Effective profiles for building constructions

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Abstract. Describes a new more efficient double-tee rolling bar comprising a wall and two flanges and having invariable sectional area equal to the cross section of standard profile, wherein each of the shelves is conjugate with the wall by a pair of circular triangles, with the radius of each of them is where the flange width the wall thickness of the I-profile rolling and the thickness of at flange coupling area with increased wall 3 ... 3.5 times the excluded likelihood of fatigue cracks in that zone.

Introduction

The main cause of fatigue cracks in the zone under-rail crane girders (operated under severe conditions of work of overhead cranes) are moving-twisting moments you encountered the rolling wheels of cranes on rails. Local stresses from torsion significant and contribute to the emergence of fatigue cracks in the congested area of under-rail beams. One of the most effective ways to eliminate the possibility of the appearance of fatigue cracks in the under-rail area is the use of new profiles for crane girders [1].

Improved I-profile

I-rolled profiles, used in the industry (including as crane beams), according to the authors, have a major drawback, namely the steel profile at the box office over the cross section of the beam is not rationally distributed, and can be distributed more efficiently. That is, the rolling resistance moment W_x I-profile, as well as the moment of inertia J_X can be increased without increasing its consumption of materials. What has been confirmed in several studies [2, 3].

The task of improving endurance under-rail rolling zone I-profile (when used as crane beams), without increasing its material intensity is solved as follows:

1.	Each of the flanges of the beam to match the circular wall by a pair of triangles (fillets), the radius of which is determined by the formula $r = 0{,}6(b - t_w)$ where the b – width of the shelves, t_w – the wall thickness of the double-T profile rolling [4].

2.	the beam waist paired with the wall by four circular triangles (fillets), and the radius of each of them is $r = \dfrac{b - t_W}{3}$, where the b – width of the shelves, t_w – the wall thickness of the double-T profile rolling

Such distribution of material in the cross section enhances the profile of the main characteristics of the rolling material consumption without increasing it, namely: W_x – moment of resistance, moment of inertia J_X, endurance and most importantly under-rail rolling zone I-profile when used as crane beams operated under heavy continuous operation (8K, 7K) in the workshops of ferrous and nonferrous metallurgy. Material consumption structure remains unchanged.

Fig. 1 shows the I-section profile of each of the shelves, which is associated with the wall by means of two pairs of circular triangles.
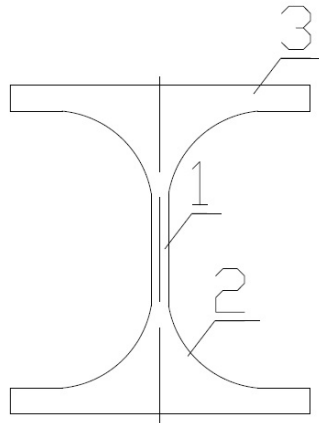
Fig. 1 New I-section profile.

I-profile comprises a wall 1, four circular triangle 2 and two flanges 3. The radius of each circle is equal to the triangle 2 $r = \dfrac{b - t_w}{3}$, where the b – width of the shelves, t_w – the wall thickness of the double-T profile rolling

The radius of each circular triangle 2   3 ... 3,5 times greater than r the radius of the fillet rolling a standard double-T profile. The radius of each circle and the triangle $R > r$ increases the moment of resistance W_x ; proposed new rolling profile. The thickness of the wall in the zone pair fillets increases by several times, making it impossible occurrence of fatigue cracks in that zone.

That is, the height of the flat wall section is significantly reduced compared with analog that reduces the flexibility of the wall $\lambda_w = h_w / t_w$, h_w – sectional height of the flat wall portion.

To hire a new profile in the roll stand is enough to change the forming rolls forming the radius of each circle of the triangle $R > r$ and due to this we get from the blank of the same material consumption, but with moments of resistance W_x and inertia J_x considerably larger than in the standard profile.

Example of a particular implementation.

Compare developed a new profile with analogue, for example, I-profile I 100B4:

$A - const$

$A = 397$ sm^2;

$J_x = 662170$ sm^4;

$W_x = 13060$ sm^2

radius of gyration $i_x = 40,8$ sm;

$i_y = 6,85$ sm;

beam height $h = 101,4$ sm ,

sectional area of the two flanges $2A = 2 \cdot 32,31 \cdot 3,3 = 213,246 \, sm^2$

wall height $h_w = 101,4 - 2 \cdot 3,3 = 94,8$ sm,

thickness $t_w = 1,86$ sm,

flexible wall $\lambda_w = 94,8/1,86 = 51$

New profile remained unchanged $A = 397$ sm^2 , sectional height $h = 101,4 \, sm$ shelf width $b = 32,31$ sm, flange thickness $t_w = 3,3$ sm

Assign the radius of each circle of the triangle [4]

$$R = 0,3(b - t_w) = 0,3(32,31 - 1,86) = 9,135 \text{sm}$$

Area 1 circular triangle

$$A_n = 0,215r^2 = 0,215 \cdot 9,135^2 = 17,94 \text{ sm}^2$$

$$4A_n = 4 \cdot 17,94 = 71,7654 \text{ sm}^2$$

Moment of inertia of the four circular triangles

$$4J_x^n = 4 \cdot 0,00755R^4 = 4 \cdot 0,00755 \cdot 9,135^4 = 210,3 \text{sm}^4$$

We calculate the sectional area of the wall:

$$A_w = A - 2A - 4A_n \; ; \; A_w = 397 - 213,246 - 71,7654 = 111,9885 \text{ sm}^2$$

wall thickness: $t_w = A_w/h_w = 111,9885/94,8 = 1,1813 \text{ sm}$

wall flexibility: $\lambda_w = (h_w - 2r)/t_w = 94,8 - 2 \cdot 9,135/1,1813 = 64,78 < 74,8$

