



“PERFORMANCE ANALYSIS AND DESIGN OF CONCRETE STEEL COMPOSITE SECTION”

Mr. Abhijit Madhukar Chavan¹ Prof. Vinesh Thorat²

ABSTRACT:

This study offers a comprehensive comparison of the mechanical properties and vibrational behaviors of four distinct types of beams: RCC Beam, Composite Beam with Headed Stud, Composite Beam T Shape, and Composite Beam with Corrugated Sheets. Utilizing ANSYS software for finite element analysis, the investigation focused on beams with dimensions of 500mm width and 250mm depth, created in millimeters, with a minimum value of 0.00 and a maximum value of 1000.00. The analysis aimed to evaluate various aspects, including equivalent stress, shear stress, normal stress, principal stress, elastic strain, total deformation, natural frequency, and time period. The data reveals that the Composite Beam with Corrugated Sheets consistently demonstrated lower stress values across equivalent, shear, normal, and principal stresses. This beam type also exhibited shorter time periods in natural frequency analysis, indicating a higher flexibility and more rapid vibration response compared to other beam types. In contrast, RCC Beams showed longer time periods, reflecting greater stiffness and structural rigidity. Elastic strain analysis further supported these findings, with the Composite Beam with Corrugated Sheets displaying the least strain, highlighting its capability to endure deformation without significant structural compromise. Total deformation measurements corroborated these results, showing the Composite Beam with Corrugated Sheets to have the lowest deformation values, suggesting superior performance in scenarios requiring minimal deflection. This study provides critical insights into the structural behaviors of various beam compositions, with practical implications for their use in construction and engineering.

KEYWORDS: Concrete-Steel Composite, Structural, Performance, Finite Element Analysis, Beam Design, Equivalent Stress, Shear Stress

INTRODUCTION

The use of composite structures is increasingly present in civil construction works. A composite section is much lighter than the equivalent plain pre stressed, and, therefore, there is a saving in cost of handling, shipping and erection. A structure according to the present invention is Not merely a combination of pre stressed rein forced concrete and composite construction, as it seems to be, but a new structure with properties heretofore thought impossible to achieve in rein forced concrete or steel construction. To force the precast pre stressed beam to act together with the poured-in-place concrete slab, an effective shear connector is required and the problems involved in designing such a connector are quite different from those in designing a connector for a composite section that uses a steel beam for the tension member. A pre stressed concrete beam composite structure has great advantages compared with all here to known constructions used in floors for buildings and bridges. It requires 85% to 95% less steel than a plain steel beam construction, has considerably less deflection under load, pro vides more lateral stiffness and forms a homo generous floor System, more adapt to Sustain in pact. It requires 70% to 80% less steel than steel beam composite construction and provides the same rigidity. It requires 65% to 75% less steel than a reinforced concrete beam construction, which has 50% more dead load, and produces tensile cracks.

Objective: –

- To analyze the structural performance of steel – concrete Composite sections.
- To investigate the failure pattern of the members for different parameters.
- To study the comparative analysis of the steel – concrete composite section and RCC members under flexural performance.

METHODOLOGY

The primary data was gathered through a Literature survey targeted by web searches and review of e books, manuals, codes and journal papers. After review the problem statement is defined and 3 specimens are taken up for detail study and analysis purposes.

MODELLING AND PERFORMANCE ANALYSIS**Table 1.1 Model (A4) > Mesh**

Object Name	<i>Mesh</i>
State	Solved
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Coarse
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	18.0 mm
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Advanced	
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Defeaturing	
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No

Automatic Mesh Based Defeaturing	On
Defeaturing Tolerance	Default
Statistics	
Nodes	149549
Elements	14064
Mesh Metric	None

