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Experimental research of lightWood roofing model

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ABSTRACT: Currently the specific attention is being paid to issues of energy saving in construction, and the use of lightweight structures that do not affect the strength of the building as well. On this purpose, one of the important task is to have been considered of creating and applying of energy-efficient lightweight structures in the construction.

It is known that heavy reinforced concrete slabs are used in the construction of building and roofing in which their large mass, high thermal conductivity, energy savings, and seismic stability pose problems when they are viewed. Therefore, it is expedient to be regarded the exploiting light wooden tiles being determined.

The article proposes the main results of solving these problems, taking into account all the operating conditions providing for the current building codes and regulations in the calculation and design of lightweight roofing covers. Moreover, improving the calculation and contemplating various mechanical properties of materials were introduced.

KEY WORDS: Light tile, calculated length, resistance moment, bending moment, static moment, moment of inertia, given geometric characteristics, priority, deformation.

I.INTRODUCTION

At present time, the creation of lightweight, energy-efficient structures and their application in practice is great of importance in the world construction practice. Generally heavy structures are often used in the roofing of residential buildings. However, present one of the priority issues in the construction technology is to create lightweight versions of these structures and so more to set up their production [1-4].It is known that heavy reinforced concrete slabs are used in the construction of buildings and roofing. Their large mass, high thermal conductivity, energy savings, and seismic stability pose problems when viewed. Therefore, it is advisable exploiting light boards made of wood for roofs and partitions. Because the mass of such covers is light, their assembling process is convenient. Their dimensions are designed to match the modular system in construction and the dimensions of the slabs. The layers of tiles can be determined the thermal on the base of technical and strength and as well as hardness by Russian codes “23-02-2003- The Thermal Safety of Buildings [2-10]”.Slab contraction joints can be fixed to the main load-bearing constructions and the second slab by mechanical trusses. The cladding of the recommended lightweight slabs and the main load-bearing structure are made of a wooden element.

II. METHODOLOGY

Lightweight roofing tiles have a flat prefabricated structure, as well as modern thermal insulation materials that can adequately retain heat in the room due to their convenient location.

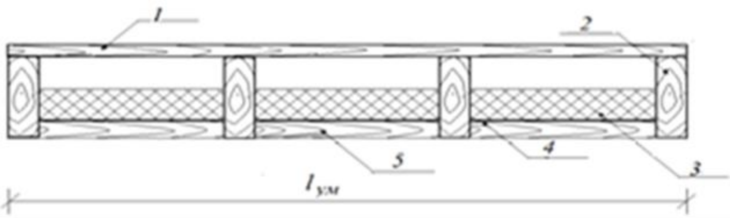

Figure 1. Lightweight roofing plate. 1 - wooden board; 2 - longitudinal ribs; 3 - insulation; 4 - rolled metal mesh, 10x10 mm; 5 transverse ribs.

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In order to increase energy efficiency in buildings, slabs can be used as effective heat-retaining materials between the longitudinal walls, including mineral wool slabs, foam plastic and others. Natural ventilation should be provided in buildings where all types of tiles are used. As a vapor seal, bitumen covering, gluing, painting with moisture-resistant paint, enamelling or varnishing the interior and exterior of the underlayment maintains the roofing element to be decorative simultaneously[10-16].The cross-section of the roofing slab is calculated as a simple beam in the form of I-beam or T-beam. In this case, the state of stress and deformation of the slab is determined using the computational methods of construction mechanics.

Figure 2. Lightweight wooden roofing slab before loading.

Figure 3. Lightweight wooden roofing slab in boot.

III. EXPERIMENTAL RESULTS

So far, the following formula has been used in the calculation of this type of slab:

$$l_{calculated} = l_{general} - c$$

ISSN: 2350-0328
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Vol. 8, Issue 9 , September 2021

It is recommended to determine the calculated spacing of the plate using the following formula:

$$l_{calculated} = l_{general} - \frac{4}{3}c \quad (1)$$

based on the law of distribution of the normal stress in the local compression along the length of its supporting surface according to the triangular rule:

where: $l_{general}$ - is the total length of the slab or the pitch of the load-bearing structure; c ≥ 5.5 cm is the length of the slab resting on the supporting structure.

