection systems);

- high-tech (high tech building, advanced building) - houses using modern advanced technologies, energy-efficient building materials and structures, high degree of their unification, automated service processes;

- "smart" (smart building, intellectual building) - buildings, whose life is provided by a system of designed control and control devices connected to a single network. The software allows you to analyze data, program microclimate indicators, dynamically respond to changes in the environment, which in general allows you to optimize the operation of the house and improve its energy efficiency.

Separately, it should be noted the types of buildings that were formed on the basis of new approaches to design, construction and operation.

"Passive House" is designed in compliance with strict quantitative indicators of energy consumption to achieve a favorable microclimate and ensure energy consumption for its functioning. One of the main criteria for determining a "passive" house is the need for no more than 15kWt hours/(m^2 year) for heating. Modern categories of "passive houses" are: "Passive House Classic"; «Passive House Plus», «Passive House Premium».

"Multi-comfort house," offered by Sint-Gobain Corporation, in addition to energy standards provides for achieving a high level of comfort thanks to good acoustics, optimal lighting, air quality, fire safety and environmental friendliness.

"Active house" also follows these principles and aims to achieve comfortable living conditions, positive energy balance of the house, without negative impact on the environment.

CHAPTER 2

ARCHITECTURAL PART

2. Architectural part

2.1. General Data

The residential building will be located in Shevchenkivskyi district and is surrounded by urban development: from the north-east side - Desyatynna Street, from the south-east - the British embassy, from the south-west - the courtyard and the sports ground, from the north-west - a 5-storey residential building. The location of the building is shown in figure 2.1.

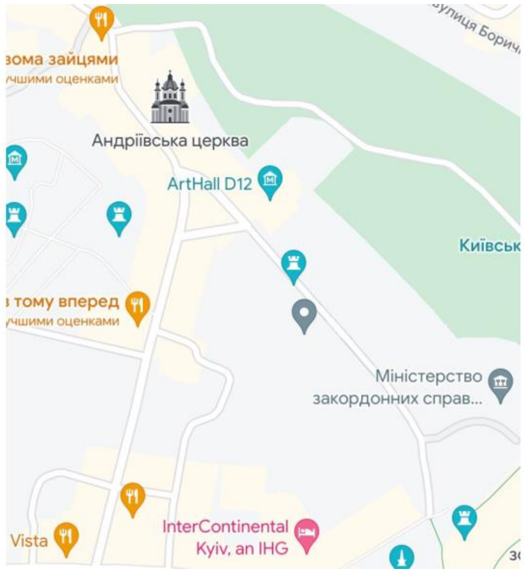


Fig.2.1. Situational plan

Technical and economic indicators:

Design area 0.061 hectares;

Building area 555.0 m^2;

Float coverage of 195 m_2;

Pavement area 110 m^2;

Landscaping area 25m^2;

Landscaping area of the adjacent territory 500 m^2.

Main technical and economic indicators shown in the table 2.1.

Table 2.1.

Main technical and economic indicators

Number	Indicator	Units of measurement	Number
1	Superficiality	Floor	2
2	Area of apartments	m2	634,7
3	Area of summer premises, with coef. 0.3	m2	38,3
4	The total area of the apartment	m2	673,0
5	Construction volume	m3	3785,7

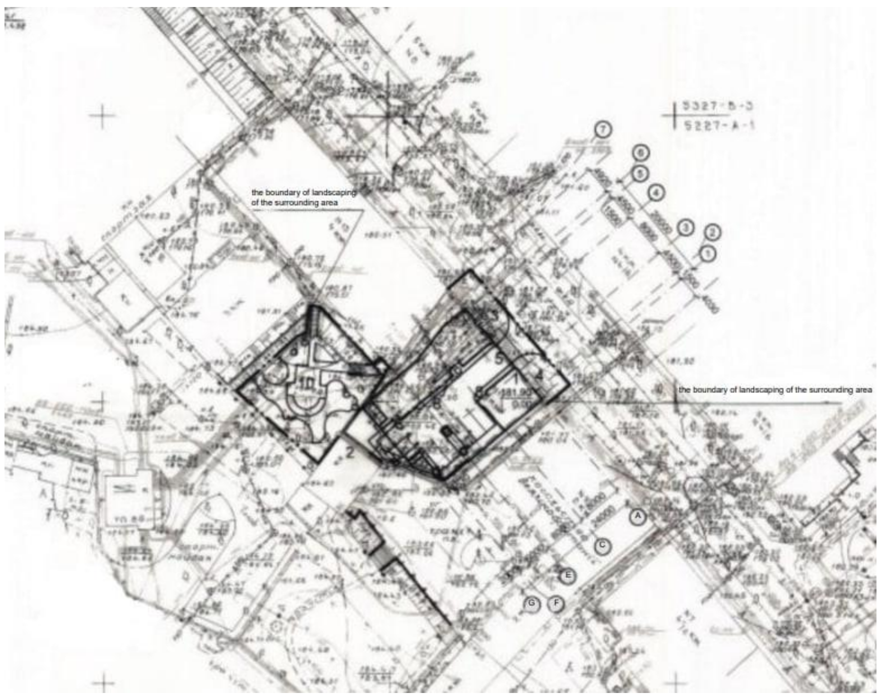


Fig.2.2. Master plan

2.2. Natural conditions

Climatic information for the construction site of a residential building in Kiev according to DSTU-N B B.1.1-27: 2010 "CONSTRUCTION CLIMATOLOGY".

Kyiv is located in the 1st North -Western climatic region (Polissia, Forest Steppe).

The climate is temperate continental, with mild winters and warm summers.

estimated winter temperature of external air te.a. = -22 ° C;

estimated summer temperature of external air te.a. = -28 ° C;

average annual temperature = 8 ° C;

the temperature of the external air of the cold five-day provision 0,98 = -25,0 ° C;

duration of the period with an average daily temperature of less than 0 ° C 195 days;

depth of soil freezing 100-120 cm.

2.3. Volume-planning decisions

During the work on the graduation work, a two-storey individual house was designed, in the axes "1-6" x "A-G."

Residential is made according to the frame-monolithic scheme.

Designed partitions will be made of sound insulation systems GK. The outer walls are made of brick and insulated. Decoration of facing of external and internal corners, window openings, partitions is performed using soundproofing materials.

Foundations of low depth and shallow laying are made of monolithic reinforced concrete slab:

- on a natural basis - prefabricated, monolithic or prefabricated-monolithic ribbons in the form of solid, intermittent, cross tapes (sometimes ribbons under columns), columns, tile, dense, etc.

Foundation beams are designed to carry panels. Foundation beams have nominal dimensions in length 6 and 12 m, as interpoles. The foundation beam is laid so that its upper limit falls above the soil level, but below the clean floor of the room.

This is done, firstly, so that the soil does not touch the structure of the wall and does not moisten it, and secondly, so that it is possible to arrange a gate or door in any span without thresholds. The width of the beams depends on the thickness of the wall.

The stairs consist of monolithic reinforced concrete marches and platforms.

Windows, balcony doors and stained glass windows are metal-plastic and are performed on an individual order. Interior doors - wooden. Entrance doors are made of metal.

In my project, I used a shallow strip foundation. The foundations are low-depth and shallow laying transmit the load on the base on the sole of pressure. The foundations are recessed on the sole - pressure, on the side surface of the foundation and the recessed part of the load-bearing enclosing structures - friction. This type is most used for small-storey buildings, which is very suitable for my two-story individual building. The depth of laying the foundations corresponds to the depth of soil freezing. According to DBN

B.2.1-10-2009. "THE BASICS AND FOUNDATIONS OF EQUIPMENT" The depth of freezing for my city (Kyiv) is 1.2 m.

The depth of my foundation is more than the normative freezing of the soil in my area from the ground level. Under the foundation is poured concrete preparation .

The main advantage of the foundation is its price category and the speed of its construction. With professional quality construction of the basis of this type will provide you with a long service life of the building.

In this project, I used partially prefabricated and partially monolithic floors in connection with the wrong shape of the building and cost savings on installation. As a prefabricated rectification, I took a reinforced concrete slab with oval voids. To balance the mark between the two types of ceilings, I used a plasterboard that closed the difference and acted as an additional sound insulation between the floors.

The walls of elevator shafts are also monolithic.

The floor in the building - water heat - from the marble plate laid on the glue.

For drainage from the roof, a system of internal and external gutters is designed.

The project uses a green roof made of non-combustible materials.

Parapets are made of aerated concrete blocks.

2.4. Architectural and constructive decisions

The degree of fire resistance of the house - II, according to DBN B.1.1-7:2016 "Fire safety of construction facilities".

The class of consequences - CC1 is determined according to DSTU-N B B.1.2 16:2013 "Determination of the class of consequences (liability) and the category of complexity of construction objects".

Individual house, size in axles "1-6" x "A-G" - 20x24m. Ground floor at -0,540 m.

The height of the first floor is 3450 mm, the height of the second floor on the axes "3-4" and "C-E"-2530 mm and 3430 mm on the axes "A-B","E-G" and "2 -3","4-5."

Ground floor at -0,540. Shallow foundation with a depth of 1.3 m. Under the foundation is poured concrete preparation 100 mm concrete C8/10 and pour sand bedding 30 cm.

Cement-sand screed is poured under the slab M150 - 30 mm, 2 layers of waterproofing - glass insulation are laid, concrete preparation of B10 - 50 mm is poured and a 300 mm thick sand is poured. Overlap - reinforced concrete slab 300 mm thick. For the foundation, a protective shell is created, that is, insulation of the foundation structures in contact with the soil, thanks to which the thermal resistance increases and the formation of condensates is prevented.

The overlap consists partly of hollow slabs of 220 mm, and 80 mm of plasterboard.

On the terrace of the second floor laid decking - Tik thickness 22 mm.

Stairs inside the building with dimensions 290x170 mm, on the terrace of the second floor the dimensions of the stairs 300x140.

The water floor in the building is 16 mm on top of which is poured Knauf FE 30, 1.8 kg/m^2 with a reinforced mesh of = 50 mm.

External brick walls with a thickness of 250mm on the perimeter are insulated with thermal insulation material with a total of 450mm. Partitions are made of brick or plasterboard width 150 mm.

Walls of elevator shafts - 150 mm thick monolithic. Dimensions of the elevator shaft 1200 x 1470 with a slot under the door 900 mm.

