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

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Head of the Department

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MASTER THESIS

(EXPLANATORY NOTE)

Topic: *Reconstruction and strengthening of load-bearing structures of the hotel complex in Kyiv*

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Kyiv 2020

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

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
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ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА

ОСВІТНЬО-ПРОФЕСІЙНА ПРОГРАМА «ПРОМИСЛОВЕ І ЦИВІЛЬНЕ БУДІВНИЦТВО»

Тема: "Реконструкція та підсилення несучих конструкцій готельного комплексу в Києві".

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Київ 2020

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Introduction

1.1 Analytical review

Formulation of the problem in general. Tourism industry - a set of different subjects of tourism (hotels, tourist complexes, campsites, motels, boarding houses, restaurants, transport, cultural institutions, sports), which provide reception, service and transportation of tourists. Simultaneously with the increase in the total number of tourists, the tourism infrastructure and its main component - the hotel sector, which seeks to get its share of business - has developed significantly.

In modern conditions, hotels are forced to fight for a "place under the sun", and if possible - to seek to expand their business. Recently, due to the recent economic downturn in the developed world, competition in the hospitality industry has sharpened.

Survival and growth of business activity are the most important directions in the activity of hotel enterprises in all countries of the world. Some of them are already aware of this fact and are taking the necessary measures to ensure a stable future by meeting the changing needs of consumers and encouraging re-turnover in the provision of hotel services.

The rapid changes in telecommunications, media and related technologies have increased consumer expectations regarding the quality of service, the professionalism of the staff and the variety of hotel services offered. Therefore, we can no longer expect that consumers will be satisfied with poor service. As part of their marketing policy, hotels should inform potential customers about the level and quality of services they can count on, and then ensure that the services they offer meet the stated level.

Analysis of recent research and publications. Hotel business is one of the most promising and successfully developed areas of business in Ukraine. The peculiarity of this business is the focus on European service standards and the rapid transition to them. Like any business, the hotel business seeks to increase revenue and seeks effective ways to achieve the desired financial result.

Over the past year, the interest of tourists in Ukraine has increased. According to official statistics, the increase in tourists to Ukraine in the first half of 2007, compared to the same period in 2006, amounted to 16%. The number of foreign tourists for the period in 2007 amounted to 6.6 million - the same as for the whole of 2006.

There are currently 117 hotels of various forms of ownership and departmental subordination in Kyiv. Of these, 23 - large hotels with more than 100 rooms, 60 - small hotels (up to 100 rooms) and hotel-type dormitories. In total in hotels of Kiev 8,7 thousand numbers calculated on 15,6 thousand places. This provides accommodation for more than 1 million people a year, a third of whom are foreigners. About 400 new rooms in large and medium-sized hotels have been introduced in the last two years, including the Premier Palace and Radisson SAS hotels.

In general, in Ukraine the number of hotel places per 1 thousand population is 2, in Kiev - 6. While in Moscow - 9, Paris - 38, and on average in Europe - 14-18.

In large cities of Ukraine there are 12-15 thousand hotel rooms. Of the 8,700 rooms in the capital's hotels, only 3% meet international standards. At the same time, the cost of hotel services in Kiev is from $ 60 to $ 400 per day, which is constantly growing. Thus, in Ukraine the prospects for the development of the hotel industry are obvious.

In order to realize the hotel potential of Ukraine, the state must take the following measures:

- to provide tourists with comfortable and safe conditions for arrival and stay in Ukraine;

- pursue an effective policy of mass tourism development;

- take measures to improve the condition of attractions;

- make changes to land use laws,

- amend the rules for issuing appropriate permits to organizations in related industries to attract investment in the opening of new mass tourism facilities.

The hotel market of Ukraine has faced a number of problems in its formation. One of them is the weakness of domestic competition due to lack of free funds and high tax rates, which makes it difficult to ensure economic stability, maximize profits, increase the competitiveness of the hospitality industry in the hotel market, as well as the lack of strong international hotel chains.

The indicator of low competitiveness of hotel services is formed due to the level of price and quality of services. Due to high tax rates, hotels are forced to set high prices. Prices are determined by the conditions of competition, the state and ratio of supply and demand.

In Poland, after the privatization of hotels and market reforms, the number of hotel rooms increased by 50% as a result of the emergence of new enterprises, especially in the form of networks.

The expansion of the latter increases productivity by improving the structure of the industry and strengthening the competitive position in the market. Taking into account the Polish experience, it can be assumed that labor productivity in the Ukrainian hotel services sector will increase significantly if the structure of the industry is changed (high-category hotels in chains and small family-type hotels should appear).

It should be noted changes in the state of large international hotel chains in the Ukrainian market. If earlier such large world chains as "Hilton", "Marriott", "Sheraton", "Radisson", "Kempinski", "Accor" invested money in the construction of hotels in Turkey and Egypt, now Ukraine is becoming attractive for investment. in the hotel business.

The analysis shows the activation of investors in the hotel segment of commercial real estate, and this primarily applies to the hotel market of Ukraine. Such changes are facilitated by a number of reasons, among which are:

- the inability of existing hotels to meet the growing demand for hotel services;
- a steady increase in demand for world-class apartments;
- saturation of real estate market segments with a minimum payback period;
- increase in capital of investment companies;

- relative stability of the Ukrainian economy;
- changes in foreign policy;
- gradual integration of the state into the European and world community;
- improving the investment and business climate in Ukraine;
- gradual growth of business activity in the middle of the country,
- increasing the share of business visits from abroad;
- growth of tourist attractiveness of Ukraine.

There have also been changes in the rules of mandatory certification of hotel services. The new certification rules affect the dynamics of hotel business development and contribute to improving the quality of services provided. This will be the basis for the stability and prosperity of the hotel business in Ukraine.

It should be noted that in Ukraine, especially in large cities, including Kyiv, it is necessary to develop a segment of low-cost hotels with affordable prices for people with average wealth. Given the increase in domestic business activity, in the regions, three-star hotels may be attractive to foreign investors.

Today, more and more international operators are showing interest in managing ready-made facilities. The international operator allows the hotel to integrate more quickly into international networks, guarantees brand recognition, provides access to international booking systems.

The number of hotels can be increased through the reconstruction and modernization of existing ones. Conducting an objective analysis of the existing base, it can be noted that it is able to meet the needs of hotel places.

For this purpose it is necessary to bring in the corresponding condition the hotels constructed earlier, to pay attention to objects of unfinished construction, departmental houses and hostels.

The hotel business in Ukraine is promising for at least four reasons. First, there is an increase in business activity in the country, which, as a rule, inevitably causes an increase in "business tourism", not only domestic but also inbound.

Second, the increase in income of the population of Ukraine leads to an increase in the number of people traveling, which makes it necessary to increase the

means of accommodation and the provision of quality hotel services. Third, Ukraine, which has declared its integration into the European space, is gradually becoming attractive to Europeans. Fourth, the abolition of the hotel tax has reduced the tax burden on hotels.

Representatives of foreign capital in general assess the Ukrainian hotel business market as complex, but promising for investors and pay more attention to the possibility of implementing projects in the regions of the country. At the same time, the most interesting in terms of project implementation are such large cities as Kharkiv, Donetsk, Dnipropetrovsk, Odessa and Crimea.

Thus, the Ukrainian hotel market has great prerogatives and is one of the most promising in Eastern Europe, but with all the potential for hotel business in Ukraine, the number of available hotels is insufficient for a country with high investment attractiveness, rich historical past and great tourist opportunities.

2. Architectural part

2.1. General architectural preview

The reconstruction site is located in the central planning zone of the city. The site is located next to the NSC "Olympic", in the quarter bounded by the streets Zhylyanska, Velyka Vasylkivska and Fizkultury. On the land there is an 18-storey hotel building with superimposed technical floors.

On the allotted site there is an extension of the medical institution "Boris", which will be operated during the reconstruction of the hotel "Sport".

The main bearing elements are prefabricated monolithic and monolithic frames, prefabricated and monolithic slabs of floors and coverings. External enclosing structures - brick walls, foundation - monolithic grille on used piles.

In geomorphological terms, the site is located within the thalweg of the Klovsky ravine at the confluence with the Lybid river valley and is characterized by absolute marks of the earth's surface of the order of 124.4-125.9 m. organic matter content and peat. From the surface, these deposits are covered with a layer of loose soil composed of sands, sandstones, loams with construction residues, the content of which in some places reaches 80% and humus. The thickness of this layer reaches 1.8-10.8 m.

Groundwater for the period of exploration was recorded at depths of 2.9-3.2 m, within the absolute limits of 121.2-122.6 m.

The waterproof layer of this aquifer is the deposits of the Paleogene period. The forecast rise in the groundwater level of the main horizon is possible up to 1.5 m higher than the level recorded during the survey. The projected groundwater level is 122.6 m, the estimated groundwater level is 123.6 m.

The project provides:

1. Arrangement of sections of floors on metal beams on axes In; 1; M; 9 floors from 6 on 20 inclusive, for installation of front system.

2. Construction of a four-storey extension along the axis 9 in the axes VI. The basis of the extension is a monolithic reinforced concrete grille that exists. The

extension is designed according to the frame scheme, the frame is supposed to be made of steel cold-bent profiles according to DSTU BV.2-6-8-95.

3. Arrangement of hinged facades of crossbar system with double-glazed windows with external tempered glass of thicknesses. 6 mm.

4. Construction of a two-storey extension in the axes of RT with an elevator for sedentary groups. The basis for the extension is bulk soils compacted for many years, before arranging the foundations, the soils should be compacted with rubble, the materials of the foundations are concrete class. C12 / 15, fittings class. A400C. The extension is designed according to the frame scheme, the frame is supposed to be made of steel cold-bent profiles according to DSTU BV.2-6-8-95.

5. Installation of a roof from roofing sandwich panels on steel profiles at the level of the 20th floor for the device of cafe "Sky bar".

6. Reconstruction of the stairwell in the axes KM and elevator in the axes 7-8 (extension to the 20th floor), which will be used for transportation of fire departments.

Building with longitudinal load-bearing walls. Exterior and interior walls are made of brick. The external walls are designed with a multilayer structure: the first layer is made of facing ceramic brick 120 mm thick, the second layer is made of ISOVER insulation in two layers, 130 mm thick, the third layer is made of silicate brick, 390 mm thick.

The seam system is multi-row.

Masonry reinforcement is performed every 5 rows.

The thickness of the outer walls is 640 mm, the inner walls are 510 mm, and between the apartment walls are 380 mm. Binding of external walls 440 mm from the outside, from the inner - 200 mm, inter-apartment walls 380 mm thick - binding 190x190 mm, and 510 mm thick - binding 255x255 mm. The walls of the stairwell have a double-sided binding 190x190mm.

The thickness of horizontal seams is 12 mm, and vertical - 10 mm. The seams on the inner surface of the walls are filled into the seam, the outer seams are processed in the form of a roller.

Partitions are designed industrial.

Interior partitions - plasterboard 90 mm thick. In bathrooms partitions are made of a ceramic brick 120 mm thick. Laying is performed on cement mortar M-75, the seams that occur at the bottom are closed with elastic gaskets with ORP, the top is filled with foam.

Partitions to walls, ceilings are fastened by means of fastening elements - anchors. Glue the corners at the joints of two plasterboard panels with a cloth and putty.

Gypsum plasterboard partitions are made by installation of a framework from profiles on which gypsum cardboard sheets "KNAUF" fasten with screws or self-tapping screws.

The vertical planning of the projected 9-storey residential building is due to the existing terrain, taking into account the marks of existing buildings and structures, the existing coverage of driveways, adjacent streets, location of roads and communications, the condition of surface water drainage. Planning marks are given on top of the road, pavement and ground surface.

Use luminous chamfers and fluorescent coatings to mark the routes of cars and main target points (signs, etc.).

Special fire-retardant coatings and impregnations applied to the open surface of structures must be periodically restored or replaced in case of their destruction (failure in whole or in part) or in accordance with the service life specified in the technical documentation for these coatings and impregnations.

In addition to the designed building on the site are provided:

- sports grounds;
- laundry drying area;
- laundry area;

3. Structural part

3.1. Characteristics of construction.

The construction site refers to II in the climatic region and is characterized by the following data and are summarized in Table 1.

• design winter outside air temperature - 24 °C below zero;

3.2. Geological servey information

The geological structure of the site is composed of sands of various sizes, loams, which are covered on top with alluvial sand and bulk layer.

According to engineering and geological surveys and laboratory analyzes at the site, the following engineering and geological elements (IGE) are identified:

IGE - 1 Bulk layer - gray sand, light gray, with gravel content, slightly moist ().

IGE - 2 Alluvial layer - sand grayish-yellow, light yellow, fine with a layer of sand of medium size, slightly moist and saturated with water, medium density ().

IGE - 3 Loam gray, brownish-gray, in places with layers of peat, soft-plastic consistency ().

IGE - 4 Sand is dark yellow, light gray, shallow, saturated with water, dense ().

IGE - 5 Sand is light gray, medium-sized with layers of fine sand, saturated with water, dense ().

IGE - 6 Sand is light gray, dusty, saturated with water, dense ().

IGE - 7 Sand is greenish-gray, dusty, saturated with water, dense ().

The power, boundaries and conditions of engineering-geological elements are shown in engineering-geological sections.

Processes in soils.

Sloping, erosion processes and landslides are absent on the site. The soils of the site are not sedentary.

Impact of construction on the geological environment.

The construction of residential buildings will be carried out on alluvial sands, as detached buildings on stilts. The impact of construction on neighboring buildings,

as well as on the geological environment will not be. Design of underground parking should be performed taking into account the maximum level of groundwater.

Physico-mechanical properties of soils.

Physico-mechanical properties of soils are given on the basis of statistical processing of laboratory analyzes and with use of archival materials on the area of works.

The geological structure of the territory involves the upper and middle Quaternary sediments represented by alluvial sands of various sizes, loams, which are covered with alluvial sand and bulk layer, and underlain by the sands of the Buchak tier.

Groundwater during the survey period (June - July) was found at a depth of 7.50 - 8.30 m, at absolute marks 92.05 - 92.90 m.

The maximum level of groundwater, taking into account seasonal fluctuations and flooding by flood waters, should be taken at the absolute mark of 98.00 m.

The site is potentially flooded by groundwater.

In relation to concretes of the W4, W6, W8 brands on water permeability, underground waters are not aggressive.

The recommended type of foundations is made of drilled or drilled injection piles. The basis for piles are recommended sands of medium size (IGE - 5).

The recommended immersion depth of the pile tip is at least 18.0 meters.

The calculation of the bearing capacity of piles can be performed according to statistical soil sounding.

The average value of the resistivity of the soil on the side surface and under the tip of the probe are given in table №2 p.5.3.

The normative depth of seasonal freezing of soils is 108 cm.

The seismicity of the area is not seismic.

The category of complexity of engineering and geological conditions, according to - the third.

3.3 Design of metal structures of the new roof

Thickness of the platform t_p depends on the span equals to spacing between first beams $l_p = a$, service rating load g_e and limit deflection f_u. The thickness of the platform is calculated by the formula:

$$t_p = \frac{l_p = a}{\xi \cdot (1 + \frac{1}{\chi \cdot g_e})},$$

where $\xi = \frac{4n_0}{15}$, where n_0 – conditional deflection.

$\chi = \frac{n_0}{72 \cdot E_1}$, where $E_1 = \frac{E}{1 - \nu^2}$, ν – coefficient of shearing strain, that is assumed in elastic range equals *0.3* and $E=2.06 \cdot 10^5 MPa$

$E_1 = 22637{,}36 \frac{kN}{cm^2}$

Table №1

n_0	120	125	130	135	150
ξ	32	33.33	34.67	36	40
$\chi, m^2/kN$	0.0127	0.015	0.0175	0.0204	0.0311

There is information about limit deflection for bending elements. The limit deflection depends upon span of the elements and requirements intended to it. The limit deflection assumed by the aesthetic psychological requirements when the elements of the beam cage open for examination and there are not layers capable to crack.

Table №2

Span l, m	*≤1*	*3*	*6*	*24(12)**	*36(24)**
$f_u = l / n_0$	*l/120*	*l/150*	*l/200*	*l/250*	*l/300*

* - $h \le 6m$

Intermediate value of limit deflection is calculated by the formula:

$$f_{ui} = f_{u1} + \frac{f_{u2} - f_{u1}}{l_2 - l_1} \cdot (l_i - l_1)$$

And the conditional deflection:

$$n_{0i} = \frac{l_i}{f_{ui}}$$

The strength of the platform is check up in elastic range by the formula

$$\max \sigma = \frac{E_1 \pi^2 t_p^2}{4 l_p^2} \cdot \psi(\psi + 2) \le R_y$$

$E_1 = 22637.36 kN/cm^2$

If service rating load less than 50kN/m2 and limit deflection less or equals $g_e \le 50 kN/m^2$ and $f_u \le \frac{1}{150} \Rightarrow$ the strength of the metal platform is provided and need not to check up.

Calculation of the 1-st variant "Normal type of beam cage with metal platform"

$g_{n1} = 4{,}85 kN/m^2;$

$g_1 = 5{,}3 kN/m^2$

$l_1 = 1m$

For beams we use steel C235 with design resistance $R_y = 230 MPa.$

$P_n = 16 kN/m$

$g_e = 20{,}05 kN/m^2;$

$g_m = 23.54 kN/m^2;$

Assume $t_p = 7mm$

And conditional deflection is $n_{oi} = \frac{100 cm}{0.833} = 120$

$f_{ui} = \frac{100}{120} = 0.833 cm$

$\xi = 4 * \frac{120}{15} = 32$

$\chi = \frac{120^4}{72 * 22637{,}36} = 127{,}22 cm/kn^2$

$t_p = \frac{100}{32(1 + \frac{1}{0.012722 * 20.05})} = 0.635 cm;$

$l_p = a = 100 cm$

Checks on stress in the platform.

Coefficient ψ depends on the limit rating load in accord with formula

$g^* = \frac{g_m a^4}{E t_p^4} = \frac{23.54}{2.06 \cdot 10^8} \cdot (\frac{100}{0.7})^4 = 47.59$

From the diagram 2.5 $\psi = 1.2$

$\max \sigma = \frac{22637.36 \cdot 3.14^2 \cdot 0.7^2}{4 \cdot 100^2} \cdot 1.2 \cdot (1.2 + 2) = 10.5 kN/cm^2 = 105 MPa < R_y = 230 MPa$ - the strength is provided on 54%

$\frac{230 - 105}{230} \cdot 100\% = 54\%$

Assume $t_p = 7mm$

Calculation of the 2-nd variant "Complicated type of beam cage with metal platform"

$f_u = \frac{100}{120} = 0.833cm$

And conditional deflection is $n_{oi} = \frac{100cm}{0.833} = 120$

$\xi = 4 * \frac{120}{15} = 32$

$\chi = \frac{120^4}{72*22637,36} = 127,22cm/kn^2$

$t_p = \frac{100}{32(1+\frac{1}{0.012722 * 20.05})} = 0.635cm;$

From diagram 2, the thickness of the platform is

$t_p = 6.4mm;$

$l_p = a = 95cm$

Assume $t_p = 7mm$

Limit deflection $f_{ui} = 0.833cm$

And conditional deflection is $n_{oi} = 120$

Checks on stress in the platform.

Coefficient ψ depends on the limit rating load in accord with formula

$g* = \frac{g_m a^4}{Et_p^4} = \frac{23.54}{2.06 \cdot 10^8} \cdot (\frac{95}{0.7})^4 = 38.76$

From the diagram 2.5 $\psi = 1.1$

$\max \sigma = \frac{22637.36 \cdot 3.14^2 \cdot 0.7^2}{4 \cdot 95^2} \cdot 1.1 \cdot (1.1+2) = 10.33kN/cm^2 = 103.3MPa < R_y = 230MPa$ - the strength is provided on 55%

$\frac{230 - 103.3}{230} \cdot 100\% = 55.09\%$

Assume $t_p = 7mm$

Calculation of the 3-rd variant "Normal type of beam cage with reinforced concrete platform"

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

Thickness of the reinforced concrete platform, cm

Table 3

Design span of the r.c. platform, m	Service rating load, kN/m^2			
	15-20	21-25	26-30	31-35
1.5-2.0	10	12	12	14
2.1-2.5	12	12	14	16
2.6-3.0	14	14	16	18

$g_e = 22.63 kN/m^2$;

$l_p = a = 2m \Rightarrow t_p = 12cm = 120mm$.

