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Review Paper on Castellated Beam in Pre-Engineered Building

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ABSTRACT

Castellated beam is new concept in Civil Engineering filed. This system was started from 1849 to enhance the bending moment of the beam. After World War II, there is shortage of steel for this reason this beam is adopted for increasing strength of beam. In 1950 there is also advancement in this system firstly opening was provided in hexagonal pattern but from 1950 it was provided in circular pattern and these beam is called as cellular beam. The global steel industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. Consequently efforts have been made in the steel industry to use waste materials as steel beam for structure. Castellated beam is section in which increase width of section without increasing the self-weight of section. From which we can manufacture more width of section without damaging to the atmosphere.

Keyword- Castellation, Pre-engineered.

I. Introduction

Castellated beam is defined as the increasing depth of beam without increasing the self weight of section. In this process I steel section should cut in hexagonal pattern and the welded one part on another part to increase the width of the section. Due to increase in depth the deflection of beam get reduced. This is very beneficial for pre-engineered structure. Pre-engineered building started from 1960. In this system I section are manufactured by welding steel plate on each other. Due to this manufacturing we can manufacture section according to our requirement.

A castellated column is fabricated from a standard steel I-shape by cutting the web on a half hexagonal line down the center of the column. The two halves are moved across by one spacing and then rejoined by welding. This process increases the width of the column and hence the major axis bending strength and stiffness without adding additional materials. Due to the opening in the web, castellated column is more susceptible to lateral-torsional buckling. The main benefit of using a castellated column is to increase its buckling resistance about the major axis. However, because of the openings in the web, castellated columns have complicated sectional properties, which make it extremely difficult to predict their buckling resistance analytically.

II. Technical parameters of PEB

Pre Engineered Buildings are custom designed to meet clients requirements. PEBs are defined for definite measurements. The produced members fit to the designed dimensions. Measurements are taken accurately for the requirements.

The basic parameters that can define a PEB are

1. Width or Span of Building The centre to centre length from one end wall column to the other end wall column of a frame is considered breadth or span of the building.
2. Length of Building The length of PEB is the total length extending from one frontend to the rear end of the building. The length of PEB can be extendable in future.
3. Building Height Building height is the eave height which usually is the distance from the bottom of the main frame column base plate to the top outer point of the eave strut. When columns are recessed or elevated from finished floor, eave height is the distance from finished floor level to top of eave strut.
4. Roof Slope This is the angle of the roof with respect to the horizontal. The most common roof slopes are 1/10 and 1/20 for tropical countries like

India. The roof slope in snowfall locations can go up to 1/30 to 1/60. Any practical roof slope is possible as per customers' requirement.

Photo 1 Pre-engineered building.

III. Terminology in castellated beam

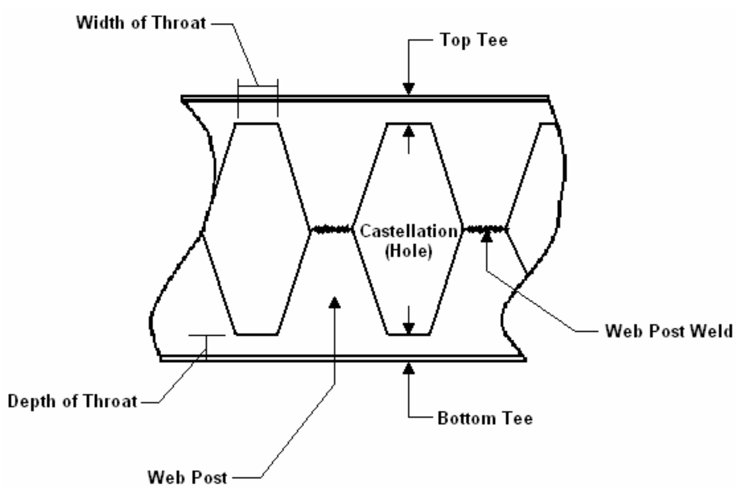


Photo 2 Component part of castellated section

1. Web Post: The cross-section of the castellated beam where the section is assumed to be a solid cross-section.
2. Castellation: The area of the castellated beam where the web has been expanded (hole).
3. 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.
4. Throat Depth: The height of the portion of the web that connects to the flanges to form the tee section.
5. Expansion Percentage: The percentage change in depth of the section from the root (original) beam to the fabricated castellated section.