2.5 Rooms list

Explication of the premises on the 1st floor:

1.Staircase hall -18,32 m^2;

2.Living room - 76,74 m^2;

3. Hallway - 33,31 m^2;

4.Bathroom - 20,32 m^2;

5.Bedroom - 37,0 m2;

6.Pantry - 4,18 m2;

7.Sleeping area hall - 4,07 m^2;

8.Utility room - 12,70 m^2;

9.Bathroom - 3,80 m^2;

10.Hall - 7,14 m^2;

11.Dressing room - 19,74 m^2;

12.Dressing room - 9,42 m^2;

13.Living room with bedroom - 33,62 m^2;

14.Master bedroom - 43,05 m^2;

15.Bathroom - 24,74 m^2;

16.Pantry - 1,55 m^2;

17.Hall - 18,45 m^2;

18.Kitchen-dining room - 33,12 m^2;

19.Elevator hall - 31,96 m^2;

20.Greenhouse 15,16x0,3 - 4,54 m^2;

Total area - 437.80 m^2.

Explication of the premises on the 2nd floor:

1.Staircase - 15,18 m^2;

2.Living and dining room - 63,88 m^2;

3.Utility Room - 12,33 m^2;

4.Kitchen - 11,51 m^2;

5.Part of Staircase - 7,22 m^2;

6.Part of Staircase - 4,92 m^2;

7.Hall - 2,84 m^2;

8.Hall - 3,81 m^2;

9.Dressing Room 1 - 7,84 m^2;

10.Dressing Room 2 - 7,84 m^2;

11.Bathroom 1 - 9,22 m^2;

12.Bathroom 2 - 9,22 m^2;

13.Bedroom 1 - 22,20 m^2;

14.Bedroom 2 - 23,36 m^2;

Total area - 201,50 m^2;

15.Terrace 1 - 22,15 m^2;

16.Terrace 2 - 12,23 m^2;

17.Terrace 3 - 22,99 m^2;

18.Terrace 4 - 32,93 m^2;

19.Terrace 5 - 22,05 m^2;

Total area of terraces - 112,40 m^2;

General area of terraces with coef. 0.3 - 33,70 m^2.

CHAPTER 3
STRUCTURAL REVIEW

3. Structural part

3.1. SNOW LOADS

Snow load is determined according to DBN B.1.2-2:2006 "Loads and impacts".

Snow load is variable, for which three calculated values are set:

- maximum calculation value;

- operational calculation value;

- quasi-constant calculation value.

The **maximum calculation value** of the snow load on the horizontal projection of the coating (structure) is calculated by the formula:

$$\mathbf{S_m=\gamma_{fm}*S_o*C; \quad (3.1)}$$

where: γ_{fm} - reliability coefficient for the limit value of snow load;

The reliability coefficient for the maximum design value of the snow load γ_{fm} is determined depending on the specified average recurrence period T according to table.3.1.

Table 3.1.

T, років	1	5	10	20	40	50	60	80	100	150	200	300	500
γ_{fm}	0,24	0,55	0,69	0,83	0,96	1,00	1,04	1,10	1,14	1,22	1,26	1,34	1,44

$\boldsymbol{\gamma_{fm}}$ **= 1.04;**

S_o - characteristic value of snow load (in PA);

The characteristic value of snow load S_0 (in PA) is equal to the weight of snow cover per 1 square meter of soil surface, which may exceed an average of one once in 50 years.

The characteristic value of snow load S_0 is determined by appendix E.

For Kyiv region **S_0 = 1550 Pa.**

C - coefficient is determined by the formula: $C=\mu C_e C_{alt}$; (3.2)

For my project, μ = 1; C_e=0.8; C_{alt}=1.

C=1*0.8*1=0.8;

S_m=1.04*1550*0.8=1289.6 Pa = 129 kg/m^3;

The **operationa**l design value is calculated by the formula:

$$\mathbf{S_e=\gamma_{fe}*S_o*C; \quad (3.3)}$$

where : γ_{fe} - reliability factor for the operational value of the snow load;

γ_{fe} =0.1;

S_e=0.1*1550*0.8=124 Pa;

Quasi-constant calculated value is calculated by the formula:

$$S_p=(0.4*S_o-\dot{S})C; \quad (3.4)$$

where: $\dot{S}$ = 160 Pa;

S_p=(0.4*1550-160)*0.8=368 Pa.

The design scheme for the snow load is shown in the figure 3.1.

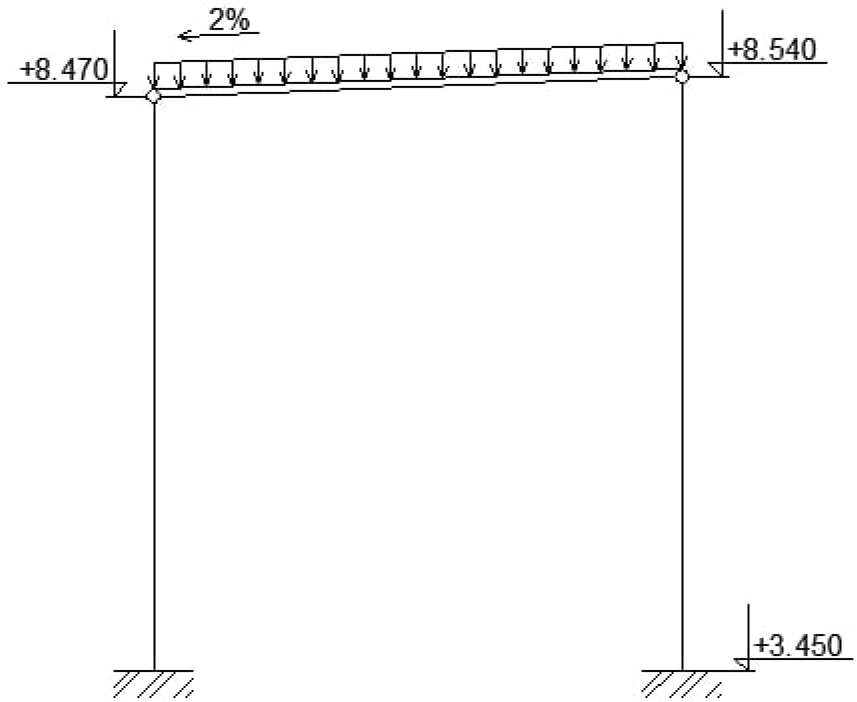


Fig.3.1. Design scheme for snow load

3.2. WIND LOADS

Wind loads are determined according to DBN B.1.2-2:2006 "Loads and impacts."

Wind loading is a variable load for which two calculated values are set:

- maximum calculation value;
- operational calculation value.

The **maximum estimated value** of the wind load is determined by the formula:

$$W_m=\gamma_{fm}*W_o*C; \quad (3.5)$$

where: γ_{fm} - reliability coefficient according to the maximum calculated value of wind load, according to table 3.2.

Table 3.2.

T, років	5	10	15	25	40	50	70	100	150	200	300	500
γ_{fm}	0,55	0,69	0,77	0,87	0,96	1,00	1,07	1,14	1,22	1,28	1,35	1,45

When T= 60, so $\boldsymbol{\gamma_{fm}}$ **=1.04;**

W_o - characteristic value of wind pressure;

The characteristic value of wind pressure is determined according to the DBN B.1.2-2:2006 "Loads and impacts," appendix E. City Kyiv belongs to the 1 wind area and equals to 370 Pa.

W_0 =370 Pa.

The coefficient C is determined by the formula:

$$C=C_{aer}*C_h*C_{alt}*C_{rel}*C_{dir}*C_d; \quad (3.6)$$

where:

C_{aer} - aerodynamic coefficient, determined by appendix I depending on the shape of the structure or constructive element;

C^{+}_{aer} = +0,8 (windward side);

C^{-}_{aer} = -0,6 (leeward side);

C_h - height coefficient of construction, determined by Change # 1 DBN B.1.2-2:2006 "System for ensuring reliability and safety of construction facilities. Loads and impacts. Design Standards. "

C_{h1} = 0,60 (for level +5.100);

C_{h2} =1,0 (for level +8.540);

C_{alt} - geographical height coefficient;

C_{alt} = 1;

C_{rel} - relief coefficient;

C_{rel} =1;

C_{dir} - direction coefficient;

C_{dir} =1;

C_d - dynamic coefficient, determined by figures 3.2, for buildings with a reinforced concrete framework = 0,95

C_d = 0.95.

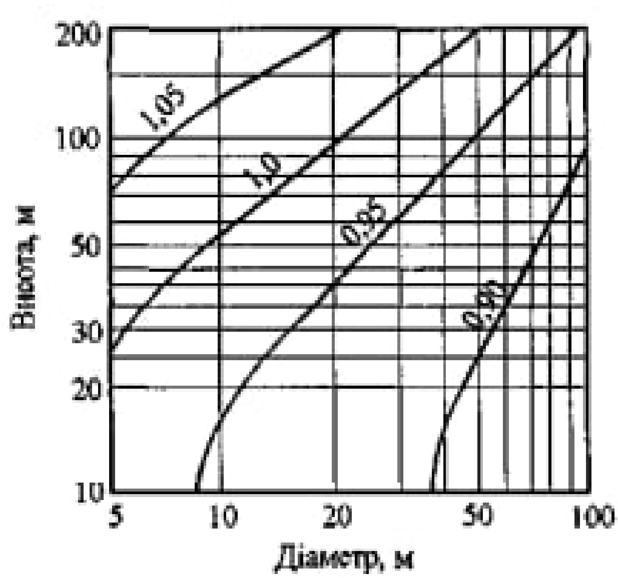


Fig.3.2. The coefficient C_d for buildings with a reinforced concrete framework

Since the coefficient C_{alt}, C_{rel}, C_{dir} is equal 1, I can reduce the formula to the form:

$C=C_{aer}*C_h*C_d$;

Windward side:

$C_1=C^+_{aer} * C_{h1} * C_d = 0.8*0.60*0.95=0.456$;

$C_2=C^+_{aer} * C_{h2} * C_d = 0.8*1.0*0.95=0.76$;

Next, I substitute these values in the original formula: $W_m=\gamma_{fm}*W_o*C$; (3.7)

$W^r_{m1}=\gamma_{fm}*W_o*C_1=1.04*0.37*0.456=0.18$ kN/m^2;

$W^r_{m2}=\gamma_{fm}*W_o*C_2=1.04*0.37*0.76=0.29$ kN/m^2;

$q^r{}_1=W^r{}_{m1} * b * \gamma_n = 0.18*5.47*1=0,98$ kN/m;

$q^r{}_2=W^r{}_{m2} * b * \gamma_n = 0.29*5.47*1=1,59$ kN/m.