CALCULATION AND DESIGN THE MAIN BEAM OF THE WORKING PLATFORM

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

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

   The height of the platform space

   H=7.6m; h_{str}=1.9m

   $h = H - h_{str} = 7.6 - 1.9 = 5.7m < 6m;$

   Main beam in all variants has span $l_i = 16m$

   $l_1 = 12m \qquad f_{u1} = \frac{1200}{250} = 4.8cm;$

   $l_2 = 24m \qquad f_{u2} = \frac{2400}{300} = 8cm;$

   $f_{ui} = 4.8 + \frac{8 - 4.8}{24 - 12}(16 - 12) = 5.9cm$;

   $n_{oi} = \frac{1600}{5.9} = 271.19$

   The first beam from variant 1 and 3 and second beam from variant 2 have the span $l_i = 7.6m$

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

   $l_2 = 12m \qquad f_{u2} = \frac{1200}{250} = 4.8cm;$

   $f_{ui} = 3 + \frac{4.8 - 3}{12 - 6}(7.6 - 6) = 3.48cm;$

   $n_{oi} = \frac{760}{3.48} = 218.39;$

   Limit deflection for the first beam of the 2nd variant $l_i = 4m$

   $l_1 = 3m \qquad f_{u1} = \frac{300}{150} = 2cm;$

$l_2 = 6m$ $\qquad\qquad$ $f_{u2} = \frac{600}{200} = 3cm;$

$f_{ui} = 2 + \frac{3-2}{6-3}(4-3) = 2.33cm;$

$n_{oi} = \frac{400}{2.33} = 171.67;$

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

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

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

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

The limit value of design resistance for secondary beam, if first beams are simple f

$$opt\ R_y = 523 \cdot \gamma_f \sqrt[3]{\frac{g_e \cdot d}{n_{0SB}^2 \cdot t_{wSB}}}$$

γ_f - average overload factor, $\gamma_f = \frac{g_m}{g_e}$;

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

t_w - the thickness of web of the first beam and secondary beam;

$t_{wFB} \approx 0.005 - 0.007m$

$t_{wSB} \approx 0.007 - 0.01m$

g_e - service rating load;

g_m - limit rating load;

Calculation:

1. First beam of I variant(metal platform):

$$opt\ R_y = 492 \cdot 1.174 \sqrt[3]{\frac{20.05 \cdot 1}{218.39^2 \cdot 0.006}} = 237.97 MPa; \qquad \gamma_f = \frac{23.54}{20.05} = 1.174;$$

2. First beam of II variant(metal platform):

$$opt\ R_y = 492 \cdot 1.174 \cdot \sqrt[3]{\frac{20.05 \cdot 0.95}{171.67^2 \cdot 0.006}} = 274.83.28 MPa;$$

3. Secondary beam of II variant(metal platform):

$$opt\ R_y = 523 \cdot 1.174 \cdot \sqrt[3]{\frac{20.05 \cdot 4}{218.39^2 \cdot 0.009}} = 351.01 MPa;$$

4. First beam of III variant(reinforced concrete):

$$opt\ R_y = 492 \cdot 1.167 \cdot \sqrt[3]{\frac{22.63 \cdot 2}{218.39^2 \cdot 0.006}} = 310.5 MPa; \ \gamma_f = \frac{26.41}{22.63} = 1.167;$$

The grade of steel is chosen according to Building Code (table 51) by thickness of the flange:

$t_f = 5 - 10 mm$ for first beam;

$t_f = 11 - 15 mm$ for secondary beam;

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

Assume:

1. For the first beam of I variant C235 R_y=230MPa;
2. For the first beam of II variant C275 R_y=270MPa;
3. For secondary beam of II variant C375 R_y=345MPa;
4. For first beam of III variant C275 R_y=270MPa;

3. Determination of linear density of beams

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

1. For FB of I variant $q_{l.FB} = 608 \cdot 7.6 \cdot \sqrt{\frac{23.54 \cdot 1}{230 \cdot 10^3}} = 46.75 kg/m;$
2. For FB of II variant $q_{l.FB} = 608 \cdot 4 \cdot \sqrt{\frac{23.54 \cdot 0.95}{270 \cdot 10^3}} = 22.13 kg/m;$
3. For FB of III variant $q_{l.FB} = 608 \cdot 7.6 \cdot \sqrt{\frac{26.41 \cdot 2}{270 \cdot 10^3}} = 64.63 kg/m;$

For secondary beam $q_{l.SB} = 754 \cdot l \cdot \sqrt{\frac{g_m \cdot d}{R_y \cdot 10^3}};$

4. For SB of II variant $q_{l.SB} = 754 \cdot 7.6 \cdot \sqrt{\frac{23.54 \cdot 4}{345 \cdot 10^3}} = 94.67 kg/m;$

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

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

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

Design load $$q_m = g_1 \cdot a + [\frac{(t_p - t) \cdot \rho \cdot a \cdot \gamma_f + q_l \cdot 1.05}{100} + P_n \cdot a \cdot 1.2] \cdot \gamma_n;$$

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

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

γ_f - for metal platform 1.05;

-for reinforced concrete platform 1.1;

For metal platform $\rho = 7850 kg/m^3$;

For reinforced concrete platform $\rho = 2500 kg/m^3$;

Calculation:

1. For the first beam of I variant

$g_{n1} = 4.85 kN/m^2$;

$g_1 = 5.3 kN/m^2$;

$P_n = 16 kN/m^2; t_p = 7 mm$;

$$q_e = 4.85 \cdot 1 + [\frac{(0.007 - 0.01) \cdot 7850 \cdot 1 + 46.75}{100} + 16 \cdot 1] \cdot 0.95 = 20.27 kN/m;$$

$$q_m = 5.3 \cdot 1 + [\frac{(0.007 - 0.01) \cdot 7850 \cdot 1 \cdot 1.05 + 46.75 \cdot 1.05}{100} + 16 \cdot 1 \cdot 1.2] \cdot 0.95 = 23.77 kN/m;$$

2. For the first beam of II variant

$t_p = 7 mm$;

$$q_e = 4.85 \cdot 0.95 + [\frac{(0.007 - 0.01) \cdot 7850 \cdot 0.95 + 22.13}{100} + 24 \cdot 0.95] \cdot 0.95 = 19.05 kN/m;$$

$$q_m = 5.3 \cdot 0.95 + [\frac{(0.007 - 0.01) \cdot 7850 \cdot 0.95 \cdot 1.05 + 22.13 \cdot 1.05}{100} + 16 \cdot 0.95 \cdot 1.2] \cdot 0.95 = 22.36 kN/m;$$

3. For the first beam of III variant

$g_{n1} = 7.43 kN/m^2;$

$g_1 = 8.13 kN/m^2;$

$t_p = 150 mm;$

$$q_e = 7.43 \cdot 2 + [\frac{(0.12 - 0.01) \cdot 2500 \cdot 2 + 64.63}{100} + 16 \cdot 2] \cdot 0.95 = 45.97 kN/m;$$

$$q_m = 8.13 \cdot 2 + [\frac{(0.12 - 0.01) \cdot 2500 \cdot 2 \cdot 1.1 + 64.63 \cdot 1.05}{100} + 16 \cdot 2 \cdot 1.2] \cdot 0.95 = 53.48 kN/m;$$

Service load for secondary beam $F_{e,SB} = q_{e,FB} \cdot d + \frac{q_{l,SB} \cdot a \cdot \gamma_n}{100};$

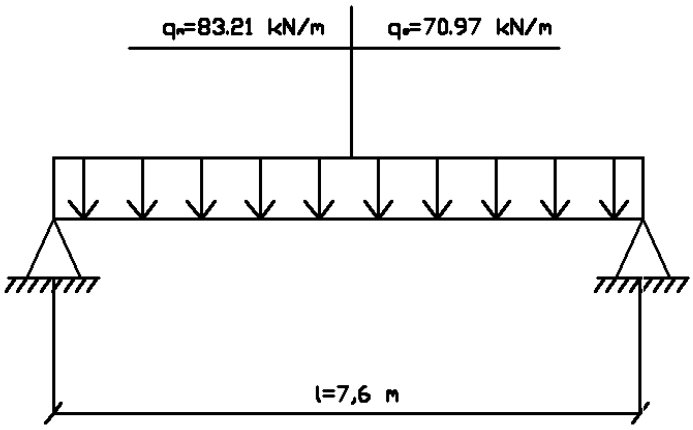
$$F_{e,SB} = 19.05 \cdot 4 + \frac{94.67 \cdot 0.95 \cdot 0.95}{100} = 77.05 kN/m;$$

Design load for secondary beam $F_{m,SB} = q_{m,FB} \cdot d + \frac{q_{l,SB} \cdot a \cdot 1.05 \cdot \gamma_n}{100};$

$$F_{m,SB} = 22.36 \cdot 4 + \frac{94.67 \cdot 0.95 \cdot 1.05 \cdot 0.95}{100} = 90.34 kN/m;$$

Let`s consider 3 types of loading of the beams

Variant II for secondary beam



$q_e = \frac{\sum F_e}{l};$ $\quad q_e = \frac{77.05 \cdot 7}{7.6} = 70.97 kN/m;$

$q_m = \frac{\sum F_m}{l};$ $\quad q_m = \frac{90.34 \cdot 7}{7.6} = 83.21 kN/m;$

4. Determination of bending moment and choose the number of rolled I-beams

Number of concentrated load **Table 4**

M, kN·m	*2*	*3*	*4*	*5*	≥ 6
	$\frac{1}{3}F_m \cdot l$	$\frac{1}{2}F_m \cdot l$	$\frac{3}{5}F_m \cdot l$	$\frac{3}{4}F_m \cdot l$	$\frac{q_m \cdot l^2}{8}$
f, cm	$\frac{23}{648}\frac{F_e \cdot l^3}{EI \cdot 10}$	$\frac{19}{384}\frac{F_e \cdot l^3}{EI \cdot 10}$	$\frac{63}{1000}\frac{F_e \cdot l^3}{EI \cdot 10}$	$\frac{11}{14}\frac{F_e \cdot l^3}{EI \cdot 10}$	$\frac{5}{384}\frac{q_e \cdot l^4}{EI \cdot 10}$

The data from the examples of calculations are summarized in table №5.

Results of calculations **Table 5**

Rating values and formulas	Variant I	Variant II		Variant III
	FB	FB	SB	FB
1	2	3	4	5
Bending moment due to external load, M(kN·m)	$\frac{23.77 \cdot 7.6^2}{8} = 171.62$	$\frac{22.36 \cdot 4^2}{8} = 44.72$	$\frac{83.21 \cdot 7.6^2}{8} = 600.78$	$\frac{53.48 \cdot 7.6^2}{8} = 386.12$
Design resistance R_y, MPa	230	270	345	270
Necessary moment of resistance of the beam, $W_{nec} = \frac{M \cdot 10^3}{c_1 \cdot R_y}$, *cm³*	$\frac{171.62 \cdot 10^3}{1.09 \cdot 230} = 684.56$	$\frac{44.72 \cdot 10^3}{1.09 \cdot 270} = 151.95$	$\frac{600.78 \cdot 10^3}{1.055 \cdot 345} = 1650.6$	$\frac{386.12 \cdot 10^3}{1.09 \cdot 270} = 1312$
Choice of cross-section	I40Б1	I20Б1	I50Б2	I50Б1
W_x, cm³	803.6	194.3	1709	1511
I_x, cm⁴	15750	1943	42390	37160
Linear density, kg/m	48.1	22.4	80.7	73
q_e, kN/m	20.27	19.05	70.97	45.97
F_e, kN	-	-	77.05	-
f_u, cm	3.48	2.33	3.48	3.48
$f \leq [f_u]$	2.71<3.48	1.59<2.33	2.25<3.48	2.61<3.48

1. $f = \frac{5}{384}\frac{q_e \cdot l^4}{EI \cdot 10} = \frac{5}{384}\frac{20.27 \cdot 7.6^4 \cdot 10^8}{2.06 \cdot 10^5 \cdot 10 \cdot 15750} = 2.71;$

2. $f = \frac{5}{384}\frac{q_e \cdot l^4}{EI \cdot 10} = \frac{5}{384}\frac{19.05 \cdot 4^4 \cdot 10^8}{2.06 \cdot 10^5 \cdot 10 \cdot 1943} = 1.59;$

3. $f = \frac{63}{1000}\frac{q_e \cdot l^4}{EI \cdot 10} = \frac{63}{1000}\frac{70.97 \cdot 7.6^3 \cdot 10^8}{2.06 \cdot 10^5 \cdot 10 \cdot 42390} = 2.25;$

4. $f = \frac{5}{384}\frac{q_e \cdot l^4}{EI \cdot 10} = \frac{5}{384}\frac{45.97 \cdot 7.6^4 \cdot 10^8}{2.06 \cdot 10^5 \cdot 10 \cdot 37160} = 2.61;$

Expenditure of materials

Mass of steel:

Variant I: for platform $g_p = t_p \cdot \rho = 0.007 \cdot 7.85 = 0.055 t/m^2;$

for first beam $g_{FB} = \frac{q_l}{a} = \frac{0.0481}{1} = 0.0481 t/m^2;$

Total: 0.103t/m^2;

Variant II: for platform $g_p = 0.007 \cdot 7.85 = 0.055 t/m^2;$

for first beam $g_{FB} = \frac{q_l}{a} = \frac{0.0224}{0.95} = 0.0236 t/m^2;$

for secondary beam $g_{SB} = \frac{q_l}{d} = \frac{0.0807}{4} = 0.0202 t/m^2;$

Total: 0.0988t/m^2;

Variant III: first beam $g_{FB} = \frac{q_l}{a} = \frac{0.073}{2} = 0.0365 t/m^2;$

Volume of the reinforced concrete platform is 0.14m^3/m^2;

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

$K_2 = \frac{0.0037 R_y + 0.2773}{0.0037 R_{y(235)} + 0.2773};$

Variant I: first beam (R_y=230MPa)

$K_2 = \frac{0.0037 \cdot 230 + 0.2773}{0.0037 \cdot 230 + 0.2773} = 1;$

Variant II: first beam (R_y=270MPa)

$K_2 = \frac{0.0037 \cdot 270 + 0.2773}{0.0037 \cdot 230 + 0.2773} = 1.131;$

Variant II: secondary beam (R_y=345MPa)

$$K_2 = \frac{0.0037 \cdot 345 + 0.2773}{0.0037 \cdot 230 + 0.2773} = 1.377;$$

Variant III: first beam (R_y=270MPa)

$$K_2 = \frac{0.0037 \cdot 270 + 0.2773}{0.0037 \cdot 230 + 0.2773} = 1.131;$$

Cost of assembling construction

$$C_{as} = \frac{K_1 \cdot g_p + K_1 \cdot K_2 \cdot g_{FB} + K_1 \cdot K_2 \cdot g_{SB}}{0.5};$$

Cost of assembling constructions is determined with allowance that cost of materials consist of 50% from cost of assembling constructions.

Variant I

$$C_{as} = \frac{1 \cdot 0.055 + 1.07 \cdot 1 \cdot 0.0481}{0.5} = 0.213;$$

Variant II

$$C_{as} = \frac{1 \cdot 0.055 + 1.07 \cdot 1.131 \cdot 0.0236 + 1.07 \cdot 1.377 \cdot 0.0202}{0.5} = 0.227;$$

Variant III

$$C_{as} = \frac{0.60 \cdot 0.14 + 1.07 \cdot 1.131 \cdot 0.0365}{0.5} = 0.256;$$

The technical economic parameters are summarized in the table

Table 6

Parameter		Measure units	Values for variants		
			1	2	3
Expenditure of materials	metal platform	t/m^2	0.103	0.0988	0.036
	Reinforced concrete platform	m^3/m^2	-	-	0.14
The cost of assembling constructions		r.c.u./m^2	0.213(83.2%)	0.227(88.67%)	0.256(100%)
Number of beams types		pcs	1	2	1
Quantity of beams		pcs	16	32	8

Conclusion: we use the third type of beam cage – normal type with reinforced concrete platform because the labour consumption at construction is the least ones. The maximal height of the main beam could be increased by decreasing the thickness of the floor.

CALCULATION AND DESIGN OF THE MAIN BEAM

Let`s calculate maximum height of the main beam in accord with structural height of the working platform

$$h_{\max MB} = h_{str} - t_f - t_p - h_{FB} - f_{MB} - 50;$$

Where t_f – is thickness of the flange (from assortment);

h_{FB} – is height of first beam (from assortment);

f_{MB} – is a limit deflection of main beam;

a)conof first beam over main beam

$$h_{\max MB} = 1900 - 180 - 120 - 492 - 59 - 50 = 999 mm;$$

b) first beam is supported over main beam in one level

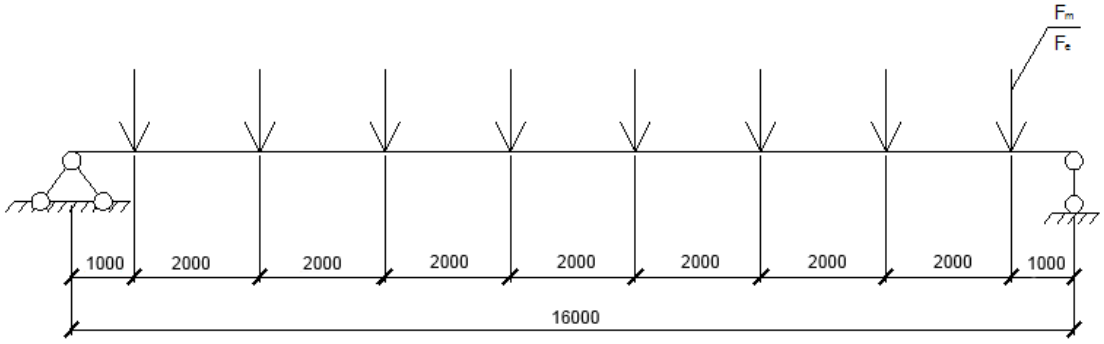
$$h_{\max MB} = 1900 - 180 - 120 - 59 - 50 = 1491 mm;$$

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

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

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

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



Design scheme of loading main beam

$$V_m = \frac{53.48 \cdot 7.6}{2} = 203.22 kN;$$

$$F_m = 2 \cdot 203.22 \cdot 1.025 = 416.6kN;$$

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

$$q_m = \frac{F_m}{a} = \frac{416.6}{2} = 208.3kN/m;$$

Maximum value of bending moment in the middle of the span

$$M_{\max} = \frac{q_m \cdot l^2}{8} = \frac{208.3 \cdot 16^2}{8} = 6665.6kN \cdot m;$$

$$Q_{\max} = \frac{q_m \cdot l}{2} = \frac{208.3 \cdot 16}{2} = 1666.4kN;$$

Service rating load

$$F_e = 2V_{e(3)} \cdot K_{dw} = 2 \cdot 174.69 \cdot 1.025 = 358.1kN;$$

$$V_e = \frac{q_e \cdot l}{2} = \frac{45.97 \cdot 7.6}{2} = 174.69kN;$$

Average overload factor

$$\gamma_f = \frac{F_m}{F_e} = \frac{416.6}{358.1} = 1.16;$$

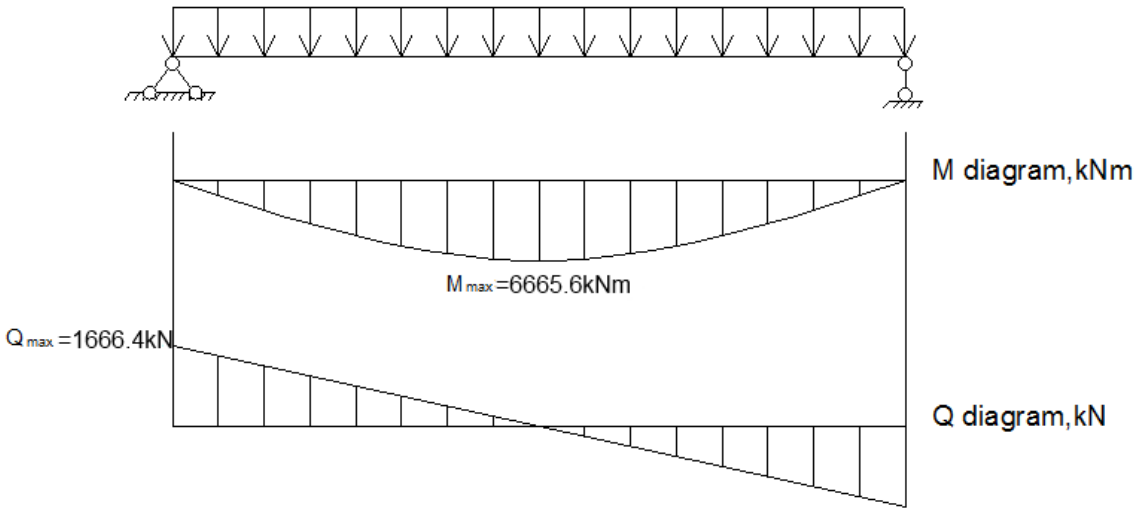


Diagram of bending moments and shearing force

The minimum height of a beam is determined from the condition of the optimal one from the stand point of the amount of material required. The determination of the

most advantageous cross-section of the beam consists of the finding the minimum area A of the section for the given moment of resistance $W = \frac{M}{R_y}$ and in the most efficient distribution of this section area between the web and flanges that dependent on the height h and thickness of the web t_w

