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STUDY ABOUT BRIDGE PLATE GIRDERS WITH VARIABLE DEPTH

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ABSTRACT

У статті наводиться порівняльний аналіз двох типів фланців сталевої двотаврової балки: перший фланець з жолобом, другий з параболічним перетином. В результаті порівняльного аналізу фланець з параболічним перерізом показав більш низьке критичне напруження і як наслідок більш високий коефіцієнт безпеки.

Article present yhe comparison between two type for haunched steel girder variable depth for bridges where the shear force different between together and the parabolic haunch has slightly lower critical stresses and, therefore, a slightly higher factor of safety.

KEY WORDS

welding, beam, critical stress, flange, parabolic

INTRODUCTION IN TYPE OF HUNCHED GIRDER

It has been pointed out* that the sloping bottom flange if the parabolic haunch has a vertical component of its compressive force and this will reduce the shear stress (τ_{xy}) in the girder web in this region. In addition, the concave compression flange produces a radial compressive stress (σ_y) in the web depending on the radius § curvature of the flange.

In contrast, the fish belly haunch provides no appreciable reduction in shear in the critical portion of the web near the support. This is because the slope of the bottom flange is small in that area. Also, the Convex compressive flange produces a radial tensile Stress (σ_y) in the web, which is greater than the radial compressive stress in the parabolic haunch. This is because of the sharper curvature of the fish belly haunch.

It is seen by observation of the Huber-Mises formula (1) that both of these factors will result in the yield criterion (σ_{cr}) having a lower value in the case of the parabolic haunch. This result compared with the yield strength of the steel (in uniaxial tension) would indicate a higher factor safety.

(Huber-Mises Formula)

$$\sigma_{cr} = \sqrt{\sigma_{x^2} - \sigma_x \sigma_y + \sigma_{y^2} + 3\tau_{xy^2}} \ldots \quad (1)$$

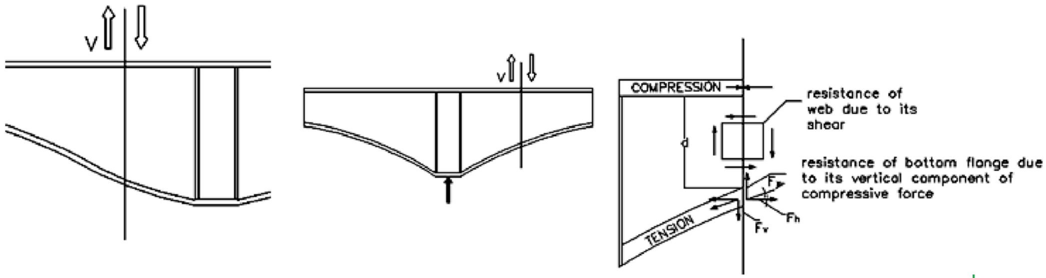

Fig. 2. Simply supported girder straight or curved bottom flange.

Haunched girders do not present much increase in cost for welded construction for longer spans. The web plates are normally trimmed by flame cutting, so that a gradual curve would add little to the cost. In most cases the curved flange plates can be added without forming; the flat flange plates are simply pulled into place against the curved web. Although the trans-verse stiffeners would vary in length, this should be no problem. The flange can still be automatically fillet Welded to the web by placing the web in the horizontal position. The portable automatic welder would then ride against the curved flange.

NEED FOR MODIFIED SHEAR FORCE VALUE

The horizontal force (F_h) in the sloping flange is equal to the bending moment at that section divided by the vertical distance between the two flanges:

$$F_h = \frac{M}{d}.$$

Or, this force may be found by multiplying the flange area by the bending stress in the flange using the section modulus of the girder. This method wall produce a more accurate value.

From this value, the actual force in the flange (F_x) may be found, as well as the vertical component (F_y) of this force:

$$F_X = \frac{F_h}{\cos\theta} = \frac{M}{d\cos\theta} \text{ and}$$

$$F_V = F_h \tan\theta = \frac{M}{d}\tan\theta.$$

This vertical component (F_v) acting along with the shear force in the web resists the external shear (V) at this section.

Modified shear is the resulting shear force in the web after the vertical component of the flange force (F_v) is subtracted or added, depending upon whether it acts in the same direction or opposite direction as the shear in the web.

