Development of Software for Design of Girder

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ABSTRACT- Double girder-box type, over head cranes are used for heavy duty applications in the industry. Overhead cranes are used in many areas of industry such as in automobile plants and shipyard etc. Their design features vary widely according to their major operational specifications such as: the type of motion of crane structure, weight and type of the load, location of the crane, geometric features & environmental conditions which creates complex design procedure of crane and it is to be standardized.

Based on above discussion, design of girder is a complex task for the designer. So in the present work software is developed to calculate the final dimensions of the box type girder. This girder is designed on the based of rigidity. User has to just give the required input and the software will give the required output immediately which improves the efficiency of designer.

Keywords: Box type girder, software development, overhead crane.

1. INTRODUCTION

A box girder bridge is a bridge in which the main beams comprise girders in the shape of a hollow box. The box girder normally comprises either prestressed concrete, structural steel, or a composite of steel and reinforced concrete. The box is typically rectangular or trapezoidal in cross-section. Double girder-box type, over head cranes are used for heavy duty applications in the industry.

Single-web girders and trusses have to be checked for adequate stiffness in terms of deflection. The allowable deflections of crane bridges under vertical live load alone without allowance for overloading is given below in fractions of the span:

Hand operated bridges crane…………..1/400
Beam cranes ……………………………1/500
Electrical bridges cranes 1/600
In continuous and severer duties……...1/700
Aluminum alloy crane bridges………...1/500

Main girder or trusses of bridges with a span exceeding 17 m are given camber equal to L/1000 to avoid excessive deflection of the girder that may interfere with trolley operation under load [1].

Low-capacity cranes beam cranes in particular, have commonly rolled I-section girder proportioned so as to ensure the bottom flange to carry the trolley or hoist.

2. CRANE BRIDGES

Stiffened box girders interlinked by end carriages supported by wheels or a solid structure composed of two vertical trusses, 2 and 3, and Two horizontal ones 1 and 4. The vertical trusses 3 carrying the transverse rails on its top chord and supporting the entire mass of the trolley and hook load, is the main truss. The vertical auxiliary truss 2 running parallel to the main one is interlinked with it by the horizontal outrigger trusses 1 and 4 serving to resist horizontal loads resulting at breaking the crane. The main auxiliary trusses are attached to end carriages 5 riding on wheels. The traveling mechanism is commonly fitted to the upper outrigger truss. Torsional moments set up at the main truss are resisted by the entire solid structure consisting of the main truss, auxiliary and outrigger trusses, and end carriages.

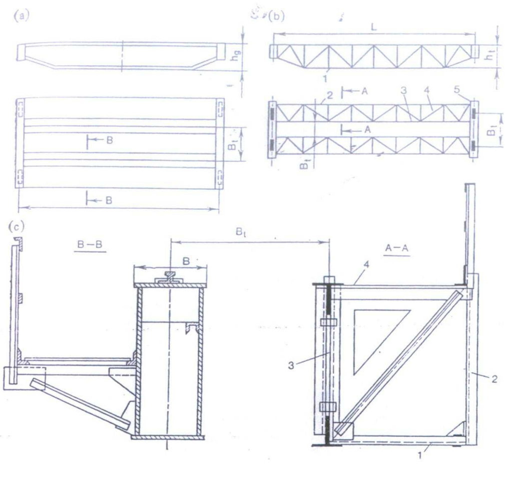

Fig. 1 Crane bridges

(a) Stiffened box girder (b)Trussed bridges
(c) Sectional views of bridges;
B_t –trolley wheel tread; L- bridge span

By virtue of this arrangement the main trusses of fourtruss bridges can be design for a lesser bending and torsional stiffness in the horizontal plane than box girder of single and double girder bridges. Not infrequently a plate girder is used as the main member of a four-truss structure.

Light gauge built-up tubular structures gain ground due to comparatively low labour required for their manufacture and low cost, the latter advantage being attributed to the use of automatic welding technique and sheet metal instead of rolled shapes. A less restricted, compared with latticed structures, transmission of the flux of forces in tubular structures provided for easing the stress concentrating at joints and adds to the reliability of the structure in resisting varying loads. However, the entire cross- sectional area of tubular structures cannot be fully utilized on low capacity installations, implying that they are effective in transmitting high loads. In these connections, holding out a special promise for bridges cranes of under 15 ton capacities are tubular structures made up of cold formed members .in fig. below. Here, the effectively shaped section alone provides for the stability of light-gauge walls, dispensing with stiffeners.

