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Research on Structural Behavior of Concrete Encased Steel Castellated Beam for Different Sections

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ABSTRACT--- This paper study about the analytical behaviour of Concrete beam encased with Steel castellated beam as composite member with various web opening section of the castellated beam as optimization of section by its maximum Load carrying capacity and deflection. The modelling and Finite Element Analysis was done using Ansys Workbench 16.2. The Concrete beam having section size of 150mm x 170 mm x 1500mm encased with Structural Steel ISMB100 of span 1400mm is used for castellated beam for various shape of web opening are provided. The parametric study has shown the Deflection and Load carrying capacity of the various cross sectional beams with Hexagonal opening (inscribed in the circle 25mm radius) which has high load carrying capacity and the less deflection while compared to the other sections of circular web opening (25mm radius), hexagonal wide web opening (25mm with 1:1:1 web ratio), and rectangular web opening of (25mm x 50mm). Alternate incremental loading is applied by using Ansys workbench 16.2 and results and graphs are plotted.

Keywords: Composite Beam, Castellated Beam, finite element analysis, web opening, circular web opening, hexagonal web opening, rectangular web opening, hexagonal wide web opening.

I. INTRODUCTION

In construction industry composite structures are widely used. In general concrete is high in compression strength and steel is high in tension strength. In composite construction the steel and concrete combined in such a fashion that the advantages of the both the materials are used effectively. In the composite member like steel encased i-section in increases the fire resistance and also it will increase the load carrying capacity of the section.

A castellated beam is a beam where I section is subjected to a longitudinally cut along its web followed in a specific pattern in order to divide it, and design the beam with a higher depth of web will be advantage while cutting. Castellated beam has a regular pattern of holes (circular, hexagonal or octagonal) in its web and made from hot rolled section, which is first divided by a lengthwise cut into two halves following a special pattern, then welded together to increase its depth. Sometimes additional flats are used between two web cuts for even further deeper section. Special pattern can even generate tapered beam, where depth of the beam will gradually increase along the length of the beam.

II. MATERIAL PROPERTIES IN ANSYS

A. Material Properties

Table 1. Properties of Concrete

Modulus of Elasticity	22360 N/mm^2
Poisson Ratio	0.15
Compressive Yield Strength	20 N/mm^2

Table 2. Properties of Hot Rolled Steel

Modulus of Elasticity	2x10^5 N/mm^2
Poisson Ratio	0.3
Yield Strength	310 N/mm^2

B. Modelling and Meshing

The modelling is done using AutoCAD 2016 as a 2D element. The thickness is assumed very smoothly over the area of the element. It was then imported in the DESIGN MODELLER of ANSYS 16.2 for the verification of the solid element. Then the ANSYS STATIC STRUCTURAL was opened to mesh the element. It was found that the good stimulation results could be obtained by using the element (mesh) in medium size respectively.

C. Specimen Detail

Table 3. Specimen Detail

Beam	150 x 170 mm
I Section - Hexagonal opening	25 mm inscribed in circle
I Section-Hexagonal wide opening	25 mm wide (1:1:1)
I Section-Circular opening	25 mm Radius
I Section-Rectangular opening	25 mm x 50 mm

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D. Boundary Condition And Loading

Concrete Beam of 150mmx170mmx1500mm encased with castellated beam of hexagonal opening 25mm, hexagonal wide open of 25mm, circular opening 25mm radius, rectangular opening of 25mm x 50mm were modelled for a length of 1500mm and the boundary conditions were modelled and analysed for the load carrying capacity. The end of the specimens were simply supported. The specimen were loaded at its mid-span till failure and the results were obtained by linear analysis. Step loaded form 20 kN to 600 kN.

