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

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| Educational and professional program: «Indu         | ustrial       | and civil | engineering»    |
|   |               |           |                 |
| Theme: "Air passenger terminal in Kharkiv"          |               |           |                 |
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# МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ ФАКУЛЬТЕТ АРХІТЕКТУРИ, БУДІВНИЦТВА ТА ДИЗАЙНУ КАФЕДРА КОМП'ЮТЕРНИХ ТЕХНОЛОГІЙ БУДІВНИЦТВА

ДОПУСТИТИ ДО ЗАХИСТУ

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| ЗА СПЕЦІАЛЬНІСТЮ 192 «БУДІВНИЦТВ  | 8О ТА ЦИВІЛЬНА ІНЖЕНЕРІЯ»    |  |  |  |
| Освітньо-професійна програма: «Промислове і цивільне будівництво»   |                              |  |  |  |
| Тема: «Пасажирський аеровокзал у м. Харків»   |                              |  |  |  |
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Факультет архітектури, будівництва та дизайну Кафедра комп'ютерних технологій будівництва Спеціальність: 192 «Будівництво та цивільна інженерія» Освітньо-професійна програма: «Промислове і цивільне будівництво»

| 3A         | ГВЕРД           | <b>ДЖУЮ</b>  |
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### ЗАВДАННЯ

### на виконання дипломної роботи

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- 1. Тема роботи <u>«Пасажирський аеровокзал у м. Харків»</u> затверджена наказом ректора від «30» березня 2021 р. №513/ст.
- 2. Термін виконання роботи: з 24.05.21 по 11.06.21
- 3. Вихідні дані роботи: бетон C25/30, арматура A400C, навантаження відповідно до ДБН В.1.2-2:2006 «Навантаження та впливи».
- 4. Зміст пояснювальної записки: Аналітичний огляд літературних джерел з темою дипломної роботи. Архітектурно-будівельний розділ. Розрахунковоконструктивний розділ. Технологія будівництва. Висновки.
- 5. Перелік обов'язкового ілюстративного матеріалу: слайди 7, креслення 7.

6. Календарний план-графік

| $N_{\underline{0}}$ | Завдання                           | Термін            | Підпис    |
|---------------------|------------------------------------|-------------------|-----------|
| 3/П                 | Завдання                           | виконання         | керівника |
| 1                   | Аналітичний огляд                  | 24.05.21-25.05.21 |           |
| 2                   | Архітектурно-будівельний розділ    | 26.05.21-30.05.21 |           |
| 3                   | Розрахунково-конструктивний розділ | 31.05.21-06.06.21 |           |
| 4                   | Технологія будівництва             | 07.06.21-07.06.21 |           |
| 5                   | Вступ. Висновки. Список            | 08.06.21-10.06.21 |           |
| )                   | використаних джерел. Додатки       |                   |           |
| 6                   | Підготовка доповіді та презентації | 11.06.21-12.06.21 |           |

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| 3   | використаних джерел. Додатки       |                                       |   |  |
| 6   | Підготовка доповіді та презентації | 11.06.21-12.06.21                     |   |  |
| 7. Дата видачі завдання: « <u>24</u> » <u>травня 2021</u> р. Керівник дипломної роботи: <u>Родченко О.В.</u> (П.І.Б.) |                                    |                                       |   |  |
| Завда   | ння прийняв до виконання:          | <u>ка)</u> <u>Єрмак О.Т.</u> (П.І.Б.) |   |  |
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#### INTRODUCTION

Airport terminals go through frequent transformations to accommodate technological advancements as well as changes in regulations. The ever-growing aviation industry requires airport terminals to be planned, designed and constructed in a way that should allow flexible operating conditions.

An airport terminal needs to accommodate a wide range of allied operations and facilities where the performance of any operation influences the other. Airport terminals are composed of large-scale, multi-stakeholder buildings that require an innovative design approach to tackle several strongly interacting services and stakeholders [21]. The airport terminal design approach entails an appropriate recognition of the relationship between all interdependent activities to ensure smooth operation and a high level of passenger satisfaction. The aviation industry is growing rapidly – in the past decade air travel has grown 7% per year [22] with travel for both business and leisure purposes showing strong growth worldwide. This ever-increasing growth in air transport propagates into the need for providing more efficient airport terminal services that can accommodate growth in demand along with the changing needs of an airport environment.

The random transformation in the airport terminal environment is driven by numerous factors; technological advancements, changes in regulation, and changes in terminal facilities are the ones that affect most. The traditional concept of airport design and planning is typically driven by long-term point forecast, fixed standards and established clients. Current forecasting models, typically used in designing airport terminals to predict the growth of traffic volume, could fail to grasp many future uncertainties. In reality, most instances permit the creation of several conflicting forecasts depending on the forecast method, and no single forecast can be entirely correct because the small differences in assumption can yield large differences in outcomes [24]. New design concepts are required that could accommodate these uncertainties with possible design alternatives to tackle emerging challenges in airport terminal design. The airport terminal is a complex

"building" whose usage could change widely during its lifetime. Provisions to accommodate such changes should be one of the most important factors in determining the economic efficiency and performance of this building. The concept of "flexible design" is intended to respond specifically to changing situations and operations. Continuous and rapid changes required in airport management to incorporate technological advancements warrant new approaches of design to allow for short to long-term flexibility in airport terminal development. Several researchers [25] identified that incorporating flexibility in terminal design will help to reduce the risk of high costs of change, both financial and material, and will reduce uncertainties in adopting new technologies. Appropriate integration of flexibility within the standard design process has, therefore, been identified as an efficient way of dealing with uncertainties. Considerable studies are available in works of literature that guide the planning and design of airport terminals. Previous research related to airport design was primarily aimed at designing passenger terminal buildings and their optimum configuration, wayfinding, Level of Service (LOS) space requirements, terminal performance analysis etc. [25]. Modelling of airport terminal operations and their performance evaluation also attracted considerable attention from researchers []. A variety of models and tools were proposed to highlight the importance of airport terminal decision-making dynamics, where the ultimate objective is to facilitate decision-making for airport terminal planning, design and operational management [21]. However, very 3 limited attention has been given to highlighting the importance of flexibility in airport terminal design [24]. The concept of flexibility in terminal design is a relatively new initiative; a limited number of preliminary rules, guidelines and principles are available for designers to incorporate flexible design elements.

This bachelor thesis is about to construct an airport terminal for domestic airlines in Kharkiv, the second-largest city in Ukraine with a population of 1.419 million people. Like one article I read said 'airport terminal is most often the first point of contact with the country to a travelling passenger and for that reason, it

should leave a very good impression in the mind of the passenger'. The architectural point should speak of show some bit of culture of the host country. The building should have a very suitable and functional layout. The terming shouldn't depend on the number of checked-in passengers but it must also have regard for the type of the airport operations, that is, is the airport serving as an airline hub or serving as a focal point to point traffic. Most importantly the airport terminal must be easy to be accessible and use.

#### CHAPTER 1. ANALYTICAL REVIEW

An airport terminal is a building at an airport. It is where passengers are able to get on and off aircraft. Inside the terminal, passengers can buy tickets, leave or pick up their luggage, and be checked by security staff. The buildings that provide access to the airplanes through gates are usually called concourses. However, the words "terminal" and "concourse" are sometimes interchangeably used to mean the same thing. Small airports have only one terminal, while large airports can have several terminals and/or concourses. At small airports, the single terminal building usually has all of the functions of a terminal and a concourse [26].

There are different types of airport terminal according to their design or concept. These are as follows [26]:

- the pier finger terminal;
- the linear terminal concept;
- the open apron terminal concept;
- satellite terminal concept;
- compact module unit concept.

### 1.1. The pier finger terminal

This is also known as the centralized airport concept or design because it has a common hall through which all passengers must pass. The hall contains facilities for checking passengers and for handling their bags and also houses auxiliary services such as restaurants and stores. Passengers connect with the aircraft along corridors. In the finger pier design, the aircraft are located along the corridors. In the satellite design, the aircraft are placed at the end of the corridors. Examples are shown in Fig. 1.1. Both designs provide essentially the same services, but satellites may allow somewhat more room for aircraft to maneuver,

depending on their location. If the airport is large, the terminal area may include several centralized terminals. This occurs at Paris (Orly), London (Heathrow), Chicago (O'Hare), and San Francisco airports, for example. Centralized terminals have many advantages. Airlines and airport operators like them because they promote intensive use of facilities and equipment and, thus, reduce the average costs of providing check-in and baggage-handling services. Passengers who have to transfer between flights also like centralized terminals because they are relatively compact. Conversely, the essential disadvantage of centralized terminals is that-at large airports-all passengers must go through a congested place and must travel a considerable distance between the vehicles that bring them to the airport and the aircraft. Although this distance may be covered on foot or via some form of moving sidewalk or automatic device like the sky-bus in use at Tampa or Seattle-Tacoma airports, it is an inconvenience, especially to commuters and others who may be in a great hurry [26].

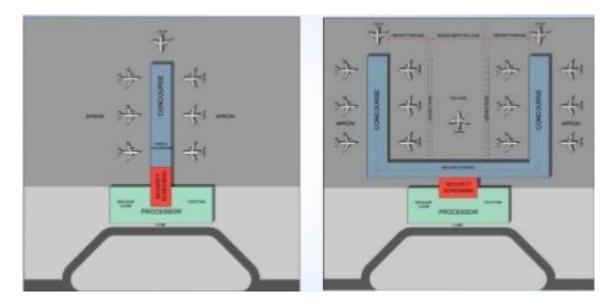


Fig. 1.1. Pier finger terminal

Advantages of pier airport terminal concept are as follows:

- high percentage of passengers can be accommodated under "one roof";
- it permits low mean connecting time if flight pair are properly coordinated;

- it allows variable expansions possibilities of the piers, independent of the main processor;
- centralization of airline and government inspection services stuff;
- it permits use of relatively simple flight information passing system.

Disadvantages of pier airport terminal concept are

- long walking distance during flight transfers;
- it requires secondary concession outlet in piers;
- curbside is normally congested;
- long taxiway for aircrafts;
- early checking and closing time for passengers;
- baggage mishandling [25].

### 1.2. The Linear Terminal Concept

The linear or gate-arrival concept was devised to eliminate long distances between the place of arrival and the aircraft. It allows a passenger to be driven right up to the gate to the aircraft. The airport is linear and has roads on one side and aircraft on the other (Fig. 1.2). The gate-arrival design became fashionable in the late 1960s, possibly because few people had experienced, or thought about, the disadvantage of this approach. A gate-arrival terminal naturally requires separate baggage-handling and check-in facilities at or near each aircraft position, significantly increasing the equipment and personnel needed to serve passengers. The maximum distance from one end to the other is much longer in a linear terminal than in a centralized terminal, especially if the former has aircraft on only one side of the building. The gate-arrival terminal can thus be quite unattractive both for transferring passengers and for returning travelers who wish to pick up cars they may have parked in front of some distant gate [21].

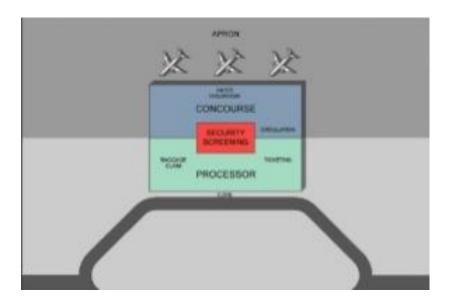


Fig. 1.2. Linear / Curvilinear air terminal concept

Advantages of the linear airport concept are as follows [25]:

- short walking distance if check-in facilities are semi centralized;
- easy passenger orientation;
- design of terminal is simple and expansion is very easy;
- separating of the arrival and departure is relatively easy especially when using two level system;
- compact baggage conveying/sorting systems if remote drop point is not utilized in concourse.

Disadvantages of the linear airport concept are

- if the system is decentralized it will be required duplication of air terminal facilities and workers;
- aircraft movement to the rear of the concourse may be retracted due to the need of engine noise levels;
- long walking distance especially for passengers transferring between extreme concourses [24].

### 1.3. The Open Apron Terminal Concept

These vehicles, generically called transporters, carry passengers between a central terminal and the aircraft parked on the apron. These transporters are also called apron passenger vehicles in England and mobile lounges in North America. The term mobile lounge is really inappropriate since it is inefficient to use vehicles as lounges; they and their drivers should be in use, moving passengers to and from aircraft, as much as possible. The prototype for this arrangement are Washington (Dulles) Airport and Hamburg (Fig. 1.3), which serves essentially all passengers with transporters (a few walk to small aircraft through a miniscule finger pier). The transporter reduces the amount of walking a passenger must do, but requires a large labor force of drivers and attendants and is potentially expensive. It is also potentially economical, since transporters can be parked and operated only when needed so that drivers can be hired for a fraction of the time, either for a specified shift or season. The transporter concept thus has a distinct economical advantage for handling peaks of traffic [25].

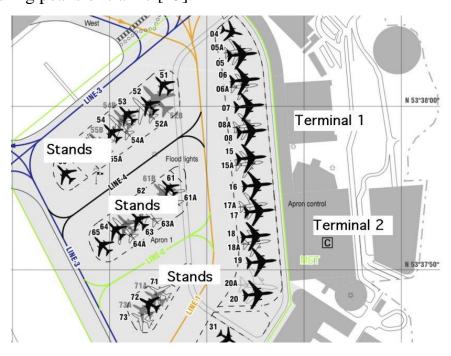


Fig. 1.3. Open apron terminal concept at Hamburg

Advantages of open apron air terminal are:

- constant compatibility of terminal geometry to accommodate new generation large aircraft (NLA);
- easy aircraft maneuverability;
- simplified passenger orientation;
- reduced walking distances for passengers;
- more efficient central processor.

Disadvantages of open apron air passenger terminal are as follows:

- low percentage of contact stands;
- increased of loading and unloading processing times;
- additional airline staff required.

Each of the aforementioned concepts of terminal design functions efficiently for some kinds of traffic: Centralized terminals are easier for transferring passengers; gate-arrival terminals are better for commuters; and opengate terminals handle traffic peaks more economically. Any airport is likely to have a significant proportion of more than one of these types of traffic, and we should therefore expect that effective designs for terminals would combine the appropriate features of all the concepts [26].

Airport designers, however, typically develop master plans for terminals around only 1 out of the 3 concepts and argue about which concept is best for all purposes. This debate is remarkably dogmatic. Recent controversies over new airports have demonstrated a singular unwillingness to compromise or to combine design concepts. The protracted arguments over the new Montreal (Mirabel) Airport are an example. The architects and planners in charge decided early on that a transporter design should be built and resisted compromise when airlines and others subsequently showed that this plan had several drawbacks. Finally, some sort of combination of concepts was agreed upon, but only after various airlines applied strenuous pressure. Elsewhere, for example at Frankfurt (Main), Dallas-

Fort Worth, and Washington (Dulles) airports, the situation has been similar: Politically powerful institutions or persons have imposed their favorite design on the users [26].