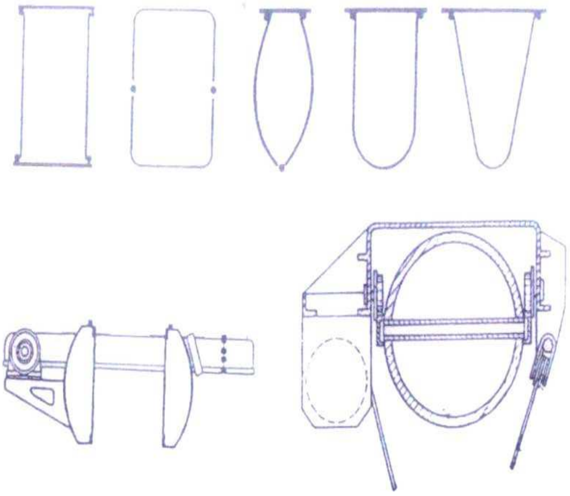

Fig.2 Tubular section girder

Met with are bridges girders with outriggers in which the auxiliary girder is a Veradale-type truss with flanged openings and the main girder is fitted with the stiffeners arranged in a saw-tooth pattern all the way down the span to provide for extra stability. The trolley is commonly of the top running type supported by the main girders. The long-travel mechanisms and cross wiring are located on cantilever platforms providing easy to access to the roll-out axle boxes of the track wheels supporting the end carriages.[2]

3. ALGORITHM OF BOX-GIRDER DESIGN

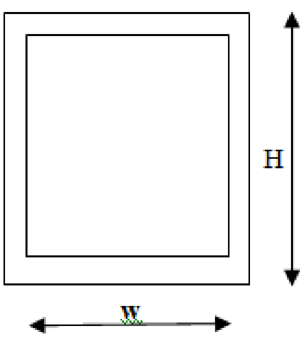

Fig . 3 Cross-section of box-girder

Step: 1 Select the Box Type of rigidity based Girder.

Step: 2 Select the Class & No. of the Girder = n.

Step: 3 Enter the Load Carrying capacity of the GIRDER =Q in N.

Span length of the Girder =L in mm.

Strength = σ_b N/mm^2

Plate thickness =t in mm.

Density of the Material = ρ kg/m^3.

Step: 4 find the Cross-section area of the Box Girder

$$A= 8Wt-4t^2 \text{……. (i)}$$

Step: 5 calculate the value of Q_s

$$Q_s = A*L*\rho*g \text{……. (ii)}$$

Step: 6 Calculate the total load on each Girder Q_t

$$Q_t = (Q/n) + Q_s \text{……. (iii)}$$

Step: 7 calculate the Maximum bending Moment.

$$M= (Qt*L)/4 \text{……. (iv)}$$

Step: 8 Calculate the Section of Modulus.

$$Z = (WH^3 – wh^3)/ (12*H/2) \text{ ……. (v)}$$

Step: 9 Bending Moment $M = \sigma_b*Z$

Find all the dimension of cross section of Girder =W, H, w, h

By using W=3H, w=W-2t

Step: 10 Calculate the Moment of Inertia.

$$I= (WH^3 – wh^3)/12 \text{……. (vi)}$$

Step: 11 Calculate the Deflection.

$$\delta= Q_t*L^3/ (48EI) \text{ ……. (vii)}$$

Step: 12 Calculate permissible deflection

$$\delta_{per} = L / 600 \text{……. (viii)}$$

Step: 13 Check condition If $\delta < \delta_{per}$ Design is safe.

4. CASE STUDY

Problem Definition: Load capacity = 50000N, Span= 10 m Class = III, Strength = 85 N/mm^2, Girder section = Box-section, No. of girder = 2 ,Plate thickness for box section =08 mm, Height to width ratio for girder section =3, Permissible deflation δ =L/600 So, find the all dimension of Box-type girder.

Solutions:

Load due to Q = 50 KN

Load on each girder = 25 KN

Load due to Self weight of the girder

Q_s= L * Area * ρ * g

= [(2 * W* t) + 2(H- 2t)*t] * 9.81*7.8*10^{-2}

= 48.97W-195.88

Now total load on each girder

Qt = Q + Q_s

= 48.97W + 24804.11 Newton

Max. Bending moment on girder

M = Q_t * L /4 = 122425W+ 62010275 N-mm

Now section modulus for cross-section of box-girder

$Z= (WH^3 –wh^3)/12*(H/2)$

By simplifying the equation we get **,**

$Z = (108 W^3 *t - 144 W^2 * t^2+ 80 W*t^3 – 16 t^4) / 18$

$= (864 W^3 - 9216 W^2+ 40960W – 65536) / 18 W$

Bending Moment

M= σ *Z

122425W+ 62010275 = σ * ((864 W^3 - 9216 W^2+ 40960W – 65536) / 18 W))

σ= ((122425W+ 62010275)*18W)/ (864 W^3 - 9216 W^2+ 40960W – 65536)

Solve equation using trial & error method

If W= 50 mm

σ= ((122425(50) + 62010275)*18(50))/ (864 $(50)^3$ - 9216 $(50)^2$+ 40960(50) – 65536)

= 739.27 N/mm^2

When W=112

σ= ((122425(112) + 62010275)*18(112))/ (864 $(112)^3$ - 9216 $(112)^2$+ 40960(112) – 65536)

