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NOTIONS OF SHARE FORCE RESISTANCE OF DOUBLE T THICK STEEL WELDED SHEETS WITH SINUSOIDAL WEBS PRODUCED IN ROMANIA

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Abstract: *The use of double T welded sinusoidal web sections to obtain both metal elements or metal structures, demonstrated good efficiency on steel consumption, compared to the use of I and H laminated sections. The paper aims to present the dimensional range of these products, that can be manufactured in Romania, and the calculation to obtain the shear strength using SREN -1 1993-5: 2008 For this purpose we will present tabulary the capable shear forces of these mechanized sinusoidal webs produced in Romania.*

Key words: *steel structures,* welded corrugated elements, *double T welded sinusoidal web sections, I and H laminated sections*

1. Introduction

Metal sections made of welded corrugated elements are commonly used to achieve elements that are predominantly submitted to right bending strain, but in time they showed a good behavior taking composed stress like oblique bending (biaxial bending) compression with bending or even axial straines.

Compared with similar elements, structures made of these profiles were found to be more economical, registering lower steel consumption. The producers of double T welded sections with corrugated webs, also known as SIN profiles (commercial profiles name), affirm that this type of structures made of special sections like SIN are 15% ÷ 45% lighter compared to the same structures built of laminated ones, with I and / or H transversal section shapes.

The main quality of this profiles is that the SIN profiles are higher, so the material is farther disposed from the neutral axis, and it can behave more effective at taking the bending strains.

A second reason is represented by the way the web is made for these sections. Because it is profiled, it can easily ensure its stability and also allows the thickness reduction of the element, compared to a straight web.

Because the webs of the beams are profiled, the web largely can pot participate for the transfer of axial normal bending stresses. For this reason the sinusoidal web beam corresponds to a lattice girder (a plane truss), so the bending moments and axial forces are transferred only in the beams flanges and the transversal forces are transferred through the diagonals and verticals of the truss, in this case the sinusoidal web.

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The evaluation of capable strains for SIN steel sections for their dimensioning and verification is made according to SR EN 1993-1-5:2008, Annex D. The load bearing capacity verification is best performed based on internal forces and the cross sections resistances of their individual components: flanges and sinusoidal web.

The use of different lower flanges and upper flanges is possible, but because of manufacturing reasons the widths should be the same.

The technology for manufacturing double T steel welded sections with corrugated web allows the production of variable height of the cross section. Two conical elements can be manufactured from one standard height beam. The web is cut at an angle to the flanges using a cutting torch. The heights of the two webs are the same on both sides as shown is Figure 1.

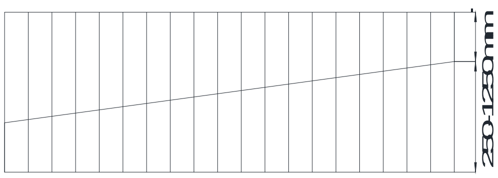

Fig.1. *The disposal of the cut for manufacture two conical SIN beams*

The materials that are usually used for the beams are wide flat steel or steel lamellas, steel type S235 JO1, S235 or S355 JR J2, according to EN 10025 / 2-2004. "Hot rolled products of structural steels".

The webs are made of cold- rolled or hot-rolled sheet according to EN 10025 / 2- 2004.

1.1. SIN Profiles Nomenclature

SIN profile name consists of a group of three letters and three groups of numbers: Three letters groups symbolize the heart thickness, as follows:

WTO- t_w = 1.5 mm
WTA- t_w = 2.0 mm
WTB- t_w = 2.5mm
WTC – t_w = 3.0 mm,
and
t_w = web thickness.

- The first group of numbers represents the height of the web expressed in mm. The machine that produces the double T sections of thick plates welded with corrugated webs, can produce metal webs with different heights like:

h_w = 333 mm, 500 mm, 625 mm, 750 mm, 1000 mm, 1250 mm, 1500 mm and h_w = web heights.

- The second group of numbers represents the width of flanges (bf). These have values between:

$$b_f = (200 \div 450) \text{ mm}.$$

- The third and last group of numbers represent the flanges thickness (t_f) and can have values between 10÷30 mm.