This kind of fight is unnecessary, for a diversity of needs can best be served by a mixture of the elements that best serve each need. We should start with the premise that the best design for an airport terminal is likely to be some hybrid of a pure concept. A rational combination of elements; however, is difficult to achieve for several reasons. In the United States, architects usually design airport terminals, and they naturally think of form and external beauty. In France and Germany, airport designers are engineers, who tend to like mathematically clever and geometric designs so us Ukraine. The designs for practically all new airport terminals, therefore, are remarkable for their symmetry, elegance, and even beauty.

The users and operators of an airport terminal want it to function smoothly and efficiently. They want a variety of significantly different kinds of services, such as easy access to all aircraft and easy transfers. The diversity and complexity of their desires inherently conflict with aesthetic preferences of the designers for simplicity of concept and form; this conflict is now dominated by the designers.

Better terminals for the airlines and the travelers can be designed if we concentrate on the functions to be served, not on the form. We may need to restrain the architectural considerations to the extent they dominate the design process. The current dominance of architects in the design of terminals is suggested by their responsibility for the available textbook treatments of the subject. I Instead, we need to emphasize pragmatic considerations in the selection of the concept for the terminal. These are largely missing. Our problem will be to determine what combination of concepts provides the most suitable design for the particular mix of traffic at any airport. To do this, we need to understand the different kinds of traffic using airport terminals and their implications for the choice of design [25].

To design the airport and also calculate the expected traffic we first have to take a look at the city the construction will be going on. Kharkiv this the first

capital city of Ukraine. Kharkiv is a city in northeast Ukraine. The city has a population of 1.5 million people. The city is the second largest city in Ukraine. The designed terminal will be hosting 400 passengers per an hour. This makes it a medium size airport so in this case the airport is not expected to be crowdy. The airport is expected to have a short walking distance from the runway to the checkin point or departure plane during transferring of passengers or travelling from this airport. In designing the terminal, we must therefore be careful in interpreting data about airport traffic. This process develops traffic estimates, for example, of the peak hour of the average day of the peak month. These figures are useful for calculating the capacity of the system for handling bags, the width of the corridors, and other dimensions [26].

### 1.4. Architectural Solution of Air Passenger Terminal

After having the necessary data for the passenger traffic at a peak day and handling of baggage, we can now examine the major questions concerning the fundamental nature of terminal facilities at an airport [25]. That is

- Should the facilities be centralized in a single major complex or decentralized into separate terminals or gates as with the gate-arrival concept?
- Should transporters be used exclusively, as at Washington (Dulles) Airport, partially as at most European airports, or not at all?
- Should the facilities be shared by different airlines, as they are in Europe and generally are not in the United States, and to what extent should they be shared?

A centralized terminal facilitates transfers. It generally implies smaller distances for persons connecting between flights. This is not to say, of course, that the distances are necessarily short: From one end to the other end at Chicago (O'Hare) Airport is more than 1 mile (1.6 km). Large as this is, it is less than the comparable figure for a gate-arrival terminal: The greatest distance between gates at Dallas-Fort Worth, an airport with far less traffic, is more like 3 miles (5 km).

Use of a central terminal also makes it possible to keep transfer passengers within a single building and thus reduce the number of security inspections that must be made. A central terminal can also provide an easy connection to a public transit system. The railroad station for the Frankfurt (Main) Airport is right below the central terminal building and curb, for example. But for an airport with decentralized terminals, such as New York (Kennedy), it is essentially impossible to locate stations that would be convenient to each unit [26].

A central terminal also creates congestion. This is both good and bad. It is good because traffic is heavy enough to support restaurants, shops, and other passenger conveniences. At gate-arrival terminals, where this density does not exist, passengers can hardly get anything to eat, for operators cannot afford to maintain the equipment and staff required to provide food service for the few persons who pass by a few gates. Conversely, however, the congestion at centralized terminals can delay and confuse traffic and is exactly the kind of inconvenience gate-arrival terminals are designed to overcome. Qualitatively, gatearrival terminals are most convenient for commuting passengers who are going directly to some destination and who have little concern for transfers or for special shops and services; they probably want to proceed as quickly as possible to their flight. From an economic point of view, the better configuration depends on the trade-off between the extra costs of providing more facilities with more personnel at decentralized terminals and the savings that occur by avoiding the costs of congestion in a centralized terminal. The extra costs of operating a gate-arrival facility can be quite high. This design requires separate check-in counters for every few gates and prevents staff from being used for many flights at once. Braniff and TWA each estimated, for example, that they needed 15 percent more staff to serve their new gate-arrival facilities at Kansas City. The special costs of a central terminal can be higher, however [24].

The complexity and the cost of the equipment required to sort bags and cargo in a large terminal are the most powerful economic incentives for decentralization. Complicated mechanisms may have to be provided to sort this

traffic through the confusion of a central hall serving dozens of destinations. Strong diseconomies of scale exist in this process: Costs increase exponentially faster than the size of the terminal. Specifically, a recent study estimated that, for cargo facilities,

Total costs = constant 
$$x (size)^{1 \cdot 16}$$

A hybrid terminal may be best for many situations. To meet the conflicting desires of different passengers for ease of access and of transfer and to keep costs within bounds may be most effectively done by including both the centralized and gate-arrival concepts in an overall design for a terminal. The gate-arrival section can serve heavy commuter traffic to a few destinations, and the finger piers can serve the remainder of the passengers. In practice, this is the formula that has successfully evolved at New York (La Guardia) Airport, where the shuttle passengers to Boston and Washington have their own gates and also Pisa Airport in Italy also serves as a commuter to other neighboring cities and countries. A similar design is planned for the new terminal at Calgary: There, the gate-arrival facilities will serve the commuter traffic to the provincial capital at Edmonton [26].

Transporters become better than constructed gates when the rate of use for the facilities becomes relatively low. When equipment is used for only a few hours a day or a few months a year, it becomes relatively expensive per passenger, for the same fixed costs get prorated over fewer people. Constructed facilities are especially sensitive to this effect since almost all of their costs consist of the fixed amortization of the capital invested. The cost per passenger served does not increase so rapidly, however, when one uses transporters. Some of their costs can be avoided when use is low: Fuel and maintenance costs drop, and drivers need not be hired. A schematic comparison of the relative costs of transporters and of constructed gates. Whatever the relative cost may be at full utilization, the exponentially rising cost per passenger of constructed gates makes it practically inevitable that transporters provide the cheaper alternative at the lowest rates of utilization. Detailed analyses in the United States and England indicate that it is

economically efficient to use transporters for a sizable fraction of the gates at a major airport. [The major public reference on this is the study by de Neufville et al. Its conclusions are supported by numerous private studies, including those of the British Airports Authority.] Although the results depend both on local costs and variability of the traffic, serving about one-third of the aircraft positions with transporters typically appears to be best. Because these should be the gates with the lowest rates of utilization, they will only serve a small fraction-about 10 percent or less-of the total number of passengers through the terminal. Relatively few would thus have to face the delays of using transporters. With regard to costs, the desirability of transporters depends on anything that influences the relative costs of capital. High interest rates make transporters more attractive, for example. But high inflation, which increases the cost of salaries and fuel and reduces the real cost of construction, favors constructed facilities [22].

The airport will have a which is an open space or lounge in air passenger terminal, used by passengers for their circulation and waiting.

Under a concourse we have departure and arrival of passengers and under these two we have lobbies of each respectively. Also, below these lobbies we have areas for additional services like public zones, internet center, rest rooms, snack bars, general departure lounge, gate lounge, VIP lounge, transit lounge etc [26].

# 1.5. IATA Planning Standards and Recommended Practice at Departure Lounge Design

- Space 1.2m<sup>2</sup> per passengers standing&1.7m<sup>2</sup> per passengers seated.
- seating for 10% of passengers where passengers do not have to wait;
- 60% where passengers do have to wait.
- Seating at food & beverage concessions 70% of passengers
- should have access to seating.

- Walking Distance maximums of 250-300m unaided & 650m with moving walkways.
- CIP Lounges 4.0 m2 per passenger.
- Retail/ Concessions Airport Authority should obtain 50 60% of total airport revenue from retail/ concessions. 70-80% of retail
- concession should be located airside. Retail/concession facilities should not interfere with passengers flows between check-in and the departure gate lounges.
- Meter -Greeter Hall Space 1.7m2 per passenger and greeter.
- 20% of space for seating. Easy access to train station [23].

# 1.6. IATA Planning Standards and Recommended Practice at Check-In Area Design

- Business Class- Maximum Queuing Time of 3-5 min.
- Economy Class Maximum Queuing Time of 15-20 min.
- Tourist (Charter/ No Frills) class Maximum Queuing Time of 25-30 min.
- Space for passengers waiting up to 30 minutes 1.8 m per international passenger, 1.3m for domestic passengers [23].

### 1.7. Check-In Layout

Recommended dimensions for Linear Type Check-in Layout with maximum queuing time of 30-35 minutes (Fig. 1.4) [26].

Recommended dimensions for Island Type Check-in Layout with single queue per flight with maximum queuing time of 30-35minutes (Fig. 1.5) [26].

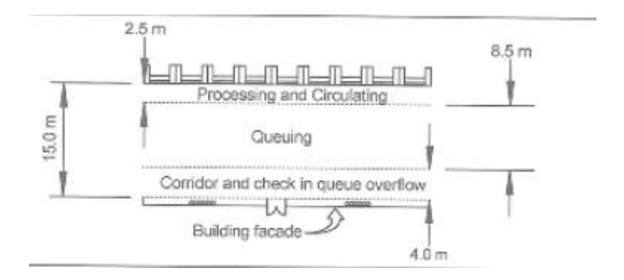


Fig 1.4. Dimensions for linear type check-in layout

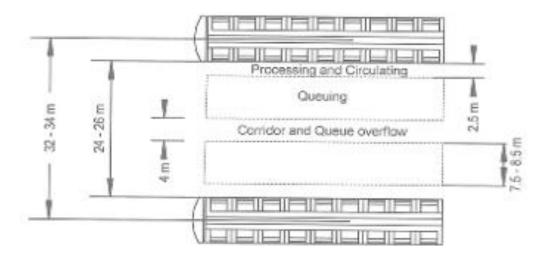


Fig 1.5. Island type check-in layout

#### **CHAPTER 2. ARCHITECTURAL PART**

### 2.1. Brief description of the current state of Kharkiv airport

The history of civil aviation of Ukraine dates back to the city of Kharkiv. On March 26, 1923, the joint-stock company Ukrvozduhput was founded, one of the tasks of which was to organize regular flights [12].

On May 25, 1924, the first regular passenger lines of Ukrpovitroshlyakh were opened: Kharkiv-Poltava-Kyiv and Kharkiv-Kirovohrad-Odessa.

In 2008, the entire complex of Kharkiv airport was leased for 49 years to New Systems AM, a member of the DCH investment group. The runway, as a strategic object, is owned by the state. Airport Consulting Vienna (Austria) and Airport Reseach Center (Germany) have developed a large-scale reconstruction project of Kharkiv Airport, which began in the second half of 2008 [12].

On August 28, 2010, a new modern passenger terminal with an area of 20,000 square meters and a capacity of 650 passengers per hour was opened, designed to service the arrival and departure of all domestic and international flights. For the first time in the history of the airport, telescopic ladders were installed in the new terminal, which allowed passengers to board the plane directly from the airport building without having to go outside. The old airport building was reconstructed and turned into a terminal for VIP passengers. The terminal has retained the style of Stalinism, on its territory opened a restaurant "Flight", decorated in the style of the 1950s. In addition, a hangar was built, which includes 3 sections for storage of private aircraft and maintenance of aircraft [26].

In 2011, a new 2,500-meter runway was put into operation, which can accommodate all types of medium-haul aircraft and some types of long-haul aircraft without restrictions.

The strip is equipped according to ICAO category II, which allows Kharkiv Airport to accept aircraft in bad weather [23].

In 2012, Kharkiv Airport successfully provided services for flights of football teams and fans of the European Football Championship Euro-2012.

On some days, the airport's congestion was so high that the old runway was used to park aircraft. In August 2013, the airport successfully received the An-124 "Ruslan", which has the largest takeoff weight of 392 tons among the aircraft ever received by the Kharkiv airport [12].

In 2016, Kharkiv Airport served almost 600,000 passengers. According to the results of 6 months of 2017, the growth of passenger traffic was 51%, and the number of passengers was 364 thousand.

Currently, such large airlines as Ukraine International Airlines, Turkish Airlines, Pegasus Airlines, LOT, Belavia fly to Kharkiv Airport to fly direct flights from Kharkov, as well as convenient connections at major hub airports anywhere in the world [12].

### 2.2. Air passenger terminal capacity

The capacity of the air terminal for domestic airlines in 2030 must be at least 400 passengers per hour. And these figures are divided into:

- passengers who are initially sent 200 people;
- Arriving passengers 200 people.

Meeting and seeing off are 160 people.

### 2.3. Choice of airport type

When developing the conceptual technological planning of the airport complex, the following "airport-forming factors" were analyzed [24]:

- its binding to the runway and RD;
- its binding to the platform configuration;
- its binding to the scheme of access to the airport;

- influencing the easy orientation of passengers at the entrance to the airport and in the building itself;
- providing the shortest possible walking distances from the parking lot to the airport;
- providing the shortest possible walking distances from passenger and luggage service areas to the aircraft and vice versa;
  - minimum changes in passenger traffic levels and no oncoming flows;
- minimum distances for delivery of passengers and / or luggage from the aircraft parking place;
- compatibility of all facilities with the characteristics of all existing aircraft, including promising aircraft.

Based on the analysis of existing in the world progressive conceptual technological planning of airport complexes such as:

- centralized airport with landing galleries (Amsterdam-Schiphol, Zurich, London-Heathrow T3);
  - linear semi-centralized airport (London-Heathrow T4, Munich);
- transport scheme of delivery with a centralized airport (Montreal Mirabelle, Washington Dallas);
- centralized airport with an island service concept (Paris Charles de Gaulle T1, Denver, Tokyo Narita T2, Pulkovo Sanki-Petersburg);
  - modular air terminal of compact technological units
  - semi-centralized (Paris Charles de Gaulle T2, Hanover).

Based on the analysis of the master plan of Kharkiv Airport and its development prospects for 20 years, the concept of a linear airport complex is recommended, which has the following advantages [22]:

- minimum walking distances with decentralized registration;
- easier orientation for passengers;
- fairly simple design of the main airport;
- the separation of arriving and departing passengers is carried out relatively easily, using passages in the controlled area of the airfield;

- the optimal time of the beginning of registration and its end;
- in the future it is possible to expand without interfering with the maintenance of fat passages and aircraft flights, such expansion can be carried out by linear extension or construction of a linear unit that runs through the controlled part of the airport.

## 2.4. Volume-planning solution of the air passenger terminal for domestic airlines at 400 passengers / hour

Based on the development of the service and technical territory of Kharkiv Airport, the best option is to place a new air passenger terminal for domestic airlines at 400 passengers per hour, taking into account the prospects for the development of the airport until 2030.