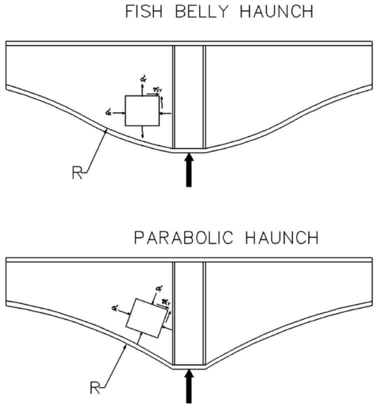

Fig. 1. Type of hunched girders for bridges.

Simply Supported Girder Straight or Curved Bottom Flange

In this case simply supported girder fish belly the vertical component is subtracted from the web shear

Here the external shear is

$$V = A_w\tau_w + \frac{M}{d}\tan\theta,$$

and the modified shear is

$$V' = A_w \tau w$$
$$= V - \frac{M}{d}\tan\theta.$$

CONTINUOUS FISH BELLY HAUNCHED GIRDER

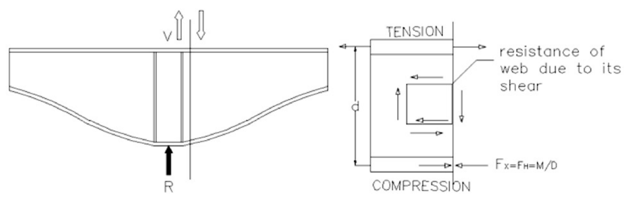

Fig. 3. Here the external shear is $V = A_w\tau$.

In this case the flange force has no vertical component, hence, there is no reduction of shear in the web.

Simply supported hunched steel girder

In this case the vertical component is added to the web shear.

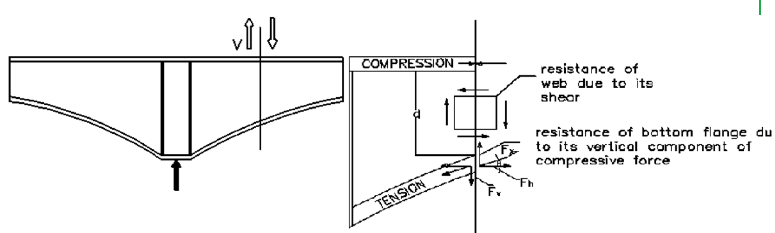

Fig. 4. Here the external shear is $V = A_w\tau_w - \frac{M}{d}\tan\theta$

and the modified shear is

$$V' = A_w \tau w$$
$$= V + \frac{M}{d}\tan\theta.$$

Continuous Parabolic hunched Girder

Here the external shear is

$$V = A_w \tau_w + \frac{M}{d}\tan\theta.$$

and the modified shear is

$$V' = A_w \tau w$$
$$= V - \frac{M}{d}\tan\theta.$$

In this case the vertical component is subtracted from the web shear

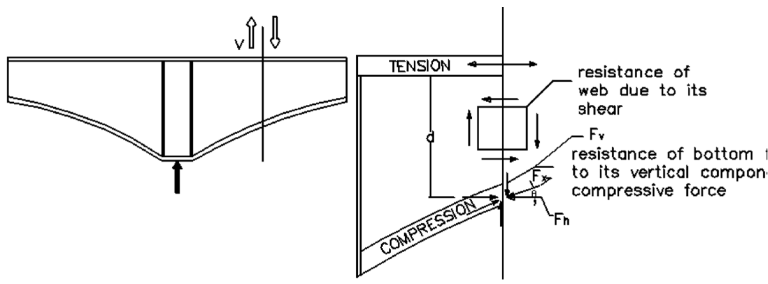

Fig. 5. Continuous Parabolic hunched Girder.

5-welds connecting slopping flange to web

In any girder, the horizontal shear force in the connecting weld between the web and the horizontal flange is found from the following formula:

$$f = \frac{V\,a\,y}{I\,n}\,lbs/in.$$

Where the flange slopes, the modified vertical shear (V') must be used. The shear component along the slope wills be

$$f_x = \frac{f_h}{\cos\theta}.$$

But the distance along this slope for every horizontal inch is $s_x = \dfrac{1''}{\cos\theta}.$

So that the shear force on the weld along this sloping flange is obtained from the above formula for the horizontal flange, using the modified value of V':

Or the approximate:

Where:

f = shear force on weld, lbs/linear in. V = external shear on the section, lbs. V' = modified shear on section if sloping flange, lbs. a = area of flange held by weld, $in.^2$ y = vertical distance between center of gravity of flange held by weld, and neutral axis of section, in. I = moment of inertia of section, in.4 n = number of welds connecting web to d = flange distance between C.J. of flanges, in.