= 137.83 N/mm^2

So by trial & error method W=146

σ= ((122425(146) + 62010275)*18(146))/ (864 $(146)^3$ - 9216 $(146)^2$+ 40960(146) – 65536)

= 83.65 N/mm^2

Value of σ is 83.85 N/mm^2 which is nearest to the 85N/mm^2

So W=146 mm

Now other dimension of girder

H= 3*W =3 * 146 = 438 mm

w= (W-2*t) = (146-16) = 130 mm

h= (H – 2*t) = (438-16) = 422 mm

Now all dimension of girder

W=146 mm	w= 130 mm
H= 438 mm	h= 422 mm

Now moment of inertia of a girder :-

I = (WH^3 –wh^3)/12

= 1020407433 mm^4

Total load on each girder = Q + Q_s

= 48.97W + 24804.11

= 31953.73 Newton

Now deflection on girder due to total load considering simply supported beam.

δ = W L^3 / 48 * E *I

= 14.90 mm

Now permissible deflection of girder,

δ_{per} = (L / 600)[1]

=16.66 mm,

$\delta < \delta_{per}$

So design of girder is safe in rigidity.

5. FEATURE OF THE SOFTWARE

There are number of feature of this software. The original manual calculation for the design of girder is very complex so with the help of the software it became a simple. With the help of the software we can obtain error less result & save the time. With the help of the software we can compare the design easily for different material & also for the different parameter while manual calculation is very complex and time consuming. The software provides flexibility to the users, easy to understand & user friendly. This software provides facility to check if the developed design is safe or not and if design is not safe so, according to we can also change material property and get the safe design.

6. DEVELOPED SOFTWARE FOR BOX-TYPE GIRDER DESIGN

For the development of the software it is necessary to convert the equation in the W form mentioned below:

a = (((72 * (w ^ 2) * t) - (36 * w * (t ^ 2))) * (n * (l ^ 2) * d * 9.81)) + (ql * l * 9 * w)

b = ((108 * (w ^ 3) * t) - (144 * (w ^ 2) * (t ^ 2)) + (80 * w * (t ^ 3)) - (16 * (t ^ 4))) * (2 * n)

Result = a / b

From the above mentioned parameters the software is developed.

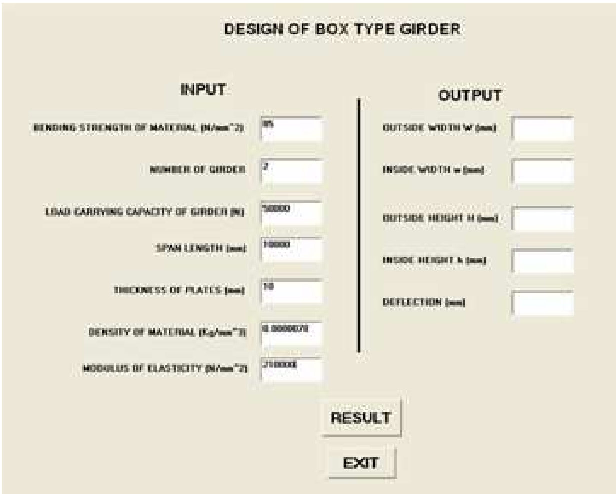

Fig .4 Input of software

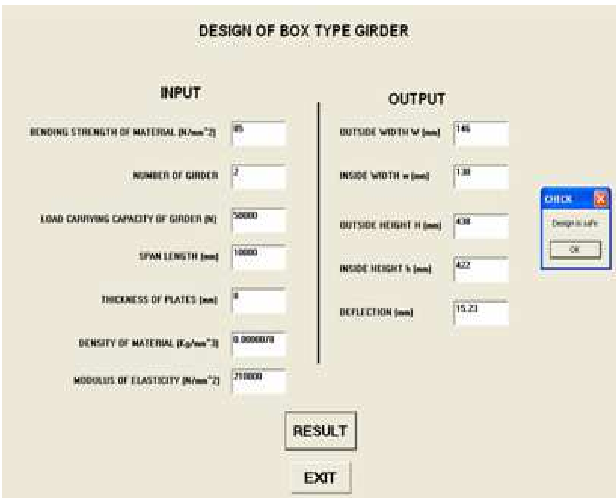

Fig. 5 Output of software

7. CONCLUSION

1. The original manual calculation for the design of girder is very complex but if the box type girder is designed with the help of this software lot of time can be saved and quick output can be obtained.
2. Errorless result also is obtained with this software.
3. While it is not possible to compare for different material property if one is making calculations manually. But while running this software one can compare for different material properties easily.
4. While it is not possible to compare for various plate thickness if one is making calculations manually. But while running this software one can compare for various plate thickness easily.
5. The software provides flexibility to the users.
6. It is very user friendly and easy to understand.
7. This software provides facility to check if the developed design is safe or not.

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