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EFFECTIVE ROOF DESIGN FOR THE UNIVERSAL GYM

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ABSTRACT

The article presents the optimal design of a metal truss designed to cover the roof of a universal gym of size 12x24 m. Trusses made of sloping welded profiles have been shown to be more efficient than traditional double-angle trusses currently used in industrial building roofing. As an example, 24 m arched farms were designed and working drawings were developed.

KEYWORDS: *Truss, Interval, Knot, Bars, Cross-Section, Angle, Band.*

1. INTRODUCTION

The grids are directly attached to the strips without fittings in farms formed of bent welded profiles (Fig. 1), and the inertia radius of the rods are 3-4% bigger than in double-angle farms of the same cross-section. In circumstances when the cladding of industrial and large arched buildings consists of lightweight, ie prongs and "SANDWICH" panels, farms built of bent welded profiles are effective. It is advised that the assortment, profiles indicated in SS 30245-2003 be used in the manufacture of such farms. **[1]**

Thin-walled bent welded profiles provide excellent mechanical qualities. It is vital to consider the characteristics of thin-walled structure design while developing trusses composed of such profiles.

2. MAINPART

The initial boundary elasticities of the profile walls can be calculated using the formula below.

$$\left[h_{ef} / t\right] \leq 1{,}29 \cdot \sqrt{R_y / E} \tag{1}$$

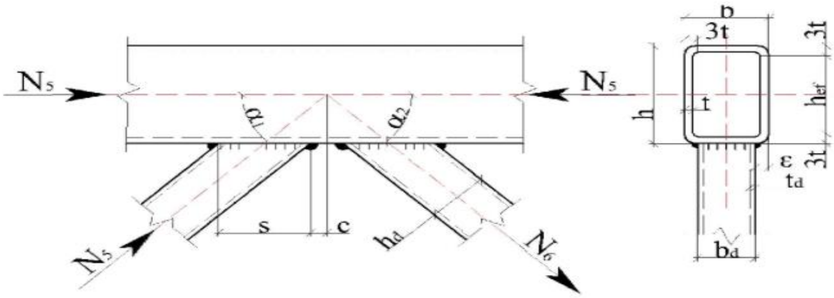

FIGURE 1. KNOT FOR DESIGNING A BENT WELDED STEM TRUSS.

Here:R_y - calculated resistance of steel, E - elastic modulus.To ensure the boundary flexibility of the profile walls determined using formula (1), h_{ef}/t=40for steels R_y =210 –220MPa, h_{ef}/t=37 for steels 220 <$R_y \leq$ 260 and h_{ef}/t =35 for steels 260 <$R_y \leq$ 300 should not exceed values.

In accordance with paragraph 9.20 of **[2],** in cases where the priority of the beam wall is greater than the boundary flexures, i.e.:

$$\frac{h_{ef}}{t} > \bar{\lambda}_{uw}\sqrt{E/R_y} \quad \text{or} \quad \frac{h_{ef}}{t} > 1{,}29\sqrt{E/R_y}\ ; \tag{2}$$

is widely used in roofing.The calculated section (A_{red}), not the full section (A), is taken into account in the calculation, the priority part of the profile wall. The value of A_{red} (h_{red}andh_{red1}) is determined taking into account the active operating heights of the profile wall parallel and perpendicular to the truss plane:
For central compression rods,

$$A_{red} = A - 2(h_{ef} - h_{red})\cdot t - 2(h_{ef1} - h_{red1})\cdot t_1\ ; \tag{3}$$

For non-center compressed and compressed bending rods,

$$A_{red} = A - 2(h_{ef} - h_{red})\cdot t\ ; \tag{4}$$

Here: h_{red} is defined for the central compression and h_{red1} for the central compression and compression bending according to the following formula:

$$h_{red} = t\left[\bar{\lambda}_{uw} - \left(\frac{\bar{\lambda}_w}{\bar{\lambda}_{uw}} - 1\right)\left(\bar{\lambda}_{uw} - k\right)\right]\sqrt{\frac{R_y}{E}}\ , \tag{5}$$