Material parameter in ANSYS.14

Concrete parameters

Table no. 1.2 Concrete parameters

Object Name	<i>Solid</i>	<i>Solid</i>	<i>Solid</i>	<i>Solid</i>	<i>Solid</i>
State	Meshed				
Graphics Properties					
Visible	Yes				
Transparency	1				
Definition					
Suppressed	No				
Stiffness Behavior	Flexible				
Coordinate System	Default Coordinate System				
Reference Temperature	By Environment				
Material					
Assignment	Concrete				
Nonlinear Effects	Yes				
Thermal Strain Effects	Yes				
Bounding Box					
Length X	19. mm			1220. mm	
Length Y	102. mm			152. mm	
Length Z	19. mm			6050. mm	
Properties					
Volume	28920 mm ³			1.1219e+009 mm ³	
Mass	0.22702 kg			2804.8 kg	
Centroid X	-41. mm	41. mm	-41. mm	41. mm	-6.347e-014 mm
Centroid Y	356. mm			381. mm	
Centroid Z	240. mm		60. mm		3025. mm
Moment of Inertia Ip1	200.9 kg·mm ²			8.5606e+009 kg·mm ²	
Moment of Inertia Ip2	10.141 kg·mm ²			8.903e+009 kg·mm ²	
Moment of Inertia Ip3	200.9 kg·mm ²			3.5329e+008 kg·mm ²	
Statistics					
Nodes	301			683	
Elements	45			80	
Mesh Metric	None				

Steel girder parameters

Table no. 1.3 Steel girder parameters

Object Name	<i>Solid</i>	<i>Solid</i>	<i>Solid</i>	<i>Solid</i>	<i>Solid</i>
State	Meshed				
Graphics Properties					
Visible	Yes				
Transparency	1				

Definition			
Suppressed	No		
Stiffness Behavior	Flexible		
Coordinate System	Default Coordinate System		
Reference Temperature	By Environment		
Material			
Assignment	STEEL GIRDER		
Nonlinear Effects	Yes		
Thermal Strain Effects	Yes		
Bounding Box			
Length X	152. mm	19. mm	
Length Y	305. mm	102. mm	
Length Z	6050. mm	19. mm	
Properties			
Volume	4.938e+007 mm ³	28920 mm ³	
Mass	387.63 kg	0.22702 kg	
Centroid X	4.4259e-015 mm	41. mm	-41. mm 41. mm
Centroid Y	152.5 mm	356. mm	
Centroid Z	3025. mm	6000. mm	5820. mm
Moment of Inertia Ip1	1.1885e+009 kg·mm ²	200.9 kg·mm ²	
Moment of Inertia Ip2	1.1829e+009 kg·mm ²	10.141 kg·mm ²	
Moment of Inertia Ip3	6.6303e+006 kg·mm ²	200.9 kg·mm ²	
Statistics			
Nodes	2446	301	
Elements	460	45	

Stud Shear Connector parameters

Table no 1. 4 Stud Shear Connector parameters

Object Name	<i>Solid</i>	<i>Solid</i>	<i>Solid</i>	<i>Solid</i>	<i>Solid</i>
State	Meshed				
Graphics Properties					
Visible	Yes				
Transparency	1				
Definition					
Suppressed	No				
Stiffness Behavior	Flexible				
Coordinate System	Default Coordinate System				
Reference Temperature	By Environment				
Material					
Assignment	STUD SHEAR CONNECTOR				
Nonlinear Effects	Yes				
Thermal Strain Effects	Yes				
Bounding Box					
Length X	19. mm				
Length Y	102. mm				
Length Z	19. mm				
Properties					
Volume	28920 mm ³				
Mass	0.22702 kg				
Centroid X	-41. mm	41. mm	-41. mm	41. mm	-41. mm

Centroid Y	356. mm		
Centroid Z	5640. mm	5460. mm	5280. mm
Moment of Inertia Ip1	200.9 kg·mm ²		
Moment of Inertia Ip2	10.141 kg·mm ²		
Moment of Inertia Ip3	200.9 kg·mm ²		
Statistics			



