Denote $$\gamma = \frac{B}{bD};\ \delta = \frac{P}{bN_x} = \frac{\sigma b_p t}{\sigma b h} = \frac{b_p t}{b h}, \qquad (8)$$

obtain an equation for the critical load:

$$N_x^{\text{кр}} = \frac{\pi^2}{a^2} D \frac{\left(m + \frac{1}{m}\cdot\frac{a^2}{b^2}\cdot n^2\right)^2 + 2\gamma m^2 \sin^2 n\frac{\pi}{2}}{1 + 2\delta \sin^2 n\frac{\pi}{2}}, \qquad (9)$$

Single out particular cases.

1. $n = 1$, $\sin^2 n\frac{\pi}{2} = 1$:

$$N_x^{\text{кр}} = \frac{\pi^2}{a^2} D \frac{\left(m + \frac{1}{m}\cdot\frac{a^2}{b^2}\cdot n^2\right)^2 + 2\gamma m^2}{1 + 2\delta}, \qquad (10)$$

To determine *m* calculate its derivative and equate the derivative to zero.

$$\frac{d}{dm}\left[\left(m + \frac{1}{m}\cdot\frac{a^2}{b^2}\right)^2 + 2\gamma m^2\right] = 2\left(m + \frac{1}{m}\cdot\frac{a^2}{b^2}\right)\left(1 - \frac{1}{m^2}\cdot\frac{a^2}{b^2}\right) + 4\gamma m = 0;$$

$$(1 + 2\gamma)m - \frac{1}{m^3}\frac{a^4}{b^4} = 0;\ m = \frac{a}{b}\frac{1}{\sqrt[4]{1 + 2\gamma}}. \qquad (11)$$

m must be an integer.

2. $n = 2$, $\sin^2 n\frac{\pi}{2} = 0$;

$$N_x^{\text{кр}} = \frac{\pi^2}{a^2} D\left(m + \frac{4}{m}\cdot\frac{a^2}{b^2}\right)^2, \qquad (12)$$

Consider as a plate without stiffener with $b_1 = \frac{b}{2}$.

3. $n = 3$, $\sin^2 n\frac{\pi}{2} = -1$;

$$N_x^{\text{кр}} = \frac{\pi^2}{a^2} D \frac{\left(m + \frac{9}{m}\cdot\frac{a^2}{b^2}\right)^2 + 2\gamma m}{1 + 2\delta} \qquad (13)$$

Here we have a plate of buckling toward *y*.
The case of $n > 3$ in this case is unlikely.

REFERENCES

1. Снитко, Н.К. Строительная механика / Н.К. Снитко. – М.: Высш. шк., 1980. – 433 с.
2. Икрин, В.А. Сопротивление материалов с элементами теории упругости и пластичности / В.А. Икрин. – М., Издат. АСВ, 2004. – 423 с.
3. Тимошенко, С.П. Устойчивость упругих систем / С.П. Тимошенко. – 2-е изд. – М.: Госиздат технико-теоретической литературы, 1955. – 567 с.
4. Айрумян, Э.Л. Рекомендации по расчету стальных конструкций из тонкостенных гнутых профилей / Э.Л. Айрумян // Стройпрофиль. – М.: 2009. − № 8. – С. 12 − 14.

UDC 69.01

DESIGN FEATURES OF OPERATED ROOF

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This article describes the design features of operated roofs in the city, as well as types and properties of used construction materials.

The idea of using flat roofs always attracted architects. Use of vacant space of the roofs in large cities, where the cost of the land is very high, is especially relevant. Intensive development of the huge empty areas of flat roofs began after the appearance of a new generation of roof materials and introduction of the most progressive technologies in building practice. There are the most common two types of operated roofs in modern designs: green roofs and roof-terrace. Often, especially in the design of large-scale residential and commercial-recreational complexes, a combination of the various options is used. Moreover, the establishment of gardens on the roof terrace, due to the scarcity of green areas in the ground level, is becoming an important compositional and spatial component of not only space-planning, but also urban-planning structure [1].