$A = A_w + 2A_f$;

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

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

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

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

Table 7

$\lambda_w = \frac{h_w}{t_w}$;	90-120	100-140	105-145	110-150	120-160	130-170	150-180
l, m	9	12	15	18	21	24	30

$l = 16m \Rightarrow \lambda = 125$;

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

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

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

$$\max R_y = 5655 \cdot (\frac{6665.6 \cdot 125}{1})^{1/4} \cdot (\frac{1.17}{271.19 \cdot 16 \cdot 1.02 \cdot 1.068})^{3/4} = 336.58 MPa;$$

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

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

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

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

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

$$W = \frac{M}{R_y \cdot \gamma_c} = \frac{6665.6 \cdot 10^3}{345 \cdot 1} = 19321 cm^3;$$

$$A = 2.512 \sqrt[3]{\frac{W^2}{\lambda_w}} = 2.512 \cdot \sqrt[3]{\frac{19321^2}{125}} = 361.73 cm^2;$$

$$opt\ h = 0.77 \cdot \sqrt{A \cdot \lambda_w} = 0.77 \cdot \sqrt{361.73 \cdot 125} = 153.73 cm;$$

$$h_w \approx 0.97 opt\ h = 0.97 \cdot 153.73 = 149.11 cm;$$

Assume $h_w = 150 cm.$

$$t_w = \frac{h_w}{\lambda_w} = \frac{150}{125} = 1.2 cm;$$

Assume $t_w = 12 mm.$

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

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

$$1.2 > \frac{150}{6} \sqrt{\frac{345}{2.06 \cdot 10^5}} = 1.02; \Rightarrow \text{the condition is provided.}$$

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

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

Area of flange

$$A_f = h_w \cdot t_w \cdot opt\beta;$$

$$A_f = 150 \cdot 1.2 \cdot 0.394 = 70.92 cm^2;$$

Assume $b_f \cdot (\frac{1}{3} ... \frac{1}{5}) opt\ h = 54.58 ... 32.75 cm$

For flanges take general purpose steel GOST 82-70 with $b_f = 360\,mm$ and thickness of the flanges

$$t_f = \frac{A_f}{b_f} = \frac{70.92}{36} = 2.00cm;$$

Assume: **for flange – 360x20mm;**

for web – 1500x12mm;

Checks on the flange for stability

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

$$\frac{0.5(36-1.2)}{2.5} = 6.96 < 0.11\frac{192.5}{1.6} = 13.98$$

The stability of the flange is provided.

Checks on stresses in the beam

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

$$I_x = \frac{t_w \cdot h_w^3}{12} + 2A_f \cdot (\frac{h_f}{2})^2 = \frac{t_w \cdot h_w^3}{12} + A_f \frac{h_f^2}{2}; = \frac{1.2 \cdot 150^3}{12} + 90\frac{152.5^2}{2} = 1384031.2cm^4;$$

$$W_x = \frac{I_x \cdot 2}{h} = \frac{2 \cdot 1384031.2}{155} = 17858.47cm^3;$$

Plastic moment of resistance of the beam equals

$$W_{xpl} = 2S_{1/2} = 2(\frac{h_w}{2} \cdot t_w \cdot \frac{h_w}{4} + A_f \cdot \frac{h_f}{2}) = 2(\frac{h_w^2}{8} \cdot t_w + \frac{1}{2}A_f h_f) = 2(\frac{150^2}{8} \cdot 1.2 + \frac{1}{2} \cdot 90 \cdot 152.5) =$$

$$= 20475\,cm^3;$$

The coefficient

$$C_1 = C = \frac{W_{xpl}}{W_x} = \frac{20475}{17858.47} = 1.15;$$

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

$$W_{x'pl} = \frac{W_x + W_{xpl}}{2} = \frac{20475 + 17858.47}{2} = 19166.7cm^3;$$

Maximal normal stresses distributed through cross-section

$$\max \sigma = \frac{M}{W_{x'pl}} = \frac{6665.6 \cdot 10^3}{19466.7} = 342.4 MPa < R_y \cdot \gamma_c = 345 \cdot 1 = 345 MPa;$$

The strength is provided on

$$\frac{345 - 342.4}{345} \cdot 100\% = 2.2\%;$$

Checks on beam deflection

$$q_e = \frac{F_e}{a} = \frac{358.1}{2} = 179.05 kN/m;$$

$$f = \frac{5}{384} \frac{179.05 \cdot 16^4 \cdot 10^2}{2.06 \cdot 1384031.2} \cdot 1.02 \cdot 1.068 = 5.84 cm < 6.4 cm;$$

The stiffness is provided.

Checks on tangential stresses

$$\tau_{\max} = \frac{Q_b \cdot 10}{t_w \cdot h_w} \le R_s \cdot \gamma_c;$$

$R_s -$ design resistance on shear.

$$\tau_{\max} = \frac{1666.4 \cdot 10}{1.2 \cdot 150} = 92.6 MPa < 190 MPa;$$

CHANGE THE CROSS-SECTION OF THE MAIN BEAM

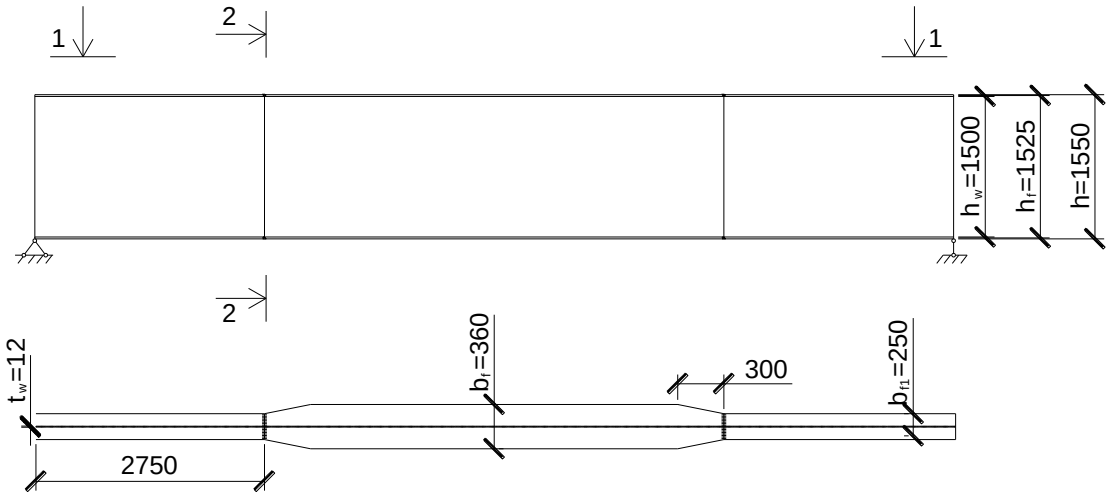
If the span of the main beam less than 30m you can to design only one change from one side of the axis. The width of flanges is changed on the distance that equals to 1/6 of the span from the bearings in case if load evenly distributed throughout the span. The calculation of reduction cross-sectional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

$b_{f1} \ge 180 mm;$

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

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

$b_{f1} \ge 0.5 b_f;$



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

$$b_{f1} = 250\,mm > 180\,mm;$$

$$b_{f1} = 250\,mm > \frac{h_w}{10} = \frac{1500}{10} = 150\,mm;$$

$$b_{f1} = 250\,mm > 0.5b_f = 0.5 \cdot 360 = 180\,mm;$$

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

$$I_x = \frac{1.2 \cdot 150^3}{12} + \frac{25 \cdot 2.0 \cdot 152.5^2}{2} = 337500 + 726757.8 = 1064257.8 cm^4;$$

$$A_{f1} = 25 \cdot 2.0 = 50 cm^2;$$

$$W_{x1} = \frac{2 \cdot 1064257.8}{155} = 13732.36 cm^3;$$

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

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

$$M_1 = W_{x1} \cdot 0.85R_y\gamma_c = 13732.36 \cdot 0.85 \cdot 345 \cdot 1 \cdot 10^{-3} = 3793.6 kN \cdot m;$$

Distance from the bearing to the butt joint equals to:

$$x_1 = \frac{V_m}{q_m} - \sqrt{\left(\frac{V_m}{q_m}\right)^2 - \frac{2M_1}{q_m}} = \frac{1666.4}{208.3} - \sqrt{\left(\frac{1666.4}{208.3}\right)^2 - \frac{2 \cdot 3793.6}{208.3}} = 2.75m;$$

where V_m - shearing force on bearings equals 1666.4kN;

q_m - limit rating evenly distributed load acting on the main beam, $q_m = 208.3kN/m;$

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

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

$$\sigma_{sum} = \sqrt{\sigma_1^2 + 3\tau_1^2} \le 1.15 R_y \gamma_c;$$

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

$$\sigma_1 = \frac{3793.6 \cdot 10^3}{13732.36} \cdot \frac{1500}{1550} = 267.34MPa;$$

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

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

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

$$Q_x = Q_{mzx} - q_m \cdot x = 1666.4 - 208.3 \cdot 2.75 = 1093.6kN;$$

$$S_{f1} = b_{f1} \cdot t_f \frac{h_w + t_f}{2} = 25 \cdot 2.0 \frac{140 + 2.0}{2} = 4765.6cm^3;$$

Tangential stresses in most loaded point

$$\tau_1 = \frac{1093.6 \cdot 4765.6 \cdot 10}{1064257.8 \cdot 1.2} = 40.8MPa;$$

Summary stresses

$$\sigma_{sum} = \sqrt{267.34^2 + 3 \cdot 40.8^2} = 276.52MPa < 1.15 \cdot 325 \cdot 1 = 373.75MPa;$$

Conclusion: the strength is provided.

ARRANGEMENT OF STIFFENERS AND CHECKS THE LOCAL STABILITY OF THE BEAMS WEB

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

$$\tau_{cr} = 10.3\frac{R_s}{\bar{\lambda}_w^2};$$

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

$$\bar{\lambda}_w = \frac{h_w}{t_w}\sqrt{\frac{R_y}{E}} = 3.2;$$

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

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

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

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

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

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

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

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

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

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

c_1 - coefficient that takes into account plastic deformations.

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

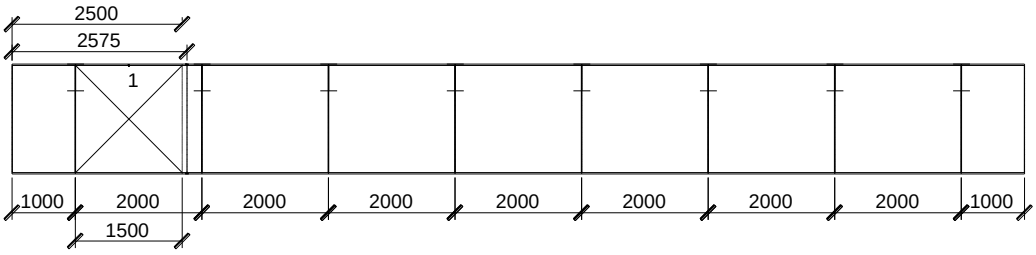
if $\sigma_1 = \sigma_2$ and $l_{pl} = L - 2x$

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

The distance between stiffeners should be less or equal

$a_{st} \le 2h_{ef}$ if $\bar{\lambda}_w > 3.2$ and $a_{st} \le 2.5h_{ef}$ if $\bar{\lambda}_w \le 3.2$

Scheme to the arrangement of stiffeners



$$\bar{\lambda}_w = \frac{150}{1.2}\sqrt{\frac{325}{2.06 \cdot 10^5}} = 4.96 < 6;$$

$$b_{st} = 100mm > \frac{1500}{30} + 40 = 90mm;$$

The thickness of the stiffener

$$t_{st} = 10mm > 2b_{st}\sqrt{\frac{R_y}{E}} = 2 \cdot 100\sqrt{\frac{325}{2.06 \cdot 10^5}} = 7.94mm;$$

The stiffeners are arranged with spacing $a = 2m < 2h_w = 3m;$

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

The length of plate $a > h_{ef} = 1.5$

Assume $a_1 = h_w$

The distance from bearings to the point 1 equals 1.750m.

Bending moment

$$M_2 = \frac{q_m x_2 (l - x_2)}{2} = \frac{208.3 \cdot 1.75(16 - 1.75)}{2} = 2597.24kNm;$$

$$Q = Q_{\max} - q_m \cdot x_2 = 1666.4 - 208.3 \cdot 1.75 = 1301.9kN;$$

$$\sigma = \frac{M_2}{W} \cdot \frac{h_w}{h} = \frac{2597.24}{13732.36} \cdot \frac{1.5}{1.55} = 183MPa;$$

W - moment of resistance of changed cross-section.

Tangential stresses

$$\tau = \frac{Q}{t \cdot h} = \frac{1301.9 \cdot 10}{150 \cdot 1.2} = 72.33MPa;$$

Let`s calculate critical stresses in accord with formula 75 from Building Code

$$\sigma_{cr} = \frac{C_{cr} \cdot R_y}{\bar{\lambda}_w^2};$$

Coefficient C_{cr} is taken from table 21 of Building Code and depends on δ

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

β - from table 22 depends on type of supporting platform.

If we have continuous platform

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

$$\sigma_{cr} = \frac{35.5 \cdot 325}{4.96^2} = 468.97 MPa;$$

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

$$\mu = \frac{a}{h_{ef}} = \frac{2}{1.5} = 1.33;$$

$\bar{\lambda}_{ef} = \frac{d}{t_w} \sqrt{\frac{R_y}{E}} = \frac{150}{1.2} \sqrt{\frac{325}{2.06 \cdot 10^5}} = 4.96;$ where $d = h_w$ less side of plate.

$$\tau_{cr} = 10.3 \cdot (1 + \frac{0.76}{1.33^2}) \cdot \frac{190}{4.96^2} = 113.75 MPa;$$

$\sqrt{\left(\frac{\sigma}{\sigma_{cr}} \right)^2 + \left(\frac{\tau}{\tau_{cr}} \right)^2} \leq \gamma_c$, where $\gamma_c = 1$ from table 6 of Building Code.

$$\sqrt{\left(\frac{183}{468.97} \right)^2 + \left(\frac{72.33}{113.75} \right)^2} = 0.746 < \gamma_c = 1;$$

Conclusion: the stability of web is provided.

The calculation of battens

Let`s determine main dimensions of battens

$b_b = \Delta + 2 \cdot 25 = 100 + 50 = 150 mm;$

The height of battens

$h_b = 0.7 b_c = 0.7 \cdot 500 \approx 350 mm;$

Δ from previous calculations

$t_b = \frac{h_b}{30} = \frac{350}{30} = 12 mm;$

Necessary flexibility between battens

$\lambda_{1,nec} = \sqrt{\lambda_x^2 - \lambda_y^2} = \sqrt{73.34^2 - 61.1^2} = 40.57;$

$\lambda_1 < \lambda_y$ therefore the distance between battens must be less than $l_{1,nec}$

$l_{1,nec} = \lambda_1 \cdot i_{y1} + h_b = 40.57 \cdot 5.07 + 35 = 240.69 cm;$

where i_{y1} - radius of gyration of 1 piece of the column

Let`s check up the condition

$\frac{I_b \cdot l_1}{I_{y1} \cdot b_0} > 5$, where I_b - moment of gyration of batten;

$I_b = \frac{t_b \cdot h_b^3}{12} = \frac{1.2 \cdot 35^3}{12} = 4287.5 cm^4;$

$\frac{4287.5 \cdot 240.69}{1534 \cdot 30} = 12.42 > 5;$

Let`s determine flexibility $\lambda_1, \lambda_y, \lambda_{ef}$

$\lambda_1 = \frac{l_{1,nec} - h_b}{i_{y1}} = \frac{240.69 - 35}{5.07} = 40.57;$

$\lambda_y = \frac{l_{ef}}{i_y}$, where i_y radius of gyration columns cross-section in accord with axis y. Is calculated by the formula

$i_y = \sqrt{\frac{I_{y1}}{A_1} + \left(\frac{b_0}{4}\right)^2} = \sqrt{\frac{1534}{59.7} + \frac{30^2}{4}} = 15.83 cm;$

$\lambda_y = \frac{631.5}{19.15} = 32.98;$

$$\lambda_{ef} = \sqrt{32.98^2 + 40.57^2} = 52.28 \approx \lambda_x = 73.34;$$

Determination fictitious shearing force

By the formula

$$Q_{fic} = 7.15 \cdot 10^{-6}(2330 - \frac{E}{R_y}) \cdot \frac{N}{\varphi} = 7.15 \cdot 10^{-6}(2330 - \frac{2.06 \cdot 10^5}{345}) \cdot \frac{3332.8}{0.81} = 50.98kN;$$

In accord with formula 23*

$$\lambda_{ef} = 52.28; \Rightarrow \varphi = 0.810*;$$

Determination loading that acting on battens

$$F = \frac{Q_s \cdot l_1}{b_0} = \frac{25.49 \cdot 240.69}{30} = 240.5kN;$$

Shearing force that acting on one edge of batten

$$Q_s = \frac{Q_{fic}}{2} = \frac{50.98}{2} = 25.49kN;$$

$$M = \frac{Q_s \cdot l_1}{2} = \frac{25.49 \cdot 240.69}{2} = 3067.6kN \cdot cm;$$

For fastening battens to the column we use the same semiautomatic welding as for the head of the column

$$R_{wf} = 215MPa;$$

$$R_{wz} = 220MPa;$$

Assume welding wire $C_в$-08Г2С d=3..8mm when K_f=3…8mm

Necessary leg of fillet weld is calculated by the formula

$$K_{f,nec} = \frac{10}{\beta_f R_{wf}} \sqrt{[\frac{6M}{(h_b - 1)^2}]^2 + (\frac{F}{h_b - 1})^2} = \frac{10}{0.9 \cdot 215} \sqrt{[\frac{6 \cdot 3067.6}{(35 - 1)^2}]^2 + (\frac{240.5}{35 - 1})^2} = 0.9cm;$$

Assume the leg of fillet weld $K_f = 9mm$ and this leg is met to the requirements.

Calculation and design the base of the column

The base is hinged with traverses and without stiffeners.

Class of foundation concrete is C15.20 with design resistance on compression $R_b = 7.5MPa.$ Longitudinal force $N = 3332.8kN$. Cross-sectional characteristics of the column $h_c = 19.8cm;\ b_c = 50cm$.Grade of steel C375.

Assume the ratio area of the top of foundation to the area of the bearing plate of base

$$\frac{A_f}{A_{pl}} = 2.5;$$

According to СНиП 2.03.02-84*, p.3.39

$$R_{b,loc} = \alpha\varphi_в R_b = 1 \cdot \sqrt[3]{\frac{A_f}{A_{pl}}} \cdot R_b = 1 \cdot \sqrt[3]{2.5} \cdot 7.5 = 10.18MPa;$$

$\alpha = 1$ for class of concrete less than B25

Dimensions “C” should be from 100 to 150mm.