Nodes	301
Elements	45

Reinforcing Bars parameters

Table no.1.5 Reinforcing bars parameters

Object Name	<i>Solid</i>		
State	Meshed		
Graphics Properties			
VVisible	Yes		
Transparecy	1		
Definition			
Suppressed	No		
Stiffness Behavior	Flexible		
Coordinate System	Default Coordinate System		
Reference Temperature	By Environment		
Material			
Assignment	REINFORCEMENT BAR		
Nonlinear Effects	Yes		
Thermal Strain Effects	Yes		
Bounding Box			
Length X	8. mm		
Length Y	8. mm		
Length Z	6050. mm		
Properties			
Volume	3.0411e+005 mm ³		
Mass	2.3872 kg		
Centroid X	-154. mm	-459. mm	
Centroid Y	333. mm	428. mm	333. mm
Centroid Z	3025. mm		
Moment of Inertia Ip1	7.2447e+006 kg·mm ²		
Moment of Inertia Ip2	7.2447e+006 kg·mm ²		
Moment of Inertia Ip3	18.905 kg·mm ²		
Statistics			
Nodes	11564		
Elements	963		
Mesh Metric	None		

MODELLING:

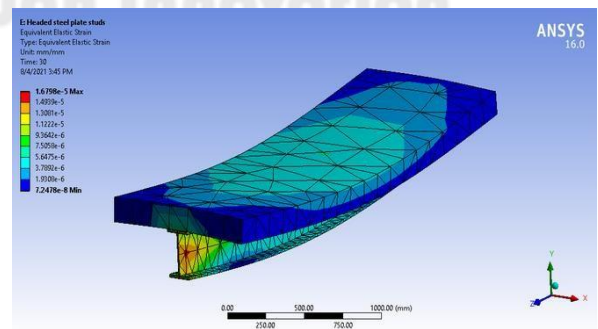
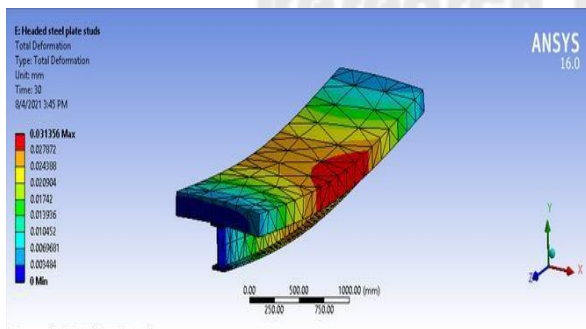


