Comparison of Steel Beams

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Abstract - *In our Project the Comparison Between Castellated Beam and Cellular Beam is carried out by different test. A concentrated load or reaction point applied directly over a web-post cause this failure mode, such a failure mode could be prevented if adequate web reinforcing stiffeners are provided.in castellated beam we have to use hexagonal, Square opening and cellular has to kept circular web.*

Use of Castellated beam for various structure rapidly gaining appeal. This is due to increased depth of section without any addition of weight, high strength to weight ratio, their lower maintenance and painting cost. A castellated beam has some limitation also Stress concentration occurs near the perforation and the shear carrying capacity is reduced. Stress concentration may be reduced by making perforation near the neutral axis where the stresses are small and making the cut in zig-zag manner.

Key Words: structural, castellated beam, FEA.

1. INTRODUCTION 1

The primary advantage of castellated beams is the improved strength due to the increased depth of the section without any additional weight. However one consequence of the increased depth of the section is the development of stability problems during erection. To fully utilize the engineering advantage of castellated beams, erection stability must be considered.

The resistance of castellated beams is frequently controlled by shearing forces. These forces may cause excessive stresses in the tee-sections above and below the holes excessive stresses at mid-depth of the web-post between holes or web-buckling involving the web-post.

The disadvantage was that the instability modes identified could be associated with bifurcation or to in-plane yield, and it was not always clear which. Furthermore, the intensive computational work made it difficult to obtain general results. Subsequent examination suggests that the response in many cases can be expected to be primarily elastic, and in view of the possibility that elastic analysis can be used to obtain general results. Tests of a number of castellated beams were reported in the same reference. These beams contained from six to twelve holes and were loaded by a central concentrated load, thus creating a uniform shear span containing several holes.[1]

2.PROBLEM DEFINITION 1

This new type of beam showed a mechanical behavior similar to that of isolated rectangular openings mainly regarding the Vierendeel bending . However, unlike rectangular or hexagonal openings where the critical sections are in the corners, it is not easy to define the position of the critical section around circular openings . Numerous investigations and especially the work of Ward based on finite element study provided substantial results that were used to develop a reliable design method to check the resistance of cellular beams with circular openings. The method proposes to check incrementally all the inclined sections around the opening starting from the straight section at the mid span of the opening. Then, the internal load of each inclined tee section is compared to its resistance as shown in where VEd and MEd are the global shear force and bending moment. Moreover, several works on castellated and cellular beams showed a new local failure mode due to the buckling of the intermediate web-post. This failure mode is observed for closely spaced openings and slender profiles.[2]

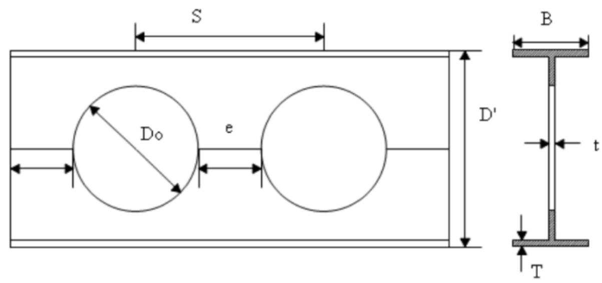

Fig – 2: Problem Definition

3.CASTELLATED BEAM 1

A) Terminology

Throughout this paper various terms will be used to discuss castellated beam components and testing results. This section introduces the reader to the definition of these terms and Figure 1.4 illustrates the terms.

- Web Post: The cross-section of the castellated beam where the section is assumed to be a solid cross-section.
- Castellation: The area of the castellated beam where the web has been expanded (hole).
- Throat Width: The length of the horizontal cut on the root beam. The length of the portion of the web that is included with the flanges.
- Throat Depth: The height of the portion of the web that connects to the flanges to form the tee section.
- Expansion Percentage: The percentage change in depth of the section from the root (original) beam to the fabricated castellated section.

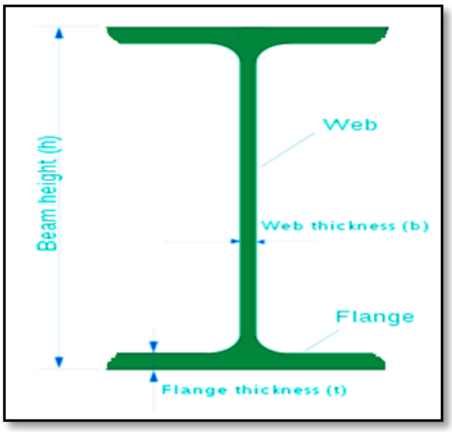

Fig – 1: Terminology

B) Fabrication Of Castellated Beam And Cellular Beam

Fabrication of castellated beams is a comparatively simple series of operations when adequate handling and controlling equipment is used. Structural Steel by burning two or more at. a time, depending upon their depth. Splitting is performed by using a component of the oxy-acetylene gas cutter equipment shown in fig.5.1 This is an electrically propelled buggy which runs on a fixed track. The buggy has building burning patterns that can be adjusted to any one of live standard longitudinal "module" dimensions and to any hall-opening height.