The air passenger terminal is located at a minimum distance from the access road. Aircraft can be placed on the platform in two rows. The concept of a linear airport complex is offered.

The building of the new air passenger terminal is complex in plan, two-storey with a basement.

The building is designed in a monolithic reinforced concrete frame.

The largest length is 78 m.

The largest width is 54 m.

Floor height -3.8 m.

Basement height \_ m.

The main grid of columns 6 \* 6 m.

On the ground floor there are all the main and auxiliary rooms for arriving passengers (lobby, waiting areas, sanitary, passport and customs control areas, baggage claim areas).

On the first floor there are all the main and auxiliary rooms for departing passengers (lobby, waiting areas, control areas, transitional galleries).

In the basement there are technical premises, premises for automated processing and storage of luggage, auxiliary premises for engineering systems, warehouses of trade enterprises and premises of the food block. Technological service of passengers is provided on 2 levels: arriving - on 1 level, departing - on 2 level.

Baggage handling of departing passengers, storage of cargo, containers, baggage of delayed flights - in the basement. Delivery of arriving passengers takes place at the first level.

Passenger communication for level 1 involves the use of the existing access road with its expansion at the entrance to the airport complex. The whole complex has an air conditioning system and heating system.

Each gate to which the aircraft arrives is equipped with an automatic docking guidance system, and because each system is connected to an information system, access to information such as flight number, arrival time and gate number will be free throughout the airport where it is located. will be technically possible. All aircraft arrivals are equipped with 400 Hz convectors and remote controls.

Constructions of partitions and their sound-insulating ability are given in Table 2.1.

Table 2.1 Soundproofing ability of partitions

|           | Thickness, mm |          |               | Sound      | Regulatory  |
|-----------|---------------|----------|---------------|------------|-------------|
| Partition | Partition,    | Isolatio | Plasterboard, | insulation |             |
| design    | D             | n, h     | d             | index Rw,  | requirement |
|           |               |          |               | dB         | [Rw], dB    |
|           | 150           | 100      | 2×12,5        | 53         | 52          |
|           | 200           | 150      | 2×12,5        | 56         | 52          |

Separate KVN-Bud partitions were used in toilets and showers. The partitions are 25 mm thick. Made of moisture-resistant chipboard 24 mm, covered with plastic.

Shower partitions are made of monolithic laminate with a thickness of 10 mm.

Entrance doors to the air passenger terminal - automatic revolving doors (1st and 2nd floors) - 24 pcs. - and automatic sliding doors Sintek - 40 pcs. - (basement of the airport and all entrance levels of the administrative and business center).

The advantages and principle of operation of revolving doors is that they are always open - always closed: always open - for the passage of visitors; always closed - for noise, dirt, drafts, temperature changes. In addition to their functionality, these doors are the decoration of the building due to the design and the ability to make both aluminum with glass and wood, bronze, brass, stainless steel. Aluminum revolving doors with glass were used in the bachelor thesis [28].

#### **CHAPTER 3. STRUCTURAL DESIGN**

### 3.1. MONOMAKH-SAPR software for airport building design

In MONOMAKH-SAPR software the analysis of the building model of air passenger terminal for domestic airlines is performed on the basis of the scheme obtained from the AutoCAD program.

MONOMAKH-SAPR software is intended for analysis and design of monolithic reinforced concrete structures and structures with brick walls. It is possible to perform analysis of the whole structure or its separate parts and generate working drawings and reinforcement patterns for structural elements.

MONOMAKH software includes several modules: BUILDING, BEAM, COLUMN, FOOTING, REWALL, SLAB, DIAPHRAGM, BRICK. These modules are integrated but they may work in stand-alone mode as well. Model of the structure is generated from structural elements (STE). Loads are collected automatically; sections of structural elements can be determined and checked. You can generate 3D design model of the structure, perform finite element analysis and evaluate analysis results. Bill of materials is generated. Data may be exported to other modules of MONOMAKH software [9]. Loads on footings are exported to DEF-PC and design model is exported to LIRA software [10].

BUILDING module enables you to generate model of the structure from columns, beams, walls, partitions, floor slabs and foundation slabs, to perform static and dynamic analyses using Finite Element Method and determine displacements, forces and stresses and to export data to other modules of MONOMAKH software [10].

Modules BEAM, COLUMN, FOOTING, REWALL, SLAB, DIAPHRAGM, BRICK can be used in stand-alone mode or you may work with data defined in BUILDING module. *DXF*-file of the drawing and text files of reports are generated in module BEAM, COLUMN, FOOTING, REWALL,

SLAB, DIAPHRAGM and BRICK. All modules contain extensive help system where you can find detailed information about options and tools of the module. You can create and analyze design models of the structure in the shortest possible time and produce fully detailed reinforced concrete drawings with minimum effort [10].

**COLUMN** module enables you: to import design model from **BUILDING** module or generate it in stand-alone model [10].

**SLAB** module enables you: to import design model from **BUILDING** module or generate it in stand-alone mode. Slab contour may be of arbitrary shape. Variable thickness of the slab and specified holes are taken into account [9].

### 3.2. Finite element method for airport building design

For air passenger terminal building analysis finite element method is used.

Finite element method (FEM) is a numerical method for solving a differential or integral equation. It has been applied to a number of physical problems, where the governing differential equations are available. The method essentially consists of assuming the piecewise continuous function for the solution and obtaining the parameters of the functions in a manner that reduces the error in the solution [10].

The finite element method originated from the need for solving complex elasticity and structural analysis problems in civil and aeronautical engineering. Its development can be traced back to the work by Alexander Hrennikoff (1941) and Richard Courant (1942). While the approaches used by these pioneers are different, they share one essential characteristic: mesh discretization of a continuous domain into a set of discrete sub-domains, usually called elements. Starting in 1947, Olgierd Zienkiewicz from Imperial College gathered those methods together into what would be called the Finite Element Method, building the pioneering mathematical formalism of the method [10].

Hrennikoff's work discretizes the domain by using a lattice analogy, while Courant's approach divides the domain into finite triangular subregions to solve second order elliptic partial differential equations (PDEs) that arise from the problem of torsion of a cylinder. Courant's contribution was evolutionary, drawing on a large body of earlier results for PDEs developed by Rayleigh, Ritz, and Galerkin [9].

Development of the finite element method began in earnest in the middle to late 1950s for airframe and structural analysis and gathered momentum at the University of Stuttgart through the work of John Argyris and at Berkeley through the work of Ray W. Clough in the 1960s for use in civil engineering. By late 1950s, the key concepts of stiffness matrix and element assembly existed essentially in the form used today. NASA issued a request for proposals for the development of the finite element software NASTRAN in 1965. The method was again provided with a rigorous mathematical foundation in 1973 with the publication of Strang and Fix's *An Analysis of The Finite Element Method*, and has since been generalized into a branch of applied mathematics for numerical modeling of physical systems in a wide variety of engineering disciplines, e.g., electromagnetism and fluid dynamics [9].

FEM is based on the idea of building a complicated object with simple blocks or dividing a complicated object into small and manageable pieces. Application of this simple idea can be found everywhere in everyday life, as well as in engineering.

The procedure of FEM in structural analysis is as following:

- 1. divide structure into pieces (elements with nodes);
- 2. describe the behavior of the physical quantities on each element;
- 3. connect the elements at the nodes to form an approximate system of equations for the whole structure;
- 4. solve the system of equations involving unknown quantities at the nodes (e.g., displacements);
  - 5. calculate desired quantities (e.g., strains and stresses) at selected elements.

```
Types of finite elements are [10]:
1) 1-D (line) element;
2) 2-D (plane) element:
   a) plate elements:
      - 4-node quadrilateral Kirchhoff plate element;
      - 6-node triangular Kirchhoff plate element;
      - 4-node quadrilateral Mindlin plate element;
      - 8-node quadrilateral Mindlin plate element;
   b) axisymmetric elements:
      - 3-node element;
      - 4-node element;
   c) shell elements:
      - 4-node shell element;
      - 8-node shell element;
      - curved shell element;
3) 3-D (solid) element:
   a) tetrahedron 3-D solid element:
      - linear (4 nodes);
      - quadratic (10 nodes);
   b) hexahedron (brick) 3-D solid element:
      - linear (8 nodes);
      - quadratic (20 nodes);
   c) penta 3-D:
      - linear (6 nodes);
```

FEM matrix form of one spring element is

- quadratic (15 nodes).

$$\begin{bmatrix} k & -k \\ -k & k \end{bmatrix} \begin{bmatrix} u_i \\ u_j \end{bmatrix} = \begin{bmatrix} f_i \\ f_j \end{bmatrix}$$

or,

ku = f

where

 $\mathbf{k} = (\text{element}) \text{ stiffness matrix}$ 

 $\mathbf{u}$  = (element nodal) displacement vector

f = (element nodal) force vector

## 3.3. Finite element modelling of air passenger terminal in MONOMAKH-SAPR

First, a typical floor is created, partitions are added and loads are set. Then this floor is copied to the required number of floors, according to the task (in my case 3 floors) (Fig. 3.1).

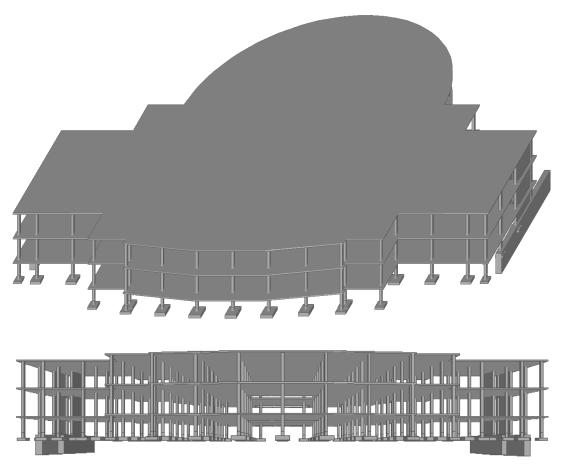


Fig. 3.1. Three-dimensional model of the air passenger terminal building

After the design, the software creates a finite element model of the building (Fig. 3.2), on the basis of which the calculation is performed.

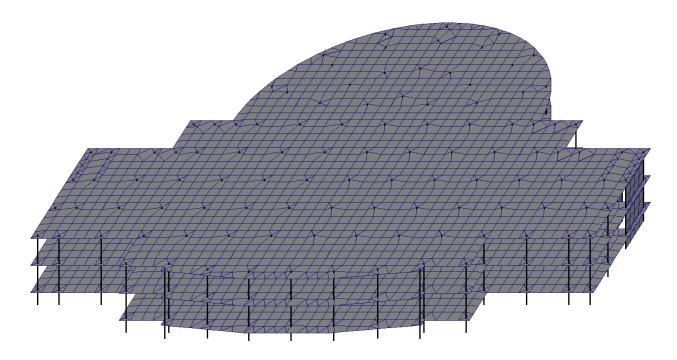


Fig. 3.2. Finite element model of the air passenger terminal building

By short-term snow loading is a snow loading with operational design values.

Operational estimated value is as follows:

$$S_e = \gamma_{fe} S_0 C = 0.77 \cdot 1600 \cdot 1 = 1232 (Pa)$$

where:  $\gamma_{fe}$  - ratio of reliability for the operational values of the snow loading  $(\eta=0.01\Rightarrow\gamma_{fe}=0.77);$ 

 $S_0$  – the characteristic value of the snow loading (in Pa) [2], for the given 5 construction district (Kharkiv)  $S_0 = 1600$  Pa;

C – ratio determined by the formula

$$C = \mu_{C_e C_{alt}} = 1$$

where  $\mu$  – ratio of transition from the weight of the snow cover on the surface of the soil to the snow loading on the roof,  $\mu$  = 1 when sloping the roof  $\alpha \le 25^{\circ}$  [2];

 $C_e$  – ratio taking into account the operation of the roof, for this type of structures  $C_e$ =1;

 $C_{alt}$  – ratio of geographical height  $C_{alt} = 1$  (at H < 0.5 km).

Kharkiv H < 0.5 km.

To long-term snow load is a snow loading with quasi-constant calculated values [2].

Quasi-constant calculated snow loading value is determined by the formula:

$$S_p = \sqrt{4S_0 - S} = (0.4 \cdot 1480 - 160) \cdot 1 = 480 (Pa)$$

where  $\overline{S} = 160 \text{ Pa}$ .

Wind and seismic loadings are automatically set in the BUILDING program, after selecting areas for these loads [1].

For our 2 district 450 Pa (Kharkiv).

The results of the calculation in the program "BUILDING" are shown on Fig. 3.3-3.15. After the calculation of the building in the Layout program, the results of the calculation are reviewed and analyzed, namely the plot of efforts, mosaics of displacements and stresses.

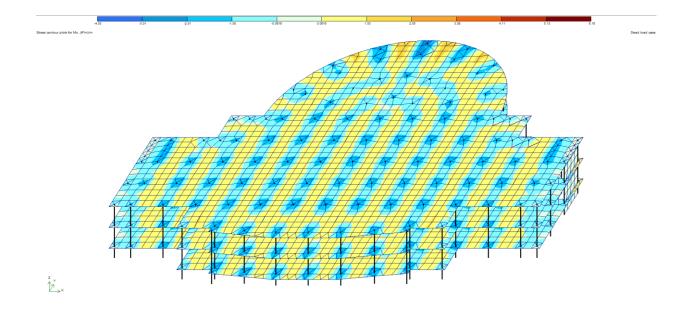


Fig. 3.3. Stresses in the building on  $M_x$ 

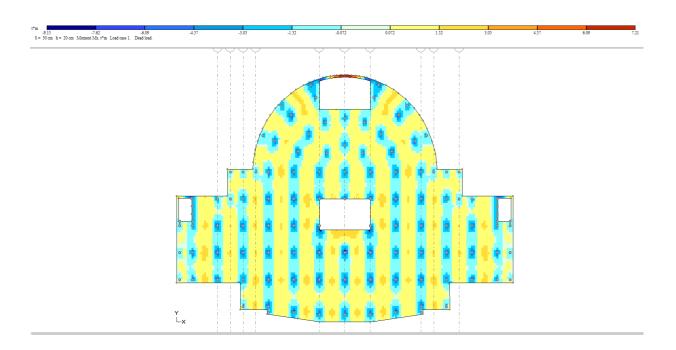


Fig. 3.4. Isopoly stresses in the building on  $M_x$ 

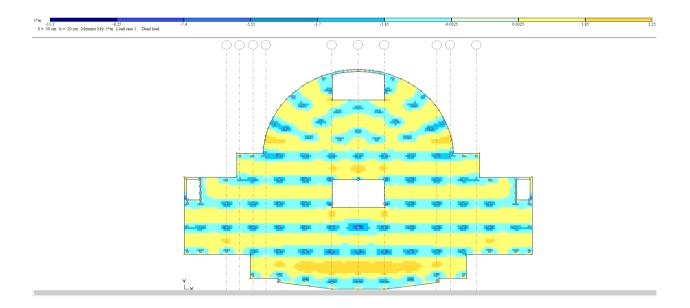


Fig. 3.5. Stresses in the base plate according to  $\ensuremath{M_{\scriptscriptstyle y}}$ 

