COMPARATIVE ANALYSIS OF CONVENTIONAL TRUSS SYSTEM AND CELLULAR BEAM SYSTEM

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ABSTRACT

The conventional roof truss system is time consuming for construction also difficult for maintenance and a huge vertical space is made idle in truss geometry, it is combustion for utility services as well. Use of castellated beam for various structures rapidly gaining appeal, this is due to increased depth of section without any additional weight, high strength to weight ratio, their lower maintenance and painting cost. The principle advantage of castellated beam is increase in vertical bending stiffness, ease of service provision and attractive appearance. The study is related to the comparison between conventional truss system and the cellular beam system and which system is better in economy as well as suitable for the structure is find out. Economy is the main objective of this study involving comparative study carried out between conventional Howe truss and different cellular beam systems which can be design and analyzed by using SAP2000 Software. This study is carried out to determine the percentage economy and the percentage weight achieved by cellular beam system over conventional truss system. For the analysis shed having length 44m and spans 10m, 15m and 20m has been taken. The study reveals that the spine cellular beams are significantly better in economy as compared to conventional truss system.

Keyword: - *Conventional truss, Castellated beam, Cellular beam, Economy, Spine cellular beam.*

1. INTRODUCTION-1

Any building structure used by the industry to store raw materials or for manufacturing products of the industry is known as an industrial building. Industrial buildings may be categorized as Normal type industrial buildings and Special type industrial buildings. The industrial building can be constructed by using conventional truss structures or by using cellular beam structures. Trusses are triangular frame works in which the members are subjected to essentially axial forces due to externally applied load. Trusses are used in roofs of single storey industrial buildings, long span floors and roofs of multistory buildings, to resist gravity loads. Over years, it is observed that the roof truss system is time consuming for construction also difficult for maintenance and a huge vertical space is made idle in truss geometry, it is combustion for utility services as well. Therefore A new option can be thought to replace the truss system by spine cellular, castellated beam and tapered cellular beams. Castellated or cellular beams are the beams which has openings in its web portion. The provision of beams with web openings has become an acceptable engineering practice, which will eliminates the probability of a service engineer cutting holes subsequently in inappropriate locations. Castellated beam is the latest development in the conventional beam which fulfills the desired requirement. Due to their design and constructional advantages, engineers are increasingly utilizing castellated beams in their design. Design advantages include a reduced weight per unit length of beam and improved flexural stiffness (lateral section modulus).Constructional advantages include the ability to run utilities through opening. This study is carried out to determine the percentage economy and the percentage weight achieved by cellular beam system over conventional truss system.

2. LITERATURE REVIEW-2

A substantial research work has been done and is going on the analysis of trusses and cellular beams. The research work done by various researchers in discussed here in brief.

Saju and George [5] in this study, Buckling analysis of the web post as a failure mode of castellated beam has been studied and concluded that cellular beam is best for structural applications. Wakchaure and Sagade [6] Paper includes the beams with increase in depth are then compared with each other and with parent section for various parameters and for serviceability criteria, And concluded that the Castellated steel beam behaves satisfactorily with regards to serviceability requirements up to a maximum web opening depth of 0.6h. Patil and Kumbhar [9] in this paper, an attempt has been made to review existing literature, concerned with strength of beam using stiffeners. The literature survey indicates that use of stiffeners in web portion of castellated beams helps in increasing the strength and also minimizing the deflection. Mohan and Prabhakaran [11] In this paper, finite element analysis was performed to compare the deflection of steel beam with and without web openings of ISMB 150 section, Results showed that the castellated beam with hexagonal opening showed more load carrying capacity and lesser deflection compared to solid beam and steel beam with circular opening (cellular beam).

2.1 Objectives-1

- To study the suitability of spine cellular beam structure against conventional howe truss structure for 10m, 15m 20m span.
- To compare spine cellular beams with spine castellated beams for shear stresses and bending stresses.
- To compare spine cellular beam with tapered cellular beams for shear stresses and bending stresses.
- To study the effect of shape of opening on analysis.
- To study the effect of depth of opening as well as beam with varying depth on analysis.