$\bar{\lambda}_{uw}$ - the conditional elasticity is determined using formulas when m=0.
$\bar{\lambda}_w = \frac{h_{ef}}{t}\cdot\sqrt{\frac{E}{R_y}}$ is the conditional elasticity of the wall, which is assumed to be $\bar{\lambda}_{w1} = \frac{h_{ef1}}{t_1}\cdot\sqrt{\frac{R_y}{E}}$ when calculating h_{red1}.

k - the coefficient is determined using the following formula:

$$k = 2{,}6 + 0{,}2\cdot\bar{\lambda} = 0{,}7\cdot\bar{\lambda}_w\ . \tag{6}$$

If $\overline{\lambda}_w > 2,3$, $\overline{\lambda}_w = 2,3$,

Here: $\overline{\lambda} = \lambda\sqrt{\frac{R_y}{E}}$ - conditional elasticity of the element; $\lambda = \frac{l_{ef}}{i}$ - flexibility.

The following inspections should be performed when designing truss nodes consisting of bent welded profiles:

- To assure the local priority of the belt wall as a result of pushing or pulling the compressive or extended grid rods, the following condition must be applied at the nodes where the grids are linked to the belts:

1. If $0 \le c/s \le 0,25$ and $h_b/b \le 0,9$,

$$N \le \frac{\gamma_c \cdot \gamma_1 \cdot R_y \cdot t^2 \cdot (s + c + \sqrt{z \cdot b \cdot \varepsilon}}{\left(0,4 + 1,8 \cdot \frac{c}{s}\right) \cdot \varepsilon \cdot \sin\alpha}; \qquad (7)$$

2. If $c/s \ge 0,2$ and $h_b/b \le 0,9$

$$N \le \frac{\gamma_c \cdot \gamma_1 \cdot R_y \cdot t^2 \cdot (s + c + \sqrt{0,8 \cdot b \cdot \varepsilon}}{\varepsilon \cdot \sin\alpha}; \qquad (8)$$

Here: h_b, b, c, s, ε, t, α, dimensions according to Figure 3;

N - longitudinal force (compression, elongation) on the grid element; γ_c - operating condition coefficient, for elongated rods, and is assumed to be equal to $\gamma_c = 1,5 - \frac{N_1}{A \cdot R_y}$ for all grid elements when γ_c=1and $\frac{N_1}{A \cdot R_y} \ge 0,5$ when $\frac{N_1}{A \cdot R_y} \le 0,5$ is present for the compression grid rods.

Where: A, R_y -belt cutting face and calculated resistance; N_1 is the calculated force on the side of the calculated mortar, which is formed on the belt; the coefficients of tearing and crushing of the belt wall under the action of an elongated, compressed mortar added to the γ_c -node, respectively, is taken as 1; 1,15.

Where the compression grid element is connected, when the strength of the belt wall is $b_d/b > 0.85$ in the plane of the node;

$$N \le \frac{2 \cdot \gamma_c \cdot \gamma_2 \cdot k \cdot R_y \cdot t \cdot h_d}{\sin^2\alpha}; \qquad (9)$$

Here: If $R_y = 290$ *MPa* and $h/t \le 45$, $k = 1$; the value of γ_c is the same as in formulas (8),(9).

If $h/t < 25$, $\gamma_c=1$;

If $h/t \ge 25$, $\gamma_c=0,8$;

- to assure the local priority of the belt wall where the springs are connected, the following condition must be met:

$$F \le 2,5 \cdot 10^{-4} \cdot t \cdot R_y \left[3050 + 23\frac{z}{t} - 0,09\frac{z(h-6t)}{t^2} - \frac{5(h-6t)}{t}\right]\rho \qquad (10)$$

Here: F –ceiling beam base reaction, *κH*;
t – the thickness of the tape wall, *cm*;
h – belt height, z –the width of the steel plate under the ceiling beam, *cm*;
$r_i = 2t$ –inner semicircle (fig.2)