Figure.1.1. Total deformation

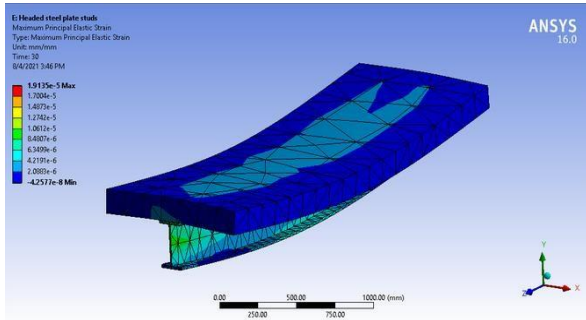


Figure.1.2. Equivalent Elastic strain

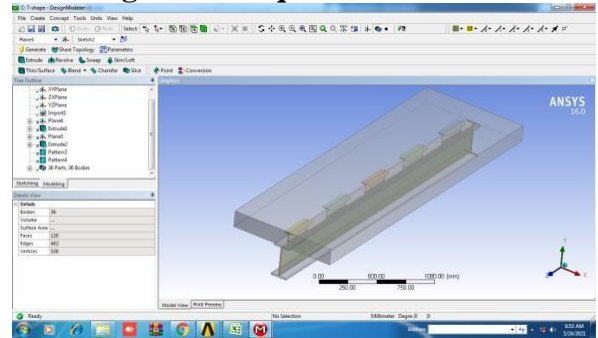


Figure.1.3. Maximum Principal Elastic

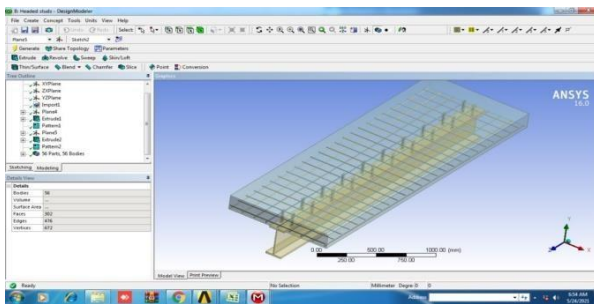


Figure.1.4 T-shape beam Strain

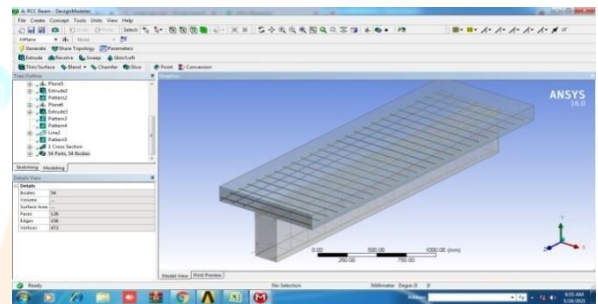


Figure.1.5 Headed studs

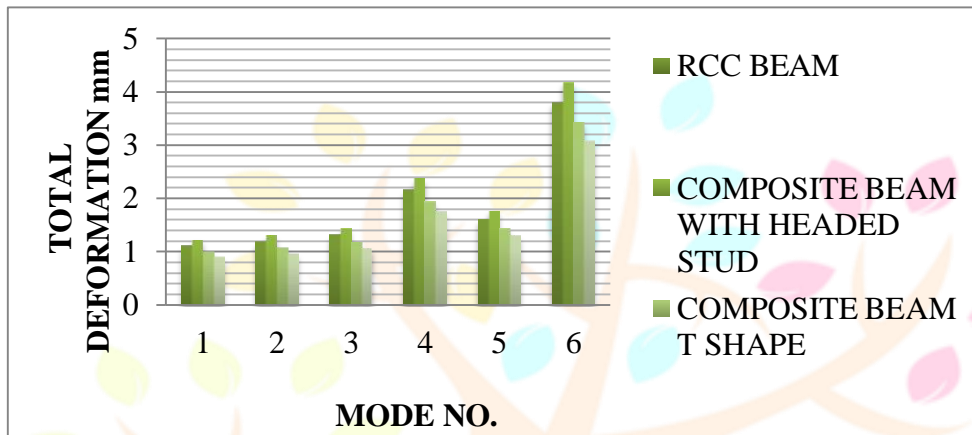
Figure.1.6 RCC beam

RESULT:



Table 1.6 TOTAL DEFORMATION mm

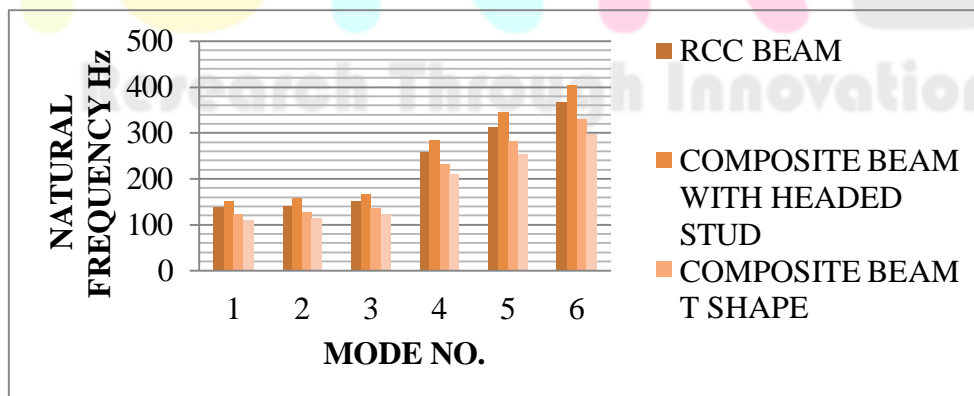
TOTAL DEFORMATION mm				
MODE NO.	RCC BEAM	COMPOSITE BEAM WITH HEADED STUD	COMPOSITE BEAM T SHAPE	COMPOSITE BEAM CORUGATED SHEETS
1	1.1	1.21	0.99	0.891
2	1.18	1.298	1.062	0.9558
3	1.3	1.43	1.17	1.053
4	2.15	2.365	1.935	1.7415
5	1.6	1.76	1.44	1.296
6	3.8	4.18	3.42	3.078



