THE TECHNIQUE OF OPTIMIZATION CONSTRUCTIVE DECISIONS ABOUT RIBBED COMBINED PLATES

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The analysis of the works in the sphere of designing, calculation and optimization of ribbed combined covering, overlapping and wall protection plates showed that until that moment in normative, scientific and technical literature there were no clear recommendations on the optimum projection of these plates. Anisotropy and non-linear nature of deformation of the wood and covering material (plywood, OSB, LVL, etc.) should be taken into account.

For the purpose of reduction of material consumption for both the separate plate and a full covering and wall protecting plate there were held the number of optimizing researches. They were done for combined glue plywood plates as constructions “on distance» which work on compression with a bend with the help of the “girder” rated scheme. Let’s consider the example of the searching technique of the most optimal constructive decision for bent ribbed plates, which are applied in coverings and overlappings of different functions buildings on the example of constructions with plywood covering.

The construction of a plate (1, 5×12,0m) was admitted as a basic variant. It consists of two glue plywood main ribs of constant or linearly various heights. They together with the pasted covering form P-shaped transverse section. Supporting transversal ribs are settled down through 750m. Each end face of transversal ribs is connected on a toothed thorn (rigid joint) with framing elements. To provide the stability of transversal section between the main ribs we use the diaphragms. Glue connection of coverage with the main and supporting ribs help partly to introduce it in a cooperative work with these elements. The filling polyfoam of such brands as: FRP, FBP, polyurethane and other similar materials is used as a heater .The sizes of sections of basic plate elements are defined by durability and deformability equal to the requirements [1,2]according to the regular snow load $p_н$=1,5кН/м^2.

The task of the plate optimization is put as a task of non linear mathematic programming [3]. Variable design (various parameters) should be divided into 2 levels.

The first level includes the parameters, which define the sizes of the panel elements sections. Let’s take the following numeration of the first level varied parameters:

$b=X_1$, $h_{оп}=X_2$ –the width and height of the main ribs

$b_{вр}=X_3$, $h_{вр}=X_4$ – the width and the height of the supporting ribs

$\delta_ф=X_5$ – the thickness of the plywood covering

$i=X_6$ – the parameter defining the linear change of the height of the main ribs. (If $X_6=0$- the height of the basic ribs is constant).

The second level includes the discrete integer parameter X_7, which define the number of main ribs, and the parameter of the width of the panel X_8 which can continuously change, but due to the modularity requirements it also will take the different measures(1m;1,5;2,3,6m).

The solution of the task for the optimization is carried out for the plates, which distances are between 6-24m.

At this stage of research the minimum of the charge of the materials (wood, plywood) on the m^2 of the square is accepted as a criterion of optimality of the plate of the given distance. Thus charges of the materials on the panel are brought to the timber according to a ratio:

$$V_м=1,6 \cdot V_{др} + 2,5 \cdot V_ф \ ,$$

where $V_м$ –the volume of the materials used on a one plate in a timber.

$V_{др}$, $V_ф$ – the volume of the wood and plywood materials in the panel being made.

Taking into account the previous designations for various parameters the aim function looks like:

$$f(X) = \frac{\left[1,6\left(X_7X_1(X_2+0,25 \cdot l_nX_6)l_n+\sum_{i=1}^{N_д} b_{дi}h_{дi}(X_8-X_7X_1)+N_{вр}X_3X_4l_{вр}\right)+2,5X_8X_5l_n\right]}{l_nX_8},$$

where l_n –the distance of the plate;

$N_д$ –the number of the diaphragm rows;

$b_{дi}$, $h_{дi}$ –the width and height of the i-row diaphragm's section;

$N_{вр}$, $l_{вр}$ –the number and the length of the supporting ribs.

The restrictions of the optimization reflect the requirements of norms of design [1,2] on durability of the elements and rigidity of the plate. They include:

- The restrictions on the max normal wood tension on stretching and compression in main ribs
- The restrictions on the max normal tension on compression in plywood covering.
- The restrictions on the tangent (spinning off)in bearing sections.
- The restrictions on the max normal tension on bend during the short-term mounting and local rated load.
- The restrictions on the max deflection.

In addition to above-mentioned restrictions during the solution of the optimization task the number of constructive and parametrical restrictions also would be taken into account. They are due to the experiment, norms of design and also from the best assortment. Particularly next restrictions on the width of main and supporting ribs and thickness of the plywood are:

$$X_1 \geq \frac{X_2 + 0,25X_6 \cdot l_n}{8,5}; \quad X_3 \geq 45мм; X_5 = 6\ldots20мм.$$

Step $a_{вр}$ of the supporting ribs must be no more than $100X_5$, and step of diaphragms- $a_д \leq 6м$.

By setting up the restrictions of the supporting ribs, a skip of plywood covering with the width of $b_{ф}^{пр} = 40X_5 + X_3$ was considered in the work.

The settlement load of the 1m^2 plate was defined according to a ratio:

$$q^{н} = q_{кр}^{н} \cdot \gamma_{f_{кр}} + q_{сн}^{н} \cdot \gamma_{f_{сн}} + q_{св}^{н} \cdot \gamma_{f_{св}} ,$$

$_р, q_{сн}^{н}, q_{св}^{н}$ - the standard values of the load from the roof, snow and own weight ;

$\gamma_{fкр}, \gamma_{fсн}, \gamma_{fсв}$ - reliability coefficients on the loads.

Running loads along a surface of a plate are:
$q = q \cdot X_8$; $qн = q_н \cdot X_8$.

Epyurs of bends which we have at assembly and local settlement of loads in cross supporting ribs are built according to their jamming in the main ribs.

The meaning of a special function for the first basic option (without optimization) is $f_б$=0,136м3/м^2. As a result of statement and solution of the task of the plate basic option optimization only at the variation of the width of the plate and parameters of the first level is received the basic variant: $f_{оп}$=0,120м^3/м^2. The economy of the timber is 11, 78%.

The analysis of the results of an optimization task solution gives us evidence about the presence of the extremum corresponding to rather great value of a plate width (5m). In case when the restrictions are imposed on the plate width $b_n \leq$3м, optimum projects reject (a little) from the global extrema. For example, for the distance of 12m these restrictions are about≈5%.

The analysis of the results of the optimization research allows to make a conclusion, that if the width of the plate is no more than 3,0m, the most rational are the plates with two main ribs.

The results of the settlement calculations show us the great need of the corresponding optimization tasks, especially in developing design methods of new constructive variants of the plates.

Statement and solution of the optimization tasks for the combined plates allowed us to reveal the economic reservations of the material which was put in the offered options of the constructive forms.

The economy of the materials in optimum projects can be quite essential. For example, in considered basic option of a plate with a distance of 12m at a variation of all parameters of the first and second levels the economy was ((1,36-0,0986)/1,36)·100%= 27,5%. However the optimum parameter for the width of the plate was 5m. So it is hardly acceptable in the production and transportation of the plates. The projects for plate with two main ribs, which correspond to the width of the plates of 3m, are more preferable than projects of plates with the width of 1,5m and 2m.

To make final recommendations about design of optimum options of plates we need to analyze the constructive schemes with longitudinal supporting ribs and with different types of covering. We plan to execute it at the final stage of the researches of the master's degree thesis.

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