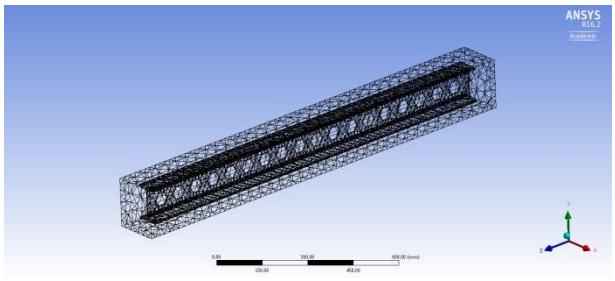

Fig 1. Mesh of hexagonal opening

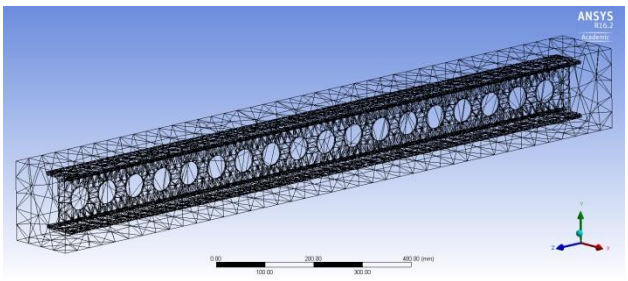

Fig 2. Mesh of rectangular opening

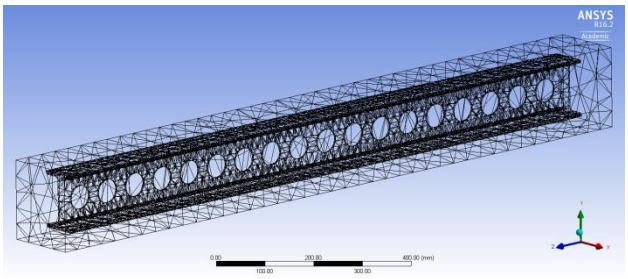

Fig 3. Mesh of circular opening

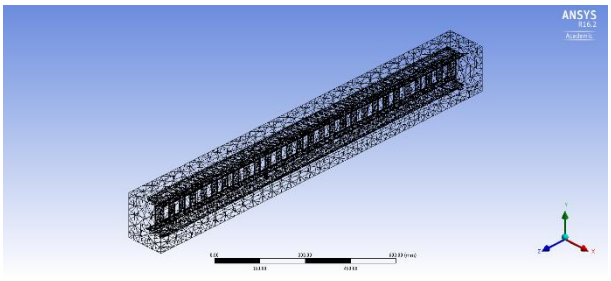

Fig 4.Mesh of hexagonal wide opening

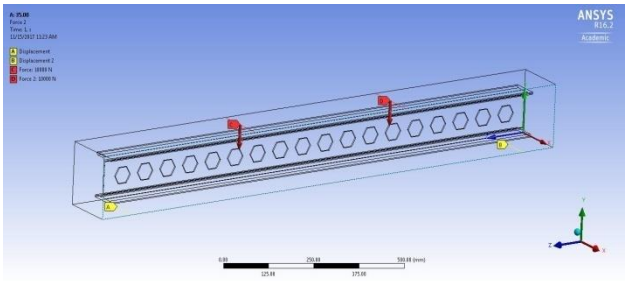

Fig 5. Loading and support conditions

III. NUMERICAL INVESTIGATION

The concrete encased steel castellated beams of various openings are numerically analysed in transverse two point loading at the mid span with simply supported condition. Loading was given till the failure. The vertical deformation, maximum principal stress maximum principal strain by calculating using ANSYS 16.2 linear analysis is done and the obtained results were given below.