Leeward side:

$C_1=C^-{}_{aer} * C_{h1} * C_d =(-0.6)*0.60*0.95=-0.342;$

$C_2=C^-{}_{aer} * C_{h2} * C_d =(-0.6)*1.0*0.95=-0.57;$

$W^l{}_{m1}=\gamma_{fm}*W_o*C_1=1.04*0.37*(-0.342)=-0.13$ kN/m^2;

$W^l{}_{m2}=\gamma_{fm}*W_o*C_2=1.04*0.37*(-0.57)=-0.22$ kN/m^2;

$q^r{}_1=W^r{}_{m1} * (b_1+b)/2 * \gamma_n =(-0.13)*5.47*1=-0.711$ kN/m;

$q^r{}_2=W^r{}_{m2} * (b_1+b)/2 * \gamma_n =(-0.22)*5.47*1=-1.2$ kN/m.

The design scheme for the wind load is shown in the figure 3.3, and 3.4.

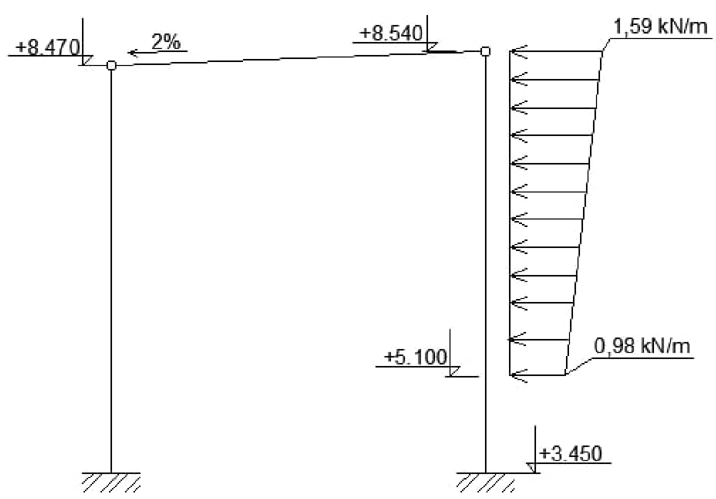


Fig. 3.3.Design scheme for wind load (windward side)

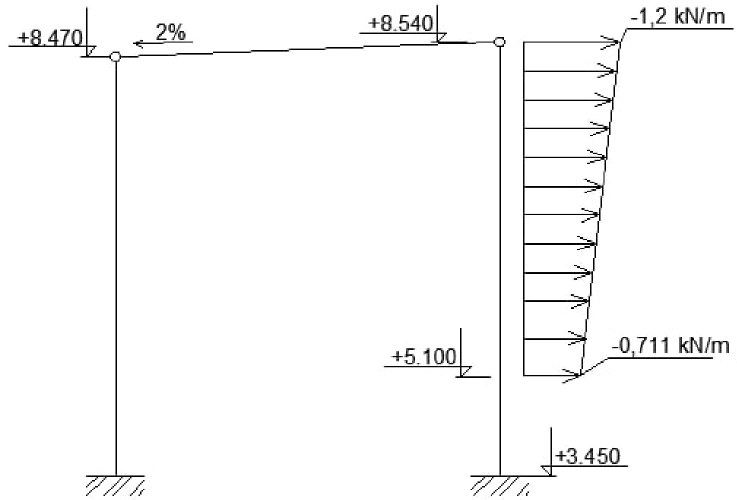


Fig. 3.4. Design scheme for wind load (leeward side)

3.3. Layout of the structural scheme of prefabricated beam overlap:

The size of the building in the plan	Number of floors	Floor height, m	Estimated soil resistance MPa	District of construction	Temporary load on the overlap (normative value), kPa
20x24	2	3,45	0,33	Kiev	15,5

The project is carried out for Kiev, which by weight of snow cover belongs to the V-th snow district with <u>So = 1.55 kPa</u> and wind pressure of the I wind area with <u>Wo = 0.37 kPa.</u>

Calculation of the load on the overlap is given in the table 3.3.

3.4. Calculation and construction of reinforced concrete on a pre-stressed plate with oval voids.

3.4.1. Derivatives

Table 3.3

Load on 1 m^2 of overlap

Type of load	Normative load, $Н/м^2$	Load reliability coefficient	Estimated load, $Н/м^2$
1	2	3	4
Interstorey floor			
Floor made of marble tiles, t = 20mm, p = 2500 ($25кН/м^3$)	500	1.2	600
Glue for marble, t = 10mm, p = 5 ($0.05кН/м^3$)	0.5	0.8	0.4
Self-leveling floor KNAUF FE 30, t = 50mm, p = 1800 kg/m^3 ($18кН/м^3$)	900	1.3	1170
Water Floor Heating, t = 16mm, p = 200 kg/m^3 ($2кН/м^2$)	32	2	64
GCLW KNAUF, t = 12,5 mm, p = 5 kg/m^3 ($0,05кН/м^2$)	0,625	1.3	0,8
StropRock Rockwool, t = 30 mm, p = 78 kg/m^3 ($0.78кН/м^2$)	23.4	1.3	30.42

Tem.-sand screed, t = 50 mm, p = 1800 kg/m^3 (18кН/$м^2$)	900	1.3	1170
Expanded clay filling, t = 30 mm, p = 500 kg/m^3 (5кН/$м^2$)	150	1.15	172.5
Gypsobeton, t = 80 mm p=1500kg/m^3(15кН/$м^2$)	1200	1.2	1440
Hollow floor slab with jointing, t = 220 mm, p□=2500 kg/m^3,	3200	1.1	3520
Constant load, g	6906.5	-	8168.1
Temporary load, including:	7700	1.3	10010
short-term	2000	1.3	2600
long-term	700	1.3	910
Partitions, long-term	5000	1.3	6500
Total load (g + d)	**13906.5**	-	**18 178,1**

Load on 1 p.m. plate length at the nominal width of 1.5 m, taking into account the reliability factor for the purpose of the building (II class of responsibility) $\gamma_n = 0{,}95$

- estimated constant g = 4,646 kN/m;

- estimated total (g + d) = 8.168 kN/m;

- normative constant g_n = 6.907 kN/m;

- normative full ($g_n + d_n$) = 13.907 kN/m;

- normative constant and long-term (gn + $d_{lon, n}$) = 12.608 kN/m.

Materials for the plate:

Concrete - a heavy class of compressive C25/30 strength. $f_{cd} = f_{ck}$ =22 MPa, $f_{ctd} = f_{ck}$ =1.8 MPa; f_{cd} = 17 MPa, f_{ck} =1.2 MPa ; coefficient of working conditions of concrete y_c=0.9. The plate is subject to heat treatment at atmospheric pressure. Initial modulus of elasticity E_{cd} =29*10^3 MPa .

The crack resistance of the plate is subject to the requirements of the 3rd category. Plate manufacturing technology - aggregate-flow. Tension of the stressed reinforcement is carried out electrothermally.

Reinforcement:

Working longitudinal reinforcement class A300C, and p/n class VR-II.

For A300C: f_{yk} =295 MPa, f_{yd} =280 MPa, E_s =21*10^4 MPa. For VR-II: f_{yk} =1000 MPa, f_{ywd} =680 MPa, E_s =20*10^4 MPa.

Conditional reinforcement class A-I (A240C), f_{yk} =235 MPa, f_{yd} =225 MPa, E_s =21*10^4 MPa.

3.4.2. Calculation of the plate by boundary states of the first group.

Determination of internal efforts

To establish the calculated span of the plate, set the initial dimensions of the bolt. The bolt of the multi-storey floor is an element of the frame structure with dimensions:

-High accept h_r =220 mm;

-width b = 1500 mm;

l = 6000 mm - crossbar span;

Estimated span of the plate:

Calculation of floor slabs must be performed, taking into account the permissible minimum depth of cleaning: for aerated concrete and foam concrete - 15 cm:

first and second span: l_0 = 6000-30=5970 mm;

Drawing of floor slabs in cross section is shown in the figure 3.5.

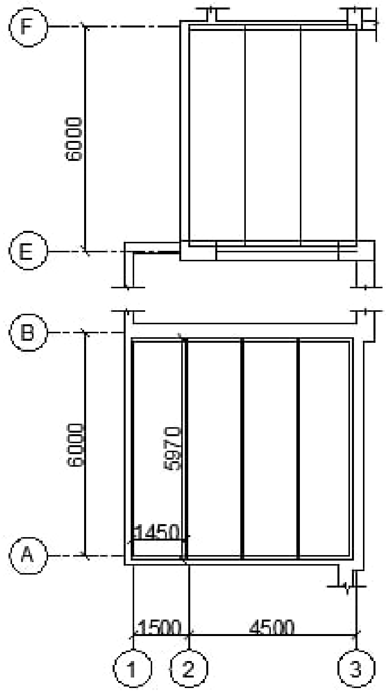


Fig.3.5. Layout of floor slabs in cross section.

Estimated span of the panel l_o=5.970 m. The calculation of loads on 1m^2 overlap is given in Table 1. Pre for calculation set the mass of the hollow plate equal to 3000 N/m^2. Height of hollow cross section (8 round voids with a diameter of 15.5 cm) pre-stressed plate:

$h = l_o/30 = 597/30 = 19.9$ cm. Accept: h = 22 cm.

Working height of cross section:

h_o= h-a=22-3=19 cm;

Thickness of the lower and upper shelf of the plate:

$h`_f$ = (22-15.5) /0.5=3.25 cm;

Width of edges:

- average: 25 mm;

- extreme: 32.5 mm.

In calculations on the first group of boundary states, the estimated thickness of the compressed shelf of the stigma section $h`_f$ =2.5 cm, ratio $h`_f$/h=2.5/22=0.11=0.1, while the entire width of the shelf is inserted into the calculation $b`_f$ =147 cm the estimated width of the edge: b=147-8*15.5*0.9=35.4 cm.