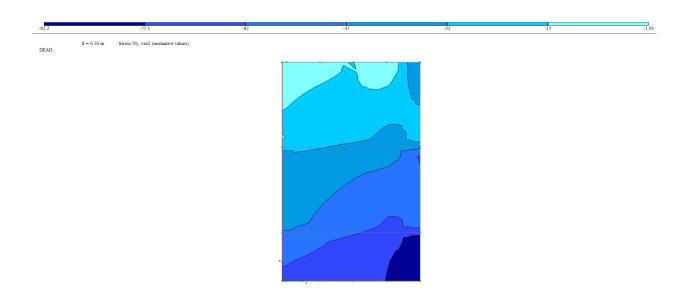


Fig. 3.6. Stresses in bearing wall on  $N_{\mbox{\tiny y}}$ 

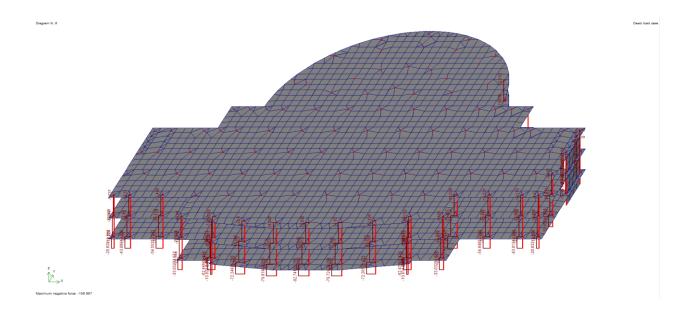


Fig. 3.7. Plots of longitudinal forces N in columns

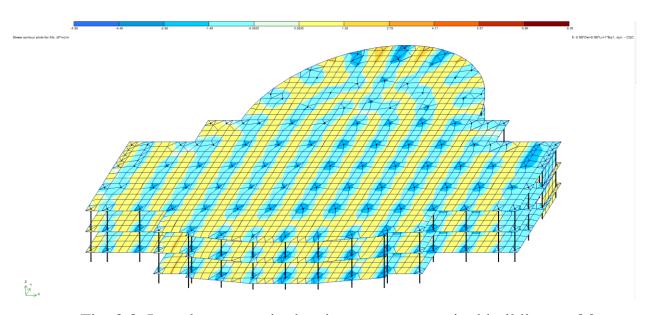


Fig. 3.8. Isopoly stresses in the air passenger terminal building on  $M_x$  on the fifth combination of efforts

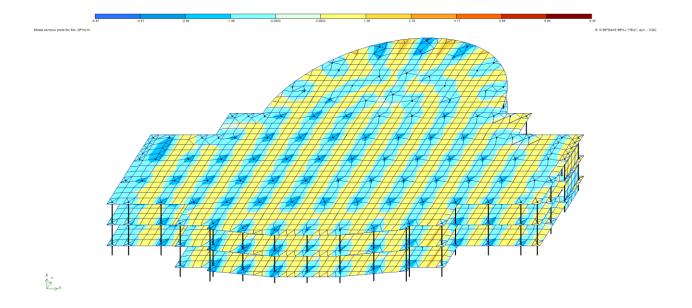


Fig. 3.9. Stresses in the air passenger terminal building on  $M_x$  on the sixth combination of efforts

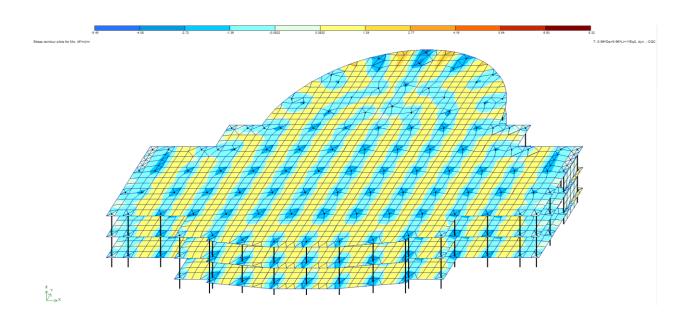


Fig. 3.10. Stresses in the air passenger terminal building on  $M_x$  on the seventh combination of efforts

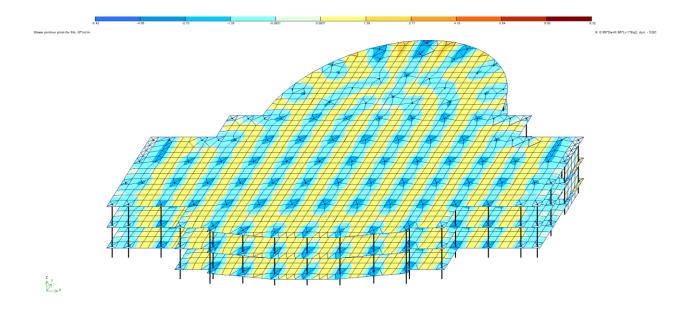


Fig. 3.11. Stresses in the air passenger terminal building on  $M_x$  on the eighth combination of efforts

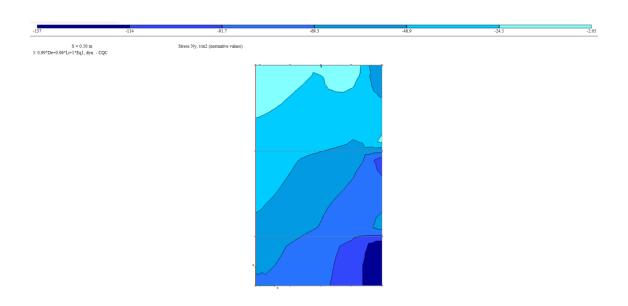


Fig. 3.12. Stresses in bearing walls on  $N_y$  on the fifth combination of efforts

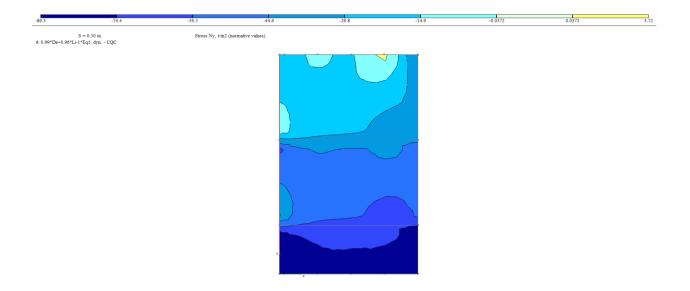


Fig. 3.13. Stresses in bearing walls on  $N_{\text{y}}$  for the sixth combination of efforts

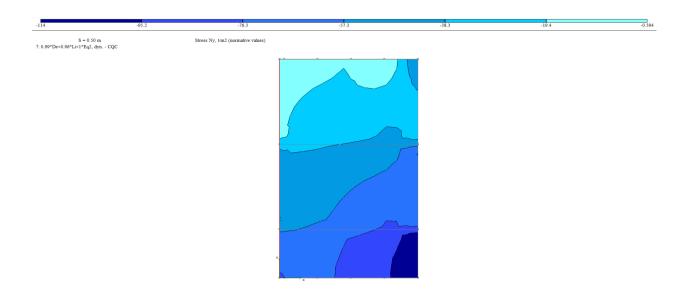


Fig. 3.14. Stresses in bearing walls on  $N_{\text{y}}$  for the seventh combination of efforts

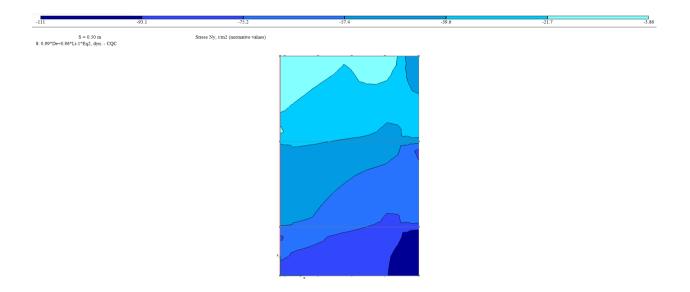


Fig. 3.15. Stresses in bearing walls on  $N_y$  for the eighth combination of efforts

### CHAPTER 4. TECHNOLOGY OF CONSTRUCTION

## 4.1. Preparations

Before laying the foundations it is necessary [20]:

- organize the removal of surface water from the site;
- pave the necessary passages and access roads for the transportation of construction equipment;
- to prepare places of storage, assembly of a timbering, consolidation of reinforcing grids and frameworks, to deliver assembly equipment and adaptations;
  - deliver formwork kits, reinforcing mesh and frames to the warehouse;
- perform the necessary sand, gravel, concrete preparation for the foundations;
- to carry out geodetic breakdown of axes and breakdown of position of the bases according to the project;
- indicate the position of the working planes of the boards of the formwork of the foundations with a berth, pins, other clamps;
- check the correctness of the arrangement of concrete preparation and marking the position of the axes and marks of the foundations. Acts for hidden works must be drawn up for the preparation of foundations. The prepared basis for the foundations must be adopted by the act of the commission.

Prior to the installation of large-panel formwork of walls and ceilings on the next working horizon, the following preparatory measures must be performed [20]:

- leveling of the floor surface;
- breakdown of axes and marking of position of walls according to the project;
- application of paint on the surface of the floor, fixing the position of the formwork:
  - preparation of mounting equipment and tools;

• cleaning the surface from dirt and debris, and in winter - in addition from snow and ice.

# 4.2. Formwork manufacturing and installation technology

Inventory formwork is made, as a rule, centralized at specialized enterprises and will be delivered complete with fasteners and connections. The manufacturer accompanies the kit formwork passport with the operation manual, which indicates [20]:

- name and address of the manufacturer;
- number and date of passport issuance;
- nomenclature and number of formwork elements;
- date of manufacture of the formwork; warranty obligation;
- list of spare parts

Formwork manufacturing technology:

- clean shields and other elements from dirt and mortar;
- apply anti-adhesive coating on the formwork;
- attach the scaffolding brackets to the formwork board;
- connect the formwork panels together into a single formwork panel with locks; on height in angular and central zones establish three locks;
- formwork panels are lifted from the assembly site by means of a mounting crane, fed to the installation site and installed close to the concrete base, which was concreted earlier;
  - fasten formwork panels by means of braces;
  - lay working decks on scaffolding brackets;
- screeds on one side through the holes in the boards and bushings located between the boards, stretch to the other side;
- tighten the screeds with nuts on one or two sides until the complete connection between the boards and the sleeve located between them, the length of which is equal to the thickness of the structure;

• check the reliability of fastening of formwork elements and the quality of its assembly

When installing the formwork under special control is the displacement of the axes of the formwork from the design position and the deviation of the plane of the formwork from the vertical along the entire height of the formwork panel.

The arrangement of the formwork of the foundations is done in the following sequence:

- mount and fix the enlarged formwork panels of the lower steps of the shoe;
- install the assembled box strictly on the axes and secure the lower steps with metal pins to the base;
- apply lines to the edges of the enlarged panels, indicating the position of the box of the second stage of the foundation;
- in accordance with the lines install a pre-assembled box of the second stage of the foundation;
  - on the put risks arrange a box of the third degree;
  - on the top box put the lines indicating position of a box of a subcolumn;
  - arrange a box of a subcolumn;
  - install and fix the formwork of the liners

In the course of installation of a timbering of overlapping the following processes are consistently carried out:

- cleaning of formwork elements from dirt and sticky mortar;
- fixing in the supporting frames of support forks for longitudinal beams;
- connecting frames with each other by means of cross ties;
- installation of longitudinal beams on support forks;
- coating of sheets of laminated plywood with anti-adhesive solution;
- layout and fastening of plywood sheets on cross beams [20].

During the installation of boards and panels for formwork, it is necessary to constantly monitor the tightness of the elements to each other, the size of the gaps in the butt joints, as well as the lack of backlash in the hinged joints of the formwork. The gaps in the butt joints should not be more than 1 mm. Regular

control is required by the amount of deflection of the vertical surfaces of the formwork of walls and columns, the deflection of the floor formwork

At acceptance of the established formwork are checked [20]:

- the density of the base, which guarantees the absence of subsidence;
- correctness of installation of a timbering, and also bearing and supporting elements, anchor devices and fasteners;
  - geometric dimensions of the assembled formwork;
  - displacement of the formwork axes from the design position;
  - correct installation of plugs and mortgage parts

In the mounted formwork check [20]:

- correct installation of formwork, supporting elements and fasteners;
- conformity of forms and geometrical sizes of a timbering to the working drawing;
  - coincidence of formwork axes with centering axes;
  - verticality and horizontality of formwork planes;
  - correct installation of embedded parts, plugs, holes, etc .;
  - density of joints and connections of formwork elements

Permissible deviations at acceptance of the prepared formwork accept within the following limits:

- vertical deviation of the formwork plane per 1 m of height 5 mm, for the entire height of the formwork 14 mm;
  - displacement of the formwork axes from the design position 8 mm;
  - offset of the formwork axes relative to the axes of the structure 10 mm.

Dismantling of a formwork is allowed to be carried out after achievement by concrete of necessary durability. In the process of detachment of the formwork, the surface of the concrete structure should not be damaged [20].

Dismantling of a timbering is carried out in the order of return installation.

After removal of a timbering it is necessary:

- conduct a visual inspection of the structure and formwork;
- clear all elements of a timbering from the stuck concrete;

• lubricate the shield deck, check and apply grease to the fasteners [20].

## 4.3. Technology of manufacturing and reinforcement of the structure

Reinforcement of reinforced concrete structures is desirable to carry out welded reinforcing frames and nets of factory production.

Reinforcement elements and prefabricated grids are delivered to the construction site and placed on the storage site.

Elements of the frame, which require prior aggregation, are brought to the assembly site. Reinforcing frames and grids are assembled on the stand of a large assembly using the necessary conductors and all types of welding: contact, spot, electric arc, in some cases viscous. Reinforcing frames and grids are completed in packages and in such kind by the assembly crane give in a zone of performance of works [20].

Reinforcing grids of foundation shoes are arranged in the formwork on the clamps that provide a protective layer of concrete according to the project. Other elements of the reinforcing frame of the foundation are installed and fastened by welding or knitting wire with the necessary protective layer of concrete. In the process of installation of reinforcement in the formwork of walls and floors, special attention is paid to ensuring the design dimensions of the thickness of the protective layer of concrete, displacement of reinforcing bars during their installation in the formwork, as well as on-site fabrication of reinforcement frames and grids [20].

At installation it is necessary to provide:

- strength, stability and immutability of the structures of the erected part of the building or structures at all stages of installation;
  - safety of production of works;
- the accuracy of the position of structural elements and the shape of the building / structure / by means of constant geodetic control.

Until the end of the calibration and reliable fixing of the installed mounting the element is not allowed to rest on it overlying structures, if any resistance is not provided by the project of production of works.

Mounted reinforcement must be securely fastened and protected from deformations and displacements in the process of concreting structures. The cross-sections of the reinforcement rods, laid one by one, must be fastened at the intersections with a knitting wire or with the help of special wire connecting clips. The design position of reinforcing bars and grids must be ensured by the correct installation of supporting devices, templates, clamps, gaskets and stands. Reinforcement scraps, wooden bars, pieces of brick, rubble, gravel cannot be used as supports [20].