We determine the calculated width of a T-beam plate with I-beam or a longitudinal rib step and the length of the plate by the following formula (2):

$$L_{general} \geq l_{calculated} + \frac{4}{3}c \geq 6a, \; where b_{calculated} = 0{,}9 \cdot b_{top\ cover} \quad (2)$$

where: a – is the spacing of the longitudinal ribs (along the axes);
$b_{top\ cover}$- is the constructive width of the top cover.

We determine the calculated width of the light slab longitudinal rib - $b_{longitudinal\ rib}$ using the formula:

$$b_{longtidude\ rib}^{calculated} = n_{number\ of\ ribs} \cdot b_{longtidudinal\ rib} \quad (3)$$

where: $n_{number\ of\ ribs}$ - number of longitudinal ribs; $b_{longitudinal}$ - the width of the longitudinal rib.

The cross-section of the roofing slab is calculated as T-beam in the shape of a simple beam in the form of a roof (unless the slab has a subfloor).In simple practical calculations, it is easier to calculate the width of the longitudinal rib given in the determination of geometric characteristics, and it is equal to (4):

$$b_{set\ calculated} = n_{number\ of\ ribs} \cdot b_{longtidudinal\ rib} \cdot n_{set} \quad (4)$$

Slabs are considered normal components of permanent and temporary loads in the slab plane. Temporary snow load is not taken into account in attic roofs. The reason is that these tiles are used in the interspace covering and the top floor roofing (except when the slab is placed on top of the rafters).However, in the calculations, the specific gravity of the plate is also taken into account. The load on the slab is calculated using the following formula (5):

$$q_{spcific\ weigh} = \frac{1}{b_{true} \cdot l_{true}} \cdot V \cdot \rho \cdot g \quad (5),$$

where: b_{true} - the actual width of the slab; l_{true}-is the actual length of the plate; V-is the sum of the volumes of elements of the same type; ρ- is the density of the element material; ; g=9.81 m / sec^2 - speed of free fall;

Roofing slabs usually work for flexing. In this case, the cross-section surface is one of the main indicators within the geometric characteristics of compression and stretching, since the upper part of the neutral axis is in the state of compression and the lower part is in the state of elongation.

The main indicators are the static moment of the cross- section, the moment of inertia, the moment of resistance in torsion, bending, and also, in the calculations of priority, more complex geometric characteristics.At the same time, the simplification and reduction of the cost of roofing constructions play an important role in designing it in the most optimal shape and size. The following formula (6) is appropriate for calculating a surface with a known shape:

$$A = \int_A dA \quad (6)$$

ISSN: 2350-0328
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Vol. 8, Issue 9 , September 2021

If in the calculation scheme, the cross-sectional surface has a complex surface consisting of several shapes, in the calculations they are divided into finite surfaces. In this case, formula (7) takes the following form:

$$A = \sum_{i=1}^{n} A_i \tag{7}$$

Calculations of the reduced static moment with respect to the *x* and *y* axes are performed using the following formulas (8). In this case, the cross-sectional area is the simplest geometric characteristic, which does not depend on the choice of coordinate system.

$$\begin{gathered} S_x = \int_A ydA, \qquad S_y = \int_A xdA; \\ S_x = \iint_A ydxdy, \qquad S_y = \iint_A xdxdy \\ S_x = Ay_c, \qquad S_y = Ax_c \end{gathered} \tag{8}$$

where:y_c -is the distance from the center of gravity to the *x*-axis; xc. is the distance from the center of gravity to the *y*-axis. The moment of a complex section with respect to any axis is equal to the sum of the static moments of all parts with respect to that axis:

The above formula (9) includes definitions such as A_1, A_2, A_3, ... A_n - surfaces of simple elements; are the coordinates of the centers of gravity that make up the simple cutting surfaces relative to the *x* and *y* axes obtained. The coordinates of the center of gravity in the case of a single-section of cross-sectional surface are calculated using the following formula (10):

$$x_c = \frac{S_y}{A}; \qquad y_c = \frac{S_x}{A}. \tag{10}$$

Also, the coordinates of the center of gravity of a complex cross-sectional surface in several shapes are determined using the following formula (11):

$$\begin{gathered} x_c = \frac{S_y}{A} = \frac{A_1x_1 + A_2x_2 + \cdots + A_nx_n}{A_1 + A_2 + \cdots + A_n}; \\ y_c = \frac{S_x}{A} = \frac{A_1y_1 + A_2y_2 + \cdots + A_ny_n}{A_1 + A_2 + \cdots + A_n} \end{gathered} \tag{11}$$

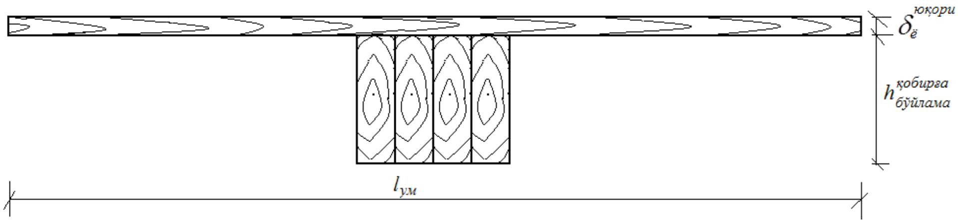

Figure 4. T-beam cross-section of calculation scheme of light wood roofing slab.

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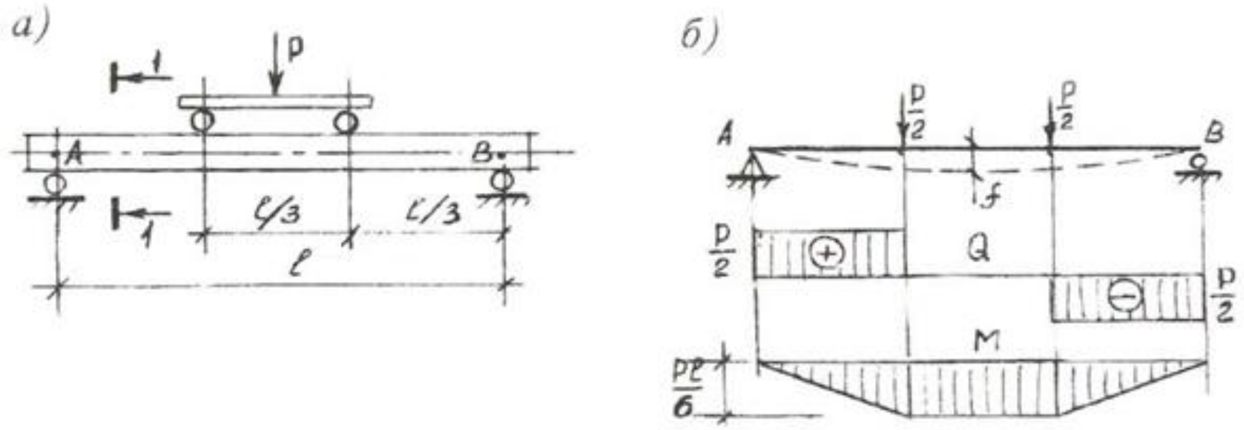

Figure 5. Slab test diagram: a- slab loading scheme and geometry; b - shearing force and bending moment under load.

$$\sigma = \frac{M}{W} = \frac{M_{calculated}}{W_{x(set)}^{lower}} \leq R_{\mathrm{elongation}} \quad (12)$$

$$\sigma = \frac{M_{calculated}}{W_{\mathrm{x(set)}}^{upper}} \leq R_{compression} \quad (13)$$

$$where{:}M_{calculated} = \frac{Pl}{6} = \frac{P(l_{total} - \frac{4}{3}\mathrm{c})^2}{6} \quad (14)$$