3.4.3. Static plate calculation

Estimated load on 1 m linear slabs with its width 1.5 m taking into account the reliability factor for the purpose of the building y_n=0.95.

g = 14.656*1.5*0.95 = 20.885 kN/m;

Normative load on 1 m linear plates:

g_n =11.791*1.5*0.95 = 16.8 kN/m;

Effort from calculation and regulatory loading:

From the estimated load:

$M = (g*l^2_0)/8 = (20.885*5.970^2)/8 = 93.05$ kN/m;

$V = (g*l_0)/2 = (20.885*5.970)/2 = 62.34$ kN;

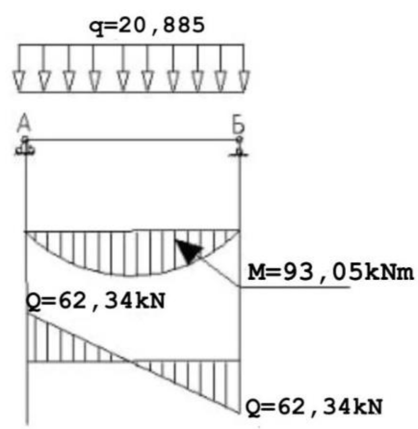


Fig.3.6. Epure of transverse forces and moments of the floor slab.

From normative load:

$M = (g_n*l^2_0)/8 = (16.8*5.970^2)/8 = 74.85$ kN/m;

$V = (g_n*l_0)/2 = (16.8*5.970)/2 = 50.15$ kN;

From constant and long-term load:

$M_n = ((g_n+g_{lon,n})*l^2_0)/8 = (9.791*5.970^2)/8 = 43.62$ kN/m;

3.4.4. Characteristics of the strength of concrete and reinforcement

Pre-stressed plate with round voids reinforced rod reinforcement class A-II. To crack resistance of the 3rd category. The panel is subjected to thermal treatment at atmospheric pressure.

Calculation characteristics of concrete C25/30 at the coefficient of working conditions y_{b2}=0.9:

-accountable strength: f_{cd} =0.9*17=15.3 MPa;

- resistance to stretching: f_{ctd} =0.9*1.2=1.08 MPa;

-normative strength on axial compression: f_{ck} =22 MPa;

- resistance to stretching: f_{ctk} =1.8 MPa;

- initial module of elasticity of concrete : E_{cd} =29000 MPa;

Working longitudinal fittings - rod pre-stressed class A300C:

-accounting resistance stretch: f_{yd} =280 MPa;

-calculation compression resistance: f_{yd} =280 MPa;

-elasticity module: E_s =210000 MPa;

The initial stress is taken equal:

σ_{sp} =0.60*R_{sn}=0.60*295=177 MPa;

Check the fulfillment of the condition:

p=30+360/l=30+360/6=90;

σ_{sp} +p=177+90=267< f_{yk} =295 MP - a the condition is met;

We calculate the maximum deviation of the previous stress at the number of strained rods n_p=9 (The number of stressed rods is preliminarily taken equal to the number of edges in the multi-pressure plate, n_p=9). So:

Δy_{sp} =0.5*(p/σ_{sp})(1+1/√n_p)=0.5*(90/177)*(1+1/√9)=0.339 >0.1;

The factor of accuracy of tension is calculated by the formula:

y_{sp} =1-Δy_{sp} =1-0.339=0.661;

When checking for cracks in the upper zone of the plate take:

y_{sp} =1+Δy_{sp} =1+0.339=1.339;

Preliminary tension taking into account the accuracy of tension:

σ_{sp} =0.661*177=117.0 MPa;

The panel is calculated as a beam of rectangular cross-section with specified dimensions bxh = 150x22 cm (where b- nominal width, h - nominal height of the panel). We design a panel of eight hollow. In the calculation of the cross section of the hollow panel, we bring to the equivalent two-tier cross section. Replace the area of round voids with rectangles of the same area and the same moment of inertia. Calculate:

h_1=0.9d=0.9*15.5=13.95 cm;

h_f=$h``_f$ =(h-h_1)/2=(22-13.95)/2=0.9d=4.025=4 cm;

The thickness of the edges is given b=147-8*13.95=0.9d=35.4 cm, (the estimated width of the compressed shelf $b``_f$ =147 cm).

3.4.5. Calculation of plate strength by cross section, normal to longitudinal axis

T-section with a shelf in the compressed zone, calculate:

$a_m=M/(y_{b2}*f_{cd}*b`_f*h^2_0)=9305000/(0.9*17*147*19^2*100)=0.1$;

At a_m=0.1; ξ=0.11; ζ=0.945 . x=ξ*h_o=0.1*19=1.9<3 cm- neutral axis passes within the compressed shelf; $\zeta=z_p/h_o$=0.95.

The limit relative height of the compressed zone is determined by the formula :

$\xi=\omega/(1+\sigma_{sR}/\sigma_{scu}*(1-\omega/1.1))$ = 0.728/(1+225/500*(1-0.728/1.1)) =0.632, where:

ω - characteristics of the compressed concrete zone, determined by the formula:

$\omega = a-0.008*f_{cd}$;

a - coefficient equal to for heavy concrete a = 0.85;

σ_{sR} - voltage in the reinforcement, MP a, which is accepted for A240C class fittings;

$\sigma_{sR} = f_{yd}$=225 MPa;

σ_{Sp}- voltage taken at the coefficient y_{sp}<1;

$\Delta\ \sigma_{Sp}$- voltage loss, equal in unautomatized electrothermal method of zero tension;

$\sigma_{sc,u}$- maximum tension in the reinforcement of the compressed zone, taken for structures made of heavy concrete, taking into account the current loads of $\sigma_{sc,u}$=500 MPa.

$\omega = a-0.008*f_{cd}*y_b$=0.85-0.008*17*0.9=0.728;

The value σ_{sp} - must satisfy the condition (1) [1]: $(\sigma_{sp} + p) \leq f_{yk}$ and

$(\sigma_{sp} + p) \geq 0.3 * f_{yk}$. In the electrothermal method of tension

p=30+360/l=30+360/6=90 MPa, where l - the length of the stretched rod (the distance between the outer faces of the stops), m.

When fulfilling the condition, $\sigma_{sp} + p \leq f_{ctk}$, we will receive

σ_{sp} =177 MPa.

Δy_{sp}=0.367, with a favorable effect of previous tension y_{sp}=1-Δy_{sp}=1-0.367=0.632

Preliminary tension taking into account the accuracy of the tension will be:

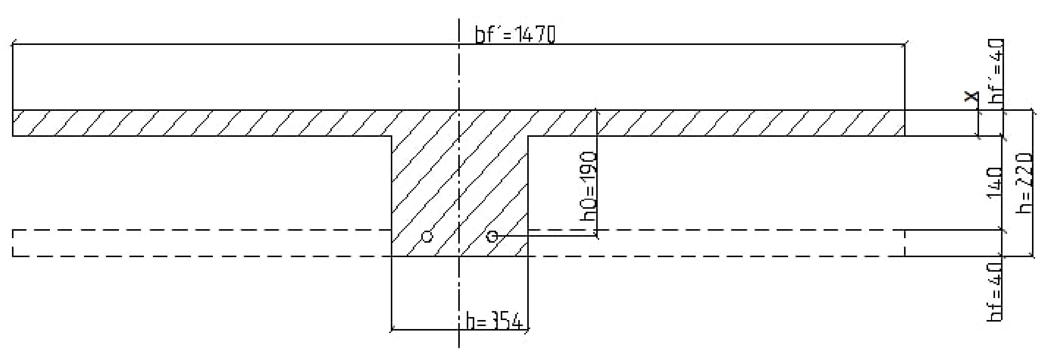
σ_{sp} =117.0 MPa.

Provided that the total loss is approximately 30% of the initial previous voltage, the latter, taking into account the total losses, will be equal to: σ_{sp} =81.9 MPa.

The coefficient of working conditions, taking into account the resistance of the strained reinforcement above the conditional limit of fluidity, is calculated according to the formula: $y_{sb}=\eta-(\eta-1)*(2*\xi/\xi_R -1)=1.15-(1.15-1)*(2*0.11/0.632 -1)= 1.247=\eta$;

where: η = 1.15 for the reinforcement class VR-II, we accept y_{sb}=1.247;

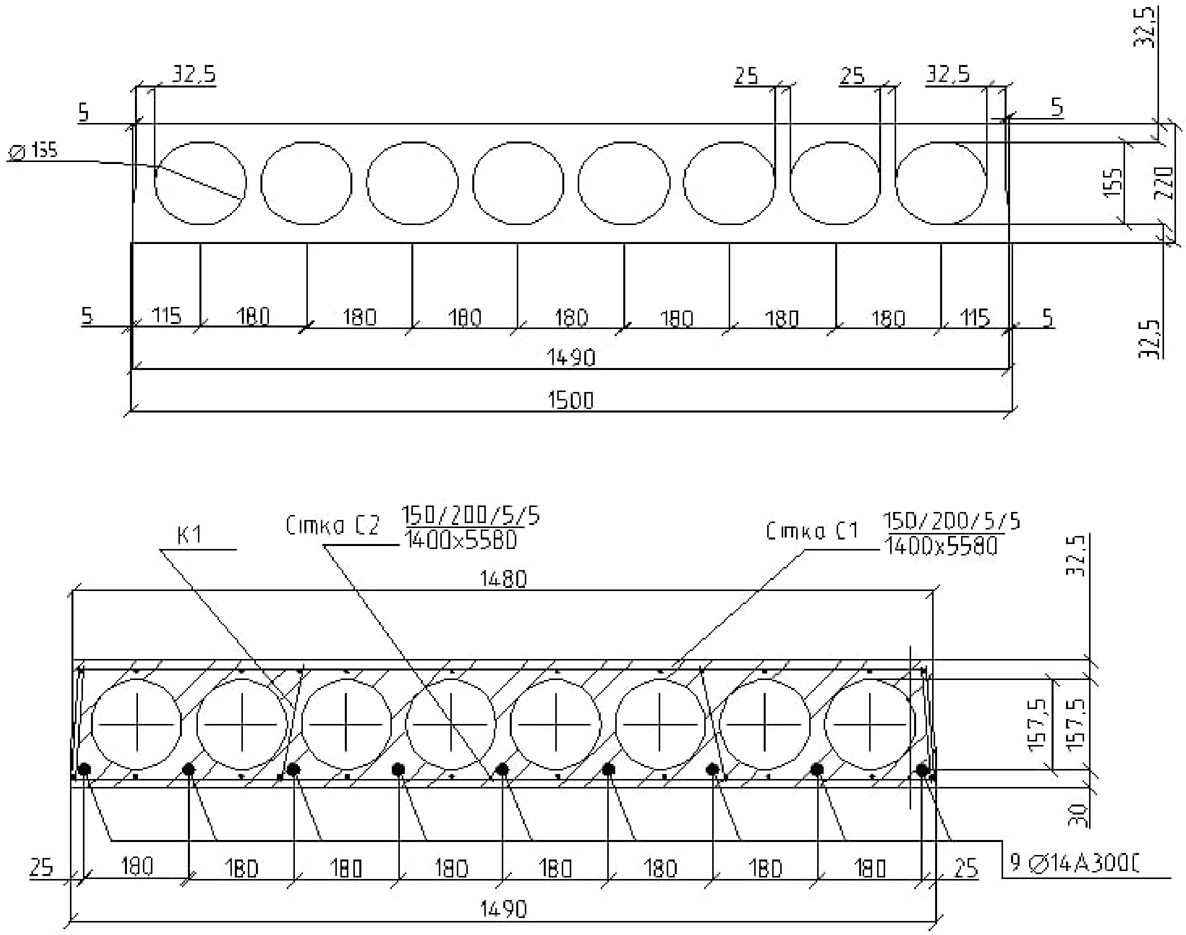
Fig.3.7. Cross-stigma for calculating strength.