Acceptance of the mounted reinforcement, all butt joints should be carried out before laying the concrete mix and formalized by an act of concealed work. The act must indicate possible deviations from the project, give an assessment of the quality of the installed fittings.

After installation of armature and a formwork, check of quality of the executed works the permission for production of concrete works is given [].

# 4.4. Concreting technology

Prior to the start of work on laying the concrete mixture in the formwork of walls and floors, it is necessary to complete the installation of reinforcement and formwork within the grip. Before laying the concrete mixture, you need to check the quality of installation and fixing of the formwork, as well as all structures and elements that are closed in the process of concreting (reinforcement, embedded parts, etc [20].

Before laying the concrete mix it is necessary:

• check the correct installation of reinforcement and formwork, installation and fastening of clamps that provide the required thickness of the protective layer of concrete:

- to accept according to the act all hidden designs and elements to which access after concreting will be impossible;
  - clean fittings and formwork from debris, dirt and rust

Before concreting rock bases, horizontal and inclined concrete the surfaces of the working seams must be cleaned of debris, dirt, oils, and snow ice, cement film, etc. Immediately before laying the concrete mix cleaned surfaces should be washed with water and air dried.

The concreting of individual structures includes:

- reception of concrete mix and its giving in a zone of carrying out works;
- laying and compaction of concrete mix;
- care of concrete in the process of gaining the necessary strength

Concreting of the foundation with a subcolumn is performed in two stages. At the first stage all steps of the base and a subcolumn to a mark of a bottom of an insert are concreted, at the second - the top part of a subcolumn after installation and fixing of an insert [20].

When concreting with the use of a truck concrete pump, the radius of action of its distribution boom allows to lay the concrete mixture in the structure in the area of the boom. Normal operation of the truck concrete pump can be provided at pumping of concrete mix of the allowed mobility that will promote transportation of concrete on extreme distances without stratification and formation of stoppers.

The concrete mixture is laid in horizontal layers with a thickness of 0.3... 0.5 m, without gaps in length and with a consistent direction of laying in one direction in all layers. Each layer is carefully compacted with deep vibrators. At consolidation of concrete mix support of vibrators on armature, embedded details, screw couplers and other elements of a timbering is not allowed [20].

When compacting the concrete mixture, the end of the working part of the vibrator should be immersed in the previously laid layer of concrete by 5... 10 cm. The step of permutation of the vibrator should not exceed 1.5 radius of its action.

Vibration at one position should provide sufficient compaction, the main features of which are [20]:

- cessation of subsidence of the laid concrete mix;
- the appearance of cement laitance on its surface;
- cessation of air bubbles on the surface

Remove the vibrator during the permutation should be slow and, without excluding it, thus allow the voids under the tip to be evenly filled with concrete mixture. Laying the next layer of concrete must be performed before setting the concrete mixture of the previous layer. The interval between laying the layers of the concrete mixture can be within 40 minutes, but the next layer must be laid before the setting of the concrete mixture [20].

After laying the concrete mixture in the formwork, it is necessary to create the necessary temperature and humidity conditions for hardening of concrete. Horizontal surfaces of the concrete structure are covered with wet burlap, tarpaulin, sawdust, rolled materials for a period that depends on climatic conditions and in accordance with the recommendations of the technological map for these works [20].

To avoid the possible occurrence of thermal stress in monolithic structures under direct sunlight freshly laid concrete should be protected with self-destructive polymer foams, inventory heat and moisture insulating coatings, polymer film with a coefficient reflection more than 50% or any other heat-insulating material [20].

# 4.5. Formwork dismantling technology

The minimum strength of concrete when stripping unloaded monolithic structures should be for vertical structures, provided that their shape is preserved - 0.2... 0.3 MPa. The minimum strength of concrete when stripping load-bearing structures is, depending on the span 70... 80% [20].

Dismantling of the floor formwork, which is allowed only after the concrete reaches the required strength, includes the following processes:

• lowering of a bearing design of a timbering on some centimeters by means of screw jacks of frames or telescopic racks;

- separation of plywood sheets from the formwork surface;
- dismantling of longitudinal and cross beams;
- disassembly of the cross ties between the support frames and the rack.

When installing intermediate supports in the span of the floor and with partial or sequential removal of the formwork, the calculated strength of concrete may be insufficient, so in places of installation of intermediate supports must provide additional reinforcement [20].

### **CONCLUSIONS**

This bachelor thesis review on airport terminal design highlighted the linear concept of airport construction. The proposed Terminal is a medium airport which is to be constructed in Kharkiv, the 2<sup>nd</sup> largest city in Ukraine.

The Architectural part of this research or thesis opens with the Aviation history of Ukraine.

The to be constructed air passenger terminal for domestic airlines must have at least 400 passenger per house and these figures should be divided into:

- passengers who are initially sent 200 people;
- arriving passengers 200 people.

Meeting and seeing off are 160 people.

Whiles developing the conceptual technological planning of the airport complex, the following "airport-forming factors" were analyzed or taken into consideration.

its binding to the runway and RD;

- its binding to the platform configuration;
- its binding to the scheme of access to the airport;
- influencing the easy orientation of passengers at the entrance to the airport and in the building itself;
- providing the shortest possible walking distances from the parking lot to the airport;
- providing the shortest possible walking distances from passenger and luggage service areas to the aircraft and vice versa;
  - minimum changes in passenger traffic levels and no oncoming flows;

- minimum distances for delivery of passengers and / or luggage from the airport to the aircraft parking place;

- compatibility of all facilities with the characteristics of all existing aircraft, including promising aircraft.

Whiles making the volume planning and space decision, the number of passengers too was also considered. The airport is to be located at a minimum distance from the access road. Aircraft can be placed on the platform in two rows. The concept of a linear airport complex is offered.

The building of the new airport is complex in plan, two-storey with a basement.

The building is designed in a prefabricated monolithic reinforced concrete frame.

The largest length is <u>78</u>m.

The largest width is <u>54</u>m.

Floor height -4,2 m.

Basementheight 2,4 m.

Themaingridofcolumns 6 \* 6 m.

On the ground floor there should be a main and auxiliary rooms for arriving passengers (lobby, waiting areas, sanitary, passport and customs control areas, baggage claim areas).

On the second floor there should also be a main and auxiliary rooms for departing passengers (lobby, waiting areas, control areas, transitional galleries).

In the basement there are technical premises, premises for automated processing and storage of luggage, auxiliary premises for engineering systems, warehouses of trade enterprises and premises of the food block. Technological

service of passengers is provided on 2 levels: arriving - on 1 level, departing - on 2 level.

Baggage handling of departing passengers, storage of cargo, containers, baggage of delayed flights - in the basement. Delivery of arriving passengers takes place at the first level.

Passenger communication for level 1 involves the use of the existing access road with its expansion at the entrance to the airport complex. The whole complex has an air conditioning system and heating system.

Each gate to which the aircraft arrives is equipped with an automatic docking guidance system, and because each system is connected to an information system, access to information such as flight number, arrival time and gate number will be free throughout the airport where it is located. will be technically possible.

Foundations was also discussed in this bachelor thesis. We discussed that, before laying the foundation there are things to be considered first. We should

- organize the removal of surface water from the site;
- pave the necessary passages and access roads for the transportation of construction equipment;
- to prepare places of storage, assembly of a timbering, consolidation of reinforcing grids and frameworks, to deliver assembly equipment and adaptations;
  - deliver formwork kits, reinforcing mesh and frames to the warehouse;
- perform the necessary sand, gravel, concrete preparation for the foundations;
- to carry out geodetic breakdown of axes and breakdown of position of the bases according to the project; indicate the position of the working planes of the boards of the formwork of the foundations with a berth, pins, other clamps;

• check the correctness of the arrangement of concrete preparation and marking the position of the axes and marks of the foundations. Acts for hidden works must be drawn up for the preparation of foundations. The prepared basis for the foundations must be adopted by the act of the commission.

It was also said that prior to the installation of large-panel formwork of walls and ceilings on the next working horizon, the following preparatory measures must be performed:

- leveling off the floor surface;
- breakdown of axes and marking of position of walls according to the project;
- application of paint on the surface of the floor, fixing the position of the formwork;
  - preparation of mounting equipment and tools;
- cleaning the surface from dirt and debris, and in winter in addition from snow and ice

Formwork manufacturing and installation technology was also discussed. All the necessary steps needed to do this technological step was ironed out was properly addressed.

To draw the curtains on this. This airport is a medium sized airport which takes the conceptual form of the linear form of terminal design. The airport will be majorly used for local flights within the borders of Ukraine and might serve as a connecting hub to nearby countries in the future.

Air passenger terminal building plans, facades and section are designed.

Reinforced concrete column is designed.

Reinforced concrete wall is designed.

Reinforced concrete slab is designed.

Construction procedure of monolithic structures is developed.

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# **APPENDICES**

# APPENDEX A. FINITE ELEMENT ANALYSIS RESULTS

| 1_1  |                                  |  |  |  |  |  |
|--|----------------------------------|--|--|--|--|--|
| Building code  |                                  |  |  |  |  |  |
| Concrete   |                                  |  |  |  |  |  |
| Class  | C20/25                           |  |  |  |  |  |
| Reinforcement  |                                  |  |  |  |  |  |
| Class of longitud.reinf.   | A400C                            |  |  |  |  |  |
| Class of transv. reinf.  | A240C                            |  |  |  |  |  |
| Max diameter of longit. reinforc., mm  | 40                               |  |  |  |  |  |
| Concrete cover for longitud., mm   | 20                               |  |  |  |  |  |
| Distance to longitud., mm  | 40                               |  |  |  |  |  |
| Active Rebar Catalogue for longitud.reinf.   | 12,14,16,18,20,22,25,28,32,36,40 |  |  |  |  |  |
| Requirements Select corner rebars Tied reinforcing cage. Module for reducing spacing of transverse reinf. 25 mm Seismicity of the site 7 units of magn. Mixed structural model |                                  |  |  |  |  |  |
| Select corner rebars  Tied reinforcing cage. Module for reducing   |                                  |  |  |  |  |  |
| Select corner rebars  Tied reinforcing cage. Module for reducing   |                                  |  |  |  |  |  |
| Select corner rebars  Tied reinforcing cage. Module for reducing Seismicity of the site 7 units of magn. Mixe  |                                  |  |  |  |  |  |
| Select corner rebars  Tied reinforcing cage. Module for reducing Seismicity of the site 7 units of magn. Mixe  |                                  |  |  |  |  |  |
| Select corner rebars  Tied reinforcing cage. Module for reducing Seismicity of the site 7 units of magn. Mixed Section  h  |                                  |  |  |  |  |  |
| Select corner rebars  Tied reinforcing cage. Module for reducing Seismicity of the site 7 units of magn. Mixed Section  Section  Dimensions, mm:                               | ed structural model              |  |  |  |  |  |
| Select corner rebars  Tied reinforcing cage. Module for reducing Seismicity of the site 7 units of magn. Mixed Section  Section  Dimensions, mm:                               | ed structural model 400          |  |  |  |  |  |

2400

Column No.:

<u>Levels</u>

Storey height, mm

Height of floor slab, mm 200

Levels, m:

column bottom 0,000 floor slab top +2,400

#### Effective length

Effective length factors:

 $\begin{array}{ll} \text{m X} & 0.7 \\ \text{m Y} & 0.7 \end{array}$ 

Effective length, mm:

Lo X 1680 Lo Y 1680

Slenderness ratio:

Lo/h X 4.20 Lo/h Y 4.20

#### **Loads**

#### FEA results

|              | N, tf  | Mx, tf*m | My, tf*m | Qx, tf | Qy, tf   | T, tf*m  | Section |
|--------------|--------|----------|----------|--------|----------|----------|---------|
| Dead         | 33     | 1.35     | 1.37     | 1.74   | 1.71     | 0.00024  | 1_1.1   |
|              | 32.1   | -2.75    | -2.8     | 1.74   | 1.71     | 0.00024  | 1_1.2   |
| Live         | 9.15   | 0.489    | 0.502    | 0.635  | 0.621    | 9e-005   | 1_1.1   |
|              | 9.15   | -1       | -1.02    | 0.635  | 0.621    | 9e-005   | 1_1.2   |
| Wind 1       | -0.175 | -0.01    | -0.328   | -0.16  | -0.00957 | -1e-005  | 1_1.1   |
|              | -0.175 | 0.0129   | 0.0562   | -0.16  | -0.00957 | -1e-005  | 1_1.2   |
| Wind 2       | -0.171 | -0.0329  | -0.298   | -0.145 | -0.0211  | -1e-005  | 1_1.1   |
|              | -0.171 | 0.0177   | 0.0512   | -0.145 | -0.0211  | -1e-005  | 1_1.2   |
| Earthquake 1 | -3.54  | -0.125   | -4.62    | -2.09  | -0.129   | -0.00018 | 1_1.1   |
|              | -3.54  | 0.186    | 1.06     | -2.09  | -0.129   | -0.00018 | 1_1.2   |
| Earthquake 2 | -0.857 | -1.47    | -0.279   | -0.2   | -0.867   | -1e-005  | 1_1.1   |
|              | -0.857 | 0.751    | 0.209    | -0.2   | -0.867   | -1e-005  | 1_1.2   |

### Coefficients

Safety factor for purpose of structure 1

|                | Dead | Live | Short-t. | Wind | Earthq. |
|----------------|------|------|----------|------|---------|
| Load factor    | 1.1  | 1.2  | 1.2      | 1.4  | 1       |
| Duration       | 1    | 1    | 0.35     | 0    | 0       |
| Short duration | 1    | 1    | 1        | 0    | 0       |

Reducing for short-term load 1

Account in analysis:

## Coefficients for design combinations of loads (DCL)

|                          | Dead | Live | Short-t. | Wind | Earthq. |
|--------------------------|------|------|----------|------|---------|
| 1st main combination     | 1    | 1    | 1        | 1    | 0       |
| 2nd main combination     | 1    | 0.95 | 0.9      | 0.9  | 0       |
| 3rd specific combination | 0.9  | 0.8  | 0.5      | 0    | 1       |