Castellated steel beams fabricated from standard hot-rolled I-sections have many advantages including greater bending rigidity, larger section modulus, optimum self-weight–depth ratio, economic construction, ease of services through the web openings and aesthetic architectural appearance. However, the castellation of the beams results in distinctive failure modes depending on geometry of the beams, size of web openings, web slenderness, type of loading, quality of welding and lateral restraint conditions. The failure modes comprise shear, flexural, lateral torsional buckling, rupture of welded joints and web postbuckling failure modes.[2]

C) Design Of Cellular Beam

1) Guidelines for web perforations

The limits of applicability are:

a) $1.08 < S/D0 < 1.5$

b) $1.25 < D/D0 < 1.75$

Where S= centre /centre spacing, Do= Diameter of opening, D= Total depth of beam

2) Ultimate limit state:

To check the beam for the ultimate limit state condition, it is necessary to check the overall strength of the beam the strength of its elements. The following checks should be carried out:

a) Overall beam flexural capacity.

b) Beam shear capacity (based on the reduced section)

c) Overall beam bucking strength.

d) Web post flexure and bucking.

e) Vierendeel bending of upper and lower tees.

3) Overall beam flexural capacity:

The maximum moment under factored dead and imposed loading, Mu should not exceed Mp, where Mp is calculated as follows:

$Mu \leq Mp = ATee\ Py\ h$

Where ATee =area of lower Tee, Py =yield stress of steel,

h = distance between centroids of upper and lower tee.

4) Beam shear capacity:

Two modes of shear failure should be checked. The vertical shear capacity of the beam is the sum of the shear capacities of the upper and lower tees. The factored shear force in the beam should not exceed Pvy where:

Pvy = 0.6 x Py (0.9 ∑ area of webs of upper and lower tees)

In addition, the horizontal shear in the web post should not exceed Pvh where:

Pvh = 0.6 x Py (0.9 x minimum area of web post)
Horizontal shear is developed in the web post due to the change in axial forces in the tee.

5) Interaction of axial and high shear forces
In BS 5950 part 1 clause 4.2.6, the interaction between axial forces (or bending moment) and shear in the web of beam is based on a linear reduction of axial or bending capacity for forces exceeding 0.6 Pv. It follows that as the shear force given above approaches Pv, the axial or bending capacity of the web portion of the web tee reduces to zero.. This interaction may be taken into account by modifying the web thickness depending on the shear force resisted by the web.

6) Overall beam buckling strength:
To assess the overall buckling strength of a cellular beam, it is recommended that beam properties are determined at the centre line of the opening and that lateral torsional buckling strength is then determined in accordance with BS 5950: part 1, section 4. If the compression Flange is restrained sufficiently, this check may not be necessary.

7) Web post flexural and buckling strength
The web post flexural and buckling capacity should be checked using the equation.
8) Vierendeel bending of upper and lower tees:
The critical section for the tee should be determined by using one the methods as described by Olander's or Sahmel's approach. The combined forces in the tee should be checked as follows:

$$Po/Pu + M/Mp \leq 1$$

Where Po and M are forces and moments on the section at an angle θ from vertical.
Pu = area of critical section x Py and Mp = plastic modulus of critical section x Py for plastic sections Or Mp = elastic section modulus of critical section x Py for other sections The value of Mp depends on section classification.

9) Serviceability limit state
To ensure an adequate design, the secondary deflections occurring at the opening should be added to the primary deflections due to overall bending of the beam. The total deflection of the beam is found out by summation of deflection due to shear in tee and web post and bending in tee and web post for each opening. The shear force leads to additional deflections. [3].

D) Design Of Castellated Beam
1. The angle of cut is selected to be 45°. For a good design the depth of stem of the t-section at the minimum beam cross-section should not be less than by 4 of the original beam section.
2. The load over the section from the roof are a curtained and the maximum bending moments are computed.
3. The cross sectional area of the t-section at the open throat is calculated. Neutral axis of the section is determined and moment of inertia about the neutral axis is calculated.
4. The moment of resistance of the castellated beam which is the product of the resultant tensile or compressive force and the distance between the centroid of T-section is calculated.

$$M.R.= A \times \sigma at \times d$$

Where A = area of the T section at open throat
D = distance between the centroid of T section
The moment of resistance of the castellated beam should be more the maximum moment.
5. The spacing of castellated beam should not exceed the spacing determined by following equation

$$S = P/ W \times l$$

Where S= c/c distance between the castellated beam in meter.
P = net load carrying capacity in N
W = design load in N / m2
l = span of the in meter
6. Stiffeners are designed at the supports and below the concentrated loads .
7. The beam is checked in shear . The average shear at ends is calculated from following equation

$$\tau va = R/d' \times t$$

< 0.4 fy
Where R = end reaction in N
d' = depth of the stem of T section
t = thickness of stem
8. The maximum combined local bending stress and direct stress in T Segments is also workout and should be less than the permissible bending stress.
9. The maximum deflection of T Segment is calculated. This occurs at the mid span is due to the net load carrying capacity load capacity.
Let, δ1 = deflection due to net load carrying capacity
δ 2 = deflection due to local effects
I = average moment of inertia of the section
IT = moment of inertia of T section
P = number of perforation panels in half span

$$\delta 1 = \frac{5 \quad WL3}{384 \quad EI}$$

$$\delta 2 = \frac{VavgP(m+n)3}{24EIT}$$

$$\delta = \delta 1 + \delta 2 < L/325$$

4.CONCLUSIONS

From the test analysis result of this Study the following Conclusion can be reasonably drawn-

1)The composite moment of inertia of the castellated beam section as found in catalogs.

2)The castellated beam section properties should be usrd to calculate the flexure strength of castellated beam.

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