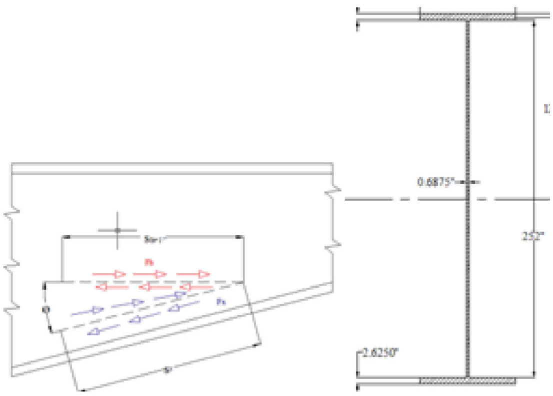

Fig. 6. Welds connecting slopping flange to web.

Procedure example for determine the deference between two type hunched

Check the hunched girder section (at point of support) shown in Figure 7, to determine the difference between the fish belly and the parabolic haunch in the area of the compression flange near the support see Figure. 1

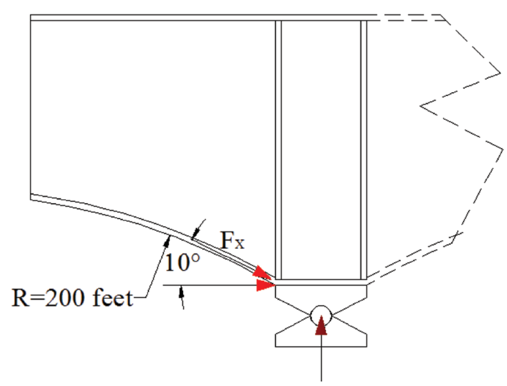

Fig. 7. Checking of the hunched girder section.

These stress in Figure 8 hand side must now be rotated 10° to line up with the sloping flange in order that the radial compressive stress may be add .this is shown on the under-hand side of figure 8.this my analysis by one of two methods :

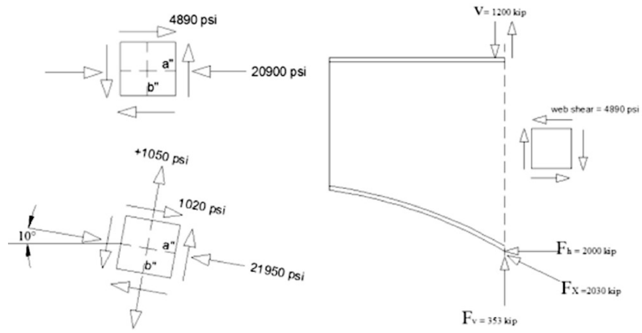

Fig. 8. Effect of stress on the sloping flange.

1- graphically, using mohrs circle of stress: Figure 9.

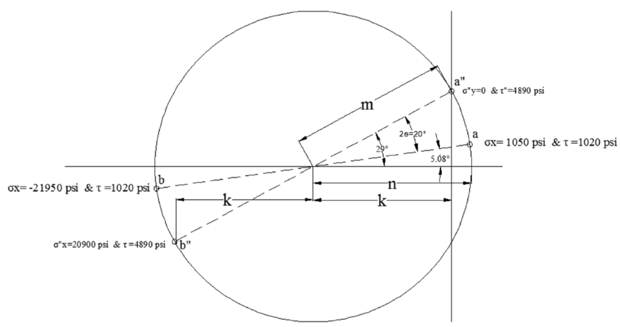

Fig. 9. Draw the given stresses (σ''_x, σ''_y, τ'') by using Mohr's circle.