Account in automatic generation of DCL:

sign variability of wind and earthquake load

## Design combinations of loads. Brief list

| N, tf          | Mx, tf*m   | My, tf*m                         | Qx, tf  | Qy, tf  | T, tf*m                          | Section  |
|----------------|--|----------------------------------|---|---|----------------------------------|--|
| states. Case b | (all loads)  |                                  |   |   |                                  |  |
| 46.3           | -4.23  | -4.31                            | 2.67  | 2.63  | 0.000372                         | 1_1.2  |
| 46.3           | -4.23  | -4.31                            | 2.67  | 2.63  | 0.000372                         | durat. part  |
|                |  |                                  |   | Sbt, Sbc,   | Slc, Ty, Sblt, Sb                | lc   1.1De+1.2   |
| 45.9           | -4.18  | -4.31                            | 2.84  | 2.6   | 0.000379                         | 1_1.2  |
| 45.7           | -4.17  | -4.24                            | 2.64  | 2.59  | 0.000367                         | durat. part  |
|                |  |                                  |   |   | Slt   1.1De+                     | 1.14Li-1.26W   |
| 47.3           | 2.08   | 2.11                             | 2.67  | 2.63  | 0.000372                         | 1_1.1  |
| 47.3           | 2.08   | 2.11                             | 2.67  | 2.63  | 0.000372                         | durat. part  |
|                |  |                                  |   |   | $\wedge$                         | lc   1.1De+1.2   |
| 47             | 2.06   | 2.5                              | 2.84  | 2.6   | 0.000379                         | 1_1.1  |
| 46.8           | 2.05   | 2.08                             | 2.64  | 2.59  | 0.000367                         | durat. part  |
|                |  |                                  |   |   | Tx   1.1De+                      | 1.14Li-1.26W   |
| 41.4           | -4.43  | -3.96                            | 2.53  | 3.16  | 0.000334                         | 1_1.2  |
| 40.5           | -3.68  | -3.75                            | 2.33  | 2.29  | 0.000324                         | durat. part  |
|                |  |                                  |   | S   | bt, Sbc, Ty   0.99               | De+0.96Li-Ed   |
| 36.2           | 1.47   | 5.99                             | 3.81  | 1.82  | 0.000418                         | 1_1.1  |
| 32.7           | 1.34   | 1.36                             | 1.72  | 1.69  | 0.000238                         | durat. part  |
|                |  |                                  |   |   | S                                | Slt   0.99De-E   |
| 45             | 1.94   | 6.47                             | 4.42  | 2.42  | 0.000504                         | 1_1.1  |
| 41.5           | 1.81   | 1.84                             | 2.33  | 2.29  | 0.000324                         | durat. part  |
|                |  |                                  |   |   | Slc, Nc, Tx   0.99               | De+0.96Li-E  |
| 44.1           | -3.87  | -4.81                            | 4.42  | 2.42  | 0.000504                         | 1_1.2  |
| 40.5           | -3.68  | -3.75                            | 2.33  | 2.29  | 0.000324                         | durat. part  |
|                | states. Case b 46.3 46.3 45.9 45.7 47.3 47.3 47.46.8 41.4 40.5 36.2 32.7 45 41.5 | states. Case b (all loads)  46.3 | states. Case b (all loads)         46.3       -4.23       -4.31         46.3       -4.23       -4.31         45.9       -4.18       -4.31         45.7       -4.17       -4.24         47.3       2.08       2.11         47.3       2.08       2.11         47       2.06       2.5         46.8       2.05       2.08         41.4       -4.43       -3.96         40.5       -3.68       -3.75         36.2       1.47       5.99         32.7       1.34       1.36         45       1.94       6.47         41.5       1.81       1.84 | states. Case b (all loads)         46.3       -4.23       -4.31       2.67         46.3       -4.23       -4.31       2.67         45.9       -4.18       -4.31       2.84         45.7       -4.17       -4.24       2.64         47.3       2.08       2.11       2.67         47       2.06       2.5       2.84         46.8       2.05       2.08       2.64         41.4       -4.43       -3.96       2.53         40.5       -3.68       -3.75       2.33         36.2       1.47       5.99       3.81         32.7       1.34       1.36       1.72         45       1.94       6.47       4.42         41.5       1.81       1.84       2.33 | states. Case b (all loads)  46.3 | states. Case b (all loads)           46.3         -4.23         -4.31         2.67         2.63         0.000372           46.3         -4.23         -4.31         2.67         2.63         0.000372           Sbt, Sbc, Skc, Ty, Sbt, Sbc         Sbc, Ty, Sbt, Sbc         Sbc, Ty, Sbt, Sbc         Sbc, Ty, Sbt, Sbc           45.9         -4.18         -4.31         2.84         2.6         0.000379           45.7         -4.17         -4.24         2.64         2.59         0.000367           8.1         1.1De+         Stc, Incompared to the second |

Ultimate limit states. Case a (live loads)

|         | N, tf | Mx, tf*m | My, tf*m | Qx, tf | Qy, tf         | T, tf*m            | Section          |
|---------|-------|----------|----------|--------|----------------|--------------------|------------------|
| Group 3 | 46.3  | -4.23    | -4.31    | 2.67   | 2.63           | 0.000372           | 1_1.2            |
|         | 46.3  | -4.23    | -4.31    | 2.67   | 2.63           | 0.000372           | durat. part      |
|         |       |          |          |        | Sbt, Slt, Sbc, | Slc, Ty, Sblt, Sbl | lc   1.1De+1.2Li |
|         | 47.3  | 2.08     | 2.11     | 2.67   | 2.63           | 0.000372           | 1_1.1            |
|         | 47.3  | 2.08     | 2.11     | 2.67   | 2.63           | 0.000372           | durat. part      |
|         |       |          |          |        |                | Nc. 7              | x   1.1De+1.2Li  |

Nc, Tx | 1.1De+1.2Li

Numbers of columns from DCL table:

1\_1

#### **Design reinforcement**



2.01 Asu

Longitudinal reinforcement, cm2:

complete 8.044 by strength 8.044 % of reinforcement 0.50 0.272644 Transverse reinforcement, cm2/m

## Arrangement of longitudinal reinforcement

Symmetric reinforcement. Ext. bars to upper column

corner 4Ø16 Total 4Ø16 Area of reinforcement, cm2 8.04248 % of reinforcement 0.50

#### **Anchorage of longitudinal reinforcement**

| Diameter of rebar, mm | Anchorage length, mm | Lap length, mm |
|-----------------------|----------------------|----------------|
| 16                    | 390                  | 470            |

#### Arrangement of transverse reinforcement

| Anchorage zone, mm: | 4∅6 |
|---------------------|-----|
| spacing             | 150 |
| distance to 1st     | 50  |
| arrangement zone    | 450 |
| distance to last    | 500 |
| Main zone, mm:      | 8⊘6 |

|   | spacing                     | 200     |
|---|-----------------------------|---------|
|   | distance to 1st             | 700     |
|   | arrangement zone            | 1400    |
|   | distance to last            | 2100    |
|   | distance to top             | 100     |
| Α | rea of reinforcement, cm2/m | 2.82743 |
|   |                             |         |

Modes of arrangement of studs:

along

#### **Notes**

no

# MEASUREMENT UNITS

Length, coordinates: m

Dimensions of cross sections: cm

Unit weight: t/m3

Concentrated loads: t

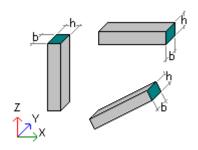
Displacements: mm

Angular displacements :rad\*1000

Forces: t\*m, tMoments: t, t/m

Stress (modulus of elasticity): t/m2

Area of reinforcement: cm2/m



### REBARS

Length, coordinates: m

| Node No.  | X   | Y   | Node No. | X   | Y   |  |  |  |
|---|---|-----|----------|-----|-----|--|--|--|
| 1-th element of elevation Section of member 40х40, Material Залізобетон |   |     |          |     |     |  |  |  |
| 1   | 6.2   | 0.0 | 2        | 6.2 | 2.4 |  |  |  |
|   | 2-th element of elevation Section of member 40х40, Material Залізобетон |     |          |     |     |  |  |  |

| Node No. | X           | Y                             | Node No.        |          | X           | Y    |
|----------|-------------|-------------------------------|-----------------|----------|-------------|------|
| 1        | 0.2         | 0.0                           | 2               |          | 0.2         | 2.4  |
|          | 3-th elemen | nt of elevation Section of me | ember 40x40,    | Material | Залізобетон |      |
| 1        | 6.2         | 2.4                           | 2               |          | 6.2         | 6.6  |
|          | 4-th elemen | nt of elevation Section of me | ember 40x40,    | Material | Залізобетон |      |
| 1        | 0.2         | 2.4                           | 2               |          | 0.2         | 6.6  |
|          | 5-th elemen | nt of elevation Section of me | ember 40x40,    | Material | Залізобетон |      |
| 1        | 6.2         | 6.6                           | 2               |          | 6.2         | 10.8 |
|          | 6-th elemen | nt of elevation Section of me | ember $40x40$ , | Material | Залізобетон |      |
| 1        | 0.2         | 6.6                           | 2               |          | 0.2         | 10.8 |

# WALLS

Length, coordinates:  $\, m \,$ 

| Node No. | X  | Y                        | Node No.   | X                    | Y    |  |  |  |  |  |
|----------|--|--------------------------|------------|----------------------|------|--|--|--|--|--|
|          | 7-th element of elevation. WALL THICKNESS 30, MATERIAL Залізобетон |                          |            |                      |      |  |  |  |  |  |
| 1        | 0.0  | 0.0                      | 2          | 0.0                  | 2.4  |  |  |  |  |  |
| 3        | 6.2  | 2.4                      | 6.2        | 0.0                  |      |  |  |  |  |  |
|          | 8-th element   | of elevation. WALL THICK | NESS 30, 1 | MATERIAL Залізобетон |      |  |  |  |  |  |
| 1        | 0.0  | 2.4                      | 2          | 0.0                  | 6.6  |  |  |  |  |  |
| 3        | 6.2  | 6.6                      | 4          | 6.2                  | 2.4  |  |  |  |  |  |
|          | 9-th element of elevation. WALL THICKNESS 30, MATERIAL Залізобетон |                          |            |                      |      |  |  |  |  |  |
| 1        | 0.0  | 6.6                      | 2          | 0.0                  | 10.8 |  |  |  |  |  |
| 3        | 6.2  | 10.8                     | 4          | 6.2                  | 6.6  |  |  |  |  |  |

## MATERIAL PROPERTIES

| N | Name        | Type    | Modulus of | Poisson's | Unit weight | Components           | Distance to   | Analysis by    |
|---|-------------|---------|------------|-----------|-------------|----------------------|---------------|----------------|
|   |             |         | elasticity | ratio     |             |                      | g.c. of       | serviceability |
|   |             |         |            |           |             |                      | reinforcement | lim.st.        |
|   |             |         |            |           |             |                      |               |                |
| 1 | Залізобетон | concret | 3000000.0  | 0.20      | 2.5         | C20/25, A400C, A240C | 3.0           | No             |
|   |             | e       |            |           |             |                      |               |                |
|   |             |         |            |           |             |                      |               |                |

| Slab contour ( Slab thickness 20.00 cm ) |         |         |       |         |         |       |         |         |  |
|--|---------|---------|-------|---------|---------|-------|---------|---------|--|
| Point                                    | Х(см)   | Ү(см)   | Point | Х(см)   | Ү(см)   | Point | Х(см)   | Ү(см)   |  |
| 1  | 1800.00 | 3411.00 | 2     | 1200.00 | 3411.00 | 3     | 1200.00 | 2811.00 |  |

|       | Slab contour ( Slab thickness 20.00 cm ) |         |       |         |         |       |         |         |
|-------|--|---------|-------|---------|---------|-------|---------|---------|
| Point | Х(см)                                    | Ү(см)   | Point | Х(см)   | Ү(см)   | Point | Х(см)   | Ү(см)   |
| 4     | 0.00                                     | 2811.00 | 5     | 0.00    | 870.00  | 6     | 1501.00 | 870.00  |
| 7     | 1500.00                                  | 269.00  | 8     | 2132.43 | 269.00  | 9     | 2132.43 | 170.00  |
| 10    | 2858.28                                  | 70.47   | 11    | 3372.13 | 0.00    | 12    | 4564.87 | 0.00    |
| 13    | 4651.85                                  | 11.24   | 14    | 5809.58 | 170.00  | 15    | 5809.58 | 269.00  |
| 16    | 6442.00                                  | 269.00  | 17    | 6441.00 | 869.00  | 18    | 7942.00 | 870.00  |
| 19    | 7942.00                                  | 2811.00 | 20    | 6742.00 | 2811.00 | 21    | 6742.00 | 3411.00 |
| 22    | 6142.00                                  | 3411.00 | 23    | 6132.59 | 3553.67 | 24    | 6105.40 | 3742.71 |
| 25    | 6083.11                                  | 3846.64 | 26    | 6029.54 | 4032.71 | 27    | 5914.61 | 4309.20 |
| 28    | 5814.02                                  | 4488.88 | 29    | 5730.52 | 4612.98 | 30    | 5608.19 | 4766.77 |
| 31    | 5408.38                                  | 4967.74 | 32    | 5242.48 | 5100.27 | 33    | 5127.69 | 5177.68 |
| 34    | 4943.57                                  | 5281.33 | 35    | 4688.94 | 5389.10 | 36    | 4488.79 | 5448.51 |
| 37    | 4432.19                                  | 5461.18 | 38    | 4314.11 | 5483.82 | 39    | 4231.83 | 5495.35 |
| 40    | 4132.35                                  | 5504.92 | 41    | 4032.10 | 5510.09 | 42    | 3970.91 | 5511.00 |
| 43    | 3883.73                                  | 5509.27 | 44    | 3784.54 | 5503.02 | 45    | 3731.91 | 5497.37 |
| 46    | 3632.48                                  | 5484.52 | 47    | 3532.20 | 5466.23 | 48    | 3453.21 | 5448.51 |
| 49    | 3253.06                                  | 5389.10 | 50    | 3140.09 | 5345.99 | 51    | 2998.43 | 5281.33 |
| 52    | 2814.31                                  | 5177.68 | 53    | 2699.52 | 5100.27 | 54    | 2533.63 | 4967.74 |
| 55    | 2481.96                                  | 4920.65 | 56    | 2398.67 | 4838.10 | 57    | 2333.81 | 4766.77 |
| 58    | 2211.48                                  | 4612.98 | 59    | 2127.98 | 4488.88 | 60    | 2027.40 | 4309.20 |
| 61    | 1965.14                                  | 4172.88 | 62    | 1913.37 | 4035.40 | 63    | 1858.89 | 3846.64 |
| 64    | 1836.64                                  | 3742.94 | 65    | 1809.42 | 3553.67 |       |         |         |
|       |  |         |       |         |         |       |         |         |

|             |           |        | OPE     | ENINGS    |        |         |
|-------------|-----------|--------|---------|-----------|--------|---------|
| Opening No. | Point No. | Х(см)  | Ү(см)   | Point No. | Х(см)  | Ү(см)   |
| 1           | 1         | 364.00 | 2245.00 | 2         | 369.82 | 2245.00 |
|             | 3         | 367.95 | 2409.97 | 4         | 366.09 | 2574.95 |
|             | 5         | 364.23 | 2739.92 | 6         | 364.00 | 2760.00 |
|             | 7         | 51.00  | 2760.00 | 8         | 51.00  | 2245.00 |
|             | 9         | 71.00  | 2245.00 |           |        |         |
| 2           | 1         | 364.00 | 2245.00 | 2         | 369.82 | 2245.00 |
|             | 3         | 367.95 | 2409.97 | 4         | 366.09 | 2574.95 |
|             |           |        |         |           |        |         |