The thickness of traverse in terms of structural requirements (10-14mm).

The width of bearing plate

$$B = h_c + 2 \cdot C + 2 \cdot t_{tr} = 198 + 2 \cdot 100 + 2 \cdot 10 = 418mm;$$

Assume B=420mm

Necessary area of bearing plate

$$A_{pl,nec} = \frac{N \cdot 10}{R_{b,loc}} = \frac{3332.8 \cdot 10}{10.18} = 3273.87cm^2;$$

$$L_{nec} = \frac{A_{pl,nec}}{B} = \frac{3273.87}{42} = 77.95cm^2;$$

Assume $L = 800mm.$

$$A = \alpha \cdot B = 80 \cdot 42 = 3360\,cm^2 > A_{nec} = 3273.87\,cm^2;$$

Average stresses in concrete under the bearing plate

$$\sigma_c = \frac{N \cdot 10}{A_{pl}} = \frac{3332.8 \cdot 10}{3360} = 9.92MPa = 0.992\,kN/cm^2;$$

Load for strip 1 cm width

$$q = \sigma_c \cdot 1 = 0.992 \cdot 1 = 0.992\,kN/cm;$$

Bending moments, which acting on the part of bearing plate:

Part I (cantilever) $M_1 = \frac{\sigma_c \cdot C^2}{2} = \frac{0.992 \cdot 10^2}{2} = 49.6 kN \cdot cm;$

Part II when $\frac{b_2}{a_2} = \frac{190}{198} = 0.96 > 0.5;$

if $\frac{b_2}{a_2} \geq 0.5$, then $M_2 = \beta q a_2^2$, β depends on $\frac{b_2}{a_2} = 0.92 \Rightarrow \beta = 0.112;$

$M_2 = 0.112 \cdot 0.992 \cdot 19.8^2 = 43.56 kN \cdot cm;$

Part III hinged support on force side

α depends on $\frac{b_c}{a_2} = \frac{500}{198} = 2.52, \Rightarrow \alpha = 0.135;$

Rating bending moment $M_{\max} = 87.18 kN \cdot cm.$

$t_{pl,nec} = \sqrt{\frac{6M_{mav} \cdot 10}{R_y \cdot \gamma_c}} = \sqrt{\frac{6 \cdot 87.18 \cdot 10}{345 \cdot 1}} = 3.39 cm.$

Assume $t_{pl} = 34 mm.$

Let`s calculate welds for fastening traverse to the column

Characteristics of welding is assumed as for head of column

$R_{wf} = 215 MPa,\ R_{wz} = 220 MPa,\ \beta_f = 0.8,\ \beta_z = 1.0,\ K_f = 9 mm.$

Loading area of a single traverse

$A_{tr} = (C + t_{tr} + 0.25 h_c) \cdot L = (10 + 1 + 0.25 \cdot 19.8) \cdot 80 = 1276 cm^2;$

Load that acting on traverse

$N_{tr} = \frac{\sigma}{10} \cdot A = 0.992 \cdot 1276 = 1265.8 kN;$

$l_{w,nec} = \frac{N_{tr} \cdot 10}{2\beta_f K_f R_{wf}} = \frac{1265.8 \cdot 10}{2 \cdot 0.8 \cdot 0.9 \cdot 215} = 40.89 cm < 85\beta_f K_f = 85 \cdot 0.8 \cdot 0.9 = 61.2 cm;$

The height of traverse

$h_{tr} = l_w + 1 cm = 40.89 + 1 = 41.89 cm;$

Assume $h_{tr} = 420 mm.$

Calculation the welds for fastening traverses and shaft of column the bearing plate

For T-joint, semi-automatic welding and $t_{pl} = 40mm$ minimal leg of 12mm.

$K_f = 12mm = 1.2t_w = 12mm.$

Summary length of welds

$$\sum l_w = 2(L-1) + 4(b_2 - 1) + 2(h_c - 1) = 2 \cdot (80-1) + 4 \cdot (19-1) + 2 \cdot (19.8-1) = 267.6cm;$$

Check up tangential strength in welds

$$\tau = \frac{N \cdot 10}{\beta_f \cdot K_f \cdot l_w} = \frac{3332.8 \cdot 10}{0.8 \cdot 1.2 \cdot 267.6} = 129.73MPa < R_{wf} = 215MPa;$$

Conclusion: the strength is provided.

4. Technical maintenance of building and structures.

4.1 General decision

The maintenance comprises three separate components namely; 1. Servicing. This is essentially a cleaning operation undertaken art regular interval of varying frequency and is sometimes termed day-to-day maintenance. 2. Rectification. This work usually occurs fairly early in the life of the building and arises from shortcomings in design, inherent faults in or unsuitability of components, damage of good in transit installation and incorrect assembly.

Rectification represents a fruitful point at which to reduce the cost of maintenance, because it is avoidable. 3. Replacement. Replacement problems involve items that degenerate with use or with the passage of time and those that fail after a certain amount of use or time. Items that deteriorate are likely to be large and costly (e.g., machine tools, trucks,

There are various categories of building maintenance as stated below:

1. Planned maintenance: “The maintenance is well organized and carried out with forethought, control and the use of records to a predetermined plan.”

2. Unplanned maintenance: “The maintenance implemented without predetermined plan.”

3. Preventive Maintenance: “The maintenance carried out at predetermined intervals of time or period and intended to reduce the probability of failure or unsatisfactory performance of an item.” This type of maintenance relies on the predicted probability that the system, equipment or even a part of it will breakdown in a specific period of time.

4. Corrective maintenance: “The maintenance implemented after failure has occurred and intended to restore or repair an item to the state that can perform its required function.” No maintenance work is carried out until there is failure.

For instance, the water pump or centrifugal pump of the swimming pool is damaged and requires repair work to restore it. 5. Emergency maintenance: “The necessary maintenance to be implemented immediately in order to prevent further

damage or serious impacts on an item." For example, the repair of serious structural cracks in a building is necessary to avoid further cracking or collapse.

6. Condition-based maintenance: "The preventive maintenance initiated as a result of knowledge of the condition of an item from routine or continuous monitoring and inspection."

7. Scheduled maintenance: "The preventive maintenance implemented to a predetermined interval of time, number of operations, mileage and others." For example, change of light bulbs or tubes for best performance according to their lifetime.

Maintenance management has also been categorized by many writers into three maintenance procedures. Corrective maintenance (unplanned) approach which is a failure-driven maintenance referring to running equipment until unexpected event breakdown of equipment or malfunctioning.

Preventive maintenance (planned) which entails time-based maintenance requiring regular task of maintenance irrespective of the condition of the item and thirdly condition-based maintenance which also entails periodic inspection of equipment to check it and replace it when a faulty condition is observed before breakdown (Figure 2).

Chan further classified management of maintenance activities in hotels into four main categories: routine, corrective, preventive, and emergency. Routine maintenance refers to the daily activities with repetitive nature, such as taking meter readings, lubricating, monitoring, start-up, and shut-down. Corrective maintenance works are scheduled or unscheduled activities to restore the equipment to asbuilt functions.

Preventive maintenance includes scheduled activities of inspection, adjustment, replacement and overhaul to prevent system breakdown and extend its useful life. Emergency maintenance refers to immediate actions to avoid further equipment damage and adverse

Four main groups of qualities must be provided

- functional - the complex must best meet its purpose, and therefore periodically need to do redevelopment, modernization and reconstruction;
- - technical - the building must successfully withstand external and internal influences, be serviceable; therefore it is necessary to monitor the technical condition of structures, make protection, reinforcement, and if necessary - replacement;

- architectural - the complex should best meet the situation in the building as an object of inspection by its people, so its appearance should always be in a different, appropriate purpose, location in the building, etc .;

- economic - construction and operation of the shopping and entertainment complex should be carried out with minimal effort and resources.

- Designed house, in accordance with the defining operational requirements:
- - has high reliability, ie performs the functions assigned to them in certain operating conditions for a given time, while maintaining the values of its basic parameters within the established limits;
- - is convenient and safe in operation that is reached by rational planning of rooms and an arrangement of entrances, ladders, fire extinguishing means, and for repair and replacement of the big technological equipment in the building hatches, apertures and fastenings are provided;
- - is convenient and simple in maintenance and repair, ie allows to carry out it on as many sites as possible, has convenient approaches to designs, introduction of engineering networks without dismantling and dismantling for inspections and service with extremely low expenses for auxiliary operations, allows to apply advanced methods labor, modern means of automation and mechanization, collapsible devices for maintenance of hard-to-reach structures, as well as has devices for mounting cradles, power sources, etc .;
- - is repairable, ie the structures of the house are adapted to perform all types of maintenance and repair without destroying related elements and with minimal labor, time, materials;

- has the maximum possible and close equivalent for all design service life;

- more economical in the process of operation, which is achieved by the use of materials and structures with increased service life, as well as minimal costs for heating, ventilation, air conditioning, lighting and water supply;

- has an external architectural appearance that corresponds to its purpose, location in the building, as well as pleasant to view, and the interior of the house is not contaminated and is easy to clean, restore.

Maintenance and repair (maintenance) of buildings is a continuous dynamic process, the implementation of a set of organizational and technical measures for supervision, care and all types of repairs to maintain them in good, usable condition for the intended condition during the specified service life.

The operation of the building is regulated by the Regulations on systems of planned and preventive repairs: Regulations on the PPR of industrial buildings. Stroyizdat. All of them are classified into groups and for them the average service life, types, periodicity of inspections and repairs, and also the works relating to current and capital repairs are established.

Of paramount importance in the operation of buildings is the timely control of their technical condition, inspection of building structures and engineering equipment. Such regular, and not only visual, but (if necessary) and instrumental control prevents premature failure of the house, allows to plan and carry out preventive measures for their saving.

When designing a shopping and entertainment complex, operational qualities are determined by the choice of materials, calculation of structures, spatial planning solution, engineering equipment in accordance with the purpose of the house, building codes and regulations (BNIP) and allocated allocations.

During the construction of the complex the values of the parameters of operational qualities accepted in the project are materialized, their probability is checked by devices and on their numerical values it is possible to confirm that the constructed house corresponds to the conceived in the project.

When operating the building, the main task is to maintain the design and materialized in the construction of operational qualities at a given level. They must fully comply with the purpose of the building, provided by certain building structures and engineering equipment.

Thus, the establishment of values of parameters of operational qualities (PEYA) and development of the instruction on technical operation completes designing of buildings, by means of the PEY made in the project their construction is controlled; according to the actual values of PEY to the project complex is put into operation and by maintaining PEY at a given level, their technical operation is carried out during the established service life.

The efficiency of operation and its cost-effectiveness depend on many factors, in particular to a large extent on the training of those who carry it out, on their ability to build operation on a scientific basis.

Persons engaged in the operation and repair of the complex must be well aware of its device, operating conditions of structures, technical standards for materials and structures required for repair. They by means of devices, and also on appearance and signs should be able to estimate at least approximately a technical condition of the house and its separate designs, to be able to reveal vulnerable places from which its destruction can begin, to choose the most effective ways and means of its prevention and elimination. violating, if possible, the use of the building for its intended purpose.

Effective operation of buildings, ie constant qualified supervision over them, periodic assessment of their technical condition (damage diagnosis) and prevention of damage, timely preventive and remediation repairs are possible only by studying the structures, features of its device and operation, operational requirements and their degree actual satisfaction, the ability to identify vulnerabilities from which the onset of damage may begin, and more.

Employees of the maintenance service must carefully study the design of the complex; during construction to control the quality of all works, to study the executive drawings and instructions for operation of the building received from the

builders, to keep a passport, logbook of technical condition (ZTS) and other documents required during the operation of BiS on each construction.

The design of the complex in accordance with the requirements of the SNIP provides for requirements for reliability, capital, durability and specified operating conditions of the whole complex and its individual elements, connections of structures and foundations; this is achieved by the choice of materials and structures, special protective measures to ensure fire resistance, frost resistance, corrosion resistance, protection against condensation and rot, water drainage, ventilation, etc.

When designing structures and buildings in general, measures are envisaged in accordance with the requirements of the DBN to reduce the negative impact of factors caused by the works.

The requirements of the SNIP are reduced so that the values of forces, stresses, deformations, displacements, opening of cracks, as well as the values of forces from other factors and influences do not exceed the limit values established by the norms. The calculations take into account the probable adverse characteristics of materials and possible favorable values and combinations of loads and impacts, as well as operating conditions and features of structures and foundations, in compliance with all requirements of regulations, standards, specifications, quality of materials, products, production works, and also to operation of BiS.

Achieving the limit states established by the norms does not pose a danger to people, but serves as a limit beyond which the building can no longer be used for its intended purpose without carrying out special restoration work. To take full account of the peculiarities of the actual operation of materials, elements and connections of structures and foundations, as well as the house as a whole, the calculations introduce a coefficient of conditions n, and to compensate for the lack of study of the boundary conditions of certain types of structures and foundations, the reliability coefficient Kn, the coefficient of unfavorable combinations of loads and impacts kn, the overload coefficient kp, etc.

To use the building for its intended purpose, it must maintain the necessary temperature and humidity conditions and a certain comfort, provided not only by serviceable building structures, but also by existing heating and sewerage systems. The activities of the maintenance service are aimed at creating such conditions in buildings and maintaining building structures and engineering equipment in good condition.

The methods of control of physical and technical parameters of buildings include: observation of cracks in structures, control of local and general deformations, as well as determination of: strength of structures; the thickness of the pipelines in the control of corrosion; humidity of wood and other materials; thickness of paints and varnishes; air permeability of joints and structures; heat-protective qualities of constructions: sound-insulating ability of enclosing constructions; places of damage of the hidden waterproofing.

5. Construction technology.

5.1. Dismantling of arched roof structures

Superstructures are a cardinal reconstructive measure. There are two types of architectural and structural schemes of their arrangement. The first includes reconstruction with the transfer of load from the superimposed floors to the old house, the second - a change in volume. A variant of the first type is a superstructure without change of the constructive-planning scheme of the house and essential strengthening of its bearing elements. Reserve reserves are used in walls and foundations. According to another scheme, part of the load from the superstructure to the existing structures is transferred.

To clarify the possibility of applying modern planning solutions in the dimensions of old houses should take into account the indicators that characterize the construction of the period.

Single-track buildings. One of the methods of punching windows in the former boundary walls - open firewalls. Another method is the planning association of adjacent single-span buildings of neighboring houses.

In a two-lane you can fit modern apartments, if the longitudinal wall is located on the axis or close to it.

When modernizing three-span buildings, first of all the expediency of their use for residential function should be investigated; in terms of planning structure, they are more convenient for public institutions.

With the appropriate orientation, such houses can be used as apartments for small families.

In solutions with ordinary apartments, the middle span is used to accommodate the utility rooms of the apartment, as well as to accommodate out-of-apartment communications.

Span width In buildings with a width of 9 to 12.5 m, the layout of the apartments is little different from the traditional one. Here the planning depends on the pitch of the window openings and the orientation of the house.

In buildings with a width of more than 13.5 m, the apartments have excessive depth. A direct consequence of large spans is an unfavorable ratio of area and light front.

A typical solution - the allocation along the middle wall of the zone for rooms that do not require natural light: hallways, bathrooms, pantries, dressing rooms.

In narrow buildings up to 9 m wide, the depth of the apartments is small, so they are stretched along the facade and the rooms are in proportions close to a square.

In narrow buildings it is possible to place apartments of bilateral orientation with sanitary-and-kitchen blocks of a parallel arrangement.

A specific planning technique for apartments in small spans is the organization of walk-through rooms and the consistent location of bathrooms and kitchens.

The pitch of the windows and their location. In the old building there are houses with windows of 3.4-3.6 m, although the old houses are characterized by a frequent grid of windows with a step of 2.2-2.6 m. In this case, to be able to differentiate the rooms in width, you have to move the partitions from the axis of the shutters or make the room double-glazed.

Floor height. With high ceilings, they try to make the rooms as large as possible, because they are small in size, but the room is poorly perceived by the eye. Excessive height of the premises is used under the mezzanine or masked by suspended ceilings.

With a floor height of 5 m and more, it is possible to install two-storey apartments, with a high common room overlooking the main facade, and other rooms with reduced height. The result is two tier apartments.

When upgrading stair-lift units, they usually try to keep the existing stairwells, especially the front ones for future use.

Black stairs are eliminated or converted into a grand staircase, when they want to increase the number of sections in the house when dismantling apartments, if they meet modern requirements for operation and fire regulations in the width of marches, the presence of escalators, the size of the slopes.

If it is necessary to increase the width of the stairwell, you need to move the walls or move the stairs to another place, while fitting into the dimensions of the house elevators and sewers. These elements of engineering are installed on the floor. If such a decision cannot be fulfilled, they are mounted on the mezzanine, which is less convenient and is allowed as forced.

Elevators are installed in houses, the floor of the upper floor of which is above the pavement more than 14 m. In residential buildings usually arrange passenger, less freight and passenger elevators.

Engine compartments with drive and control device are located at the top or bottom of the mine. Elevator shafts try to lay in unburned structures. It is logical to use the dimensions of the black stairs, if they are adjacent to the front. Reception is allowed only when they are adjacent to non-residential premises, such as kitchens and bathrooms.

If the elevator cannot be placed in the dimensions of the house, it is made attached or hung on the facade of the house.

Garbage pipes are usually installed next to elevators, but sometimes the elevator and garbage pipe are placed on different sides of the stairwell.

The vertical trunk is strengthened by clamping in the floors between floors or the mezzanine floor of the stairwell. Garbage gate valves are installed on each floor, but more often across the floor if the trunk is located between floors.

The entrance node during the modernization is solved, keeping the existing front entrances, but try to make another one, from the yard. Tambours are installed at the entrances.

Tambours are equipped with automatic locking devices with combination locks. Sometimes they are equipped with television surveillance devices.

To accommodate the concierge in the stairwell, a special room is allocated, which is solved in the form of a room equipped with a bathroom or even a small apartment.

The second method is punching or punching with a slot. It is resorted to very rarely, because it violates the plasticity of the facade and the load-bearing capacity of the walls.

Before dismantling the project sites to perform the following preparatory work:

to inspect visually a technical condition of designs, to appoint by the order of the person responsible for safe performance of works;

to release constructions from unnecessary elements, accumulations, to provide absence of people, except builders, in a dismantling zone, to close existing entrances to a place of performance of works.

Dismantling of arched reinforced concrete elements is carried out by means of LIEBHERR LTM 1200 truck cranes (v / p 120 t) and LIEBHERR LTM 1090 (v / p 90 t) with the corresponding height of lifting of a hook.

– Disassembly of existing arched structures is carried out in accordance with PVR:

– for the organization of safe performance of works all volume is conditionally divided into technological captures;

– the general direction of works on grips is defined;

– Dimensions and weight of mounting elements allow cranes to transport them to the ground for loading in dump trucks for removal. The place of export is decided by the customer;

– as the structures are dismantled, the design fasteners and connections are removed, which ensure their stability during operation. Therefore, to prevent the collapse of any site under dismantling, it is necessary to additionally (for the period of dismantling) to fix them in ways that are developed in the PVR;

- after the destruction of the structures of each gripper to carry out a visual inspection of the condition of the structures to clarify the measures of labor protection, methods of work and technological sequence of disassembly;
- in case of complications of the technical condition of structures in the process of their dismantling, stop work until new decisions are made that exclude uncontrolled collapses.

Before starting work, all workers must be familiar with the dangerous areas of disassembly. To prevent the formation of dust, debris must be pre-moistened with water. Lifting containers (containers, metal boxes, etc.) must be marked. When performing wheelbarrows and carts to move materials from disassembly and debris, it is necessary to install safety brackets on their handles to protect workers' hands from shocks. All dismantled construction materials must be removed from the construction site without reuse.

5.2. Dismantling of the old facades

Dismantling of the old facade decoration (tiles) is carried out with grips, in the direction from top to bottom, using three cradles such as ZLP 630T and a platform, or equipment that has a contractor. The number of pipes, their brand is specified according to the contractor's capacity and duration of work.