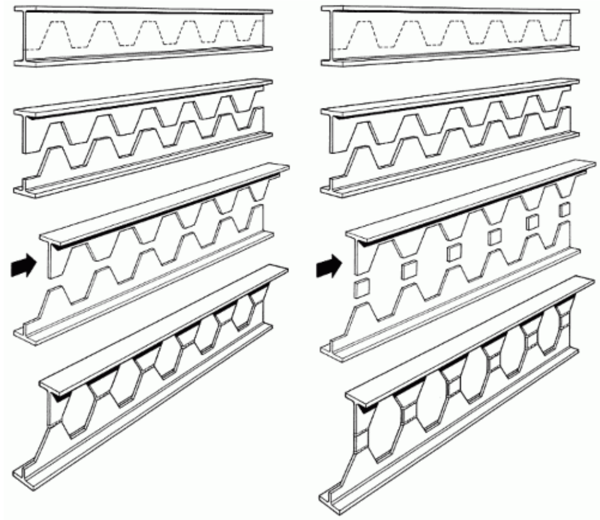
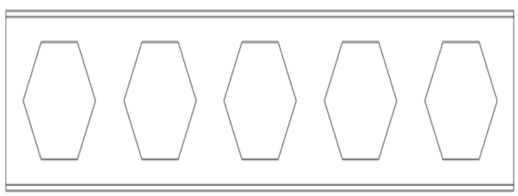


Photo 3 Fabrication Process of a Castellated beam

IV. Type of castellated beam

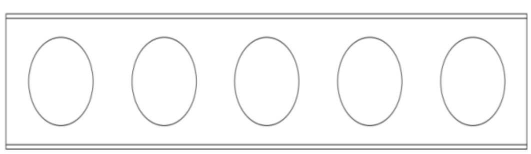
1. Hexagonal beam

In the hexagonal castellated beam the opening is provided 45' or 60'angle



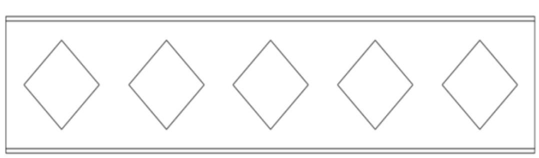
2. Cellular beam

The use of cellular beam, with regularly spaced circular openings, increases in steel construction. Those beams are made from hot rolled profiles and provide for an equivalent weight of steel higher mechanical performances compared to the parent standard profile. Cellular beam carried more load as compare to other castellated beam due to there is no any corner in the cellular beam. But in the cellular beam there is some material wastage due to this reason the cellular beam is uneconomical as compare to other type.



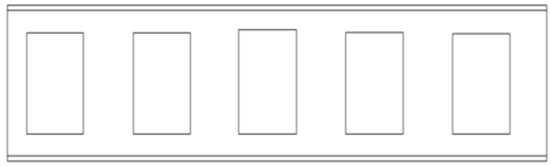
3. Diamond shape castellated beam.

The Diamond shape castellated beam is a new version of castellated beam which achieve by the diamond cutting pattern. The failure chances of this type of beam are less as compare to square castellated beam. The corners of this beam are at the centre of beam that is load axis and corners are at same position. There is no any material wastage as compare to cellular beam.



4. Square castellated beam

In square type of castellated beam due to the number of corner the failure chances are more as compare to other type of castellated beam.



V. Design criteria of Castellated Beam

Design criteria:

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 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 of compressive force and the distance between the centroid of T-section is calculated.

$$M.R.= Ax\sigma_{at}\ xd$$

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.

$$S = P/Wx1$$

Where S= c/c distance between the castellated beam in meter.
P= net load carrying capacity in N
W= design load in N/m^2
I= 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

τ_{va} = R/d'x 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,δ_1= deflection due to net load carrying capacity
δ_2= deflection due to local effects
I= average moment of inertia of the T section
I_T= moment of ineria of the T section
P= number of performance

$$\delta_2 = \frac{5\,WL3}{364\,EI}$$

$$\delta_2 = \frac{V_{avg}\,p(m+n)3}{24E\,I_T}$$

$$\delta = \delta_1 + \delta_2 < L/325$$

VI. Advantages of Castellated beam in Pre-Engineered Building

1. Increased load caring capacity of the section.
2. Reduced deflection of section.
3. Construction time: PEB reduces the total construction cost by the least 40% which leads to faster occupancy and early revenue.
4. Lower cost: Saving is accomplished in design, manufacturing and erection cost.
5. Large clear span: In PEB the buildings can be given up to 90m clear spans which is the important advantage of PEB with column free space.
6. Flexibility of expansion: PEB can be easily expanded in length by adding additional bays.
7. Quality control: PEB's are manufactured under controlled conditions depending on the site and hence the quality is assured.

VII. Conclusion

From the above studied it is concluded that the load caring capacity for pre-engineered building can be increase by castellation process. This method is also economical in the civil engineering field.

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