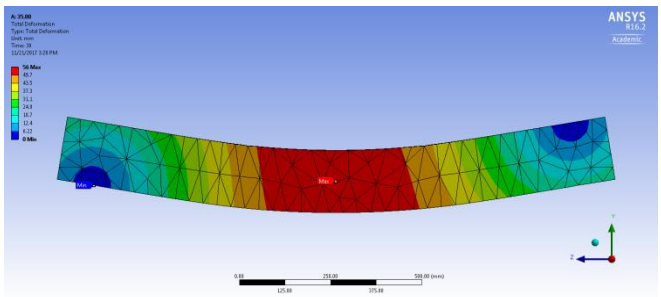

Fig 6.Total deformation for hexagonal web opening

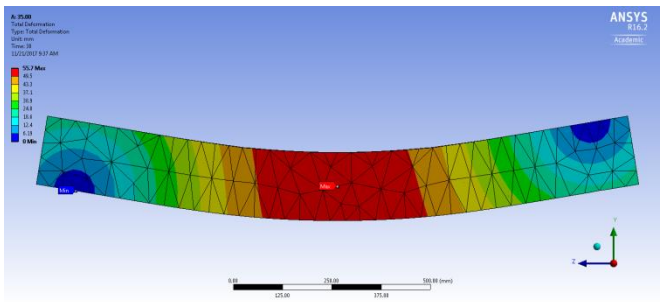

Fig 7.Total deformation for wide hexagonal web opening

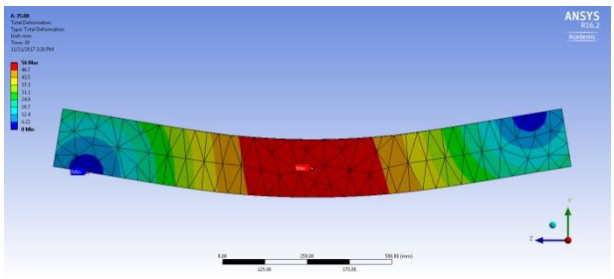

Fig 8.Total Deformation for circular web opening

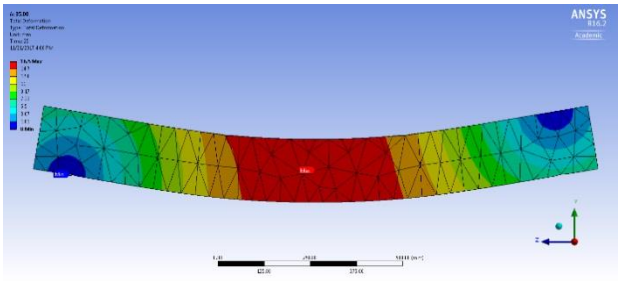

Fig 9.Total Deformation for rectangular opening

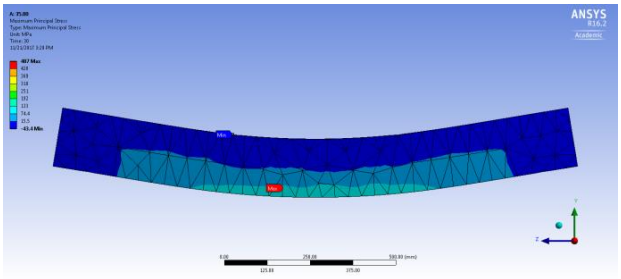

Fig 10.Maximum principal stress for Hexagonal web opening

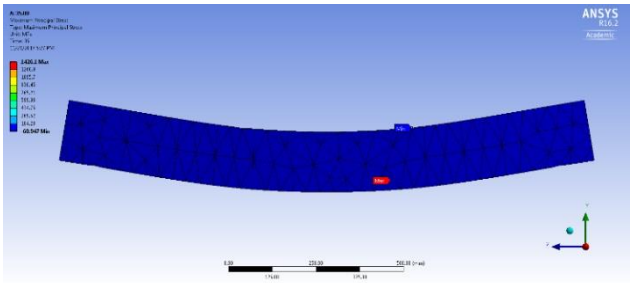

Fig 11.Maximum Principal Stress for circular web opening

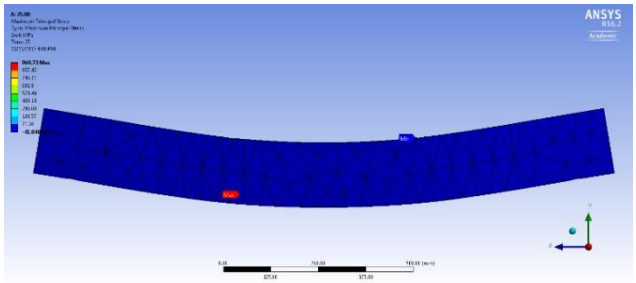

Fig 12. Maximum Principal Stress forRectangular web opening

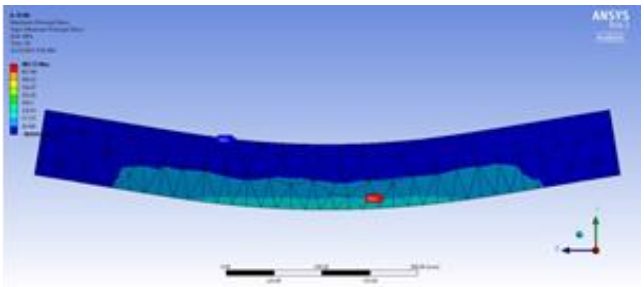

Fig 13. Maximum Principal Stress for wide hexagonal web opening

Table discussion of results:

DESCRIPTION	ULTIMATE LOAD (kN)	DEFORMATION (mm)	STRESS (N/mm^2)	STRAIN
HEXAGONAL OPEN 25 mm	545	45.620	460.01	0.004455
RECTANGULAR OPEN OF 25mm	260	7.5954	460.50	0.002318
CIRCULAR OPEN OF 25 mm	545	47.867	460.68	0.004444
HEXAGONAL WIDE OPEN25 mm	280	7.6801	460.50	2.31E-03

Fig 14. Stress strain curve of hexagonal opening 25 mm