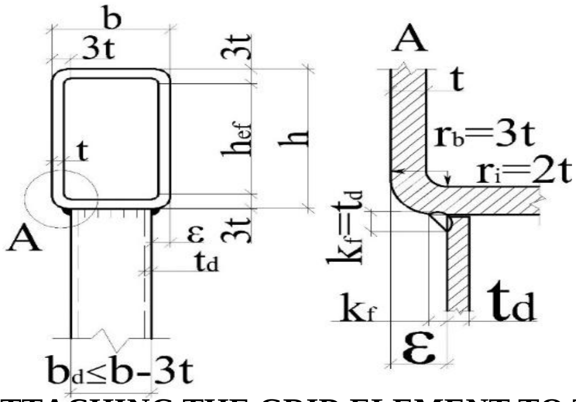

FIGURE 2. ATTACHING THE GRID ELEMENT TO THE TAPE.

$$\rho = (1{,}06 - 0{,}06t)\left(1{,}22 - 0{,}22\frac{R_y}{210}\right) \quad (11)$$

If the criteria is not met, plates are used to reinforce the upper belt wall.
When testing the strength of the stem at the nodes where eccentricity is created, bending moments should be taken into account. **[3]**
Example. It is necessary to design sloping welded profile and double-angle trusses based on the following information and compare them to working drawings: S235 grade steel (R_y= *225 MPa*) truss arch 24 m pitch 6 mm.

The calculation scheme of the farm, the loads placed on the nodes and the stresses on the farm rods (determined using the LIRA-CAD program) are shown in Figure 3.

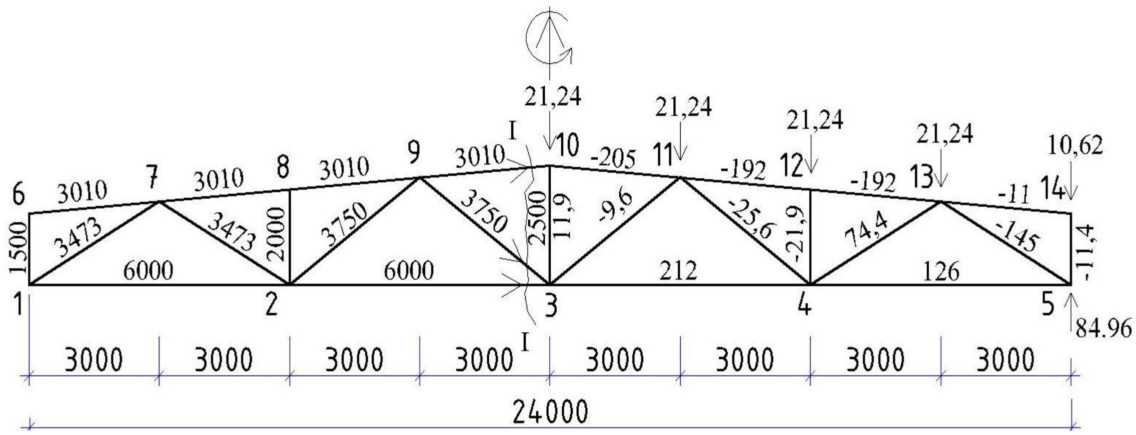

FIGURE 3. SCHEMATIC DIAGRAM OF A STROPIL FARM.

According to the pressures generated on the farm rods, different cuts (profiled and double-angled) were chosen for both choices, and working drawings of the farms were created. Steel consumption was 760 kg for profile cut farm and 980 kg for double angle, according to farm worker (KMD) designs. **[4]**

3. CONCLUSION:

1) When compared to double-angle trusses, Stropyl trusses, which are made out of bent welded profiles, will save 15-25% on steel consumption.
2) Profile farms have painted surfaces that are 130% less expensive than double-angle farms and are more corrosion resistant.
3) The utilization of such farms, which are primarily found on the roofs of industrial buildings and gyms, gives an effective and artistic compositional solution.

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