Distance from the center of gravity of the circular triangles:

$$y_1 = 0,223R = 0,223 \cdot 9,135 = 2,0371 \text{ sm}$$

$$y_w = 0,5(h_w - y_1) = 0,5(94,8 - 2,0371) = 46,3815 \text{ sm}$$

shelves: $y_s = 0,5(h_w + t_s) = 0,5(94,8 + 3,3) = 49,05 \text{ sm}$

Principal moment of inertia of a new profile (X-axis)

$$J_x = \frac{2A_s \cdot t_s^2}{12} + 2A_s y_s^2 + \frac{A_w \cdot h_w^2}{12} + \left(4J_x^n + 4A^n \cdot y_n^2\right)$$

$$J_x = \frac{213,246 \cdot 3,3^2}{12} + 213,246 \cdot 49,05^2 + \frac{111,9885 \cdot 94,8^2}{12} + \left(210,3 + 71,7654 \cdot 46,3815^2\right) = 751708,18 \text{ sm}^4$$

Comparison of a new profile with analogue principal moment of inertia indicates that $J_x = 751708,18 \text{ sm}^4$ increased with respect to the analog $751708,18 / 662110 = 1,1353$ (was 662110 sm^4). Increase at 1,1353 times.

Comparison of the time the new profile of resistance to the standard indicates that the moment of resistance $W_x = 2J_x/h = 2 \cdot 751708,18/101,4 = 14826,59 \text{ sm}^3$ (was 13060 sm^4). Increase at 1,35 times. The moment of inertia a new I-profile (vertical axis Y)

$$J_y = \frac{\pi}{64}\left(D^4 - d^4\right) + \frac{t}{12}\left(b_{max}^3 - D^3\right)$$

In accordance with current regulations prescribe the flexibility of the wall, where it is not required stability test [5].

$$\overline{\lambda_w} = \frac{h_{ef}}{e}\sqrt{\frac{R_y}{E}} = 2,5$$

$R_y = 230$ MPa; E=206000 MPa.

Then $\lambda_w = \dfrac{h_{ef}}{e} = 2,5\sqrt{\dfrac{E}{R_y}} = 74,8$

Limits the flexibility of the wall $\lambda_w = 74,8$

Sectional area remain unchanged $A = 397$ sm^2. This area is distributed over the cross section as follows: The height of the beam cross-section – 101,4 sm.

The height of the wall – 94,8 sm.

Moment resistance a new I-beam – 14826,59 sm^3.

The efficacy a new beam profile high – 13,5%.

Thus, the new rolling profile reduces material consumption by 13.5% compared with a standard profile [5].

Especially effective new profile for crane beams, since the occurrence of the fatigue crack at fillet area is not possible, because the effective stress concentration factor [6] is close to unity (K $\approx$ 1), and the thickness increased at fillet area of 3.5 ... 3 times. It has the same efficiency and T sections obtained from the proposed I-profile [7].

Effective New Elliptical Profile

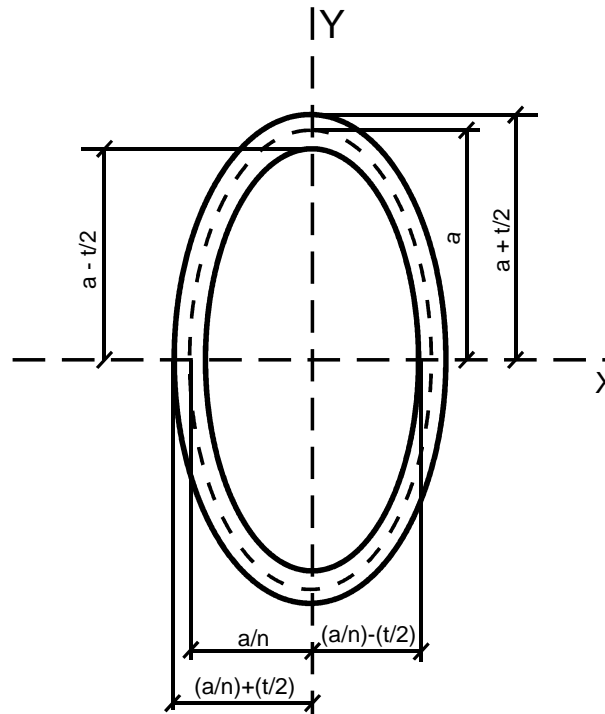In addition to the above profile, by comparison, offered more effective new elliptical profile (Fig. 2).

Fig. 2 Elliptical profile.

Introduce the following notation:

A – cross-sectional area of the pipe;

t – wall thickness;

a, b – distance from the center of gravity of the elliptical profile to the middle of the wall thickness;

$2a + t$ – the external envelope of the elliptic profile axis X.

Introduce coefficient $n = \dfrac{a}{b}$, then $b = \dfrac{a}{n}$.

In accordance with the introduction of a minimum size ratio of the elliptic profile:

$\dfrac{2a}{n} + t$ – external envelope of the elliptic profile axis *Y*.

Similarly, the record size of the cavity:

$2a - t$ – the maximum size of the cavity;

$$\frac{2a}{n} - t$$ – minimum space envelope.

Conclusion

The peculiarity of the new profiles - no stress concentrators and shock-absorbing capacity of the profile due to its cross-sectional shape. The transition to such a design reduces fatigue crack defect. Improved profiles for building structures will help significantly improve the safety of buildings and structures with a simultaneous decrease in the prices of their construction and their further exploitation. In all the above profiles obtained patents of the Russian Federation. The development of such profiles are currently going on in PGUAS.

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