3. METHODOLOGY-3

In this study the finite element analysis of the structure is done by using SAP software. This software gives the deflection, shear stresses and bending stresses for the beams by using finite element analysis. The loading on the structure is calculated manually and then they are defining to the structure by using SAP. For the study the conventional howe truss system, spine cellular beam system, spine castellated beam system, tapered cellular beam system has been considered for analysis for a shed having length 44m and span of 10m, 15m and 20m and a eave height of 10m. The trusses have been analyzed for dead load, superimposed load, wind load and combinations according to IS: 875-1897. Selection of configuration and loading for conventional howe truss is shown below,

Table-1: Loads on trusses

Span of truss (m)	Dead load (kN)		Live load (kN)		Wind load (kN)					
					Windward side			Leeward side		
	At intermediate node	At end node	At intermediate node	At end node	At intermediate node	At end node	At crown	At intermediate node	At end node	At crown
10	3.61	2.39	4.92	3.25	16.21	10.72	8.11	15.32	10.12	7.66
15	3.8	2.51	4.92	3.25	16.21	10.72	8.11	15.32	10.12	7.66
20	3.2	2.24	3.94	2.76	10.21	7.16	5.11	11.02	7.72	5.51

Selection of configuration and loading for spine cellular beam, spine castellated beam, tapered cellular beam is shown below,

Table-2: Configuration of different Beams

Span of Beam (m)	Spine Cellular Beam			Spine Castellated Beam			Tapered Cellular Beam			
	Loading (kN/m^2)	Depth of Beam (mm)	No of Openings	Loading (kN/m^2)	Depth of Beam (mm)	No of Openings	Loading (kN/m^2)	Depth of Beam (mm)		No of Openings
								At end	At center	
10	46.11	250	10	46.11	250	10	30.18	250	450	10
15	29.64	300	14	29.64	300	14	23.05	350	650	14
20	29.64	400	18	29.64	400	18	18.04	500	750	18

4. RESULTS AND DISSCUSSION-4

In the present study the analysis and comparison of conventional howe truss, spine cellular beam, spine castellated beam, tapered cellular beam is carried out on the basis of deflection, weigh and cost and the following observations has been made,

Table-3: Deflection (mm) Comparison of Howe Truss, Spine Cellular, Spine Castellated and Tapered Cellular Beams.

Span (m)	10m	15m	20m
Conventional truss	2.94	6.203	10.74
Spine cellular beam	1.345	1.124	1.015
Spine castellated beam	1.458	1.109	1.526
Tapered cellular beam	8.306	17.83	30.64

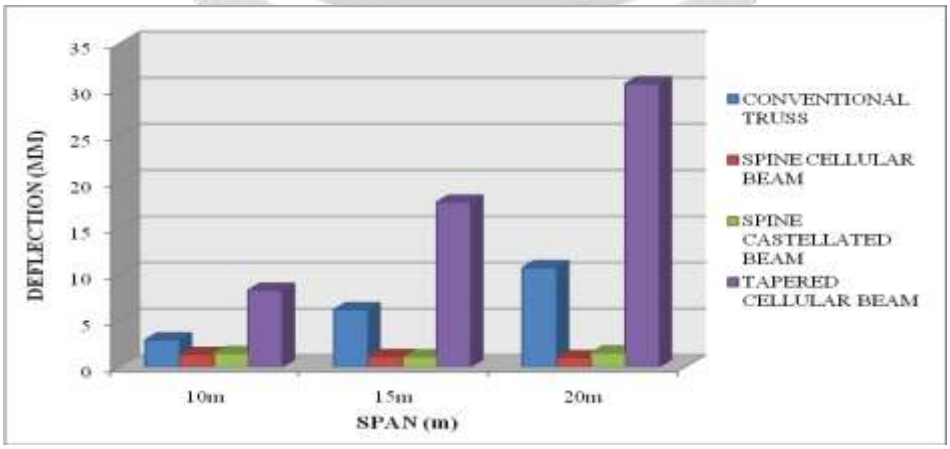

Chart -1: Deflection Comparison of Howe Truss, Spine Cellular, Spine Castellated and Tapered Cellular Beams.