Calculate the cross section of the stretched rebar:

$A_s=M/(y_{sb}*f_{yd}*\zeta*h_o)=9305000/(1.25*280*0.95*19*100)=12.96\ cm^2$;

Fig.3.8. Cross-section of the round-bottom plate.



We accept with the area 9Ɵ14 A300C with area $A_s=13.85\ cm^2>12.96\ cm^2$

3.4.6. Calculation of the strength of the plate in cross section, inclined to the longitudinal axis

Transverse force V=62.34kN.

Pre-supporting areas of the plate are arrested in accordance with the constructive requirements. To do this, on each side of the plate set four frame length *l/4* with transverse rods Ɵ□6 A240C, the step of which S = 10 cm.

(S≤ h/2[1] and S≤ 150 mm).

According to the formula, we check the condition for ensuring strength along the inclined lane between the inclined cracks. Check whether additional transverse valves are needed for the calculation:

$V \leq 0.3 * \varphi_{w1} * \varphi_{b1} * y_{b2} * f_{cd} * b * h_0$, where

φ_{w1} - coefficient, taking into account the effect of clamps, normal to the longitudinal axis of the element;

φ_{b1} - coefficient, taking into account the class and type of concrete.

$\varphi_{w1} = 1+5*a*\mu_W$, but not more 1.3, where $a=E_s/E_{cm}$ and $\mu=A_{sw}/b*s$

$a = E_s/E_{cm} = 21*10^4/29*10^3 = 7.24$. At $A_{sw}=1.13$ cm^2 4ϴ6 A240C transverse reinforcement coefficient

p_{fw} - $A_{sw}/b*s=1.13/35.4*10=0.003$;

From here $\varphi_{w1} = 1+5*7.24*0.003=1.11=1.3$. We accept $\varphi_{w1} = 1.11$.

Coefficient $\varphi_{c1} = 1-\beta*f_{cd}*y_{b2}=1-0.01*0.9*17=0.847$, where $\beta=0.01$ for heavy concrete.

Make a check: $\beta \leq 0.3*\varphi_{w1}*\varphi_{b1}*y_{b2} *f_{cd}* b* h_0$,

$V=62.34$ kN $\leq 0.3*1.11*0.847*0.9 *17* 35.4* 19*100=290252$ N= 290.25 kN.

Therefore, the dimensions of the cross section of the plate are sufficient for the perception of the load. We check the necessity of setting the calculated transverse reinforcement based on the condition:

$B_b=\varphi_{c2}*(1+\varphi_f+\varphi_n)*y_{c2}*f_{ctd}*b*h_0^2$, where

$\varphi_{c2} = 2$ - coefficient, which is accepted for heavy concrete.

The coefficient that takes into account the influence of compressed shelves in the inlet elements is equal to:

$\varphi_f = 0.75*((b`_f -b)*h`_f)/b*h_0 \leq 0.5$;

It is accepted that ($b`_f \leq b+3\,h`_f$). Taking into account this, we get:

$\varphi_f = 0.75*(3*(h`_f)^{2)}/b*h0=0.75*(3*4^2/35.4*19)=0.054 \leq 0.5$;

The coefficient taking into account the influence of the longitudinal force of the crimp P_2 is equal to:

$\varphi_n = 0.1*(P_2/y_{b2}*f_{ctd}*b*h_0 \leq 0.5$;

P_2 (the value of the crimping force, see. below) is accepted taking into account the coefficient y_{sp}=0.632

$\varphi_n = 0.1*(0.632*106645/0.9*1.2*19*35.4*100)=0.93 \leq 0.5$;

Accept $\varphi_n = 0.5$. So $(1+\varphi_f + \varphi_n)=1+0.054+0.5=1.554 \leq 1.5$;

$B_b=\varphi_{c2}*(1+\varphi_f+\varphi_n)*y_{c2}*f_{ctd}*b*h_0^2=2*1.5*0.9*1.2*100*35.4*19^2=41.4*10^5$ N.

In the calculated slope $Q_b=Q_{sw}=Q/2$, so c=Bb/0.5V,

$c=41.4*10^5/0.5*62340=132.82$ cm > $2h_0 =2*19 = 38$ cm .

Accept c = 2*19=38 cm.

In this case $V_c = B_b/c = 41.4 * 10^5/38=108947.4$ N = 108.95 kN, that more V=62.34 kN, so by calculation, the transverse reinforcement is not needed.

Conclusion: The condition is satisfied, constructive reinforcement is enough.

We constructively accept on the supporting sections (*l/4* span) transverse reinforcement 4ϴ6 A240C with a step 10 cm combined into flat frames KP-1 in the middle part of the span transverse rebar is not used.

3.4.7. Calculation of the plate by boundary states of the second group.

Geometric characteristics of the given cross section

Round outline of voids replace equivalent square with sides c=0.95b=0.95*15.5=14.725.

Dimensions of the calculated two-tiered cross section:

-thickness of shelves cm $h`_f = h_f = (22-14.725)*0.5=3.638$ cm ;

- width of the rib b = 148-14.725*8=30.2 cm ;

- width of shelves $b`_f = 150-2=148$ cm, $b_f=149$ cm.

At $a=E_s/E_{cm}=21*10^4/29*10^3=7.24$ the area of the given cross section will be:

$A_{red} = A+a*A_s=b`_f * h`_f + b_f * h_f +b*c + a*A_s =$ $148*3.638+149*3.638+30.2*14.725+7.24*13.85=1625.5$ cm^2;

The static moment of the given cross section relative to the lower face is:

$S_{red}=b`_f * h`_f *(h-0.5 h`_f) + b_f*h_f*0.5h_f+b*c*0.5h+aA_s*a=148*3.638*(22-0.5*3.638)+149.3.638*0.5*3.638+30.2*14.725*0.5*22+7.24*13.85*3=10865.93+986+4891.65+300.82=17044.4$ cm^3.

The distance from the lower limit to the center of gravity of the given cross section is:

$y_o=S_{red}/A_{red}=17044.4/1625.5=10.5$ cm.

The moment of inertia of the given cross section relative to its center of weight is:

$I_{red}=I+a*S=((b`_f*(h`_f)^3/12)+b`_f*h`_f*(h-y_o-0.5*h`_f)^2+b*c*(0.5*h-y_0)+(b_f*h_f^3/12)$

$+b_f*h_f*(h-y_o-0.5*h_f)^2+a*A_s*(y_0-a)^2=$

$=597.9+50462.05+8035.11+222.35+597.85+40850+5640.4=106405.7$ cm^4

The resistance moment of the given cross section on the lower zone is equal to:

$W_{red}=I_{red}/y_o=106405.7/10.5=10133.9$ cm^3;

The same, on the upper zone:

$W`_{red}=I_{red}/h-y_o=106405.7/22-10.5=9252.67$ cm^3;

The distance from the center of gravity of the given cross section to the core point, the most distant from the stretched zone, according to the formula:

$r = \varphi * W_{red}/A_{red}$; $\varphi=1.6-\sigma_c/f_{uk}$.

The maximum voltage in the compressed concrete from the external load and the force of the previous tension will be :$\sigma_c=P_2/A_{red}+(M-P_2*e_{op})/W`_{red}$, where

M - bending moment from the full normative load, M = 74.85 kN*m = 7485000 N* cm^2;

P_2- crimping force, taking into account all losses σ_{los} (cm. cost calculation),

$P_2=A_{sp}*(\sigma_{sp}-\sigma_{los})=13.85*(177-100)*100=106645$ N.

The eccentricity of the crimping force is equal to: $e_{ob}=y_o-a=10.5-3=7.5$ cm;

$\sigma_c= 106645/1625.5+(8187000-106645*7.5)/9252.67=65.61+798.38=$

$=864$ N/cm^2$=8.64$ MPa;

$\varphi = 1.6-8.64/22=1.21\geq1$, assume $\varphi = 1$. $r =1*10133.9/1625.5=6.23$ cm.

The distance from the center of gravity of the given cross section to the core point, the least distant from the stretched zone, is:

r_{inf} =φ * $W`_{red}/A_{red}$=1*9252.67/1625.5=5.69 cm.

Elastic-plastic moment of resistance over the stretched zone, determined by the formula: $W_{pl}=y*W_{red}$.

For symmetric two-tiered cross sections at

$b`_f/b=b_f/b=148/35.4=4.2\geq2 \rightarrow y=y`=1.5$;

So $W_{pl}=1.5*W_{red}=1.5*10133.9=15200.9$ cm^3;

$W`_{pl}=1.5*W_{red}`=1.5*9252.67=13897$ cm^3.

3.4.8. Loss of previous reinforcement tension

When calculating losses, the accuracy coefficient of reinforcement tension $y_{sp}=1$.

Losses from the relaxation of stresses in the reinforcement during the electrothermal tension method of the rod fittings are equal:

$\sigma_1=0.03*\sigma_{cp}=0.03*177=5.31$ MPa.

Losses from the temperature difference between the tensioned reinforcement and stops $\sigma_2=0$, since the aggregate-flow technology form with stops heated together with the product.

Losses from the deformation of anchors σ_3 and shapes σ_5 during the electrothermal tension method is 0.

Losses from friction of the fittings about the bypassing device $\sigma_4=0$, since the stressed fittings do not bend.

Losses from fleeting creep σ_6 are determined depending on the ratio $\sigma_{cp}/f_{ctd.}$

In the table $\sigma_{cp}/f_{ctd}\leq 0.95$. For this condition, the transmitting strength is set f_{cd}.

Crimping force taking into account losses $\sigma_1...\sigma_5$ is calculated by the formula:

$P_1=A_{sp}(\sigma_{sp}-\sigma_1)=13.85*(177-5.31)*100=237790.7$ N.