The work is performed in the following direction: in the axes 1-B, 2-1`, 3-M, 4-9.

Due to the height of the hotel building (~ 65m) and thus the significant width of the danger zone (DBN A.3.2-2-2009), which is located in a concise environment of urban development, on the facades, on top of the pipes, hung a protective net.

5.3. Installation of translucent enclosing structures

Installation of translucent enclosing structures is performed in stages with 4 grips:

Stage 1 - breakdown of vertical axes and horizontal marks.

Stage 2 - installation of anchor fastenings of details.

Stage 3 - installation of glass panels h = 2.8m.

Installation is performed using electric winches.

5.4 Installation of facades from composite panels.

Installation of ventilating facades is carried out from construction and assembly pipes and is carried out in stages:

Stage 1 - breakdown of vertical axes and horizontal marks.

Stage 2 - installation of anchor fastenings of details.

Stage 3 - installation of insulation.

Stage 4 - installation of a wind barrier.

Stage 5 - installation of aluminum substructures.

Stage 6 - installation of facing composite panels.

5.5. Construction of a four-storey extension on axis 9 in the axes B-I and a two-storey extension in the axes RT.

Soil development for foundations for a two-storey extension should be done partly manually and partly with a HITACHI mini-excavator. Remains of soil are taken to landfill. Backfilling of the sinuses of the pit is performed by imported sand. The work is performed by an excavator and manually.

Concrete is delivered to the construction site by truck concrete mixers type 581412 on the basis of the KamaZ-55111 machine with a drum capacity of 5 m3. The concrete is fed into the structure of the foundation by buckets suspended from the crane hook.

Formwork when performing monolithic structures to use a lifting adjustable.

Mortar and concrete are delivered to the construction site centrally from the reinforced concrete plants of Kyiv.

Works on the arrangement of foundations, installation and arrangement of structures of the projected building must be performed in compliance with additional safety rules, which must be developed in the design of works (PVR).

Installation works at construction of extensions are carried out by the KS-55713 truck crane.

The work is performed using a truck crane LIEBHERR LTM 1090 (w / n 90t) with the appropriate height of the hook.

Formwork when performing monolithic structures to use a lifting adjustable metal.

Execution of finishing works in the middle of the building is provided from inventory tables and metal or wooden easy collapsible scaffoldings. Finishing works of the premises are performed after glazing of facades, completion of installation of heating systems, arrangement of electrical wiring and heating of premises.

6. Organization of construction

6.1 General decision

Buildings and installations should be designed of such prefabricated component which, while being functionally efficient, would also meet erection effectiveness requirements. The process effectiveness of a structure is a degree of feasibility of its manufacture, transportation and erection with minimum consumption of materials, labor and other resources. The erection effectiveness is ease of erection with minimum consumption of Labor, time and other means. Characteristic of erection effectiveness are an efficient pre-assembly of structures, relatively equal weights of erection units, high degree of prefabrication and accuracy of manufacture, and last but not the simplicity of butt joints and provision of fastening devices.

Prefabricated construction is the practice of assembling a variety of components of a structure at a manufacturing site and transporting those sub-assemblies to the location of the construction jobsite. Prefabricated construction is sometimes thought of as a low-end and mass produced mode of construction. In reality however, it is quite the opposite. Prefabricated construction is becoming more common, improving in quality and has become available in a variety of budgets. Despite the perception of prefabrication, there are numerous benefits to this type of construction. This article assesses the advantages that prefabricated construction presents for both businesses and customers.

Eco-Friendly

Modular construction is often commended for energy efficiency and sustainable construction. Traditional construction methods require extra materials that lead to increased waste. However, since prefabricated sub-assemblies are constructed in a factory, extra materials can be recycled in-house. This is a considerable improvement over sending waste directly to a landfill from a traditional construction site. Also, the controlled environment of a factory allows for more accurate construction, tighter joints and better air filtration, which in turn allows for better wall insulation and an increase in energy efficiency. For more on the benefits of green technology in the construction industry click HERE.

Financial Savings

One of the greatest advantages of prefabricated construction would be financial savings. Although the perception of custom-made pieces may seem expensive, with prefabricated or modular construction, this is not the case. Modular construction targets all budgets and price points, creating an affordable option. Prefabrication manufacturers often receive bulk discounts from material suppliers which then trickles down to the cost of a construction project. Modular construction also sidesteps the possibility of unreliable contractors and unproductive staff. Additionally, the reduction in construction time can significantly save on construction financing costs.

Flexibility

Modular construction can be easily be disassembled and relocated to different sites. This significantly reduces the demand for raw materials, minimizes expended energy and decreases time overall. Also, modular construction allows for flexibility in the design of the structure allowing for a limitless number of opportunities. Since prefabricated construction units can be used in different spaces, its neutral aesthetics is able to blend in with almost any building type.

Consistent Quality

Since prefabricated construction occurs in a controlled manufacturing environment and follows specified standards, the sub-assemblies of the structure will be built to a uniform quality. Construction site-built structures are dependent upon varying skill levels and the schedules of independent contractors. These all contribute to the craftsmanship and overall quality of given structure. With prefabrication, each sub-assembly is built by an experienced crew in a weather-resistant factory, with multiple quality checks throughout the entire process. Some components of the building are constructed using precise machine equipment to ensure conformity to building code.

Reduced Site Disruption

Since many components of a building are completed in the factory, there is significantly less truck traffic, equipment and material suppliers around the final construction site. This limits the disruption of traditional jobsites that suffer from noise, pollution, waste and other common irritants. This streamlined approach to construction provides a far more efficient atmosphere for productivity, and eliminates unnecessary distractions and interference that are typical of construction sites.

Shorter Construction Time

Portable construction takes significantly less time to build than on-site construction. In many instances, prefabrication takes less than half the time when compared to traditional construction. This is due to better upfront planning, elimination of on-site weather factors, subcontractor scheduling delays and quicker fabrication as multiple pieces can be constructed simultaneously. Shorter construction times allows construction companies to take on multiple projects at once, allowing businesses to grow rather than putting all their focus and resources on one or a few projects at a time.

Safety

Since sub-assemblies are created in a factory-controlled environment utilizing dry materials, there is less risk for problems associated with moisture, environmental hazards and dirt. This ensures that those on the construction site, as well as a project's eventual tenants are less likely to be exposed to weather-related health risks. Also, an indoor construction environment presents considerably fewer risks for accidents and other liabilities. There are strict factory processes and procedures that protect the worker from on-the-job injury. At a construction site, although safety is of utmost importance, workers are subjected to weather-related conditions, changing ground conditions, wind and other crew members who are at the site.

Final Thoughts

With the continued popularity of prefabricated construction, it is likely that it will only continue to grow in popularity. Customers who choose this option are able to enjoy a high quality, quicker, cost-effective, and eco-friendly construction method. Furthermore, construction companies may soon increase their investment in modular

construction processes, benefiting both their business and customer relationships. Prefabricated construction is proving to be an extremely viable option, and as manufacturing technology continues to improve, expect to see its benefits and advantages rise in the future.

It is recommended to perform all work on the site in the current method with the maximum combination of individual flows and types of work in time.

All hidden works are subject to certification with drawing up of acts in the form according to DBN A. 3. 1-5-2009.

Organization of preparatory activities:

- general organizational and technical training in accordance with the provisions of the document "On general conditions for concluding and executing contracts in capital construction";

- preparation for construction of the object: conditions of use for the needs of construction of existing transport and engineering communications;

2. Preparation of the construction organization: acquaintance with the design and estimate documentation; development of the project of performance of works.

3. Preparation for construction and installation works: execution of actual works of the preparatory period:

- off-site works:

-organization of access roads from the street. Physical education;

- installation of a temporary water supply network.

- on-site works:

- fencing of the construction site with a continuous protective fence with the arrangement of means of protection and supervision in accordance with GOST 23407-78, the requirements of DBN A.3.2-2-2009. Danger zones shall be marked with safety signs in accordance with GOST 12.4.026-76. The fence is installed within the allotment of the site and taking into account the possibility of servicing the medical institution "Boris". The use of an existing fence as a construction site fence is subject

to the condition that it meets regulatory requirements. Adjacency of a fence of a construction site to a fence of the next site is specified on the city.

- providing the construction site with water from the existing water supply network from the street. Physical education. To be clarified at the stage of coordination with the Department of Water Supply Operations.

- providing the construction site with a drainage network to the existing wells of the city network.

provision of the construction site with electricity according to the permanent scheme from TP-5164.

- determining the location of premises for the needs of builders. In case of insufficient space, the customer decides on the location of the premises in agreement with the general contractor.

- arrangement of access to the construction site from the street. Physical education.

- organization of traffic and pedestrians to the medical institution "Boris", which is operated during the works.

- installation of temporary canopies: - for passages to the hotel and to the medical institution "Boris".

- installation of protective visors.

At the entrance (exit) to the construction site, a billboard with a scheme of traffic and well-visible signs "Speed limit", "Give way", "Beware of the car" and the passport of the object.

- relocation of the existing kiosk from the territory of reconstruction, dismantling of existing buildings.

- organization of safe movement of vehicles and pedestrians of the surrounding buildings.

- cutting off the fertile layer of vegetation and organizing its storage for further improvement after construction. The remains are taken to a specialized enterprise.

Completion of external and internal preparatory work in the amount that ensures the construction of the facility must be approved by an act drawn up by the customer who performed the preparatory period, the trade union committee, a representative of the territorial body of the State Labor Inspectorate in accordance with paragraph 1.5 DBN A. 3. 1- 5-2009.

The preparatory period of construction must be carried out in difficult conditions. These difficulties are a consequence of the short terms of reconstruction, adjacency to the territory of dense existing buildings, which makes the organization of the construction site problematic. All these circumstances determined the complex organizational schemes of construction and influenced the choice of methods of work.

II. The main period.

- reconstruction of the building of the hotel "Sport";
- laying of engineering networks, improvement, landscaping.

6.2 General layout

In the section, in accordance with the requirements of DBN A.3.1-5-2009 developed budget plan and preparatory and main periods. The budget plan indicates the place of installation of the assembly crane, temporary passages and fencing of the construction site.

To prevent access by unauthorized persons, to fence the construction site on the ground for construction with a continuous security fence made of inventory boards or a metal fence 2 m high, the existing fence is used within the existing limits.

Zones of permanent and potentially operating hazardous production factors - a fence height of 1.2 m in accordance with GOST 23407-78. Danger zones shall be marked with safety signs in accordance with GOST 12.4.026-76. Mark with red flags (in the dark, red lights) areas outside which the load is prohibited to take the boom of the assembly crane.

Organize travel to the construction site: from the street. Physical education. Driveways and unloading platforms on the construction site are arranged with a hard surface (a / b surface of the construction site is used).

The passage of pedestrians for the period of work is carried out on the odd side of the street. Physical education.

External lighting of the construction site is carried out at the expense of the existing city lighting. If the work is performed in dark places (dismantling of arched structures), then temporary lighting of workplaces with lighting of at least 25 lux should be arranged.

Technological captures, temporary fences are defined as a part of the project of performance of works.

Provision of construction in water is performed from the existing water supply network, in electricity is performed from TP 5164.

Methods of instrumental quality control of buildings

Production quality control is performed during the preparation and execution of construction and installation works and includes: input, operational and acceptance control.

Quality control of concrete is reproduced by mechanical or physical devices.

Inspection of welded joints is carried out by radiographic or ultrasonic methods in accordance with current regulations.

Control of accuracy of installation of prefabricated elements and other designs is carried out by means of a level and theodolite.

Conditions for preserving the environment

Construction and installation and special works must be carried out in compliance with the rules of environmental protection, taking into account the requirements of regulatory documents:

- Sanitary norms and rules (SanPin);
- DBN A.3.1-5-2009, section 7.

Construction waste - construction waste, transported to landfill. It is forbidden to burn and bury waste.

During construction, temporary roads must be paved, which reduces the removal of debris on the treads of vehicles outside the construction work.

All damaged pavements of the carriageway and sidewalk of existing streets, as well as lawns are subject to restoration.

Execution of works in the winter period

Execution of works in the winter period requires measures to ensure manufacturability, quality and uninterrupted construction work.

When performing installation and welding work at low temperatures, installation and welding equipment must be used, which is intended for use in these conditions.

Winter activities:

- arrangement of premises for heating of workers;
- insulation of concrete and mortar tanks;
- constant cleaning of workplaces and structures from snow and ice.

Installation of asphalt pavement in winter conditions is carried out in accordance with the requirements of DBN B.2.3-5-2001 "Streets and roads of settlements".

Occupational safety measures

The composition and content of safety decisions on the construction site must meet the requirements of sections DBN A.3.2-2-2009 "Occupational safety and industrial safety in construction". Safety in construction solves the issue of injury prevention and the exclusion of accidents at work.

The construction area is fenced with a fence 2.0 m high, safe areas near buildings and cargoes must be fenced with a fence 1.2 m in accordance with GOST 23407-78.

The transfer of structures and materials outside the assembly area is strictly prohibited.

The territory of the construction site, work areas, workplaces, driveways and passages to them are illuminated in the dark.

At the entrance and entrance to the construction site is a scheme of traffic. The speed of traffic near the work sites should not exceed 10 km / h. on straight sections, and 5 km / h. on turns.

Loading and unloading areas must be planned and have a slope of no more than 5º.

The construction is provided by telephone.

For firefighting at the construction site, a temporary water supply system is provided from the existing networks, which is located in the project building, from the side of the Operetta building; specially designated places for firefighting equipment, barrels of water and sand, smoking areas.

The fire safety of the construction site must be ensured and meet the requirements of the "Rules of fire safety in Ukraine". All persons on the construction site must wear protective helmets. Workers, engineers and technicians, employees engaged in construction and installation work must be provided with overalls, footwear and other personal safety equipment.

Prior to construction, the primary means of extinguishing the fire must be placed on the construction site: install a fire shield, painted in the appropriate colors and equipped with trench tools, hooks, shovels, crowbars, axes, fire extinguishers, sandbox, basket.

In the sanitary facilities there are places for first aid kits and first aid kits.

It is not allowed to perform works without a project.

Operation of jib cranes should be performed in accordance with the "Rules of construction and safe operation of cranes".

Electrical hazard on the construction site, work sites and workplaces must be provided in accordance with the requirements of GOST 12.1.013-78.

All work must be performed in accordance with DBN A.3.2-2-2009 "Occupational safety and industrial safety in construction".

Operational and dispatching construction management is carried out for operational planning and control over the progress of construction production.

The modern operational control system includes telephone and mobile communication.

Temporary telephone communication for the construction period is provided by telephoning the customer's services. One number is assigned to the dispatcher, the other - to the linear ITR with connection to the headquarters of the object.

Only temporary administrative premises directly on the construction site are provided with operational communication.

Duration of construction

The duration of the reconstruction is determined on the basis of the current norms of construction duration and scope of work and is 10.0 months, including the preparatory period of 3.0 months.

№ .	Items	Measurement	Quantity
1.	Duration of construction	month.	10,0
			3,0
2.	Maximum number of employees	worker.	97

Statement of needs for basic construction machinery, mechanisms and vehicles

№ .	Item	Used on construction site	Quantity
1	DZ-42 bulldozer	cleaning the area	1
2	DZ-42 bulldozer	cleaning the area	1
3	The KS-2571 truck crane with a loading capacity of 6,3 t	unloading of materials and auxiliary works	1
4	HITACHI mini excavator	development of ditches, trenches	1
5	Car crane KS-55713.	construction of outbuildings	1
6	LIEBHERR LTM 1090 truck mounted crane 90t	assembly and disassembly works	1
7	LIEBHERR LTM 1200 truck mounted crane 120 t	assembly and disassembly works	2
8	The welding unit like TD-300 with mind. power 19.4 kW. The brand and number of electrodes is decided by the general contractor.	welding works	1
9	Concrete mixer	transportation of concrete mix	8
10	MAZ-503, KAMAZ dump trucks	transportation of dismantling elements	1
11	Compressor DK-9M	power supply of pneumatic tools	4
12	Electric winch	installation of translucent enclosing structures	2
13	CEDIMA threaded equipment	dismantling	4
14	Cradles like ZLP 630T	dismantling of finishing of facades	2
15	Mounting platforms are two-mast	dismantling of the old facade decoration and installation of a new one	2
16	Watering and washing machines (capacity 6000 l)		1

Statement energy and water needs

The need for water.

The calculation is carried out in accordance with the Manual to DBN A.3.1-5-96 and to the volume of consumers.

The amount of water demand is determined by 3 components: production needs, water consumption for household needs and for firefighting.

The main consumers of water on the construction site are construction machines, mechanisms and installations, technological processes (concrete works, brickwork, finishing works, etc.).

The total water consumption for production needs is determined by the formula:

Q1 = K1 q1 h1K′1: (t1 x 3600);

where: q1 - specific water consumption for production needs, l;

h1 - the number of production consumers in the busiest shift;

K1 - coefficient for unaccounted for water consumption (equal to 1.2)

K′1 - coefficient of hourly non-uniformity of water consumption (equal to 1.5);

t1 - the number of hours per shift.

Q = 1.2x 1060 x 4 x 1.5: (8 x 3600) = 0.27 l / sec.

The costs of economic and production costs are determined by the formula:

Q2 = K2 (q2 h2 K2: t 1 x 3600) + q′2 h′2: t2;

where: Q2 - specific water consumption for household needs, l;

h2 - the number of employees in the busiest shift;

K2 - coefficient of hourly non-uniformity of water consumption (equal to 1.5)

q′2 - water consumption for showering by one of the workers, l;

h′2 - the number of workers who use the shower (40%);

t2 - duration of use of a shower installation (45 min.)

Q2 = 1.5 (30 x 71 x 1.5): 8 x 3600 + 35 x 17: (73 x 60) = 0.17 + 0.14 = 0.31l / sec.

The need for firefighting according to table 6 p.50 is Q 3 = 15 l / sec. The total need for water to ensure the construction is

Qzah = Q 1 + Q2 + Q3 = 0.27 + 0.31 + 15 = 15.6 l / sec.

Calculation of electricity demand for a construction site.

The main consumers of electricity at the construction site are construction machines, mechanisms and installations, as well as site lighting. The calculation is based on the capacity of the accepted construction machines and mechanisms, taking into account the demand factor, uneven electricity demand and work in the winter.

The number of employees is calculated relative to the duration of construction and in accordance with the normative indicators by category according to the type of construction ("Calculated standards for drafting projects for the organization of construction", .

According to the results of production and inspection control quality of construction and installation works, as well as by order of elimination of shortcomings identified by the technical supervision bodies of the customer ka, author's supervision of design organizations, statearchitectural and construction control, other bodies of state measures should be taken to eliminate the identified defects, about which records should be made in the general journal of works.

7. LABOUR PRECAUTION

7. Labour precaution. General provision.

7.1. Dangerous and harmful effects that occur during erection of the reinforced concrete structures.

During erection of the precast reinforced concrete structures technological processes can be divided into the two groups. First group includes processes connecting with structures' installation into the design position (preparing to the erection, lifting, installation and fastening).

Second group contains electric welding works, monolithic works, jointing. Technological processes which belong to each groups usually are performed by separate links of erectors and concreters. In this case we must take into accaunt compatibility of processes that performed at one division, building. Biggest number of accidents is happened during first group of technological processes which belong to the installation of erection elements. It is most complicated group and it required special attention to the labor safety requirements.

Before lifting precast structures must be cleared form mud and water above ice and directly during lifting they must be held from swing and rotation. Erection of precast structures at wind speed of 15 m/s and more, at sleet, big snowfall, rain and thunderstorm is not permitted. During erection of vertical dead panels and structures similarly to them work must stopped at wind speed 10 m/s and more.

Heavy columns and posts of industrial building and installations are erected after their equipment with erection suspended stepladders which must be removed after erection finishing, reconciliation of column and its final fastening. During erection of column with height more than 5 m are usually applied single conductors and during multi-layer building column erection group conductor is applied. Columns with height more than 8m are additionally tiered with bracing

on which screw boxes are installed.