When we design operated roof, we need to take into account several features. The design of operated roof must withstand significant operational load:

- the radiation exposure;
- atmospheric precipitations;
- temperature differential;
- load from exploitation (walking, car movement);
- materials gravity load;
- wind load;
- snow load.

At the device of 'green roofs' it is also necessary to create a watering system and remove excess moisture through the drainage system , to solve the security problems associated with evacuating people from the operated roof, to provide the necessary fire prevention measures.

To repair the operated roof, in contrast to conventional, is difficult. Therefore, it is necessary to use such technical solutions and materials that guarantee the highest possible maintenance-free service life. There are some main elements that make up the design of operated roofs: supporting structures, waterproofing, heat insulation, vapor barrier, drainage and cover (Fig. 1).

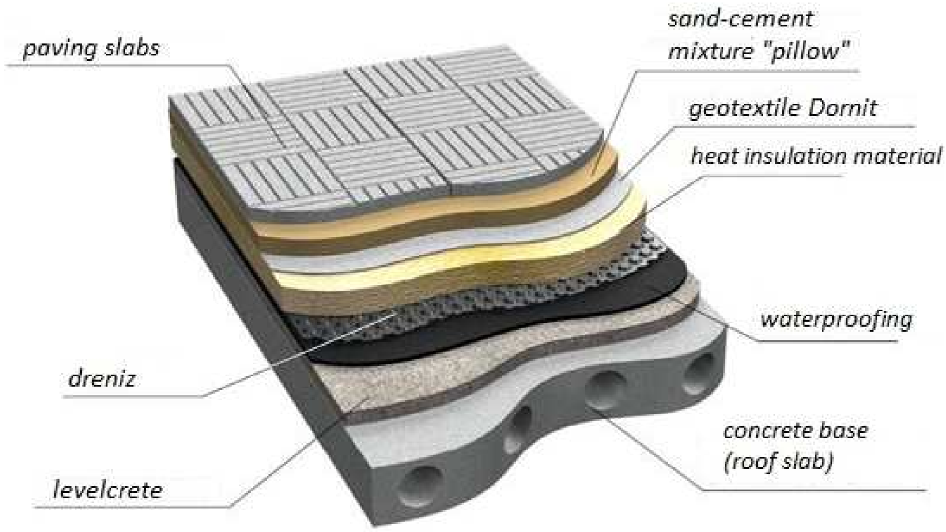

Fig. 1. The design of operated roof

Supporting structures can be: prefabricated reinforced concrete slabs, beams, etc. Standard methods are used for calculation supporting structures of operated roofs such as precast concrete roofs. However, it is necessary to take into account a number of additional loads, in particular, vibrational. During the design it is necessary to consider deflections of bearing beams, fixation of overlap relatively to supports building and resistance to compression of all involved in the roofing materials 'working' on the distribution of loads.

Waterproofing layer is in the design of a 'pie' roof. Therefore, when we choose the type of waterproofing and technology of installation, they should be guided by considerations of the greatest reliability. There are some main characteristics of the coating materials used for waterproofing flat operated roofs:

- elasticity;
- resistance to mechanical impacts;
- fire resistance;
- lifetime;
- manufacturability stacking;
- the safety of fixed properties when temperature changes (from -50 to +50).

Today the building market offers a wide range of roof materials: rolled materials (stekloizol, stekloelast, rubiteks, polysilicon, ELAST), which are based on bitumen, fiberglass or polyester and without polymer rolled bituminous or mastic asphalt roof. etc.

These materials have a relatively high lifetime before repair (from 15 to 75 years), so their exploitation is much more advantageous than using standard ruberoid.