|             |           |        | OPEN    | INGS      |        |         |
|-------------|-----------|--------|---------|-----------|--------|---------|
| Opening No. | Point No. | Х(см)  | Ү(см)   | Point No. | Х(см)  | Ү(см)   |
|             | 5         | 364.23 | 2739.92 | 6         | 364.00 | 2760.00 |
|             | 7         | 51.00  | 2760.00 | 8         | 51.00  | 2245.00 |
|             | 9         | 71.00  | 2245.00 |           |        |         |
| 3           | 1         | 364.00 | 2245.00 | 2         | 369.82 | 2245.00 |
|             | 3         | 367.95 | 2409.97 | 4         | 366.09 | 2574.95 |
|             | 5         | 364.23 | 2739.92 | 6         | 364.00 | 2760.00 |
|             | 7         | 51.00  | 2760.00 | 8         | 51.00  | 2245.00 |
|             | 9         | 71.00  | 2245.00 |           |        |         |
| 4           | 1         | 364.00 | 2245.00 | 2         | 369.82 | 2245.00 |
|             | 3         | 367.95 | 2409.97 | 4         | 366.09 | 2574.95 |
|             | 5         | 364.23 | 2739.92 | 6         | 364.00 | 2760.00 |
|             | 7         | 51.00  | 2760.00 | 8         | 51.00  | 2245.00 |
|             | 9         | 71.00  | 2245.00 |           |        |         |

|          | Columns |        |                 |          |           |        |        |        |        |        |        |
|----------|---------|--------|-----------------|----------|-----------|--------|--------|--------|--------|--------|--------|
| Col. No. | Х ,см   | Ү ,см  | Type of section | b(d) ,см | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |
| 1        | 1571.00 | 340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 2        | 2171.00 | 340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 3        | 2171.00 | 210.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 4        | 5771.00 | 210.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 5        | 5771.00 | 340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 6        | 6371.00 | 340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 7        | 7871.00 | 940.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 8        | 7571.00 | 940.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 9        | 6971.00 | 940.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 10       | 6371.00 | 940.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 11       | 5771.00 | 940.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |

|          |         |         |                 | C       | Columns   |        |        |        |        |        |        |
|----------|---------|---------|-----------------|---------|-----------|--------|--------|--------|--------|--------|--------|
| Col. No. | Х ,см   | Ү ,см   | Type of section | b(d),cm | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |
| 12       | 5171.00 | 940.00  | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 13       | 4571.00 | 940.00  | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 14       | 3371.00 | 940.00  | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 15       | 2771.00 | 940.00  | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 16       | 2171.00 | 940.00  | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 17       | 1571.00 | 940.00  | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 18       | 971.00  | 940.00  | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 19       | 371.00  | 940.00  | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 20       | 71.00   | 940.00  | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 21       | 71.00   | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 22       | 371.00  | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 23       | 971.00  | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 24       | 1571.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 25       | 2171.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 26       | 2771.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 27       | 3371.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 28       | 4571.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 29       | 5171.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 30       | 5771.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 31       | 6371.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 32       | 6971.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 33       | 7571.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 34       | 7871.00 | 1540.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 35       | 7871.00 | 2140.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 36       | 7571.00 | 2140.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 37       | 6971.00 | 2140.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
| 38       | 6371.00 | 2140.00 | rectangle       | 40.0    | 40.0      |        |        |        |        |        |        |
|          | l       | l       | I               | l       |           |        |        |        |        |        | I I    |

|          |         |         |                 | C        | Columns   |        |        |        |        |        |        |
|----------|---------|---------|-----------------|----------|-----------|--------|--------|--------|--------|--------|--------|
| Col. No. | Х ,см   | Ү ,см   | Type of section | b(d) ,см | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |
| 39       | 5771.00 | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 40       | 5171.00 | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 41       | 4571.00 | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 42       | 3371.00 | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 43       | 2771.00 | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 44       | 2171.00 | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 45       | 1571.00 | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 46       | 971.00  | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 47       | 371.00  | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 48       | 71.00   | 2140.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 49       | 364.23  | 2739.92 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 50       | 971.00  | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 51       | 1271.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 52       | 1571.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 53       | 2171.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 54       | 2771.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 55       | 3371.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 56       | 3971.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 57       | 4571.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 58       | 5171.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 59       | 5771.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 60       | 6371.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 61       | 6671.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 62       | 6971.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 63       | 7571.00 | 2740.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 64       | 6671.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 65       | 6371.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| i l      |         |         | I               | I        | l l       |        | l      | l      | l      | I      | ı l    |

|          |         |         |                 | C        | Columns   |        |        |        |        |        |        |
|----------|---------|---------|-----------------|----------|-----------|--------|--------|--------|--------|--------|--------|
| Col. No. | Х ,см   | Ү ,см   | Type of section | b(d) ,см | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |
| 66       | 6071.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 67       | 5771.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 68       | 5171.00 | 3340.04 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 69       | 4571.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 70       | 3371.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 71       | 2771.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 72       | 2171.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 73       | 1871.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 74       | 1571.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 75       | 1271.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 76       | 2035.84 | 4155.56 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 77       | 2308.02 | 4028.83 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 78       | 2862.35 | 3799.22 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 79       | 3122.47 | 4188.53 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 80       | 2698.21 | 4612.79 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 81       | 2486.08 | 4824.92 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 82       | 3511.78 | 4448.66 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 83       | 3289.38 | 5002.08 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 84       | 3167.37 | 5280.15 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 85       | 3971.00 | 4539.83 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 86       | 4774.64 | 5280.15 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 87       | 4652.62 | 5002.08 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 88       | 4430.22 | 4448.66 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 89       | 5455.93 | 4824.92 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 90       | 5243.79 | 4612.79 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 91       | 4819.53 | 4188.53 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 92       | 5906.16 | 4155.56 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
|          |         | Ī       | I               | I        | l         | Ī      | l      | l      | I      | I      | ı İ    |

|          |         |         |                 | C        | Columns   |        |        |        |        |        |        |
|----------|---------|---------|-----------------|----------|-----------|--------|--------|--------|--------|--------|--------|
| Col. No. | Х ,см   | Ү ,см   | Type of section | b(d) ,см | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |
| 93       | 5633.98 | 4028.83 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 94       | 5079.66 | 3799.22 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 95       | 4395.27 | 3764.26 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 96       | 3971.00 | 3940.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 97       | 3546.74 | 3764.26 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 98       | 2771.19 | 215.62  | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 99       | 5171.00 | 215.62  | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 100      | 4571.00 | 165.72  | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 101      | 3371.00 | 165.72  | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 102      | 3971.00 | 940.00  | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 103      | 3971.00 | 1540.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 104      | 3971.00 | 165.72  | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |
| 105      | 3971.00 | 3340.00 | rectangle       | 40.0     | 40.0      |        |        |        |        |        |        |

|     | Walls          |         |         |         |         |  |  |  |  |  |  |
|-----|----------------|---------|---------|---------|---------|--|--|--|--|--|--|
| No. | Thickness (см) | Х1 (см) | Y1 (см) | Х2 (см) | Y2 (cм) |  |  |  |  |  |  |
| 1   | 30.0           | 364.00  | 2760.00 | 371.00  | 2140.00 |  |  |  |  |  |  |
| 2   | 30.0           | 71.00   | 2245.00 | 71.00   | 2140.00 |  |  |  |  |  |  |
| 3   | 30.0           | 7871.00 | 2245.00 | 7871.00 | 2140.00 |  |  |  |  |  |  |
| 4   | 30.0           | 7571.00 | 2740.00 | 7571.00 | 2140.00 |  |  |  |  |  |  |

| Material properties                                   |               |  |  |  |  |  |  |
|---|---------------|--|--|--|--|--|--|
| Class of concrete                                     | C20/25        |  |  |  |  |  |  |
| Type of concrete                                      | - heavyweight |  |  |  |  |  |  |
| Design compression strength of concrete               | 1170          |  |  |  |  |  |  |
| Modulus of elasticity for concrete                    | 2.75e+006     |  |  |  |  |  |  |
| Class of longitudinal reinforcement (along X)         | A400C         |  |  |  |  |  |  |
| Design tensile strength of longitudinal reinforcement | 37500         |  |  |  |  |  |  |
| Modulus of elasticity for reinforcement               | 2e+007        |  |  |  |  |  |  |

| Material properties                                   |          |
|---|----------|
| Class of longitudinal reinforcement (along Y)         | A400C    |
| Design tensile strength of longitudinal reinforcement | 37500    |
| Modulus of elasticity for reinforcement               | 2e+007   |
| Class of transverse reinforcement                     | A240C    |
| Design tensile strength of transverse reinforcement   | 18000    |
| Modulus of elasticity for reinforcement               | 2.1e+007 |
| Unit weight   | 2.5      |
| Modulus of subgrade reaction of soil in compression:  | 0        |
| Modulus of subgrade reaction of soil in shear:        | 0        |
| Location of gravity centres of reinforcement:         |          |
| from bottom   | 3        |
| from top  | 3        |

|           | Loads     |       |    |    |    |    |    |    |    |    |  |  |
|-----------|-----------|-------|----|----|----|----|----|----|----|----|--|--|
| Load case | Load type | Value | X1 | Y1 | X2 | Y2 | X3 | Y3 | X4 | Y4 |  |  |
| Dead      | U-distr.  | 0.30  |    |    |    |    |    |    |    |    |  |  |
| Live      | U-distr.  | 0.30  |    |    |    |    |    |    |    |    |  |  |

|                          | Coefficients of combinations |      |            |            |      |  |  |  |  |  |  |
|--------------------------|------------------------------|------|------------|------------|------|--|--|--|--|--|--|
|                          | Dead                         | Live | Short-term | Earthquake | Wind |  |  |  |  |  |  |
| Safety factor            | 1.10                         | 1.20 | 1.20       | 1.00       | 1.40 |  |  |  |  |  |  |
| Duration                 | 1.00                         | 1.00 | 0.35       | 0.00       | 0.00 |  |  |  |  |  |  |
| 1st main combination     | 1.00                         | 1.00 | 1.00       | 0.00       | 1.00 |  |  |  |  |  |  |
| 2nd main combination     | 1.00                         | 0.95 | 0.90       | 0.00       | 0.90 |  |  |  |  |  |  |
| 3rd specific combination | 0.90                         | 0.80 | 0.50       | 1.00       | 0.00 |  |  |  |  |  |  |

|       | Контур Плити ( Товщина плити 20.00 см ) |         |       |         |         |       |         |         |  |  |  |  |  |
|-------|---|---------|-------|---------|---------|-------|---------|---------|--|--|--|--|--|
| Точка | Х(см)                                   | Ү(см)   | Точка | Х(см)   | Ү(см)   | Точка | Х(см)   | Ү(см)   |  |  |  |  |  |
| 1     | 1800.00                                 | 3411.00 | 2     | 1200.00 | 3411.00 | 3     | 1200.00 | 2811.00 |  |  |  |  |  |
| 4     | 0.00                                    | 2811.00 | 5     | 0.00    | 870.00  | 6     | 1501.00 | 870.00  |  |  |  |  |  |
| 7     | 1500.00                                 | 269.00  | 8     | 2132.43 | 269.00  | 9     | 2132.43 | 170.00  |  |  |  |  |  |
| 10    | 2858.28                                 | 70.47   | 11    | 3372.13 | 0.00    | 12    | 4564.87 | 0.00    |  |  |  |  |  |
| 13    | 4651.85                                 | 11.24   | 14    | 5809.58 | 170.00  | 15    | 5809.58 | 269.00  |  |  |  |  |  |
| 16    | 6442.00                                 | 269.00  | 17    | 6441.00 | 869.00  | 18    | 7942.00 | 870.00  |  |  |  |  |  |

|       |         | К       | онтур Плити | ( Товщина п | лити 20.00 см | 1)    |         |         |
|-------|---------|---------|-------------|-------------|---------------|-------|---------|---------|
| Точка | Х(см)   | Ү(см)   | Точка       | Х(см)       | Ү(см)         | Точка | Х(см)   | Ү(см)   |
| 19    | 7942.00 | 2811.00 | 20          | 6742.00     | 2811.00       | 21    | 6742.00 | 3411.00 |
| 22    | 6142.00 | 3411.00 | 23          | 6132.59     | 3553.67       | 24    | 6105.40 | 3742.71 |
| 25    | 6083.11 | 3846.64 | 26          | 6029.54     | 4032.71       | 27    | 5914.61 | 4309.20 |
| 28    | 5814.02 | 4488.88 | 29          | 5730.52     | 4612.98       | 30    | 5608.19 | 4766.77 |
| 31    | 5408.38 | 4967.74 | 32          | 5242.48     | 5100.27       | 33    | 5127.69 | 5177.68 |
| 34    | 4943.57 | 5281.33 | 35          | 4688.94     | 5389.10       | 36    | 4488.79 | 5448.51 |
| 37    | 4432.19 | 5461.18 | 38          | 4314.11     | 5483.82       | 39    | 4231.83 | 5495.35 |
| 40    | 4132.35 | 5504.92 | 41          | 4032.10     | 5510.09       | 42    | 3970.91 | 5511.00 |
| 43    | 3883.73 | 5509.27 | 44          | 3784.54     | 5503.02       | 45    | 3731.91 | 5497.37 |
| 46    | 3632.48 | 5484.52 | 47          | 3532.20     | 5466.23       | 48    | 3453.21 | 5448.51 |
| 49    | 3253.06 | 5389.10 | 50          | 3140.09     | 5345.99       | 51    | 2998.43 | 5281.33 |
| 52    | 2814.31 | 5177.68 | 53          | 2699.52     | 5100.27       | 54    | 2533.63 | 4967.74 |
| 55    | 2481.96 | 4920.65 | 56          | 2398.67     | 4838.10       | 57    | 2333.81 | 4766.77 |
| 58    | 2211.48 | 4612.98 | 59          | 2127.98     | 4488.88       | 60    | 2027.40 | 4309.20 |
| 61    | 1965.14 | 4172.88 | 62          | 1913.37     | 4035.40       | 63    | 1858.89 | 3846.64 |
| 64    | 1836.64 | 3742.94 | 65          | 1809.42     | 3553.67       |       |         |         |
|       |         |         |             |             |               |       |         |         |

|          |         |        | OTI     | вори    |        |         |
|----------|---------|--------|---------|---------|--------|---------|
| № отвору | № точки | Х(см)  | Ү(см)   | № точки | Х(см)  | Ү(см)   |
| 1        | 1       | 364.00 | 2245.00 | 2       | 369.82 | 2245.00 |
|          | 3       | 367.95 | 2409.97 | 4       | 366.09 | 2574.95 |
|          | 5       | 364.23 | 2739.92 | 6       | 364.00 | 2760.00 |
|          | 7       | 51.00  | 2760.00 | 8       | 51.00  | 2245.00 |
|          | 9       | 71.00  | 2245.00 |         |        |         |
| 2        | 1       | 364.00 | 2245.00 | 2       | 369.82 | 2245.00 |
|          | 3       | 367.95 | 2409.97 | 4       | 366.09 | 2574.95 |
|          | 5       | 364.23 | 2739.92 | 6       | 364.00 | 2760.00 |
|          | 7       | 51.00  | 2760.00 | 8       | 51.00  | 2245.00 |
|          | 9       | 71.00  | 2245.00 |         |        |         |
| 3        | 1       | 364.00 | 2245.00 | 2       | 369.82 | 2245.00 |
|          | 3       | 367.95 | 2409.97 | 4       | 366.09 | 2574.95 |
|          | 5       | 364.23 | 2739.92 | 6       | 364.00 | 2760.00 |
|          | ,       | 304.23 | 2137.72 | U       | 304.00 | 2700.00 |