Voltage in concrete during compression:

$\sigma_{cp}=P_1/A_{red}+P_1*e_{op}/W_{red}=237790.7/1625.5+237790.7*7.5/10133.9=146.29+176=$

$=322.3$ N/cm2=3.2 MPa.

Transmitting strength of concrete $f_{ctk}=3.2/0.95=3.4$ MPa.

According to the requirements f_{ctd}≥0.5*B=10 Pa; f_{ctk}≥11 MPa.

We finally accept f_{cd}=11 MPa, so σ_{cp}/f_{ctd}=3.2/11=0.29≤0.95.

Compressive stresses in concrete at the level of the center of gravity of the stressed reinforcement from the pressure force P_1 (excluding the bending moment from the own weight of the plate):

$\sigma_{cp}=P_1/A_{red}+P_1*e^2_{op}/I_{red}$=237790.7/1625.5+237790.7*7.5^2/106405.7=146.3+125.7==272 N/cm^2=2.72 MPa.

Since σ_{cp}/f_{ctd}=2.72/11=0.25≤a=0.25+0.025*f_{ctd}=0.25+0.025*11=0.53≤0.8, the losses from fleeting creep are equal:

σ_6=0.85*40 σ_{cp}/f_{ctd}=0.85*40*0.25=8.5 MPa.

First expenses σ_{los1}=5.31+8.5=13.81 MPa.

Other losses: losses from shrinkage of concrete σ_8=35 MPa.

Losses from creep concrete σ_9 are calculated depending on the ratio σ_{cp}/f_{ctd}, σ_{cp} where is taking into account the first losses.

$P_1=A_{sp}*(\sigma_{sp}-\sigma_{los1})$=13.85*(177-13.81)*100=226018.2 N.

$\sigma_{cp}=P_1/A_{red}+P_1*e^2_{op}/I_{red}$=226018.2/1625.5+226018.2*7.5^2/106405.7=139+116.21= =255.21 N/cm^2=2.55 MPa.

When σ_{cp}/f_{ctd}=2.55/11=0.23≤0,75=0.25 and a=0.85

σ_9=150a*σ_{cp}/f_{ctd}=150*0.85**0.23=29.56 MPa.

Other losses $\sigma_{los2}=\sigma_8+\sigma_9$=35+29.56=64.56 Mpa.

Full losses $\sigma_{los}=\sigma_{los1}+\sigma_{los2}$=13.81+64.56=78.37 Mpa

Since σ_{los}=78.37 Mpa < 100 Mpa, finally accept σ_{los}=100 MPa.

P_2=13.85*(177-100)*100=106645 N.

3.4.9 Calculation for the formation of cracks normal to the longitudinal axis

The calculation is performed to clarify the need to perform a check on the crack opening. At the same time, for elements, to the crack resistance of which the requirements of the 3rd category are put forward, take the values of the reliability coefficients for loading Y_f =1; M=67.34 kNm. Bending elements are calculated on the formation of cracks based on the condition:

$$M \le M_{crc}.$$

Normative moment from the full load M=67.34 kN*m.

The moment of crack M_{crc} formation according to the method of core moments is determined by the formula:

$M_{crc} = f_{ctk}*W_{pl}+M_{rp}$, where kernel moment fracture force.

$M_{rp}=P_2*(e_{op}+r)=0.632*106645*(7.5+6.23)=925397.06$ N*cm=92.54 kN*m.

Since, M=65.86 kN*m < M_{acr} $=1.8*10^3=15200.9*10^{-6}+92.54=119.9$ kN*m in the stretched area from operational loads, crack formation does not occur. Cracks are not also formed in the upper zone of the plate in the stage of its manufacture.

3.4.10. Calculation of plate deflection

The maximum permissible deflection for the calculated plate taking into account the aesthetic requirements in accordance with the norms is accepted equal to:

f_u=l/200=560/200=2.8 cm.

Determination of deflection is carried out only on the action of constant and long loads at the coefficient of reliability on the load y_f=1 on the formula:

$f=\varphi_m*(1/r)*l_0^2$, where for a loosely operated beam the coefficient is:

-5/48 at uniformly distributed load;

-1/8 with two equal moments at the ends of the beam from the tightening force.

The complete curvature of the plate in areas without cracks in the stretched area is determined by the formulas:

Curvature from constant and long-term load:

$(1/r)_2=(M*\varphi_{c2})/(\varphi_{c1}*E_{cm}*I_{red})=3838000*2/0.85*29000*106405.7*100=3.33*10^{-5}$ 1/cm , where

M=43.62 kN*m - the moment from the corresponding external load relative to the axis, normal to the plane of action of the bending moment and passes through the center of gravity of the given cross section;

φ_{c2} = 2- coefficient that takes into account the influence of long creep of heavy concrete with a humidity of more than 40%;

φ_{b1} =0.85 - coefficient that takes into account the impact of short-term creep of heavy concrete;

Curvature from short-term regulatory load:

$(1/r)_1=(M*1)/(\varphi_{c1}*E_{cm}*I_{red})=(2.25*5.6^2)/8*10^5/0.85*29000*106405.7*100=$

$=0.34*10^{-5}$ 1/cm ,

Curvature of the short-term bending when the force of the previous crimping is in view $y_{sp}=0.632$:

$(1/r)_3=(P_2*e_{op})/(\varphi_{c1}*E_{cm}*I_{red})=0.632*106645*7.5/0.85*29000*106405.7*100=$

$=0.19*10^{-5}$ 1/cm ,

Since the tension of tight concrete upper fiber

$\sigma_{cp}=(P_1/A_{red})-(P_1*e_{op})/I_{red}*(h-y_o)=237790.65/1625.5-237790.65*7.5/106405.7*(22-10.5)=146.29-192.75=-46.46$ N/cm^2,that is, the upper fiber is stretched $(1/r)_4$, then in the formula for calculating the curvature caused by the bending of the plate due to the shrinkage and creep of concrete from the force of the previous crimp, we accept the relative deformations of the extreme compressed fiber $E`_b=0$. Then, according to the formulas:

$(1/r)_4=(E-E`)/h_o=(37.32*10^{-5}-16.67*10^{-5})/19=1.09*10^{-5}$ 1/cm ,

$E=\sigma_c/E_s=78.37/2.1*10^5=37.32*10^{-5}$, where $\sigma_b=\sigma_6+\sigma_8+\sigma_9$.

$E``=\sigma_c/E_s=35/2.1*10^5=16.67*10^{-5}$, where $\sigma_b=\sigma_8=35$

Deflection from constant and prolonged loads will be:

$f=\varphi_m*(1/r)*l_0^2=(5/48*2.93*10^{-5}+5/48*0.34-10^{-5}-1/8(0.19*10^{-5}+1.09*10^{-5}))*560^2=$

$=0.564$ cm.

<u>Conclusion:</u> The deflection does not exceed the limit value:

$f=0.564$ cm $\leq f_u=2.8$ cm.

3.5. Calculation of steel frame structure

3.5.1. Collection of roofing load on steel frame construction

To calculate a typical fragment of the design of the combined coating of a residential building on the profiled flooring is selected. Residential building with normal according to DBN B.2.6-31 "Thermal insulation of buildings" mode of operation. As a thermal insulation layer, the coating is supposed to arrange a FOAMGLAS T4 + insulation.

The thermal insulation material is made of a special category of recycled glass (> 66%), as well as natural raw materials, which are overly available in nature (sand, dolomite, lime). Thermal insulation is completely inorganic, contains no components hazardous to the ozone layer (chlorofluorocarbons, hydrochlorofluorocarbons, etc.), fire resistant additives or binder solution. Does not contain volatile organic compounds or other volatile substances.

FOAMGLAS T4 + with a density of 115 kg/m^3.

On top of the thermal insulation boards, a roofing carpet based on a PVC membrane is arranged. The general view of the constructive solution of the coating is shown in Figure .

Climatic conditions in Kiev.

The fragment of the roof is shown in Figure 3.9.

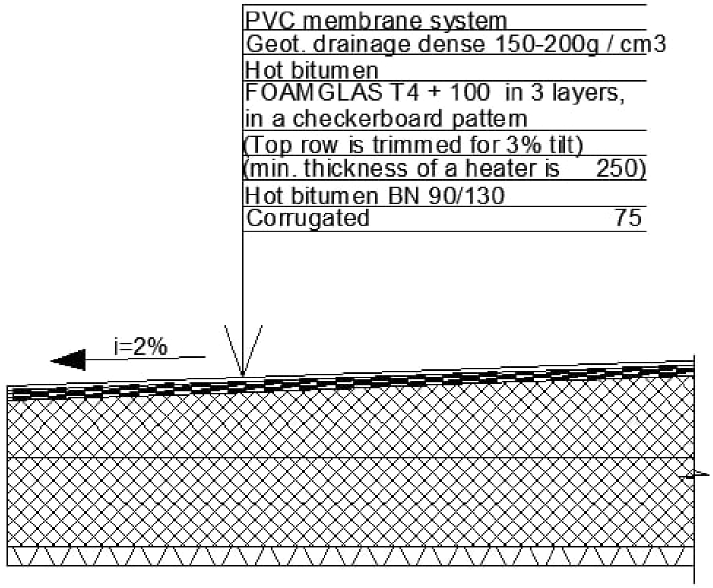


Fig.3.9. General view of the constructive solution of the coating

The collection of loads was carried out according to the DBN B.1.2-2:2006 "Loads and Effects" and data is listed in the table 3.4.

Table 3.4.