Roofing materials based on bitumen have resistance to plant roots (up to 90 days) and special antiroot additives introduced in modern coatings. Filter layer made of special geotextile which does not allow flushing to drain small soil particles, prevent siltation of the drainage system and improve its effectiveness inserted between the drain and the soil in case of roof installation with a layer of vegetation.

Material for paving a surface of operated roof must be not only attractive, but also strong enough to withstand heavy traffic and pedestrians. Besides it must securely protect the underlying layers from mechanical damage (bituminous, liquid mastic, asphalt pavements and also tiles is used for exterior applications).

The application of special liquid compositions, in particular made of polyurethane for surface of operated roof is very promising. They provide resistance to high intensity loads and retain tightness in the range of operating temperatures (from -50 ° C to 100 ° C) for more than 15 years. The layer of gravel or shingle, as a rule, is poured on heat insulation for the protection roof from wind action. In addition, it greatly reduces the undesirable effects of ozone and UV - radiation, and in some cases it is a prerequisite for compliance with fire safety.

Drainage system must ensure collection and diversion of flows formed from rainfall and snowmelt, as well as the water, that is used for watering plants (in the case of 'green roof'). In this case we must consider the size of the surface, slope, the presence of vegetation, soil type, etc. (Fig. 2).

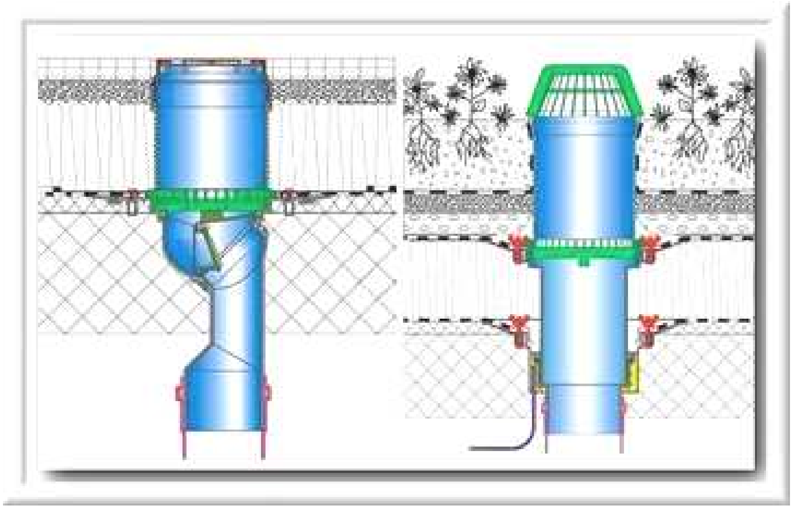

Fig. 2. Water drainage from the surface

As a rule, the materials used for paving surface of operated roof, may in time lose the tightness due to the partial destruction, mechanical displacements and deformations as a result of impact of loads or moisture. Therefore, besides providing necessary roof pitch, in the structure of the roof 'pie' provide for special drainage layer freely permeable water. It may consist of a porous concrete, pea gravel, pure coarse-grained sand etc.

When we design an operated roof we should provide measures for regular cleaning of the surface of the excess snow mechanical or otherwise. Method of removing snow by heating, both of the surface of coating and funnels gutters and trays proved itself [2].

The most important issue in the design of operated roofs is the choice of material for heat insulation and locating heat insulation layer in the roof structure 'pie'. For a long time on flat roofs for the protection heat insulation from getting wet - it was over waterproofing. Now these roofs are called traditional. Use of heat insulation materials with low water absorption on the roof have allowed waterproofing underneath. These roofs are called inversion or inverted. Such a method of stacking materials can increase the lifetime of the waterproofing carpet. Thermal resistance is 6,0 of the TAP.

When we made traditional flat roof waterproofing insulation is laid on top, and when the device inversion vice versa. The seams of protective carpet of waterproofing materials are soldered and then bitumen that coated on a polymer waterproofing is melted by gas burner. Places contiguity waterproofing with roofs elements shall be waterproof, it provides sealants and mastics based on polyurethane resins. The edge of roof waterproofing plant on the vertical plane is at a height of 20 cm. As the roof waterproofing material is used as a stone grit and bitumen-polymer waterproofing and waterproofing PVC membrane.