Graph 1.1 TOTAL DEFORMATION mm

Table 1.7 NATURAL FREQUENCY Hz

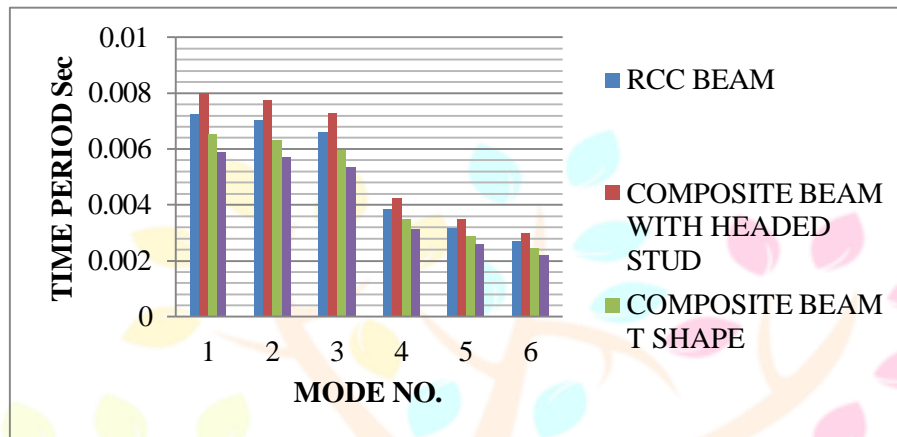
NATURAL FREQUENCY Hz				
MODE NO.	RCC BEAM	COMPOSITE BEAM WITH HEADED STUD	COMPOSITE BEAM T SHAPE	COMPOSITE BEAM CORUGATED SHEETS
1	137.68	151.448	123.912	111.5208
2	142.2	156.42	127.98	115.182
3	150.93	166.023	135.837	122.2533
4	258.23	284.053	232.407	209.1663
5	313.4	344.74	282.06	253.854
6	367.76	404.536	330.984	297.8856



Graph 1.2 NATURAL FREQUENCIES

Table 1.8 TIME PERIOD Sec

TIME PERIOD Sec				
MODE NO.	RCC BEAM	COMPOSITE BEAM WITH HEADED STUD	COMPOSITE BEAM T SHAPE	COMPOSITE BEAM CORUGATED SHEETS
1	0.007263219	0.007989541	0.006536897	0.005883207
2	0.007032349	0.007735584	0.006329114	0.005696203
3	0.006625588	0.007288147	0.005963029	0.005366726
4	0.003872517	0.004259768	0.003485265	0.003136739
5	0.00319081	0.003509892	0.002871729	0.002584556
6	0.002719165	0.002991081	0.002447248	0.002202523



Graph 1.3 TIME PERIOD

CONCLUSION:

The performance analysis of different beam types—RCC Beam, Composite Beam with Headed Stud, Composite Beam T Shape, and Composite Beam with Corrugated Sheets—provides significant insights into their structural behaviors. Utilizing ANSYS software, we conducted a finite element analysis of a concrete beam with dimensions of 500mm in width and 250mm in depth. This preliminary investigation focused on several critical parameters including equivalent stress, shear stress, normal stress, principal stress, elastic strain, total deformation, natural frequency, and time period. The results indicate that the Composite Beam with Corrugated Sheets consistently demonstrates lower stress values, deformation, and shorter time periods compared to other beam types. This suggests that the Composite Beam with Corrugated Sheets has higher flexibility and a rapid vibration response. The RCC Beam exhibited higher stiffness and longer time periods, indicating a more rigid structural behavior. This makes RCC Beams more appropriate for applications where higher stiffness and stability are essential, such as in buildings and structures where minimal deformation under load is desired. The higher stiffness of RCC Beams ensures that they can support substantial loads with minimal deflection, providing stability and durability over time. The Composite Beam with Headed Stud and Composite Beam T Shape exhibited intermediate behaviors between the highly flexible Composite Beam with Corrugated Sheets and the stiffer RCC Beam.