Fig 15. Stress strain curve of hexagonal wide opening

Fig 16.Stress strain curve of hexagonal opening 25 mm

IV. RESULT AND DISCUSSION

DISCUSSION ON STRESS AND STRAIN INTENSITY

Fig17. Stress strain curve of rectangular opening 25mm

COMPARISON ON LOAD AND DEFLECTION

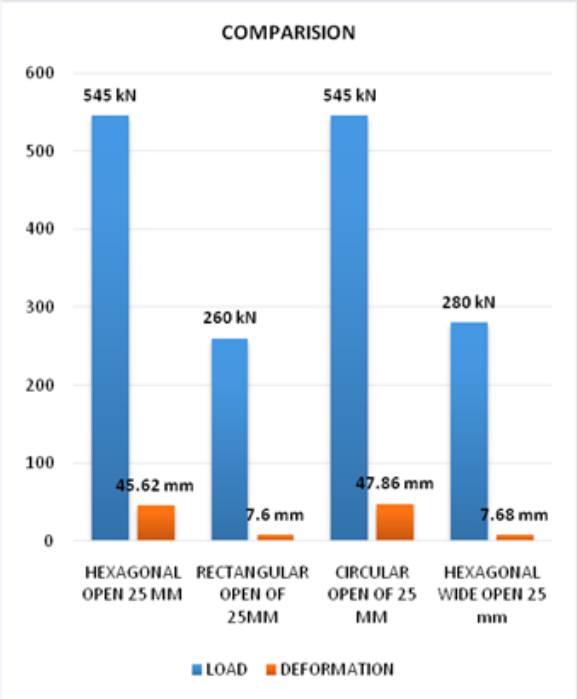

Fig 18. Comparison on Load and Deformation

V. CONCLUSION

From the results the following conclusions are made,

- Deflection is less in hexagonal opening of 25 mm while compared to the other sections.
- During Castellation process, the wastage is reduced compared to the circular sections which has an equivalent load carrying capacity.
- Load carrying capacity is higher when compared to usage of other sections like rectangular and hexagonal wide open, but equivalent load carrying capacity of circular sections.
- Using of castellated beam as composite the size of the depth of the beam can be reduced and it can used for long span and economical.
- It is concluded that, by selecting the hexagonal opening of 25 mm is more effective as mentioned above.

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