In order to make the flat roof "breathe" so that moisture doesn't accumulate in the insulation on the roof surface uniformly, we should set aerators. Contiguity to the parapet and plums requires careful execution. For this the junction of heat insulation slab to lanterns roof make the transition bumpers. For insulation of flat roofs we should use rigid insulation materials. And we should lay cables for heating of the roof, so that water near the drain funnels doesn't freeze.

REFERENCES

1. Internet resource: Article: Operated roofs "for" and "against" // Construction Technology. – 2003. – № 5. – З. 38 – 41. – http://rid.by.
2. Internet resource: http://arhbuild.ru/2013/01/green-roof/.

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CALCULATION METHODS OF BENDING MOMENTS ON SUPPORTS IN PRECAST PRESTRESSED HOLLOW-CORE SLABS WITH PLATFORM JOINTS

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Experimental results of intermediate floors strength with precast prestressed hollow-core slabs with platform joints are presented. Precast prestressed hollow-core slabs with $\varnothing$*5mm reinforcement of high-strength wire are produced by a continuous formless molding method, which imposes particular features on its reinforcement such as absence of transverse reinforcement near joints and danger of its destruction from shear on supports.*

Nowadays production of precast prestressed hollow-core formless molding slabs is launched in Belarus. These slabs have longitudinal reinforcement from high-strength wire or strand of S1400 steel. Production technology of such slabs, unlike the aggregate flow production, completely eliminates the installation of transverse reinforcement, horizontal grids in flanges, embedded steel plates and tie-down loops in such slabs, which imposes definite restrictions on the application of such slabs in designing floors.

Singularity of designing floors with platform joints of hollow-core slabs and wall panels is in emergence of bending moment on supports [1], п 6.4. [2]. In hollow-core slabs made by aggregate-flow or conveyor technology emergence of negative bending moment after cracking is perceived by longitudinal bars of upper support steel reinforcement grid and by vertical support steel frames. In precast hollow-core slabs bending moment on supports is generally perceived by concrete cross-section because minimal size of support amounts 80…120mm. Estimated length of zone of stress transfer zone for reinforcement strands and high-strength wire amounts correspondingly 500mm and 330mm. Cracking pattern of similar precast prestressed formless molding hollow-core slabs by "MAX ROTH" production in support zone testifies the danger of destruction from shear near support in the place of normal crack formation.

Herewith [2] it is recommended not to take into consideration appearing bending moments on supports when slabs are supported by masonry walls including monolithic belts made in this types of masonry. At the same time typical series [3] requires to take into consideration appearing bending moments on supports when slabs are supported by block masonry walls.

The value of negative bending moment on supports when using platform joints of precast prestressed hollow-core slabs with wall panels varies in different sources. In [1] bending moment on support for precast prestressed formless molding hollow-core slabs by "MAX ROTH" production which are reinforced by high-strength wire VR-II with 5mm diameter is defined by the coefficient of anchorage degree to the value of bending moment on support which is defined from anchorage condition of the slab in the wall panel. Herewith coefficient K=0.51…0.79 is taken according to anchorage length and stress from pressing of wall panels. In typical series for precast prestressed formless molding hollow-core slabs by "Weiler" (Italy) production which are reinforced by seven-wire steel strands with diameter 6mm, 9mm, 12mm and 15mm [3], bending moment on supports is taken equally to $M_O = ql^2/17$, where q – effective distributed load. In typical series for precast prestressed formless molding hollow-core slabs by "Vibropress" production [4] which are reinforced by high-strength wire made of S1400 steel and with 5mm in diameter bending moment on support should not exceed 11.9…14.9 kNm according to concrete class, otherwise strengthening of supporting zone is required with corresponding