REFERENCES

1. Richard Frans1, Herman Parung, Achmad Bakri Muhiddin, and Rita Irmawaty. 2017 “Finite element modelling of composite castellated beam” MATEC Web of Conferences 138, 02009 , DOI: 10.1051/201713802009
2. Tiejiong Lou, Theodore L. Karavasili. “Numerical assessment of the nonlinear behavior of continuous prestressed steel-concrete composite beams” Science Direct, Engineering structures 190,116/127
3. Kale, M. B., Student, M. E., Undre, A. R., & Pujari, A. B. (2021). Review on Performance Analysis of Steel Concrete Composite Section. International Journal of Engineering Research & Technology, 10(11), 2–7. www.ijert.org

4. Denavit, M. D., Hajjar, J. F., Leon, R. T., & Perea, T. (2014). Analysis and design of steel-concrete composite frame systems. Structures Congress 2014 - Proceedings of the 2014 Structures Congress, 2605–2616. <https://doi.org/10.1061/9780784413357.228>
5. Zhang, D., Ma, X., Shen, H., Guo, S., & Liu, C. (2023). Analysis of Structural Parameters of Steel–UHPC Composite Beams. Materials, 16(16). <https://doi.org/10.3390/ma16165586>
6. Chung, L., Lim, J. J., Hwang, H. J., & Eom, T. S. (2016). Review of Design Flexural Strengths of Steel–Concrete Composite Beams for Building Structures. International Journal of Concrete Structures and Materials, 10(3), 109–121. <https://doi.org/10.1007/s40069-016-0146-7>
7. Leaf, D., & Laman Chung, L., Lim, J. J., Hwang, H. J., & Eom, T. S. (2016). Review of Design Flexural Strengths of Steel–Concrete Composite Beams for Building Structures. International Journal of Concrete Structures and Materials, 10(3), 109–121. <https://doi.org/10.1007/s40069-016-0146-7>
8. , J. A. (2013). Steel-Concrete Beam Flexural Strength. International Journal of Structural and Civil Engineering Research, 2(3), 90–103.
9. Denavit, M. D., Hajjar, J. F., Leon, R. T., & Perea, T. (2014). Analysis and design of steel-concrete composite frame systems. Structures Congress 2014 - Proceedings of the 2014 Structures Congress, 2011, 2605–2616. <https://doi.org/10.1061/9780784413357.228>
10. Abramowicz, M., Berczyński, S., & Wróblewski, T. (2020). Modelling and parameter identification of steel–concrete composite beams in 3D rigid finite element method. *Archives of Civil and Mechanical Engineering*, 20(4). <https://doi.org/10.1007/s43452-020-00100-7>
11. Bo Chen a,d, Hang Cheng a, Haoran Kong a, Xinzhong Chen b,c, Qingshan Yang c,d. Interference effects on wind loads of gable-roof buildings with different roof slopes. *Journal of Wind Engineering & Industrial Aerodynamics* 189 (2019) 198–217
12. Jagbir Singh And Amrit Kumar Roy. Effects of roof slope and wind direction on wind pressure distribution on the roof of a square plan pyramidal low-rise building using CFD simulation. *International Journal of Advanced Structural Engineering* (2019) 11:231–254
13. IS: 875(Part 1, Part 2, Part 3)- 2015, bureau of Indian standard code of training for configuration loads.
14. IS 1893 (Part I), “Criteria for Earthquake Resistant Design of Structures”, Bureau of Indian Standards, New Delhi, 2002.
15. IS 1893 (Part I), “Criteria for Earthquake Resistant Design of Structures”, Bureau of Indian Standards, New Delhi, 2016.