Example
An relevant example for noting a SIN sections is: WTB – 750 x 250 x 15.

2. Shear Strength Calculation of the Corrugated Metal Webs

Generally by using profiled webs shaped, we avoid the loss of beam stability, before it's reached the plastic resistance of the web.

The sinusoidal profiled webs, have an advantage to the squared webs profiles (webs made of sheet units), because at the squared hearts profile can occur buckling of the flat portions and so the local buckling is almost completely eliminated.

The expression for calculating the shear resistance is:

$$V_{Rd} = \chi_c \frac{f_{yw}}{\gamma_{M1}\sqrt{3}} h_w t_w \qquad (1)$$

in which:

V_{Rd}= the shear strength of the web;

h_w= webs heights;

t_w= webs tickness;

f_{yw}= yield strength of the steel, for the steel type used for the web;

γ_{M1}= partial safety factor for buckling elements resistance;

χ_c= the lowest value of the reduction coefficient, applicable to local buckling $\chi_{(c,\,l)}$, and to the global value $\chi_{(c,\,g)}$

$$\chi_c = \min \left\{ \chi_{c,l} = \frac{1.1[illegible]}{0.9+\bar{\lambda}_{c,l}} \le 1{,}0 \; ; \; \chi_{c,g} = \frac{[illegible]1.5}{[illegible] + \bar{\lambda}_{c,g}^2} \le 1.0 \right\} \qquad (2);(3)$$

$$\bar{\lambda}_{c,l} = \sqrt{\frac{f_y}{\tau_{cr,l}\sqrt{3}}} \qquad (4)$$

in which:

$\bar{\lambda}_{c,l}$ = relative slenderness for local buckling;

$\tau_{cr,l}$ = critical shear stress value for local buckling;

$$\tau_{cr,l} = \left(5.34 + \frac{a_3\, s}{h\ \ t_w}\right) \frac{\pi^2 E}{12(1-\nu^2)} \left(\frac{t_w}{s}\right)^2 \qquad (5)$$

In which:

w = a half-wave length (see Figure 1);

d = a half-wave length developed (see Figure 1);

ν = coeficientul lui Poisson;

E = longitudinal elastic modulus, properly to the steel type which the web is made of (Young's modulus);

The relative slenderness for the global value is :

$$\bar{\lambda}_{c,g} = \sqrt{\frac{f_y}{\tau_{cr,g}\sqrt{3}}} \qquad (6)$$

$$\tau_{cr,g} = \frac{32.4}{t_w h_w^3} \sqrt[4]{D_x D_z^3} \qquad (7)$$

in which:

$\tau_{cr,g}$ = critical shear stress value to global buckling ;

$$D_x = \frac{E\, t_w^3}{12(1-\nu^2)} \frac{w}{s} \qquad (8)$$

$$D_z = \frac{E\, I_z}{w} \qquad (9)$$

in which:

I_z = moment of inertia of a wave of w length (see Figure 2);

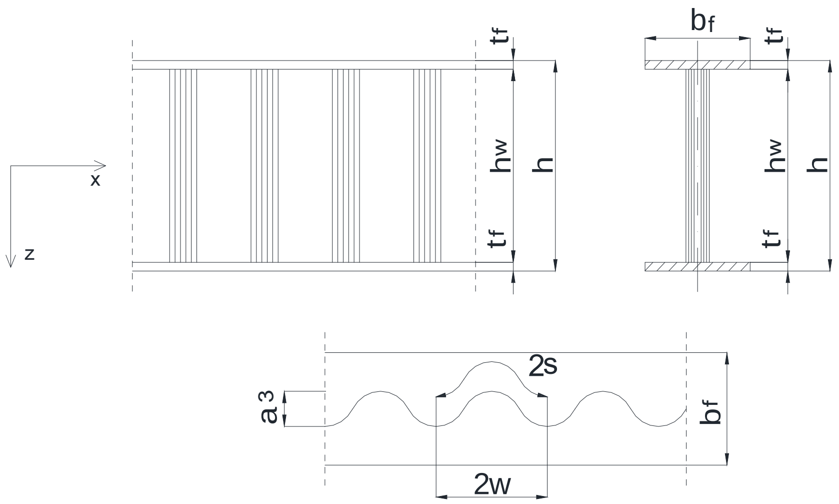

Fig.2. *The dimensions used for sinusoidal webs*

The dimensions and the shape used for manufacturing the corrugated webs of SIN profiles, produced in Romania are resented in Figure 3.