Special safety measures must be observed during erection of reinforced concrete trusses and beam with spans 6, 12, 15 and 18m. To the independent high-scalar works there are accepted persons who has 18 years old, who undergo a medical examination, have high-scalar works experience more than 1 year and not less than third wage category. Workers which permitted to the high-scalar works at first must be work under supervision of experienced workers and masters during 1 year.

According to DBN workers (erectors and concreters) can be influenced by next dangerous and harmful production effects:

- moving machines and mechanisms; moving parts of production equipment; moving products, procurements, materials; failing structures; coming down rocks;
- increased level of vibration;
- location of the working place on the significant height relatively to the earth (floor) surface;
- increased level of the noise on the working place;
- insufficient lightning of the working area;
- emotional overloads.

Most important from these effects is lightning of the construction site.

7.2. Technical and organizational measures for decreasing influence level of dangerous and harmful production effects.

Calculation of a building site lightning.

We count the general uniform lightning of a building site which has the sizes in the plan ахв=103,0х157,4 m, the building site area:

А=89.0х110.0=9790m2

According to requirements Сн81-80 standard light exposure Ен=2lux. As a light source we accept projector ПЗС-35 with ЛНГ-220-500. The quantity of projectors is:

$$N = \frac{0.15 \cdot 2 \cdot 1.5 \cdot 9790}{500} = 8.81 \qquad (7.1)$$

where m is factor which considers luminous efficacy of a light source, efficiency factor of a projector and use of a light stream (is accepted т=0.1);

k - factor of a stock for projectors (k=1.5);

is power of lamp (lamp ЛНГ 220-500 have power 500Вт).

We accept 9 projectors ПЗС-35 with ЛНГ-220-500 which are placed on a building site along temporary roads. Distance between projectors 50м.

The minimum height of an establishment of a projector:

$$h_{min} = \sqrt{\frac{I_{max}}{300}} = \sqrt{\frac{50000}{300}} = 12.9 \qquad (7.2)$$

where Imax - maximal axial power of projector = 50000 candelas

We accept h=14м. A corner of an inclination of projectors =15 °, a angle between optical axes of projectors p=15 °.

The scheme of placing of projectors see site layout.

Sources and zones of moving machines and mechanisms effect's action are zones of land transport, conveyors', underground mechanisms, movable machine's parts, instruments' motion; zones near the systems with increased pressure, reservoir with compresses gases, piping, pneumo-hydroelectric tower plants.

Organization of safety of work on a building site. The organization of a building site and workplaces should provide safety of workers on all stages of performance of jobs. It is necessary to establish zones dangerous to people. Dangerous zones should be the safety designated by signs and inscriptions of the established form. The scheme of movement of transport according to traffic rules should be established entrance on a building site.

Prevention of vibration harmful actions includes:

- all devices should be in normal condition.
- workers can have over time with vibrating equipment;
- with vibrating equipment can work only persons which are more than 18 years old, pass all necessary medical exams, have necessary level of skills and pass instructional advice according to safety exploitation.
- all workers who will deal with vibrator equipment should undergo a preliminary medical examination and an annual periodic medical examination;
- adults have provided personal protection from vibration and noise;
- should be organized special section on repair vibrating machines, with a vibration control parameters generated;
- keep all vibration devises on good quality which provide reducing of vibrations;
- use of lubricants, vibrant detail that hitting with each other by viscous liquids;
- to reduce vibrations that are distributed to neighboring premises, to design buildings, machines that create vibrations set of independent foundations, they have vibroinsulation from the floor and other buildings or structures on a specially designed steel springs with shock absorbers or springs materials.

Prevention of person falling from working place which situated on the significant height relatively to the earth (floor) surface:

- on scaffolding the protection fence of 1,1m height is arranged;
- performance of jobs during ice-slick, fog which excludes visibility within front of jobs, thunder-storm and a wind with a speed of 15m/sec and more is prohibited;
- for pass on the workplaces placed at height, it is necessary to provide stairs, transitive bridges. The width of passes to workplaces should be not less 0,6м, and the height of passes is not less 1,8м. For a stairs with inclination angle more than 20O, fencing is provided.
- lifting of workers on assembly horizon for performance of installation works is carried out with use of the inventory ladders equipped with fencing.

Actions for the prevention of noise harmful effect:

• removal of noises sources during process of technological scheme designing and creativity process of equipment creation;

• isolation of noise sources;

• using of personal means for the protection from noise;

• rational regime of work in hard noise conditions;

• preventive actions of medical sense.

7.3. Providing of fire and explosion safety on the construction site.

At performance of reinforced concrete structures erection it is necessary to observe safety requirements. Works should be carried out by specially trained workers under a management and the control of technical officers.

Fire safety of object must be provided with:

• the system of prevention of fire;

• the system of fire-prevention defence;

• organizationally technical by measures.

The dangerous factors of fire, which influence on people, are:

• opened fire and sparks;

• enhanceable ambient, objects, temperature and other;

• toxic products of burning;

• smoke;

• mionectic concentration of oxygen;

• falling parts of build constructions, aggregates, settings, and others;

The solvents are inflammable, explosive and fire dangerous substances, besides pairs of such substances, getting in respiratory ways, cause an irritation and can result in a poisoning.

The application of the faulty equipment, tool and adaptations can result to damaging of the person.

It is forbidden to use the tool, adaptations, equipment, to the manipulation with which the worker is not trained.

The worker should observe the fire prevention rules, be able to use means

of fire prevention. To smoke it is authorized only in the specially allocated places.

The worker in an operating time should be attentive, not distract on extraneous businesses and conversations.

About the noticed infringements of the requirements of safety on the workplace, and also about malfunctions of the equipment, adaptations, tool and means of individual protection painter should inform the direct chief and don't work before elimination of the revealed lacks.

It is forbidden:

- to apply open fire or electro devices not in explosion-proof execution in rooms of coloring and preparation of paints, and also in places of a storage of empty container from under paints and solvents;
- to work at the faulty or not switched on ventilation;
- to work without protective means;
- to apply petrol as the solvent and to degreasing;
- to use for paint removal the blowtorches and tool giving a spark at friction or impact;
- to raise pressure in paint raising pressure box of the factory - manufacturer, above established by the instruction;
- to keep paints and solvents in open container;
- to store(keep) foodstuff and to accept food on a workplace.

In the rooms located within the limits of a fire-prevention zone, it is not supposed to apply or store combustible gases, liquids and materials, and also to provide the processes connected to dust combustible.

For failure to meet requirements of the instruction developed on the basis of given the worker bears responsibility according to the current legislation.

7.4. Instruction on the labour protection during erection of the reinforced concrete structures.

7.4.1 General requirements of safety:

1. Instruction on the labour protection worked out with correspondence to

Law of Ukraine “About labour protection” requirements and installs the rules of works’ performance and behaviour of the worker on enterprise’s territory, in the production rooms according to state, intersectoral and sectoral normative acts about labour protection.

2. Instruction is compulsory normative document for performance for erectors of concrete and reinforced concrete structures during buildings’ erection.

3. During works’ performance on the acting enterprise it must be held instruction with the participation of workers on this enterprise which are responsible for labour protection.

4. There are accepted certified workers to the slinging of the structures which have certificate which allows to perform slinging works.

5. Erectors must be provided by next means of individual protection:

- cotton suit (wear period – 10 months);
- mittens from vinyl leather (wear period – 2 months);
- leather tie on the slip foot (wear period – 12 months).
- On the external works in winter additionally:
- cotton jacket with the insulated lining (wear period – 36 months);
- cotton trousers with the insulated lining (wear period – 36 months);
- felt boots (wear period – 48months).

6. It is prohibited to pass outsiders and also drunk workers on the territory of construction site, production, administrative-common rooms and on their working places.

7. Construction site, parts of works, working places, passages and access to them in the dark must be illuminated according to norms. Illumination must be uniform, without blinding action of illuminants into workers. Performance of works in the unlightened places does not permit.

8. Storage of materials, structures and equipment must be carried out according to design work performance requirements. Passages, accesses and working places must be cleared, not encumbered and places which situated outside the buildings must be sand or slag in winter period. Accesses with slope

more than 20°C must be equipped with ladders or staircases with railing.

7.4.2 Requirements of safety before starting of works:

1. Before starting of work erecter must:

- wear protective clothing, check it out repair and free from defects;
- wear a safety belt. It should have no damage, deformation or rupture of nodes and elements established by visual inspection. Safety belt, not having a stamp with the date of periodic test to use is not allowed. The safety belt must be tested every 6 months, the static load of 400 kg the duration of 5 min.
- to pass from the master (the superintendent), instruction on safe methods and techniques, sequencing of manufacturing tasks. Acquainted with the project works;
- inspect the workplace, test and deploy tools, equipment, fixtures and equipment for the temporary retention of structures, providing for free (in accordance with the technological map).
- Hand tools must meet the following requirements:
- hammers and sledge hammers should have been the surface slightly convex and smooth, not shot down, without burrs, faces, dents, cracks and must be tightly secured mild steel wedge on the wooden handle;
- handles hammers and sledge hammer should be made of solid and viscous rocks and dead tree planted at right angles to the axis of the hammer;
- handles hammers and sledge hammer should be straight, oval, with a slight thickening of the free end. The surface of the handle must be smooth, evenly trimmed, free from cracks, burrs and knots;
- percussion instruments (bolts, chisels, etc.) should not be mowed or downed surfaces with burrs, dents, face, cracks. Tool length should be at least 150 mm;
- ends of hand tools, which serve to check the alignment of holes for mounting should not be whipped;
- clamp assembly used to bond two or three parts for welding shall be smooth, without faces or cracks.

2. Prior to the execution of works of the zero cycle is necessary to check:

• condition of slopes. Carrying out works in the pits with wet slopes permitted only after a thorough examination of the head works (master, foreman) state of the soil slopes and the collapse of the fragile soil in areas where identified "visor" or cracks;

• strength of the safety of the walls of trenches and pits;

• availability of inventory of portable ladders and stairs for descent (ascent) in the pit.

3. Working place and passes to them on the height of 1.3 m or more and less than 2 m from the border drop height must be protected temporary fence in accordance with the requirements.

5. Before holding of construction works at the conditions of the operating company exploited electrical networks and other existing engineering systems in the work area should be disabled, and the equipment and pipes are exempt from the explosive, flammable or harmful substances.

7.4.3 Requirements of safety during performance of works:

1. Erector must perform only the work on which instructed and approved master or superintendent.

2. During the work he must be careful not to distract himself and do not distract others.

3. Lowering into the trenches and pits should be on solid ladders, which should be binding, precluding the possibility of their shift. When the length of the ladders more than 3 m intermediate piers must be installed. The width of stairways shall be not less than 0,6 m.

4. At the site where construction works are carried out, is not allowed to perform other work.

5. During moving of the cargo erector must pay special attention before cargo lifting to the fact that nothing prevented him from lifting, to give the signal, pick up cargo at 20-30 cm, and make sure that the ropes sling strung evenly, and the cargo must be slinging reliably. After that, pick up cargo at a height that

ensures the movement of goods is not less than 0,5 m above items are on his path, and not less than 1,0 m - horizontally, to signal the movement of cargo. The feed element to the team fitter should be omitted over the place of installation is not more than 30 cm, after which the installer should come up, restore and install it in place.

6. Installed in the design position structural elements must be fixed so as to protect the stability and geometrical invariability.

7. It is not allowed people to stay on the structural elements during their lifting or moving.

8. Carry cargo over people and to be in the area of the crane work to people who have no direct relation to it is prohibited.

9. Structure's erection of each subsequent tier (section) of buildings or structures should be performed only after a reliable mounting of all elements of previous tier (section) in accordance with the project.

10. During performance of construction works are prohibited:

- remove slinging from mounted element before fastening it according to the design;
- to move cargo over people and premises in which people work;
- lift cargo which filled by soil, freezed or piled by other subjects;
- to raise the elements and structures whose mass is unknown;
- the use of unmarked and damaged containers;
- remove the temporary attachment to secure a permanent design for the project;
- switch installers to determine the elements and structures, with no fences, and stay on them;
- lay on the floor-mounted units and construction materials;
- lay on the edge of the pit or trench within 1 m from the edge of repose (the boundaries of the prism of collapse);
- avoid twisting, knots, loop-like creases of steel ropes for slinging cargo.

7.4.4 Requirements of safety after performance of works:

1. To tidy the workspace, remove foreign objects from the passes; used hand tools, appliances clean and folded into the intended place for them;

2. Check that all items have been mounted permanently or temporarily secured;

3. Clean clothing, footwear and personal protection from pollution;

4. Inform the master or the foreman of any faults in equipment, accessories and tools;

5. Safety belt to pass into the pantry, and clean clothing and footwear folded into an individual cabinet. Turn off electricity, leave the living room and close it to lock.

7.4.5. Safety requirements in emergencies:

1. During appearance of emergency at the object it is necessary to withdraw from the danger zone of people and inform supervisor;

2. Before proceeding to extinguish the fire, turn off electrical lines as applying chemical fire extinguisher or water can get under action of electric current;

3. The erector is prohibited to repair the lighting, wiring, connecting power equipment (electric tools, instruments, electrical machinery, etc.). These works should perform specialist (electrician).

4. Activities that are performed at a wind of 12 m / sec or more, including the squall, tornadoes:

- securely unstable designs on mounting the horizon of buildings under construction;
- remove from mounting the horizon of buildings under construction is free of construction materials packaging, light and having a great sail materials;
- to stop work on mounting the horizon of buildings under construction;
- shut down valves;
- disconnect aerial electric line construction site.

5. Activities that are performed in heavy rain, thunderstorms, fog:

- operation of tower cranes and other mechanisms outside the house, it is necessary to suspend;
- not allowed to perform installation work at height and in open areas;
- drainage ditches at a construction site must be cleaned, it is necessary to take action on water retaining device shafts from the soil near trenches, entrances and windows basements.

6. First aid.

7. Follow the instructions of the head of works on liquidation of emergency.

8. ENVIRONMENT PROTECTION

8.1. General Preview

The diploma project provides technologies, technical solutions, modern equipment and environmental measures that provide an acceptable level of environmental impact during the operation of the facility subject to the requirements of current environmental legislation of Ukraine, the requirements of DBN and other documents. The company has no water consumption for production needs and no production effluents.

Domestic sewage provides for the collection and discharge of sewage from sanitary appliances and showers in the external network of sewage, and further, to local sewage treatment plants in BIOTAL-6 and BIOTAL-1.5 filter wells. In BIOTAL plants, wastewater undergoes a full cycle of biological treatment before discharge into the drainage ditch.

Cleansing effect:

• for suspended solids - 98.0%;

• BOD - 99.0%.

The sludge formed in the cleaning process can be used to prepare compost fertilizers.

The total flow of effluents from the designed buildings of the enterprise is 4.61 m3 / day, 1.48 m3 / h.

The system of the rain sewerage provides collection and removal of rain sewage from the territory of the enterprise in a drainage ditch.

The total flow of rainwater is 246.0 l / s. Estimated flow of rainwater, determined in accordance with the "Recommendations for the design of structures for surface runoff treatment from the territories of industrial enterprises."

The most polluted part of rainwater runoff with a flow rate of 30.0 l / s, is discharged through a well with an adjustable spillway into the chambers of treatment plants, where they are treated by settling and filtration. Separators of oil products for wastewater treatment OLEOPATOR K NS 30 with a capacity of 30.0 l / s are accepted as treatment facilities.

Cleansing effect:

• for suspended solids - 86.0%;

• for petroleum products - 89.3%.

The sludge formed in the cleaning process can be used in utilities for dumping expensive.

The project of construction of production and storage complex and office premises provides for measures that ensure the allowable level of environmental impact during the operation of the facility subject to the requirements of current environmental legislation of Ukraine, the requirements of SNiP and other documents.

The selected methods and systems of ventilation and heating of the production and storage complex will provide an acceptable level of air pollution - the maximum calculated concentrations in the shares of the MPC of settlements for all substances less than one. 0.09486 g / sec, 0.5944 t / h of pollutants will be emitted into the atmosphere from the boiler house.

In addition, from cars with running engines during maneuvering and warming up of engines in the atmosphere will be emitted pollutants in the amount of 0.00171 g / sec., 0.00365 t / h.

Vertical planning solutions involve the smallest amount of movement of earth masses and the minimum movement of soil on the site.

The vegetation layer removed from the surface is to be used for landscaping of the enterprise site - lawn device with flora up to 15 cm in places free from construction and road surface, planting of deciduous and coniferous species of trees and shrubs in decorative groups and hedges. To create a favorable microclimate and ensure technological hygiene, the project provides for the device of driveways, platforms, sidewalks with a hard surface.

The main source of noise at the operating plant is ventilation equipment. The specified equipment is installed in the warehouse case and has no effect on environment. In addition, when designing the "Ventilation" section, low-noise imported equipment was selected. Silencers and vibration isolators are installed in ventilation systems. Vibration isolators are installed on the fans of exhaust systems.

8.2. Energy saving and energy efficiency measures.

8.3. Environmental protection measures

The electrical part provides the following measures to reduce electricity consumption at the enterprise:

1. The use of modern electrical equipment, which has a low value of losses, in all newly installed electrical installations;

2. The use in electrical installations of cables and wires with copper cores that have a lower active resistance compared to aluminum;

3. The use of soft-start devices that reduce starting currents when starting automatic fire extinguishing pumps, which reduces the power of the diesel power plant and saves fuel during its operation;

4. Reactive power compensation performed at the substation allows to reduce voltage and power losses in the transformer, high-voltage supply line and low-voltage networks.

5. Use of lamps with light sources characterized by high luminosity for lighting of premises and adjacent territory; use of luminaires for gas discharge lamps with compensated ballasts; use of lamps for fluorescent lamps with electronic ballasts;6

Use of schemes of automatic control of external lighting that excludes burning of lamps in the daytime owing to forgetfulness of the personnel; use for emergency and evacuation lighting of luminaires involved in the creation of standardized lighting for work lighting;

7. Luminaires in some rooms are divided into two or more groups, which allows to reduce only part of them as the natural light decreases;

8. The use of modern control systems implemented on controllers and software relays, characterized by low power consumption and low currents in the control circuits.

8.3. Environmental protection measures

To ensure the regulatory status of the environment, the project provides comprehensive protection, protection, restoration and compensation measures.

• To prevent the formation of activation of exogenous processes:

- vertical planning of the territory adjacent to the building within the drainage strip which prevents stagnation of surface water;

- installation of culverts in low-lying areas;

- arrangement of intercepting drainage on landslide-prone areas (on slopes in places of close groundwater location).

• To reduce pollution by air emissions of pollutants:

- control over exact observance of technology of carrying out works;

- dispersal during the operation of construction machinery and mechanisms not involved in a single continuous technological process;

- restoration of damaged during construction works and creation of new forest protection plantations;

• To protect against noise:

- installation of noise protection screens near the junctions of residential buildings;

- Prohibition of work in residential areas at night.

• To protect the aquatic environment:

- removal of sewage rain and melt water outside water protection zones;

- exclusion of untreated discharges into the aquatic environment and on the terrain.

- maximum use of the existing construction infrastructure in one technical corridor of roads, crossings and temporary construction sites;

- removal and storage of vegetable soil on specially designated sites with its subsequent use in reclamation;

- to prevent waterlogging and flooding of the territory, surface water drainage from the construction site, construction of culverts and cleaning of the existing drainage system are provided;

- a ban on the storage of construction waste outside the specially designated places of temporary storage, followed by removal from the territory of the developed area;

- technical and biological reclamation of disturbed lands.• Для зменшення негативного впливу на рослинний та тваринний світ:

- exclusion of felling of trees outside the zone of temporary allotment of land;

- protection from soil filling of root necks and trunks of the trees growing near construction;

• When dealing with waste:

- regular transportation of construction materials as construction progresses, without warehousing large batches on construction sites;

- temporary storage of construction and household waste in specially designated areas and in mobile containers;

- removal and subsequent disposal of construction waste.