|          |         |        | ОТВ     | ОРИ     |        |         |
|----------|---------|--------|---------|---------|--------|---------|
| № отвору | № точки | Х(см)  | Ү(см)   | № точки | Х(см)  | Ү(см)   |
|          | 7       | 51.00  | 2760.00 | 8       | 51.00  | 2245.00 |
|          | 9       | 71.00  | 2245.00 |         |        |         |
| 4        | 1       | 364.00 | 2245.00 | 2       | 369.82 | 2245.00 |
|          | 3       | 367.95 | 2409.97 | 4       | 366.09 | 2574.95 |
|          | 5       | 364.23 | 2739.92 | 6       | 364.00 | 2760.00 |
|          | 7       | 51.00  | 2760.00 | 8       | 51.00  | 2245.00 |
|          | 9       | 71.00  | 2245.00 |         |        |         |
|          |         |        |         |         |        |         |

|        | Колони  |        |              |         |           |        |        |        |        |        |        |  |  |
|--------|---------|--------|--------------|---------|-----------|--------|--------|--------|--------|--------|--------|--|--|
| № кол. | Х ,см   | Ү ,см  | Тип перерізу | b(d),cm | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |  |  |
| 1      | 1571.00 | 339.99 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 2      | 2171.00 | 340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 3      | 2171.00 | 210.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 4      | 5771.00 | 210.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 5      | 5771.00 | 340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 6      | 6371.00 | 340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 7      | 7871.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 8      | 7571.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 9      | 6971.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 10     | 6371.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 11     | 5771.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 12     | 5171.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 13     | 4571.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 14     | 3371.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 15     | 2771.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 16     | 2171.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 17     | 1571.00 | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
| 18     | 971.00  | 940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |  |
|        |         |        |              |         |           |        |        |        |        |        |        |  |  |

|        |         |         |              | I       | Солони    |        |        |        |        |        |        |
|--------|---------|---------|--------------|---------|-----------|--------|--------|--------|--------|--------|--------|
| № кол. | Х ,см   | Ү ,см   | Тип перерізу | b(d),cm | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |
| 19     | 371.00  | 940.00  | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 20     | 71.00   | 940.00  | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 21     | 71.00   | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 22     | 371.00  | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 23     | 971.00  | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 24     | 1571.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 25     | 2171.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 26     | 2771.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 27     | 3371.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 28     | 4571.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 29     | 5171.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 30     | 5771.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 31     | 6371.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 32     | 6971.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 33     | 7571.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 34     | 7871.00 | 1540.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 35     | 7871.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 36     | 7571.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 37     | 6971.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 38     | 6371.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 39     | 5771.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 40     | 5171.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 41     | 4571.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 42     | 3371.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 43     | 2771.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 44     | 2171.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| 45     | 1571.00 | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |
| l      | l       |         | I            | I       |           |        | l      | l      | l      | I      | ı l    |

|        | Колони  |         |              |         |           |        |        |        |        |        |        |  |
|--------|---------|---------|--------------|---------|-----------|--------|--------|--------|--------|--------|--------|--|
| № кол. | Х ,см   | Ү ,см   | Тип перерізу | b(d),cm | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |  |
| 46     | 971.00  | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 47     | 371.00  | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 48     | 71.00   | 2140.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 49     | 364.23  | 2739.92 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 50     | 971.00  | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 51     | 1271.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 52     | 1571.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 53     | 2171.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 54     | 2771.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 55     | 3371.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 56     | 3971.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 57     | 4571.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 58     | 5171.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 59     | 5771.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 60     | 6371.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 61     | 6671.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 62     | 6971.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 63     | 7571.00 | 2740.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 64     | 6671.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 65     | 6371.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 66     | 6071.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 67     | 5771.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 68     | 5171.00 | 3340.04 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 69     | 4571.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 70     | 3371.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 71     | 2771.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 72     | 2171.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
|        |         | l       | I            | I       | l l       |        |        | l      | l      | l      | l l    |  |

|        | Колони  |         |              |         |           |        |        |        |        |        |        |  |
|--------|---------|---------|--------------|---------|-----------|--------|--------|--------|--------|--------|--------|--|
| № кол. | Х ,см   | Ү ,см   | Тип перерізу | b(d),cm | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |  |
| 73     | 1871.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 74     | 1571.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 75     | 1271.00 | 3340.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 76     | 2035.84 | 4155.56 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 77     | 2308.02 | 4028.83 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 78     | 2862.35 | 3799.22 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 79     | 3122.47 | 4188.53 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 80     | 2698.21 | 4612.79 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 81     | 2486.08 | 4824.92 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 82     | 3511.78 | 4448.66 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 83     | 3289.38 | 5002.08 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 84     | 3167.37 | 5280.15 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 85     | 3971.00 | 4539.83 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 86     | 4774.64 | 5280.15 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 87     | 4652.62 | 5002.08 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 88     | 4430.22 | 4448.66 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 89     | 5455.93 | 4824.92 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 90     | 5243.79 | 4612.79 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 91     | 4819.53 | 4188.53 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 92     | 5906.16 | 4155.56 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 93     | 5633.98 | 4028.83 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 94     | 5079.66 | 3799.22 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 95     | 4395.27 | 3764.26 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 96     | 3971.00 | 3940.00 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 97     | 3546.74 | 3764.26 | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 98     | 2771.19 | 215.62  | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
| 99     | 5171.00 | 215.62  | прямокутник  | 40.0    | 40.0      |        |        |        |        |        |        |  |
|        |         |         | 1            | I       | l !       |        |        | I      | l      | I      | l l    |  |

|        | Колони  |         |              |          |           |        |        |        |        |        |        |  |  |
|--------|---------|---------|--------------|----------|-----------|--------|--------|--------|--------|--------|--------|--|--|
| № кол. | Х ,см   | Ү ,см   | Тип перерізу | b(d) ,см | h(d1) ,см | b1 ,см | h1 ,см | b2 ,см | h2 ,см | b3 ,см | h3 ,см |  |  |
| 100    | 4571.00 | 165.72  | прямокутник  | 40.0     | 40.0      |        |        |        |        |        |        |  |  |
| 101    | 3371.00 | 165.72  | прямокутник  | 40.0     | 40.0      |        |        |        |        |        |        |  |  |
| 102    | 3971.00 | 940.00  | прямокутник  | 40.0     | 40.0      |        |        |        |        |        |        |  |  |
| 103    | 3971.00 | 1540.00 | прямокутник  | 40.0     | 40.0      |        |        |        |        |        |        |  |  |
| 104    | 3971.00 | 165.72  | прямокутник  | 40.0     | 40.0      |        |        |        |        |        |        |  |  |
| 105    | 3971.00 | 3340.00 | прямокутник  | 40.0     | 40.0      |        |        |        |        |        |        |  |  |

|   |              |         | Стіни   |         |         |
|---|--------------|---------|---------|---------|---------|
| № | Товщина (см) | Х1 (см) | Y1 (см) | Х2 (см) | Y2 (cм) |
| 1 | 30.0         | 364.00  | 2760.00 | 371.00  | 2140.00 |
| 2 | 30.0         | 71.00   | 2245.00 | 71.00   | 2140.00 |
| 3 | 30.0         | 7871.00 | 2245.00 | 7871.00 | 2140.00 |
| 4 | 30.0         | 7571.00 | 2740.00 | 7571.00 | 2140.00 |

| Характеристики                                    | матеріалів |  |
|---|------------|--|
| Клас бетону                                       | C20/25     |  |
| Вид бетону  | - важкий   |  |
| Розрахунковий опір бетону на стиск                | 1170       |  |
| Модуль пружності бетону                           | 2.75e+006  |  |
| Клас поздовжньої арматури (вздовж X)              | A400C      |  |
| Розрахунковий опір поздовжньої арматури на розтяг | 37500      |  |
| Модуль пружності арматури                         | 2e+007     |  |
| Клас поздовжньої арматури (вздовж Ү)              | A400C      |  |
| Розрахунковий опір поздовжньої арматури на розтяг | 37500      |  |
| Модуль пружності арматури                         | 2e+007     |  |
| Клас поперечної арматури                          | A240C      |  |
| Розрахунковий опір поперечної арматури на розтяг  | 18000      |  |
| Модуль пружності арматури                         | 2.1e+007   |  |
| Об'ємна вага                                      | 2.5        |  |
| Жорсткість пружної основи грунту на стиск:        | 0          |  |
| Жорсткість пружньої основи грунту на зсув:        | 0          |  |

| Характеристики матеріаліі          | • |
|------------------------------------|---|
| Відстань до центрів ваги арматури: |   |
|                                    | 2 |
| від нижньої грані                  | 3 |
| від верхньої грані                 | 3 |

|       |         |          |    | Ha | авантажен | ня |    |    |    |    |
|-------|---------|----------|----|----|-----------|----|----|----|----|----|
| Тип   | Вид     | Величина | X1 | Y1 | X2        | Y2 | X3 | Y3 | X4 | Y4 |
| Пост. | Р-розп. | 0.30     |    |    |           |    |    |    |    |    |
| Довг. | Р-розп. | 0.30     |    |    |           |    |    |    |    |    |

|                     | 1        | Коефіцієнти сполу | учення      |          |       |
|---------------------|----------|-------------------|-------------|----------|-------|
|                     | Постійне | Довготривале      | Короткочас. | Сейсміка | Вітер |
| 22 111              |          |                   |             |          |       |
| Надійності          | 1.10     | 1.20              | 1.20        | 1.00     | 1.40  |
| Тривалості          | 1.00     | 1.00              | 0.35        | 0.00     | 0.00  |
| I осн. сполучення   | 1.00     | 1.00              | 1.00        | 0.00     | 1.00  |
| II осн. сполучення  | 1.00     | 0.95              | 0.90        | 0.00     | 0.90  |
| III особ.сполучення | 0.90     | 0.80              | 0.50        | 1.00     | 0.00  |

|        |        |        | Переміщення   | (екстремуми | )      |      |               |
|--------|--------|--------|---------------|-------------|--------|------|---------------|
| №вузла | X      | Y      | Переміщення Z | №вузла      | X      | Y    | Переміщення Z |
|        | (см)   | (см)   | (MM)          |             | (см)   | (см) | (MM)          |
| 181    | 3970.9 | 5511.0 | -73.314865    | 150         | 3372.1 | 0.0  | 1.193434      |

|    |      |          |             | Зусилля в   | палях по зав | антаженнях |        |        |          |
|----|------|----------|-------------|-------------|--------------|------------|--------|--------|----------|
| No | палі | Постійне | Довготривал | Короткочасн | Сейсміка1    | Сейсміка2  | Вітер1 | Вітер2 | Огинаюча |
|    |      | (дм, )   | е (дм, )    | е (дм,)     | (дм, )       | (дм,)      | (дм, ) | (дм, ) | (дм, )   |
|    | 23   | -28.65   | -11.72      |             | 0.11         | 0.14       | 0.01   | 0.01   | -40.51   |
|    | 37   | -22.81   | -9.33       |             | 0.17         | -0.03      | 0.01   | 0.01   | -32.30   |
|    | 40   | -29.82   | -12.20      |             | 0.02         | 0.13       | 0.00   | 0.00   | -42.15   |

|        |          |          | Зусилля в   | палях по зава | антаженнях |        |        |          |
|--------|----------|----------|-------------|---------------|------------|--------|--------|----------|
| № палі | Постійне | _        | Короткочасн | Сейсміка1     | Сейсміка2  | Вітер1 | Вітер2 | Огинаюча |
|        | (дм, )   | е (дм, ) | е (дм,)     | (дм,)         | (дм,)      | (дм,)  | (дм, ) | (дм,)    |
| 42     | -24.64   | -10.08   |             | 0.29          | -0.10      | 0.02   | 0.02   | -35.01   |
| 50     | -23.58   | -9.65    |             | 0.01          | -0.00      | 0.00   | 0.00   | -33.25   |
| 51     | -22.77   | -9.31    |             | -0.18         | -0.04      | -0.01  | -0.01  | -32.26   |
| 54     | -28.64   | -11.72   |             | -0.11         | 0.14       | -0.01  | -0.00  | -40.49   |
| 60     | -24.63   | -10.07   |             | -0.33         | -0.11      | -0.03  | -0.03  | -35.03   |
| 64     | -26.05   | -10.65   |             | -0.42         | -0.05      | -0.04  | -0.03  | -37.12   |
| 65     | -26.15   | -10.69   |             | -0.26         | -0.05      | -0.02  | -0.02  | -37.10   |
| 66     | -29.30   | -11.98   |             | -0.20         | 0.11       | -0.02  | -0.01  | -41.48   |
|        |          |          |             |               |            |        |        |          |

|       |        | Спол   | учення зусиль (ек | сстремуми) |        |         |
|-------|--------|--------|-------------------|------------|--------|---------|
| №тр.  | Mx     | My     | Mxy               | Qx         | Qy     | R       |
| 10708 | 18.72  | 9.04   | -7.97             | 3007       | -1257  | -3.76   |
| 8927  | -12.70 | -15.29 | 0.17              | 6.81       | 105.16 | -0.53   |
| 10680 | -4.99  | 0.52   | -5.18             | -413.12    | 18.45  | -298.49 |

| Армування (екстремуми) |        |        |     |        |        |         |         |          |         |  |  |
|------------------------|--------|--------|-----|--------|--------|---------|---------|----------|---------|--|--|
| №тр.                   | Xc     | Yc     | Кут | АХ низ | АҮ низ | АХ верх | АҮ верх | АХ поп.  | АҮ поп. |  |  |
|                        | (см)   | (см)   |     | (см)   | (см)   | (см)    | (см)    | (см)     | (см)    |  |  |
| 10708                  | 7563.8 | 2231.5 | 0.0 | 47.53  | 32.88  | 33.28   | 17.88   | 10598.10 | 0.01    |  |  |
| 6155                   | 3954.4 | 1532.0 | 0.0 | 1.00   | 1.00   | 34.57   | 30.77   | 105.86   | 0.01    |  |  |
| 8927                   | 3971.0 | 188.8  | 0.0 | 1.00   | 1.00   | 27.60   | 32.28   | 293.40   | 0.01    |  |  |
| 1                      | 1766.1 | 3392.9 | 0.0 | 3.28   | 1.00   | 4.45    | 7.07    | 0.01     | 0.01    |  |  |

# APPENDEX B. DRAWINGS