The shear resistances value, of the automated produced double T welded steel sections with corrugated webs, manufactured in our country are shown in Table 1.

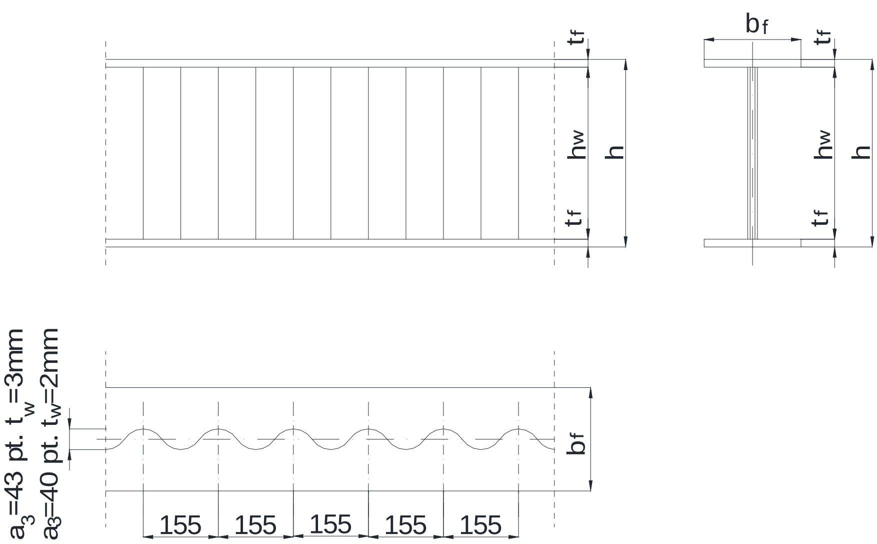

Fig. 3. *The dimensions for the sinusoidal shape webs used for automate manufactured SIN profiles*

The shear resistance of the sinusoidal hearts Table 1

		Shear resistance VRd			
Nr. Crt.	h_w	WTO t_w = 1.5 mm	WTA t_w = 2.0 mm	WTB t_w = 2.5mm	WTC t_w = 3.0 mm
	[mm]	[kN]	[kN]	[kN]	[kN]
1	333	62.9	79.7	94.6	110.7
2	500	94.4	119.7	141.9	166.2
3	625	118.1	149.5	178.7	207.8
4	750	141.7	179.5	212.8	249.4
5	1000	188.9	239.2	283.9	332.6
6	1250	236.2	299.1	348.4	415.7
7	1500	225.6	322.9	425.9	498.8

3. Conclusions

Using double T sections of welded steel thick plates with sinusoidal webs (SIN profiles) leads to low consumption of steel. This advantage is due to the fact that these profiles are higher than similar laminated I sections, and by moving away the material from the neutral axis they become more efficient and have a better behavior for bending strains.

A second reason is that by forming the web we obtain significantly increase of its resistance to buckling. It can thus be applied webs having less thickness compared to the thickness of straight webs from the laminated sections.

By keeping constant the height of the heart, over the construction elements that are intended to be realized, it may be disposed differing sections in which the thickness and / or the width feet are different.

The possibility of manufacturing variable cross sections for SIN sections brings the advantage of designing economical structures. The conic shape elements prezented in Figure 1, are frequently used for columns with articulated bases.

A disadvantage of the double T cross section steel elements with corrugated webs is that they can be manufactured only with machineries built special for this purpose. Those machineries have a large gauge and have a high acquisition cost.

Having presented in the paper all the steel types, from which there can be composed the sinusoidal webs, thicknesses, heights and the way these are shaped, we can apply the provisions regarding the estimation of their bearing capacity according to EN 1993-1-5: 2008.

The values shown in Table 1 represents the capable shear forces (V_{Rd}) of the webs made of steel type S235 for SIN profiles manufactured in Romania and it may become a convenient device for steel structures designers.

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