Thus, the analysis of the factors of the building's impact on the environment during and after construction works shows that the negative impact will occur mainly due to air pollution and acoustic impact on the population created by traffic flows and will take place in the drain zone. Contamination of surface and groundwater is excluded, as the system of design solutions for drainage of rain and melt water, provides drainage from the building itself and from the surrounding area. The impact on flora and fauna is insignificant, as the building is located almost on the outskirts of the city.Для зменшення негативного впливу комплекса на навколишнє середовище на стадії експлуатації після будівництва передбачено проведення

monitoring observations of the state of the environment (air pollution, noise, etc.) in the area of influence of the universal sports complex.8.5. Озеленення території

To give the area adjacent to the building an attractive appearance, trees and shrubs are planted. Trees can be planted both on the territory of the recreation area near the building and near the adjacent residential buildings and the access road in compliance with the necessary rules for the placement of trees and shrubs.

A total of 156 trees are expected to be planted.

Environmental protection during construction

During the construction of a universal sports complex there is a danger of a number of factors that adversely affect the environment

- industrial and domestic effluents generated at the construction site;
- construction waste;
- soil pollution;
- irrational use of soil resources;
- air pollution by construction dust.

Measures to reduce environmental hazards

To eliminate or reduce the impact of harmful factors on the environment, the following rules must be observed:

- industrial and domestic effluents generated at the construction site must be cleaned and disposed of in the manner prescribed by the project of construction and the project of works;

- it is forbidden to pour fuels and lubricants into the open ground in the parking lots of machines and mechanisms;

- construction waste must be taken to the designated places. It is strictly forbidden to bury garbage.

placement of the construction site with the most rational use of the existing territory;

- removal of vegetative soil and its use for the device of lawns, flower beds and planting of trees;

- circulating water supply in order to save drinking water;

The general sanitary and hygienic requirements to air of a working zone are executed in production rooms.

9. Scientific-Research part

9.1 Introduction

Throughout the period of operation of the building and structures are accompanied by periodic repairs of building structures, which are caused by various loads and impacts, such as additional loads, accidents, aggressive chemical environments and redevelopment.

Particular attention is paid to the implementation of the possibility of strengthening existing reinforced concrete structures, which are operated and are in a pre-stressed state or, which are being reconstructed, due to the need to increase their load-bearing capacity.

Particular attention should be paid to the reinforcement of structures in terms of reconstruction and expansion of existing production, because the existing methods of reinforcement can not be used due to their complexity and without stopping production.

The urgency of the problem of strengthening reinforced concrete structures is to solve the following problems:

- Ensuring the reliability of building structures of buildings and structures associated with the aging of structural materials, as well as the appearance of defects in concrete and reinforcement;

- Ensuring safe operation of the facility throughout the period of operation;

- Adjustment of design decisions at the design stage and during construction;

- Taking into account the negative impact of various aggressive environments that will not be taken into account in the design;

- Increasing the bearing capacity of structural elements associated with changes in design standards or changes in the functional purpose of the building and increase the load on the structure;

- Increasing the durability of structural elements of buildings and structures;

- Reinforcement or repair of building structures due to accidents, earthquakes or fires;

Work on the reinforcement of reinforced concrete structures, the main purpose of which is the adaptation and use of existing structures with increasing loads, can be divided into two main groups.

The first group includes works on the arrangement of structures that unload or replace existing structures, as well as, partially or completely perceive the increased load and exclude from work some elements of buildings and structures.

These structures for reinforcement are a system of beams, usually metal, which receives new increased loads and transmits it through its supports to existing load-bearing elements with sufficient load-bearing capacity. This method of reinforcement is quite simple, but not always rational, because existing structures are used in part or completely stop working. With such reinforcement, the usable area and dimensions of the room are reduced.

The second group is related to the work aimed at increasing the load-bearing capacity of existing structures.

Each reinforced concrete monolithic or prefabricated structure, floor or spatial framework, performing the function of a load-bearing structure, works as a spatial system. However, when designing reinforcement, structures are divided into separate planar systems to simplify complex design tasks. The reinforcement of planar systems depends on the stress-strain state of the rod static circuits, combined and hereinafter referred to as structural circuits.

The increase of the primary bearing capacity of reinforced concrete structures is performed in two main directions - reinforcement with change and without change of the structural scheme of the structural element. The method of strengthening the structural element while maintaining the same structural scheme is to increase the cross section of the element and is achieved by arranging clips, overlays and one-sided extensions.

The increase in the primary bearing capacity of the element depends on the rational change of the corresponding structural scheme, which may relate to the static circuit itself or its stress-strain state. This effect is provided by the introduction of

additional supports, fasteners and fasteners or the installation of intermediate hinges, including plastic in statically constant systems.

The method of strengthening the elements of buildings and structures by changing their structural scheme is to install additional rigid and flexible supports, various adjusting, unloading, tension and strut structures.

The positive side of this method of reinforcement should be attributed primarily to the simplicity of execution: the absence of any capital work on the entire front of the element, which is reinforced and limited to small areas.

To date, there are many traditional methods of strengthening reinforced concrete structures, namely:

- Increasing the cross section of structural elements, characterized by an increase in the own weight of the structure;

- Installation of auxiliary structures (external rods, belts, support struts, sprung beams), which leads to changes in the architectural appearance of the building and significant costs of material resources and time;

- Reinforcement of structures by gluing to the stretched or compressed area of the structure of such effective materials as: polymer concrete, reinforced concrete or carbon fiber;

- Methods of calculating the bearing capacity of reinforced concrete elements according to the deformation model with different methods of reinforcement, should take into account the physical and mechanical properties of modern effective materials, the degree of their participation in the joint work of new combined structures.

- The results of many scientific studies on the reinforcement of reinforced concrete structures, conducted by scientific organizations have shown that each of the methods of reinforcement has its advantages and disadvantages.

- The conclusions of generalized and analyzed experimental studies have shown that reinforced concrete beams reinforced in the stretched area with effective materials (fiberglass, polymer concrete and fiberglass) meet the requirements of current regulations.

Depending on the set purpose and the necessary level of strengthening it is possible to receive necessary parameters of operational qualities. The most effective material for reinforcement was a layer of reinforced polymer concrete, which showed the highest level of increase in strength and crack resistance.

In the operational stage, reinforcing structural elements and reinforcing elements, as a rule, work together. Only in the later stages of the load did the studies show that the combined structures showed signs of stratification of the reinforcing layer. However, they had little effect on the effective operation of the gain.

As a result of scientific research it was found that the calculations should take into account not only the actual characteristics of the materials, but also the features of the joint work of the "old" and "new" layers, which appear during reinforcement.

9.2. Review of research on the properties and characteristics of epoxy

The use of building materials based on epoxy resins and special solvents is relevant today.

Epoxy adhesives are one of the most versatile adhesives used in almost all industries. In mechanical engineering, epoxy adhesives are used for the manufacture of technological equipment, abrasive tools, etc. In construction, three-layer panels, reinforced concrete structures of bridges, etc. are glued with the help of epoxy adhesive solutions, and reinforced concrete road slabs are glued during the construction of roads and runways of airfields.

Epoxy resins are used for waterproofing structures in a wide range of applications. Due to their universal properties, they are suitable for both waterproofing and decorative flooring.

Epoxy materials have also become very popular among polymer self-leveling floors, both in civil and industrial construction. water-based epoxy floor coverings with high vapor permeability.

Epoxy adhesives are used to create adhesive welds in the assembly of aircraft, for gluing internal power structures to their sheathing, gluing honeycombs and

assembly of honeycomb structures. They are used in space technology in the manufacture of solar panels, for mounting internal and external thermal protection, containers for storing liquid oxygen, etc. By means of epoxy glue in shipbuilding collect vessels from fiberglass, mount highly loaded fastening knots, create glue-welded and glue-riveting connections.

Epoxy adhesives are used in the automotive industry to attach brake pads and other plastic parts to metal; in the electronic, radio and electrical industries - for installation work and so on Implementation of additives to concrete and mortar.

Adhesive solutions based on epoxy resins, which harden without the release of by-products, have valuable properties and are used more often than other adhesives. In terms of the availability of starting products, epoxy resins are slightly superior to all other resins.

They are quite versatile and bond different materials, but their use is limited to operating temperatures. Some epoxy adhesives can withstand short-term heating to 430 ° C. The operating temperature range of epoxy adhesive solutions is usually set by hardeners used to ensure curing of the compositions. The presence of many substances capable of curing epoxy resins, allows you to create bonding systems with different properties.

Epoxy adhesives exist in the form of liquid, paste and film (reinforced and non-reinforced). Two-component adhesives have become the most widespread due to their inherent extended shelf life. The components can be stored for a long time without self-curing until they are mixed. The first epoxy adhesives were one-component and had the shape of twigs that had to be heated before being applied to the parts to be joined, which created some inconvenience. Epoxy adhesives are rarely used in the form of films unless they are modified in combination with another adhesive system.

Alcohols, xylene, acetone and other organic compounds or mixtures thereof in an amount of not more than 3-5% by weight of dry resin can be used to dissolve epoxy adhesives. A large amount of solvent is undesirable due to the difficulty of

removing it from the adhesive joint. Some solvents, such as alcohols, can accelerate the curing of epoxy adhesives with amines.

Fillers of epoxy resins are powders (for example, silica, aluminum, nickel powders), fabrics of glass and synthetic fibers, fibers (glass, carbon, etc.). Depending on the nature of the fillers, their amount is 50-300% by weight of dry resin. Some fillers, such as vanadium oxide, beryllium or zinc) can act as hardeners and stabilizers of thermo-oxidative degradation.

The strength of epoxy adhesive joints is almost independent of the thickness of the adhesive layer, which cannot be said about other structural adhesives. This simplifies the task of applying them to the mating parts and increases manufacturability, as very low pressure is required during bonding, as epoxy adhesives quickly become liquid when heated to the transition to stage B. The thickness of the adhesive layer should be small, but sometimes difficult to adjust, when to use pasty or liquid glues.

The thickness of the adhesive seam can be adjusted, if necessary, by introducing into the resin glass beads of the desired diameter, which does not harm the mechanical strength of the connection, if the beads are added in small quantities. The possibility of such adjustment is one of the most important advantages of film adhesives, especially reinforced. When the parts are connected with epoxy adhesives with reinforcement, the pressure on them should be applied with special care so as not to unite the adhesive layer due to the extrusion of very liquid heated resin.

Epoxy adhesives have low tensile strength and reduced toughness compared to many other structural adhesives due to their stiffness after curing. To improve these characteristics, they are combined with various other materials in order to obtain a system that satisfies the purpose of the structure. The range of epoxy adhesives is so diverse that it is not possible to cover it in this book. In addition, reference books on epoxy resins have been released.

Consider the general features of epoxy resins, which are associated with their use:

1. Adhesion. Epoxy resins have strong adhesion to metals, glass, plastics, ceramics, paper, concrete, wood and various other materials. Due to their fragile nature, epoxy adhesives are not recommended for bonding rubber and elastomeric materials, although they have adhesion to these materials. Epoxy resins can be mixed with other substances to create low-viscosity adhesives, which result in increased fluidity, wettability and permeability. If the material to be glued is degreased and its surface is prepared, then ensuring adhesion will not be difficult.

2. Cohesion. With proper curing of epoxy adhesives, they acquire good cohesive properties, which, however, usually limit the strength. In most epoxy adhesives, the adhesive properties are superior to the cohesive ones, as a result of which cohesive fracture is observed when testing the adhesive joints in the temperature range from room temperature to the maximum working temperature.

3. Absence of solidified volatile products. Unmodified epoxy resins harden without the release of water or other condensation by-products. This allows them to be used successfully where contact pressure is required. In addition, they are convenient for bonding materials such as glass or thermoplastics, which do not withstand strong heat and high pressure. The same feature allows to make on their basis filling compounds as probability of formation in them of air bubbles or inclusions was small. Additives of silver, carbon or other conductors allow you to smoothly change the electrical properties of epoxy adhesives without compromising the mechanical properties of such adhesives.

4. Low shrinkage. Epoxy resins harden with little shrinkage, which is some proportion of the shrinkage of vinyl, polyester and acrylate adhesives. As a result, the adhesive seam is less deformed, and the connection with epoxy glue is stronger. Shrinkage can be reduced to one percent by the addition of silica, aluminum oxides or organic fillers. Shrinkage of 3% should be considered for epoxy resins as extremely large.

5. Low creep. Epoxy adhesives deform under long-term load less than adhesives based on thermoplastic and many thermosetting polymers. This is a very important advantage of epoxy adhesives, because the creep of structural adhesive

joints is considered a very big drawback, which causes a lot of concern to designers. Creep constrains the use of adhesives and plastics in construction, probably more than any other drawback.

6. Resistance to moisture and solvents. Epoxy resins are resistant to moisture. Moisture does not act on the epoxy resin, but penetrates through the adhesive joint and damages the substrate. When an epoxy adhesive is exposed to moisture or immersed in water, damage usually occurs on the interface. This indicates the importance of choosing the method of preparation of bonded surfaces. Epoxy resins are extremely resistant to solvents, which explains their increasing use as a coating.

7. Because liquids penetrate the epoxy resin without affecting or nearly impacting the system, there is a problem of damage to the substrate, which forced the use of other adhesives when it was necessary to take into account the long action of liquids such as fuels, although modification of these adhesives, such as elastomers, eliminates drawback.

8. Universal ability to modify. The properties of epoxy resin can be changed in the following ways:

a) change the initial resin and hardeners;

b) changing the curing mode (both temperature and duration of the process);

c) combining the resin with other polymers;

d) using different fillers.

8. Shelf life. Viability at room temperature of liquid and pasty epoxy adhesives, curing aliphatic primary or secondary amines, is 1-6 hours, phthalic or maleic anhydride - up to 5 days, dicyandiamide, tetrahydrophthalic or chloride - a few months. The viability of film epoxy-phenolic and epoxy-polyamide adhesives is 6-12 months at temperatures from - 10 to 40 ° C and 2-30 days at room temperature.

Hard epoxy adhesives can be stored at room temperature for 1 year, and at temperatures pax close to 0 ° C, up to 3 years.

Properties of adhesive joints

The heat resistance of the adhesive compound based on epoxy adhesives depends on the type of filler for curing, for example, in the case of maleic anhydride, it reaches 150 ° C, pyromellite - 250 ° C. Significantly affects the strength of the adhesive joint bonding temperature, holding time, as well as temperature fluctuations.

Heats that harden without heating usually contain a liquid epoxy resin, aliphatic. polyamine or their adduct, filler and plasticizer; they harden within 24-72 hours at t-20 ° C. In fact, the structuring of such adhesive solutions takes longer and at temperatures above the glass transition temperature of the resin, the adhesive is further cured, the depth of which determines the strength characteristics of the adhesive joint.

To increase the strength and constant properties of adhesive compounds based on adhesives that harden without heating, it is advisable to subject such compounds to heat treatment at 70-80 ° C for 5-6 hours. Adhesive joints that have hardened without heating have low strength characteristics. Adhesive compounds are weather-, oil- and petrol-resistant, resistant to dilute acids and alkalis.

At long stay of glue connections in water (1-3 months) their characteristics of durability considerably worsen, especially at pasting of products from wood of other hydrophilic materials. Adhesives of this type do not cause corrosion of anodized aluminum alloys, well connect vinyl products between themselves and djuralumin. The obtained adhesive joints are not broken during machining of glued products.

Epoxy adhesives for building structures, forming elastic adhesive joints, are prepared on the basis of liquid epoxy resins modified with butadiene nitrile rubber (20-100 parts by weight per 100 parts by weight of resin) and oligoether acrylate based on phthalic anhydride, triethia

The strength characteristics of adhesive solutions of this type are much lower than epoxy-oligoether acrylic, but they have sufficient elasticity at low temperatures and high weather resistance.

Adhesive compounds based on epoxy-anhydride adhesives have significant heat resistance, resistance to oils, gasoline and organic solvents, high electrical insulating properties.

The cost of glue depends on the choice of filler, but the cost-effectiveness of epoxy adhesives is determined primarily by the cost of hardener.

Epoxy adhesives insulate heat and electricity well enough, but at the same time they are easy to modify to add the right conductivity. Due to the wide possibilities of modification of epoxy resins, adhesives based on them are universal in terms of methods of their application, which can be manual, semi-mechanized and mechanized.

9.3. Recommendations for strengthening the concrete beam of overlapping.

Basic the element of reinforcement of the floor is the installation within the height of the basement and the first floor of the two additional metal columns with developed in plan heads, which would play the role of capitals beamless floor (Fig. 1, b). Additional columns halve the working spans overlap, ie compensate for the removal from operation of the ducts as auxiliary intermediate supports for floor slabs.

To prevent cracks due to a change in the static floor pattern after installation of additional columns, as well as stopping the development of existing cracks and restrictions stresses in the lower stretched reinforcement of the overlap between the columns are further enhanced by gluing composite carbon tapes CFRP, oriented normally to the possible and existing cracks, with their corresponding anchoring on the supporting sections in accordance with the design and the technological requirements of Sika's amplification system

Working drawings of the reinforcement elements are shown in Fig. 2. Used for amplification carbon tapes of the M1214 type 120 mm wide and 1.4 mm thick, glued to the bottom stretched surface of the floor slab with two-component epoxy adhesive SikaDur 30. For prevention of separation of tapes from a concrete surface the system developed by them in GNDL-88 is applied additional mechanical anchoring with

adhesive rod anchors, pasted with cement-epoxy solution SikaGroud311 in pre-drilled holes in the floor slab.

Anchor rods before gluing were wrapped with several layers of carbon fabric Wrap, brought it outside the lower surface of the plate and after cutting along the working fibers in the form "Sockets" were glued to the concrete surface of the slab. "Sockets" arranged in this way played the role of an intermediate element for the transmission of shear forces from the glued to them tapes on adhesive rod anchors.

The concrete surface of the slab to which the reinforcing composite materials will be glued, specially prepared by jet-abrasive cleaning method (sandblasting). This method guarantees exfoliation of weak concrete particles, and also at the expense of local roughnesses depth of 0.5–1.0 mm forms the required surface roughness. Prepared as follows the surface guarantees perfect adhesion.

Immediately before gluing, the entire surface of the plate was thoroughly cleaned, and also performed the appropriate marking of design places in order to accurately glue the tapes.

Permissible value of surface roughness for tapes: to 3,0 mm on length of 1,0 m. Therefore before gluing the tapes performed reprofiling of the surface with a repair solution based on epoxy resins to ensure the required smoothness of the surface. The composite tape was cut into the necessary segments and cleaned with a special solvent to remove carbon dust and other contaminants.

Composite canvases as well measured and cut to the required size with sharp scissors. Just before the start the use of canvases was activated by a special tool and before gluing kept for at least 30 minutes until complete evaporation of this tool. Strength test concrete base for separation was carried out by the method of pull-off. Actual tensile strength of concrete was 2.45… 2.95 MPa, which is more than the minimum required - 1.5 MPa. That is a small base sufficient strength.

Two-component epoxy was used for gluing composite tapes glue SikaDur 30. After preparing the required amount of adhesive mixture proceeded to it

application of the floor slab on the prepared concrete surface. The adhesive mixture was laid immediately after cleaning the concrete surface with spatulas to a width of 2 - 3 cm, greater than the width of the strips.

The average thickness of the layer applied to the surface of the plate is about 1 mm. On the tape glue applied with a special applicator-dispenser, which after pulling the tape through its gap was formed by the applied layer of glue in the form of a two-sloped "roof" with a layer thickness of 1 from the edge to 2.5 mm along the axis of the tape.

Gluing tape under the ceiling was performed by several workers.

One worker was provided for every two meters of tape, which guaranteed correctness applying the tape to the concrete and provided an appropriate period of time for gluing.

After applying the tape to the concrete, each worker using a silicone roller

pressed the tape to squeeze out excess glue. Two-slope profile of the adhesive mixture layer guaranteed complete removal of air from the places of gluing during pressing by rollers.

Excess adhesive was removed with spatulas.

The webs were glued to the sandblasted and degreased surface concrete. During their gluing, first the surface of the plate was lubricated with glue, then with a roller pressed the canvas and rolled until it is impregnated through the fibers. After gluing on the surface of the canvas was applied with a spatula to the outer layer of glue and leveled with a roller.