P- is the external force acting on the plate, $W_{x.set}^{lower} = \frac{I_{set}}{y_0}$- the applied moment of resistance of the lower cross section of the plate; $\boldsymbol{y_0}$ is the distance from the center of gravity of the slab cross section to the lower plane of the slab; $W_{x.set}^{upper} = \frac{I_{set}}{h - y_0}$- the applied resistance moment of the upper cross section of the plate; h is the height of the plate; $\mathrm{R_{coprassion}}$, $\mathrm{R_{elongation}}$-calculated resistance of wood to compression and elongation;
$l_{calculated}$– is the calculated length of the slab.

If the volume of the slab is cross-sectioned T-beam, it is sufficient to determine the moment [20-27] of inertia of the cross-section from the formula (12).Theoretical and experimental analysis of the model made of M 1: 400 slabs with 3sm wooden veneer and 4x16 cm ribs are carried out during the testing process.

(Table 1).

№	Breaking force, KN		Theoretical and practical coefficient between, k	Average coefficient, k
	Theoretical	Practical		
1-experiment	1,23	2,37	0,52	0,52
2-experiment	1,23	2,5	0,5	
3-experiment	1,23	2,43	0,51	
4-experiment	1,23	2,25	0,55	

Slab flexing should be analyzed. The value of the cross-sectional flexing is determined by the following formulas (15):

$$f = k\frac{P \cdot l^3}{EI} \quad (15)$$

where:$k$is determined by formulas of Construction (6-Figure):

$$k = 2 \cdot \left(\frac{l}{6} \cdot \frac{Pl}{6} \cdot \frac{5l}{24} + \frac{Pl}{6} \cdot \frac{l}{3} \cdot \frac{1}{2} \cdot \frac{l}{9}\right) = \frac{23}{1296}$$

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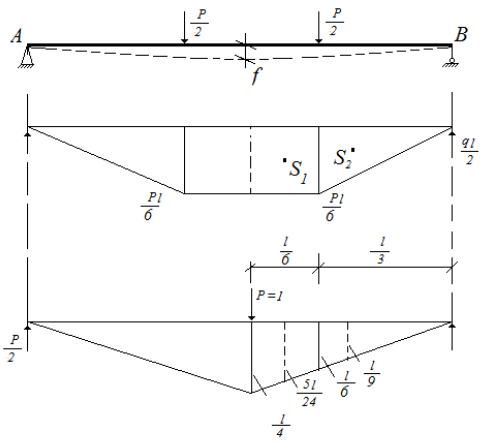

Figure 6. Calculation scheme for determining the coefficient k of deflection.

The relative slope of the slab is determined as follows $-f/l, \left[\frac{f}{l}\right] = \frac{1}{250}$, if the value is less than the allowable value, the requirement of density is considered fulfilled.

IV.CONCLUSION AND FUTURE WORK

1. It is expedient to consider the distribution of the local compression diagram formed on the basis of the slab not by the rectangular regularity but by the triangular regularity in determining the calculated length of lightweight slabs. In this case, it is recommended to use the formula$l_{calculated} = l_{general} - \frac{4}{3}c$, developed by the authors of the article, instead of the formula $\sigma = \frac{M}{W} = \frac{M_{calculated}}{W_{x(set)}^{lower}} \leq R_{elongation}$, which is still used to find the calculated length.

2. In the calculation of the plate$\sigma = \frac{M}{W} = \frac{M_{calculated}}{W_{x(set)}^{lower}} \leq R_{elongation}$ -increases the coefficient k in the formula $\sigma = \kappa \cdot \frac{M}{W} = \kappa \cdot \frac{M_{calculated}}{W_{x(set)}^{lower}} \leq R_{elongation}$makes closer the results of theoretical and practical calculations of plate.

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