A-draw the given stresses (σ''_x, σ''_y, τ'') at the two point (*a*") and (*b*"). B- construct a circle through these two points. C-rotate clock wise throught an angle of (*2θ 0r 20°*). D- read the new stresses (σ_x, σ_y, τ)

2- analytically, work is perfomed as follows:

Radial force of lower compression flange against web

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Resultate radial compressive stress in the web

This produces the final stress condition of:

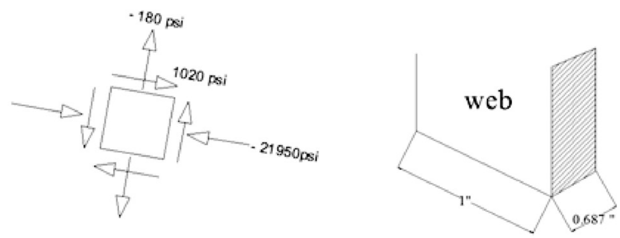

Fig. 10. Radial compressive stress in the web.

Critical stress

Using the Huber-Mises formula

This result in an indicated factor of safety against yielding

Analysis of fish belly haunch

Now using some load condition on the fish belly haunch with the same web and flange dimension:

At this point

Stress in web or lower flange from bending moment

Average stress in lower flange from bending moment

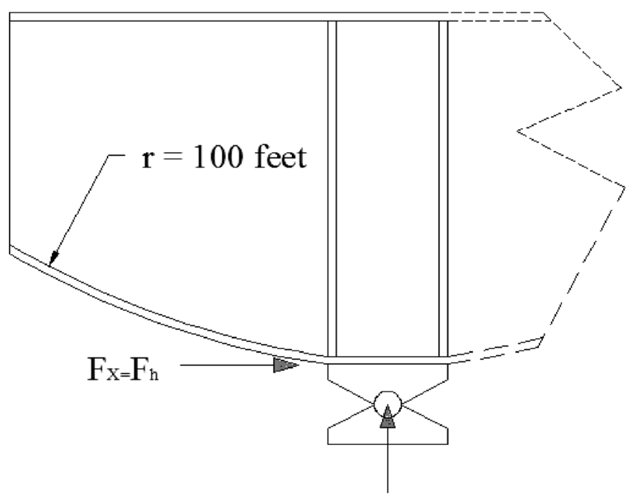

Fig. 11. Force in lower flange from bending moment.

Force in lower flange from bending moment

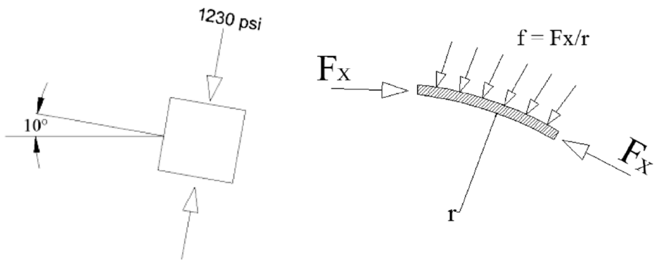

Fig. 12. Radial tensile force of lower compression flange against web.

Radial tensile force of lower compression flange against web

Combining stresses to find the critical stresses,

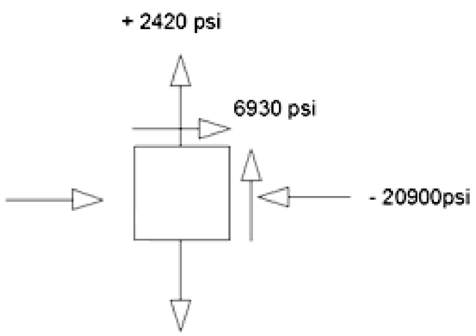

Fig. 13. Combining stresses.

using the Huber-Mises formula

This result in an indicated factor of safety against yielding of

CONCLUSION

Some difference between parabolic haunch and fish belly haunched girder in welding shear force in lower girder between lower flange and web girder and the different of value of the critical stress for two type and different between radial tensile force of lower compression flange against web as show in the following table by deepened on the last example.

So that apparent from this comparison in above table the parabolic haunch has a slightly lower critical stress and, therefore, a slightly higher factor of safety Nots.

1"=25.4mm, 1feet=12"=304.8m, 1m=39.37cm, 1ton = 2.2 kip, Kip =1000 Ib = 454.5 kg, Mpa =144.83 psi

type of haunch	critical stresses	factor of safety	radial force
Parabolic	22 000 psi	1.9	846 Ib/liner in
fish belly	25 100 psi	1.67	1670 Ib/liner in

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