Load on 1 m^2 of coating

Type of load	Normative load, Н/м2	Load reliability coefficient	Estimated load, Н/м2
1	2	3	4
Constant load			
PVC membrane system, t = 2mm, p = 1.35 kg/m2	2.7	1.2	3.24
Geotextile drainage, t = 2mm, p = 150 g/cm3 (150кН/м3)	300	1.2	360
Hot bitumen БН 90\130, t = 40mm, p = 1030 kg/m^3 (10.3кН/м3)	412	1.3	535.6

FOAMGLAS T4 +, t = 300mm, p = 115 kg/m^3 (1.15кН/м2)	345	1.2	414
Hot bitumen БН 90\130, t = 40mm, p = 1030 kg/m^3 (10.3кН/м3)	412	1,3	536.5
Corrugated, t = 75mm, p = 4.5 kg/m^2	337.5	1.2	405
Constant load, g	1809.2	-	2254.34
Temporary load			
Snow	1290	1.4	1806
Total load	**3359,2**	-	**3804,34**
Wind		1.4	

Given:

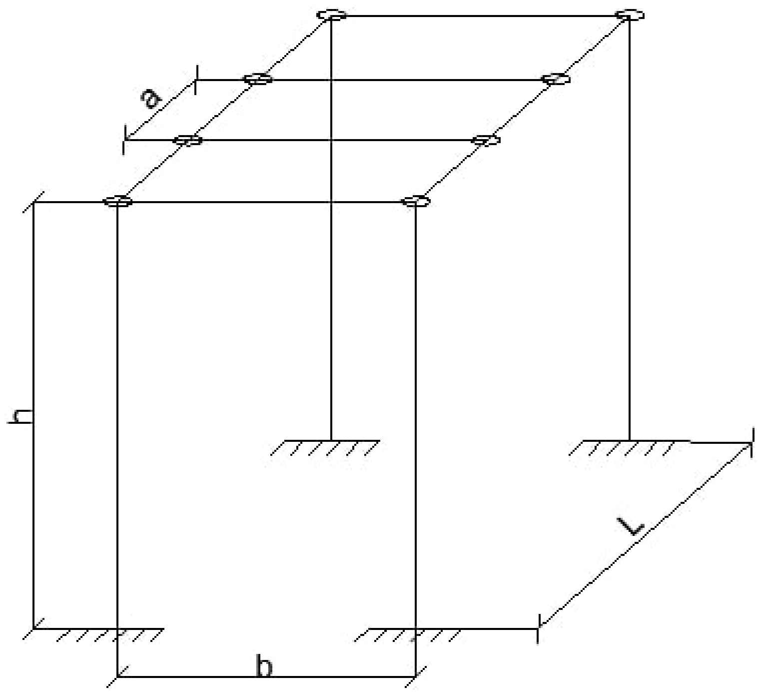
Step beams flooring - a = 1.8 m.

The span of the main beams is L = 5.4 m.

The span of flooring beams - B = 3.2 m.

Rack height - h = 4.57 m.

Fig.3.10. Design scheme



Constant loads on flooring beams:

q_n = 180.92*1.8=325.656 kg/m.

q=225.434*1.8=405.7812 kg/m.

Constant loads on the extreme beams of flooring:

q_n = 180.92*1.8/2 =162.828 kg/m.

q=225.434*1.8/2 =202.8906 kg/m.

Temporary from the snow on the beams:

S_m = 129*1.8=232.2 kg/m.

S=180.6*1.8=325.05 kg/m.

Temporary from the snow on the extreme beams of flooring:

S_m = 129*1.8/2 =116.1 kg/m.

S=180.6*1.8/2 =162.54 kg/m.

3.5.1. Static calculation of steel frame 2D

The statical calculation of the frame is done with the help of program complex LIRA-SAPR.

CHAPTER 4

BASES AND FOUNDATIONS

4.1. Calculation of the shallow foundation

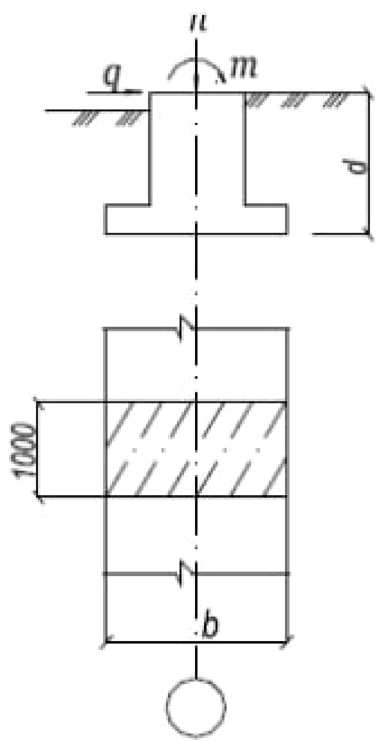
The calculation is performed in the following sequence:

- The initial data according to the task are given.
- The sizes of the sole of the base are defined.
- Checks are performed to confirm the correctness of the accepted dimensions.
- In case of fulfillment of conditions, all checks pass to calculation of deformations of a basis (calculation of subsidence), differently - the sizes of the bases are specified.

The foundations of shallow foundations under the walls are designed with tape.

The foundation is subjected to loads, which in general are reduced to the vertical - **N** and horizontal - **Q** forces, and the moment - **M**, applied at the level of its edge (Fig.4.1). For a strip foundation, the loads are reduced to its running values (per 1 m of foundation length) and are denoted by **n**, **q**, **m**, respectively.

Fig.4.1. Estimated load on the tape foundations



Foundations are characterized by the following geometric parameters:

- tape: d - height; b - width.

The first approximation determines the required width of the tape, btr, foundation from the corresponding expression:

$$\mathbf{b_{tr} = 1{,}1 * N/R_0, \quad (4.1)}$$

where: b_{tr} – the required width of the strip foundation, m;

R_0 – the calculated resistance of the soil on which the base of the foundation rests, its value is determined depending on the type of soil and its condition. The value of R0 is shown in table 4.1.

The coefficient of 1.1 approximately takes into account the weight of the foundation and soil on its edges.

Table 4.1.

Estimated resistance of sandy and dusty clay soils

Type of Soil	R_0, kPa
Sands	
Large	600/500
Medium size	500/400
Small:	
Low moisture	400/300
Wet and saturated with water	300/200
Dusty:	
Low moisture	300/250
Wet	200/150
Saturated with water	150/100
R_0 values for dense sands are given before the limit. For medium-density sands - out of limit. For loose sands- reduce the value by 20%.	
Dusty-clay	
Sands with a porosity coefficient equal to:	
0.5	300/300
0.7	250/200
Loams with a porosity coefficient equal to:	
0.5	300/250
0.7	250/180
1.0	200/100
Clays with a porosity coefficient equal to:	
0.5	600/400
0.6	500/300
0.8	300/200
1.0	250/100
R_0 values at $I_L = 0$ are given before the limit; at $I_L = 1$ out of limit; at intermediate values of e and I_L, the value of R_0 is determined by interpolation.	

The calculated soil resistance is determined by the following formula:

- for basement-free houses

$$\mathbf{R=(\gamma_{cl} * \gamma_{c2})/k*(M_\gamma*k_z*b*\gamma_{II}+M_q*d_1*\gamma'_{II}+M_c*c_{II})\ kPa} \quad \mathbf{(4.2)}$$

Determine the average and maximum pressures under the sole of the foundation p_{av}, p_{max} kPa.

Average pressure for strip foundations:

$$\mathbf{p_{av} = (n+G_f)/\ b_{rec}} \quad \mathbf{(4.3)}$$

The value of the maximum pressure:

$$\mathbf{p_{max} = p_{av} + (M + Q \cdot d_n) / W; \qquad p_{min} = p_{av}(M + Q \cdot d_n) /W,} \quad \mathbf{(4.4)}$$

Checks are performed for the accepted dimensions of the foundations.

$$\mathbf{p_{av} \leq R; \quad p_{max} \leq 1{,}2R; \quad p_{min} \geq 0} \quad \mathbf{(4.5 - 4.7)}$$

If one of the conditions of expressions (5-7) is not fulfilled, it is necessary to specify the dimensions of the foundation.

The calculation is considered complete if the accepted dimensions of the foundation in terms of their efficiency meet one of the following conditions:

$100\%(R-p_{av})/R \leq 15\%$; $100\%(1{,}2R-p_{max})/1{,}2R \leq 15\%$ (4.8)

Table 4.2.

Values of coefficients γ_{c1} and γ_{c2}

Types of soils	γ_{c1}	γ_{c2}	
		For a multi-storey building	For a one-story building
Large and medium-sized sands	1.4	1.2	1.4
The sands are fine	1.3	1.1	1.3
The sands are dusty	1.25	1.0	1.2
Sands, loams and clays, with a fluidity index:			
$I_L \leq 0.25$	1.25	1.0	1.1
$0.25 < I_L \leq 0.5$	1.2	1.0	1.1
$I_L \leq 0.5$	1.1	1.0	1.0

Table 4.3.

Values of coefficients M_γ, M_q; M_c

φ_{II} grad.	Coefficients			φ_{II} grad.	Coefficients		
	M_γ	M_q	M_c		M_γ	M_q	M_c
0	0	0	3.14	24	0.72	3.87	6.45
2	0.03	1.12	3.32	26	0.84	4.37	6.90
4	0.06	1.25	3.51	28	0.98	4.93	7.40
6	0.10	1.39	3.71	30	1.15	5.59	7.95
8	0.14	1.55	3.93	32	1.34	6.34	8.55
10	0.18	1.73	4.17	34	1.55	7.22	9.22
12	0.23	1.94	4.42	36	1.81	8.24	9.97
14	0.29	2.17	4.69	38	2.11	9.44	10.80
16	0.36	2.43	4.99	40	2.46	10.85	11.73
18	0.43	2.73	5.31	42	2.88	12.51	12.79
20	0.51	03.06	5.66	44	3.38	14.50	13.98
22	0.61	3.44	6.04	46	3.66	15.64	14.64

Calculation:

It is necessary to determine the dimensions of the foundation under the walls of a frameless house with a basement at the allowable deformation of the base equal to:

S_u = 12 cm.

Initial data:

n = 250 kN; M = 0,4k Nm; Q = 2,1 kN

When drilling on the construction site, the following sequence of layers is established (from top to bottom):

Layer-1: soil-vegetation layer, layer thickness 0.7 m.

IGE-2: fine sand, layer thickness 4.4 m.

IGE-3: fine silty sand, layer thickness 5.3 m.

IGE-4: brown Devonian clay, layer thickness 5.0 m.

The surface water level was not detected at the depth of drilling.The physico - mechanical characteristics of layer are shown in the table 4.4.

Table 4.4.