Rehabilitation Using FRP Composites The drawbacks of using the steel plate technique and the ever-increasing demand for rehabilitation of the infrastructures have prompted engineers and researchers to search for better and more reliable and innovative solutions. The advancements made in the properties of FRP materials and in the adhesives have rendered these as the ideal combination for an innovative solution for many structural problems of rehabilitation. The use of FRP materials for civil engineering applications is relatively new. However, they have been in use for a

long time in other industries such as aircraft, naval and marine boats, automobile, chemical apparatus, and other industries as well as in aeronautical for quite long time.

FRP composites have superior engineering characteristics. Among these is the high strength-to-weight ratio. For example, for 8 Y.A. Al-Salloum and T.H. Almusallam bridge strengthening, 94 kg of steel can be replaced by about 4.5 kg of FRP carbon composites . FRP composites are non-corrosive and neutral electro-magnetically and electrically. In addition, some types of FRP composites are very flexible such that they can be formed almost to any desired shape, light enough to be handled on the job site with no need for heavy equipment, and they occupy negligible space as compared to the existing structural members. Properties of FRP Composite Materials Polymer composites are defined as a matrix of polymeric material reinforced by fibers or other reinforcement with a discernible aspect ratio of length to thickness.

FRP composites can be made into many different shapes, including high strength rods, cables, grids, beams, and plates. The major factors affecting both the physical and mechanical performance of the FRP matrix composite are the orientation, length, shape and composition of the fibers, the mechanical properties of the matrix resin and the adhesion of the bond between the fibers and the matrix (i.e. type of fiber coating material).

Unlike steel, the mechanical properties of FRPs vary significantly from one product to another. Factors such as volume fraction (ratio of volume of fibers to the volume of matrix material) and type of fiber and resin, fiber orientation, dimension and quality control during manufacturing play a major role in establishing the characteristics of the product. Table 1 shows typical properties of dry fibers of glass and carbon. Dry fiber properties vary greatly depending on the fiber type, fiber grade, and the actual weight/density of fibers. Typical properties of FRP/Epoxy composite systems, which consist of dry fibers saturated with resin are presented.

Property	Fiber Type	
	Glass	Carbon
Tensile Strength (MPa)	1800 - 4800	2400 - 5000
Elastic Modulus (GPa)	70 - 90	200 - 300
Strain at Failure (%)	> 4.0	> 0.50

Table 2. Typical Properties of Glass and Carbon Composite Systems

Property	Composite Fiber Type	
	Glass/Epoxy	Carbon/Epoxy
Tensile Strength (MPa)	500 - 1500	800 - 3000
Elastic Modulus (GPa)	25 - 75	60 - 250
Strain at Failure (%)	2 - 4	1 - 2

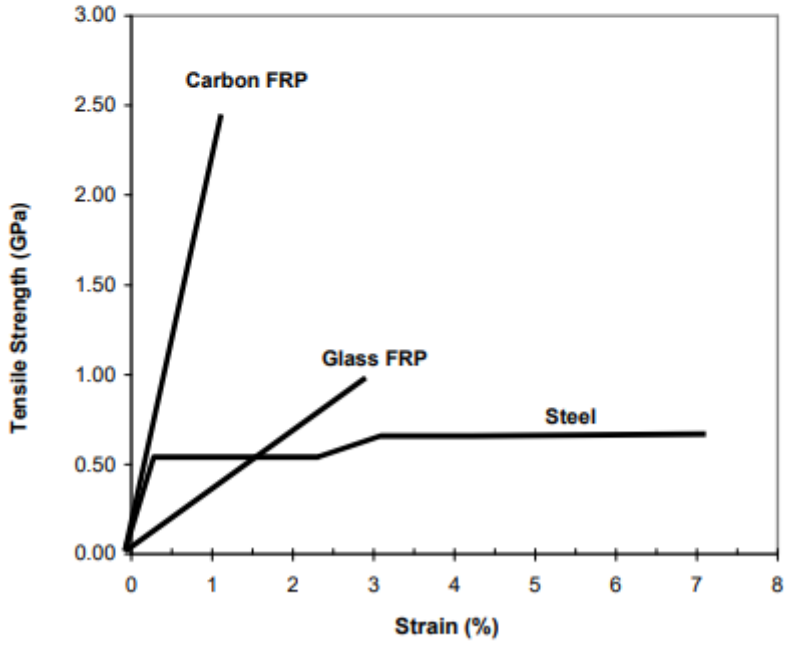


Fig. Typical stress-strain relationships of FRP composites and mild steel

FRP system properties can vary depending on the manufacturer and on other factors such as volume fraction, fiber properties, resin properties, aerial weight/density of fibers, and type of weave/stitch. One of the most important characteristics of FRP materials is their high tensile strength. The strength is about twice that of prestressing steel strands, and fairly high compared with ordinary steel as shown in Fig. 6. The tensile strength of FRP composite system is affected not only by the tensile strength of the fibers, but also by the volume fraction, resin system and the bond performance of fibers and matrix. FRP composites reach their ultimate

tensile strength without exhibiting any yielding of the material (i.e. linear up to failure.

9.4 Design of strengthening using fiber materials.

There are no fundamental differences in the approaches to calculating the strength of normal cross-sections of bending elements reinforced with external steel reinforcement, in comparison with conventional reinforced concrete elements.

Experience and information accumulated over the years on the peculiarities of the stress-strain state of sections in the stages close to failure, a detailed study of the inelastic properties of concrete and reinforcement, as well as the use in calculations of the descending branch complete diagram of concrete deformation led to in most norms of developed countries the method of calculated limit states is introduced

The main changes in the method are:

• Acceptance of the hypothesis of flat breaks (Bernoulli's hypothesis), which means that the boundary deformation of the extreme fibers of the squeezed zone and concrete can reach the value εb = 0.002-0.0035, and in reinforcement εs = 0.002-0.01.

• Replacing the actual curvilinear tension in the squeezed zone of concrete by moving the boundary mill by a straight line tension with the effective (change) height. The priority in accepting the change of mind and to establish A.F. Loleitu and O.O. Gvozdєvu

• In order to accept the linear law, the stress in the constricted zones of concrete in the stages, close to ruining, is taken into account, so that the stress will be applied to the curved ordinance of concrete in the course of the construction

Rozrakhunok mitsnosti perereziv, normal to the late axis of the original elements, whatever the profile, according to the norms Rule on such changes:

1. Look out the boundary stress-deformation mill with normal pererezu, for which stress in the reinforcement reaches the physical or mental boundaries of fluidity, and in concrete - the time support for the axial thrust Rb.

2. Boundary deformation of the extreme fiber of compressed concrete and stretched reinforcement (Fig. 4.1, b) does not overlap the following values: εb = 0.002 if γb2 1 i εb = 0.0025 if γb2 <1.

3. Determination of the concrete for stretching to be taken in such a way that the road is zero, so that a part of the concrete is stretched, the yak is stretched out below the neutral axis, not to fall (Fig. 4.1, a).

Coefficient γb2 <1 in the way of reducing the strength of the concrete during the trivial period of pre-installation and, apparently, the deformability of concrete

• Concrete of the stretched zone and when it reaches the normal overrun of the boundary mill in the robot does not break

4. The point of application of equal all squeezing stresses in the concrete of the rosary rye (Fig. 4.1, c) is the point of application of such rivodiynoi squeezing stresses in the actual epuria

5. Curvilinear block the stress in the squeezed zone of concrete with a height x1 is replaced by a modern straight-flow block with a change in height x when the maximum level is saved, the stress σb = Rb.

6. Equal stricter tendencies of the factual and rozrakhunkovoi epures are guilty of the road:

de b is the width of the recess;

x - the height of the compressed zone and concrete;

Rb - prismaticity of concrete;

ω is the efficiency of the concrete, which should be based on the empirical formula:

$$\omega = \alpha - 0{,}008R_b .$$

Coefficient for important concrete 0.85, for light 0.8

The gripping stress in the reinforcement, which is retouched in the gripped zones of the concrete, is able to accommodate the boundary deformations of the gripped zone, which could be transformed into the reinforcement and the concrete.

Accept εbu = εs, we can say:

Rsc = Es. εs = Es. εbu <Rs, ()

where i εbu = 0.002; Rsc = 400 MPa;

As soon as one hour picks up the strength of the compressed zone and concrete and stretched reinforcement, the height of the compressed zone x swelling of the boundary value xR. The value of xR is the boundary between the reinforcement not re-armored zones, which is superimposed on the fluid reinforcement and the intensive manifestation of non-external deformations to the concrete, and the re-armored reinforcement re-armatures, which are supported by the reinforcement.

In the norms [120], most often it is not the absolute value of the boundary height of the compressed zone xR, but of the boundary value, which is called the boundary value of the maximum weight of the compressed zone and concrete:

$$\xi R=xR/ho.$$

In such a rank, the boundary value of the given height of the compressed zone and the concrete lie in the form of deformative powers of the reinforcement and concrete, as it is possible from the predictions. Protect these norms recommend the value of the empirical formula:

$$\xi_R = \frac{\omega}{1+(R_s/\sigma_{scu})\cdot(1-\omega/1.1)}$$

de σsu - the boundary stress in the compressed reinforcement, but the reach is 400 MPa for the short-tipping point ($\gamma_{b2} \geq 1$), i 500 MPa for the short-arm length ($\gamma_{b2} \geq 1$)

It is recommended to calculate the strength of sections normal to the longitudinal axis of reinforced concrete beams reinforced with external FRP reinforcement similar to the calculation of strength as conventional reinforced concrete beams, but some aspects of determining the load-bearing capacity of elements need to be clarified.

The considered scheme of occurrence of limiting equilibrium of the beam clamped on supports assumes existence of three plastic hinges as necessary and sufficient condition for an estimation of bearing capacity of a beam in the conditions

of fire. But in practice cases of such constructive decisions of elements at which plastic hinges on support can not arise are not excluded. In this case, the fire resistance of the structure will be determined by the limiting moment of the most dangerous section.

In addition, in the practice of building construction, it is rarely necessary to accurately describe the stress-strain state of the element. It is usually sufficient to determine the load-bearing capacity of the element and the maximum deflections with the required accuracy. Thus, there is a need to clarify the existing methods of calculation, which will assess the load-bearing capacity and deformability of the structure.

When considering the stress-strain state of reinforced concrete elements reinforced with external steel reinforcement, the following prerequisites are accepted:

- the hypothesis of flat sections is followed;
- the conditions of statics are observed:

$$\sum N_i = 0;\ \sum M_i = 0$$

- tensile strength of concrete is assumed to be zero;
- the resistance of concrete to compression is conditionally represented by a stress equal to Rb (multiplied, if necessary, by the coefficient of operating conditions), evenly distributed over part of the compressed zone;
- compressive stresses in the sheet and rod reinforcement are taken no more than the calculated compressive strengths Ry and Rss, multiplied if necessary by the coefficient of operating conditions
- tensile stresses in the sheet and rod reinforcement are taken no more than the calculated tensile strengths Ry and Rs, multiplied, if necessary, by the coefficient of the operating condition;

When testing all the beams for bending, the destruction took place in the normal section. The reason for the failure was the achievement of stresses in the yield strength of the steel reinforcing steel element and its separation from the reinforced

steel reinforced concrete beam, followed by the destruction of concrete in the compressed cross-sectional area.

Estimation of strength of elements for the specified forms of destruction can be presented on the basis of the joint decision of balance of longitudinal forces depending on the scheme of internal efforts. In this case, two calculated schemes of forces and stresses of normal cross section are considered.

When calculating the height of the compressed zone is determined iteratively. At the first stage, the height of the compressed zone is calculated by formula. Then they are determined on the strips in the rod reinforcement and the reinforcement element, checking the balance of internal forces. If the equilibrium conditions are not met, then the height of the compressed zone must be adjusted.

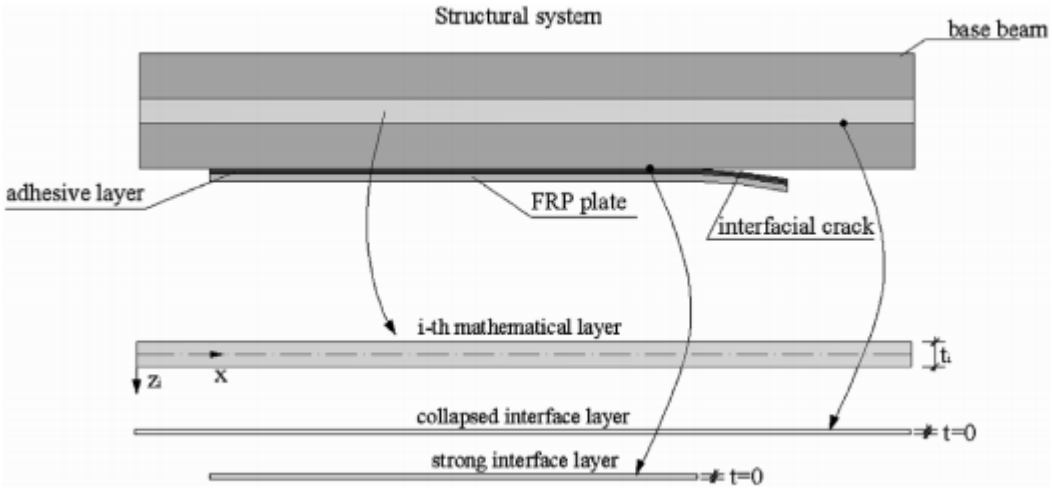


Fig. 1. Model of the strengthened structural system.

Advantages FRP laminates

Corrosion Resistance.

Lightweight.

Ease of installation.

Less Finishing.

Less maintenance.

Ductility of FRP wrapped members improves dramatically.

They are ideal for external application.

9.5 Design of beam strengthening using advanced software. Lira SAPR

The modern software complex LIRA CAD was used for computer modeling of reinforced concrete beams reinforced with external FRP reinforcements.

LIRA CAD is a multifunctional software package for calculation, numerical research and design of structures for various purposes, based on the use of the finite element method in the form of displacements, which is used as the main tool for numerical analysis of strength and stability of building structures.

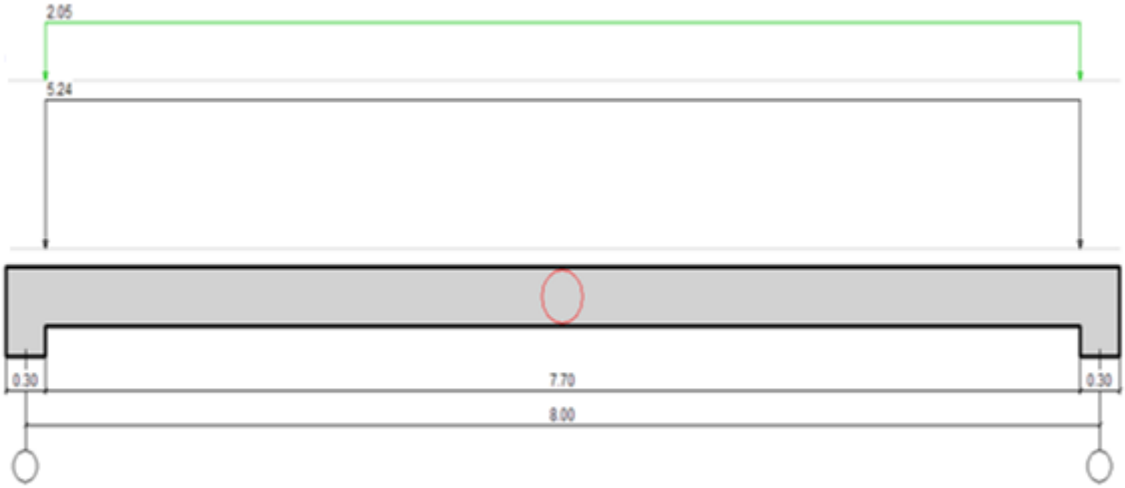
PC LIRA CAD and Monomach allows you to perform calculations taking into account: physical, geometric nonlinearities, physical and geometric nonlinearities at the same time, constructive nonlinearity.

Analysis of stress-strain state of r/c plane overlapping has shown that for the modeling of the computer model and its adequate computation it is necessary to use software package LIRA SAPR. In the given software package it is advisable to model the r/c overlapping by means of spatial FE and plates, as well as the elastic joint between the slab and plate – by typical element (55th type of FE). After the receiving of calculation results it was revealed that within the monolithic overlapping, which was strengthened by fiber plates, the decreasing of maximal strains, which appear after the loading, is about 40% comparing with the initial stress state of the non-strengthened plate. Also in the result of the experiment, bending in the plate has decreased on a half.

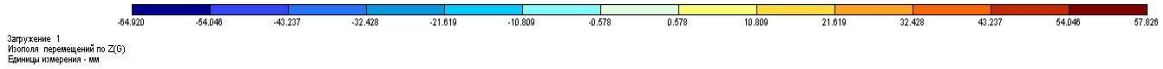
To model the design scheme there were applied uniformly distributed loads through the whole plate surface. The values of loads: permanent load equals 0.44kN/m2, long-term load equals 0.5kN/m2, short-term load equals 0.25kN/m2.

After the results analysis the maximum bend appeared in plate without strengthening was 5mm , with strengthening – 2mm

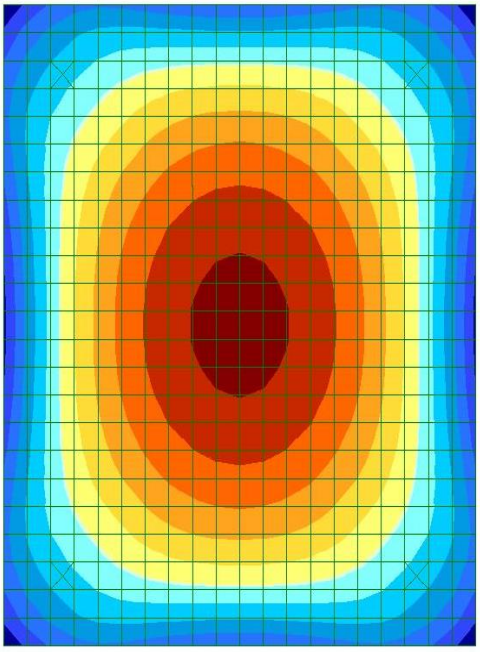
Experience of use of different adhesive mixtures in strengthening of structures showed that abovementioned adhesives are applied to provide the bond between homo- and heterogeneous materials, which allows the structure to work as an integral unit.



Geometrical scheme of the r.c overlapping



Загружение 1
Изополя перемещений по Z(G)
Единицы измерения - мм



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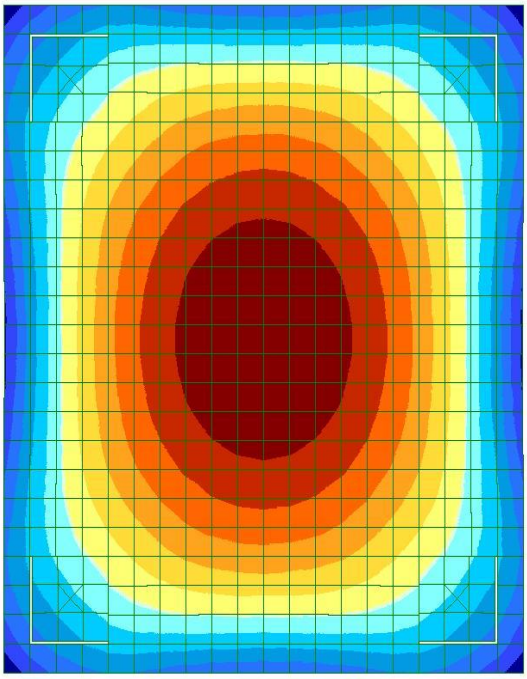

Results of bending moment before and after beam strengthening of overlapping

Conclusion

The primary reasons for the strengthening of concrete structures are typically to increase existing elements' capacity to carry new loads or to resolve an existing deficiency. Several strengthening techniques such as section enlargement, externally bonded fiber reinforced polymer (FRP) reinforcement, supplemental steel elements, and post-tensioning can be employed to increase the **load carrying capacity twice** and improve serviceability of existing structures.

However, there are many technical factors that should be considered when selecting a strengthening system. In addition to technical concerns such as serviceability, strength, durability, appearance, and fire rating, one should consider non-technical factors such as constructability, aesthetics and cost.