From Table 3 and Chart 1 of Deflection Comparison following observations has been made:-

- Deflection of Spine Cellular beam and Spine Castellated beam is nearly equal to each other.
- Deflection of Spine Cellular beam is decreased by 54.25% for 10m span, 88.87% for 15m span and 94.86% for 20m span as compared to Conventional Howe truss.
- Deflection of Spine Castellated beam is decreased by 50.41% for 10m span, 87.78% for 15m span and 92.27% for 20m span as compared to Conventional Howe truss.
- The deflection of Tapered Cellular beam is increased by 64.60% for 10m span, 48.38% for 15m span and 35.57% for 20m span as compared to Conventional Howe truss.

Table-4: Weight (Kg) Comparison of Howe Truss, Spine Cellular, Spine Castellated and Tapered Cellular Beams.

Span (m)	10m	15m	20m
Conventional truss	238.32	758.43	1507.91
Spine cellular beam	203.81	691.509	1284.976
Spine castellated beam	203.81	691.509	1284.976
Tapered cellular beam	343.12	817.34	1676.84

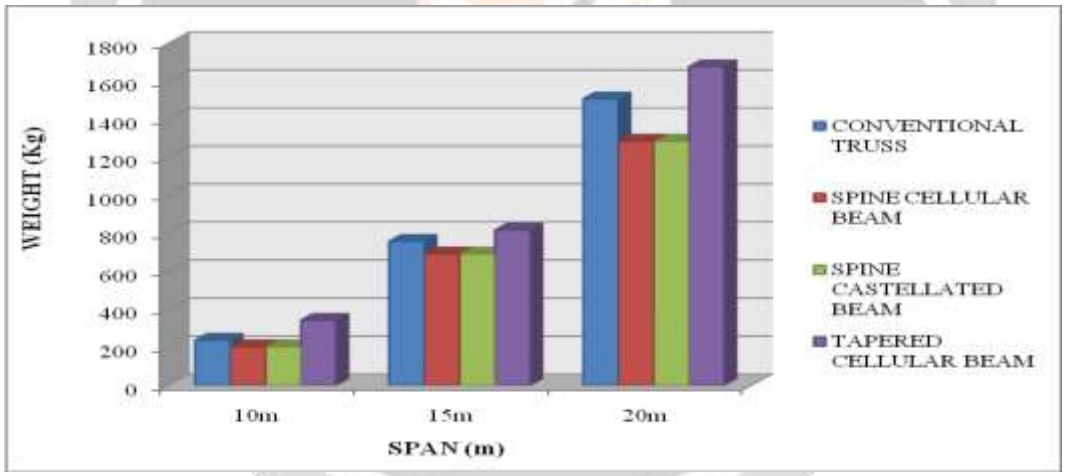

Chart -2: Weight Comparison of Howe Truss, Spine Cellular, Spine Castellated and Tapered Cellular Beams.

From Table 4 and Chart 2 of Weight Comparison following observations has been made:-

- As we used same sections for Spine Cellular beam and Spine Castellated beam Weight of the both beams are equal.
- Weight of Spine Cellular beam and Spine Castellated beam is decreased by 14.48% for 10m span, 8.82% for 15m span and 14.78% for 20m span as compared to Conventional Howe Truss.
- Weight of Spine Cellular beam and Spine Castellated beam is decreased by 40.60% for 10m span, 15.39% for 15m span and 23.37% for 20m span as compared to Tapered Cellular beam.

Table-5: Cost (Rs) Comparison of Howe Truss, Spine Cellular, Spine Castellated and Tapered Cellular Beams.

Span (m)	10m	15m	20m
Conventional truss	9532.8	30337.2	60316.4
Spine cellular beam	8152.4	27660.36	51399.04
Spine castellated beam	8152.4	27660.36	51399.04
Tapered cellular beam	13724.8	32693.6	67073.6