Physico - mechanical characteristics of geological elements

# IGE	Name of engineering and geological elements	Physico - mechanical characteristics of layer (soil)							
		p_s, g/cm^3	p, g/cm^3	E, MPa	ω	ω_L	ω_p	φ,°	C, MPa
1	Soil and plant layer	-	1.53	-	-	-	-	-	-
2	The sand is fine	2.63	1.81	10.0	0.20	-	-	34	2
3	Fine, muddy sand	2.64	1.86	7.0	0.28	-	-	28	3
4	Brown devonian clay	2.73	1.88	31.0	0.18	0.37	0.17	16	70

According to the main indicators of physical properties, we determine the derived indicators:

Density of dry soil ρ_d:

$$\boldsymbol{\rho_d = \rho/(1+\omega)\ ,\ g/cm^3 \quad (4.8)}$$

ρ_{d2} = 1.81/(1+0.20)=1.51 g/cm^3 - moderately compressible

ρ_{d3} = 1.86/(1+0.28)=1.45 g/cm^3 - moderately compressible

ρ_{d4} = 1.88/(1+0.18)=1.59 g/cm^3 - incompressible

Porosity coefficient e:

$$\boldsymbol{e=\rho_s/\rho_d -1 \quad (4.9)}$$

e_2 = (2,63 / 1,51) – 1 = 0,74 - medium density

e_3 = (2,64 / 1,45) – 1 = 0,82 - loose

e_4 = (2,73 / 1,59) – 1 = 0,72

Soil porosity, n:

$$\boldsymbol{n=e/(1+e) \quad (4.10)}$$

n_2 = 0,74 / (1 + 0,74) = 0,43

$n_3 = 0{,}82 / (1 + 0{,}82) = 0{,}45$

$n_4 = 0{,}72 / (1 + 0{,}72) = 0{,}42$

Humidity, S_r:

$$\mathbf{S_r = \omega * p_s / e * p_w;\ p_w = 1 g/cm^3 \quad (4.11)}$$

$S_{r2} = 0{,}20 \cdot 2{,}63 / 1 \cdot 0{,}74 = 0{,}71$ - wet

$S_{r3} = 0{,}28 \cdot 2{,}64 / 1 \cdot 0{,}82 = 0{,}90$ - water-saturated

$S_{r4} = 0{,}18 \cdot 2{,}73 / 1 \cdot 0{,}72 = 0{,}68$

Plasticity number:

$$\mathbf{I_P = \omega_L - \omega_P \quad (4.12)}$$

$I_{P4} = 0{,}37 - 0{,}17 = 0{,}20$ - clay

Fluidity index:

$$\mathbf{I_L = (\omega - \omega_P) / I_P \quad (4.13)}$$

$I_{L4} = (0{,}18 - 0{,}17) / 0{,}20 = 0{,}05$ - semi-solid

Specific weight, γ:

$$\mathbf{\gamma = \rho \cdot g = 10 \cdot \rho \quad (4.14)}$$

$\gamma 1 = 15{,}3$ kN/m3

$\gamma 2 = 18{,}1$ kN/m3

$\gamma 3 = 18{,}6$ kN/m3

$\gamma 4 = 18{,}8$ kN/m3

Conclusion. Analysis of engineering and geological conditions of the construction site allows us to conclude that the natural basis for the foundations of the designed building can be IGE-3 - fine silty sand ($\rho_{d3} = 1{,}45$г g/cm^3 and E = 10,0 MPa).

4.2. Determine width of the strip foundation

Determine in the first approximation the required width of the strip foundation according to the formula (4.1): $\mathbf{b_{tr} = 1{,}1\ N/R_0}$**,**

$b_{tr} = 1{,}1*250/160 = 1.72$ m,

where: $R_0 = 160$ kPa – accepted according to table. 1;

We accept the width of the foundation equal to b = 1.7 m.

We specify the calculated resistance of the soil according to formula (4.2),

$\mathbf{R=(\gamma_{cl} * \gamma_{c2})/k*(M_\gamma*k_z*b*\gamma_{ll}+M_q*d_1*\gamma'_{ll}+M_c*c_п)}$ **kPa -** for basement-free houses

substituting the following values:

γ_{cl} = 1,25, γ_{c2} = 1,0 - coefficients determined by table. 4.2;

k = 1; k_z = 1;

M_γ = 0,98, M_q = 4,93, M_c = 7,40 - coefficients determined by table. 3 depending on the angle of internal friction of the soil (φ_{ll} = 28o);

b = 0,9 m - accepted width of the sole of the foundation;

d_1 - depth of laying the foundation for basement-free houses $d_1=d_n$=1,3 m;

γ_{ll} = 18,6 kN/m^3 - the average value of the specific weight of soils below the sole;

γ'_{ll} = 17,85 kN/m^3 - the average value of the specific weight of soils above the sole;

$c_п$ = 3,0 kPa - specific soil adhesion.

R=(1,25 * 1,0)/1*(0,98*1*1,7*18,6+4,93*1,3*17,85+7,40*3,0)= 209 kPa

Substituting the obtained value of the calculated resistance, we determine in the second approximate width of the strip foundation:

b = 1,1*250/209=1,32 m,

We accept the width of the foundation equal to b = 1,3 m.

Determine, using formula (4.3), $\mathbf{p_{av} = (n+G_f)/ b_{rec}}$

the average pressure under the sole of the foundation:

where: b_{rec} – respectively accepted the width of the strip foundations;

G_f - the weight of the foundation and soil on its ledges is determined by the formula:

$$\mathbf{G_f = l \cdot b \cdot d \cdot \gamma \qquad (4.15)}$$

l - length of the base, m;

b - foundation width, m;

d - foundation height, m;

γ = 20 kN/m3 – the average value of the specific weight of the foundation and soil on its edges.

G_f = 1.0*1.3*1.3*20=33.8 kN;

p_{av} = (250+33.8)/ 1.3 = 218 kPa < R=209 kPa

Using formula (4.4), determine the marginal pressure and perform the necessary, in accordance with formulas (4.5- 4.7), checks:

$$\mathbf{p_{max} = p_{av} + (M+Q*d_n)/W; \; p_{min} = p_{av} - (M+Q*d_n)/W;}$$

where: W – the moment of resistance of the sole of the foundation, m^3, which is determined for its rectangular shape from the expression $W = (b_2 \cdot l)/6$ (for strip foundation is accepted l =1).

$$\mathbf{p_{av} \leq R; \; p_{max} \leq 1{,}2R; \; p_{min} \geq 0}$$

p_{max} = 218.0 + (2.1+0.4*1.3)/1= 220.62 kPa < 1.2R = 250.8 kPa;

p_{max} = 218.0 - (2.1+0.4*1.3)/1= 215.38 kPa > 0 ;

All checks are performed, which indicates that the perception of the existing loads of the foundation with the specified width.

We check according to expressions (4.8) efficiency of the accepted sizes of the base:

$100\%(R-p_{av})/R \leq 15\%$; $100\%(1{,}2R-p_{max})/1{,}2R \leq 15\%$

(209-218)/209 * 100% = -4.3 % ≤ 15%.

4.3. Determination of final settlement of the foundation base by the method of layered summation

This calculation is made on the assumption of condition:

$$\mathbf{S \leq S_u}, \quad \mathbf{(4.16)}$$

where: S – mutual deformation of the base and structure determined by calculation,

S_u – limit value of mutual deformation of the base and structure.

Foundation sediments are calculated by the method of layer-by-layer summation by the formula:

$$S = \beta \cdot \sum_{i-1}^{n} \frac{\sigma_{zp,i} \cdot h_i}{E_i}, \qquad \textbf{(4.17)}$$

where: β=0,8 – non-dimensional coefficient ;

$\sigma_{zp,i}$ – average value of additional stress in i layer of soil equaled semisum of indicated stresses bon upper and bottom limits of layer;

h_i and E_i – correspondently thickness and modulus of deformation of soil layer;

n – number of layers on which compressed thick of the base is broken.

Vertical stress from dead load of soil at the limit of layer located at the depth z from foundation base is defined by the formula:

CONCLUSION

LITERATURE

1. Requirements for paperwork: DSTU 4163-2003. - [Current from 2003-04-07]. – State Committee of Ukraine on Technical Regulation and Consumer Policy. 2003. - (National Standard of Ukraine).

2. Rules of architectural and construction working drawings: DSTU B A.2.4-7:2009. - [Current from 2009-01-24] - K.: Ministry of Health of Ukraine, 2011. - (National Standard of Ukraine).

3. DBN B.2.6-31: 2016 Thermal insulation of buildings.

4. DSTU-N B B.1.2-16: 2013.

5. DBN B.2.2-12: 2018 Planning and development of territories

6. Residential buildings. Main provisions: DBN B.2.2-15: 2019. - [Valid from 2019-12-01]. - Kyiv: Ministry of Regional Development of Ukraine, 2019.

7. Poluy BM Architecture and urban planning in a harsh climate / B.M. Poluy. - L.: Stroyizdat, 1989.

8. Kazakov GV Principles of improving helioarchitecture / G.V. Cossacks. - Lviv: Svit, 1990.

9. State sanitary norms of permissible noise levels in residential and public buildings and in residential buildings, 2019

10. Tabunshchikov Yu.A. Energy efficient buildings / Yu.A. Tabunshchikov, MM

11. Brodach -M.: Avok-press

12. Marcus T.A. Buildings, climate and energy / TA Marcus, E.N. Morris. –L .: Hydrometeoizdat EV.

13. Barashikov A.Ya. Building constructions: textbook for stud. universities/A.Ybarashikov, V.M. Kolyakova. - K.: Publishing House "Slovo.

14. Gorotetskyi A.S. Information technologies of calculation and design of construction structures/A.S. Gorodetskyi, V.S. Shmukler, A.V. Bondarev. - Kyiv-Kharkiv.

15. Veryuzhskiy Yu.V. Computer technologies of design of constructions: educational and methodological assistance/Yu.V. Veryuzhskyi, M.S. Barabash, Yu.V. Genzersky. - K.: Book Publishing NAU.

16. Gorodetskiy A.S. Computer models of constructions/A.S. Gorodetskiy, I.D. Evrezov. - K.: Edition "Fact".

17. Melnikov N.P. The problem of economy has become in the steel structures of industrial buildings, compartments and bridges. Design steel structure. Materials on steel structures, Nº2, 1958.

18. Magnel G. Long prestressed steel truss erected for Belgien Hangar. «Civil engineering» Nº10, 1953.

19.Prestressed steel structures (Discussion) «The Structural Engineer» No7, 1951.

20. Klepykov S.N. The situation of preconceived steel farms. "Knowledge of higher education. Construction and architecture. " 1958.

21. Klepikov S.N. Raschet preemptively tense steel farms. "Construction Industry" Nº7, 1958.

22. Speransky B.A. Steel preemptively strained farms of manufactured buildings and complexes. "Industrial Construction" Nº10, 1960.

23. DBN B.1.1-7:2016 "Fire safety of construction facilities".

24.DSTU-N B B.1.2 16:2013 "Determination of the class of consequences (liability) and the category of complexity of construction objects".

25.DBN B.2.1-10-2009. "THE BASICS AND FOUNDATIONS OF EQUIPMENT".

26. DBN B.1.2-2:2006 "Loads and impacts".

27.DBN B.2.6-31 "Thermal insulation of buildings".