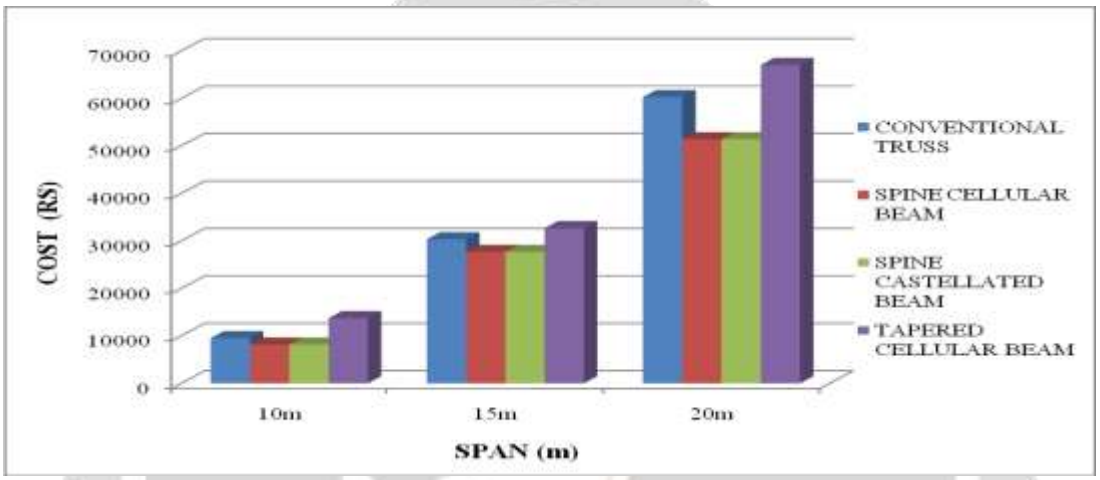

Chart-3: Cost Comparison of Howe Truss, Spine Cellular, Spine Castellated and Tapered Cellular Beams.

From Table 5 and Chart 3 of Cost Comparison following observations has been made:-

- As we used same sections for Spine Cellular beam and Spine Castellated beam Cost of the both beams are equal and therefore the Cost is also same.
- Cost of Spine Cellular beam and Spine Castellated beam is decreased by 14.48% for 10m span, 8.82% for 15m span and 14.78% for 20m span as compared to Conventional Howe Truss.
- Cost of Spine Cellular beam and Spine Castellated beam is decreased by 40.60% for 10m span, 15.39% for 15m span and 23.37% for 20m span as compared to Tapered Cellular beam.

5. CONCLUSIONS

All the work done in this dissertation work is concluded in this chapter. Also the future scope of the study has been given at the end of this chapter.

After comparison of results obtained from all the analysis, it is concluded that,

- The spine cellular beam as well as spine castellated beam has better advantage over conventional Howe truss for deflection, weight and cost which discussed below in percentage.
- Percentage weight and cost achived by spine cellular beam and spine castellated beam over conventional Howe truss for the span of 10m, 15m and 20m is 14.48%, 8.82% and 14.78% respectively.
- Percentage weight and cost achived by spine cellular beam and spine castellated beam over tapered cellular beam for the span of 10m, 15m and 20m is 40.60%, 15.39% and 23.37% respectively.

- The deflection comparison of spine cellular beam, spine castellated beam and tapered cellular beam with conventional Howe truss in percentage is discussed below.
- The deflection of spine cellular beam is less by 54.25% for 10m span, 88.87% for 15m span and 94.86% for 20m span as compared to conventional Howe truss.
- The deflection of spine castellated beam is less by 50.41% for 10m span, 87.78% for 15m span and 92.27% for 20m span as compared to conventional Howe truss.
- The deflection of tapered cellular beam is more by 64.60% for 10m span, 48.38% for 15m span and 35.57% for 20m span as compared to conventional Howe truss.
- The shear stress concentration in spine cellular beam is less by 25.82% for 10m span, 36.83% for 15m span and 61.46% for 20m span as compared to spine castellated beam.
- The bending stress in compression for spine cellular beam is more by 15.15% for 10m span, 13.66% for 15m span and less by 76.08% for 20m span as compared to spine castellated beam.
- The bending stress in tension for spine cellular beam is more by 7.58% for 10m span, 26.78% for 15m span and less by 28.42% for 20m span as compared to spine castellated beam.
- Shear stress of spine cellular beam is less by 89.41% for 10m span, 91.11% for 15m span and 95.73% for 20m span as Compared to Tapered cellular beam.
- Bending stress of spine cellular beam is more by 15.02% for 10m span and less by 32.42% for 15m and 64.10% for 20m span as Compared to Tapered Cellular beam.
- From the above conclusions it is clear that the Spine Cellular beam system is better for use as well as economical as compared to Conventional Howe truss system and Tapered Cellular beam system.

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