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Analysis of Composite Framed Structure Using Abaqus Software

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Abstract: *A composite framed structure employs a structural steel and composite metal deck floor system and concrete-encased steel columns. Composite construction is a blooming design process involved in many IT parks, colleges, high-rise structures, warehouses, and many others. The use of these so-called composite-frame structures has as its underlying principle the combination of concrete and steel which are distinctive and different building materials to produce the most effective and economical form of placement. The main aim of this paper is to find the effective usage of steel components in the composite framed structural member. To study effective cross-section of steel and concrete in both beams and columns. By changing the quantity of steel and cross-section in both column and beam and finalizing the effective member under a common loading condition. Uniformly distributed load for beam and axial loading for column members. To take advantage of current trends and technology, the complete analysis will be presented by using finite element software – ABAQUS.*

Keywords: *ABAQUS , Composite structure , Economical design , frame design.*

1. INTRODUCTION:

The composite framed structure is the most reliable form of design structure which is practiced for commercial buildings, high-rise structures, colleges, and other mixed-used buildings, The primary aim of this paper is to find the most economical form of a composite framed structure, and its other objectives are to discuss the comparison within the design of the other composite section which is used among 95% of constructions and its evolution from its earlier form of RCC section. The numerical analysis is completely worked out by using finite element software ABAQUS version 6.14. The created finite element model accurately forecasts the test beam moment capacity, its buckling, and distorted forms. The material properties of the specimen are listed with Young's modulus and Poisson ratio values respectively.

The bot is capable of modifying its rules of operation, and the software bots perform their tasks without any errors. RPA is used to create bots that satisfy frequently repeated tasks. It is the crucial feature of Robotic Process Automation. With the increase in loads of essential data, people make lots of errors, whereas the software bots will continue to function reliably. RPA has an enormous effect on many organizations where RPA saves time for different workflows. The decision-making is done by the bot, where there is no inclusion of social support to finish a task. The bot follows specific rules and regulations which are specified and fixed. The software bot is capable of making decisions concerning the flow of processing. The bot once created, can be deployed in any number of system

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2. METHODOLOGY:

The study of successive numbers of specimens is done, hence better finite element analysis tool is selected where meshing and nodal analysis is done at a more intricate state therefore ABAQUS software is selected where the above-said process is done at its finest level. The process of finalizing the better composite design process needs a study of a usual performed process with its limitation explained and then the composite frames are designed to satisfy the weaker part of the structure thereby helping to know the better form of sections which are easy to use and withstand higher loading condition .

3. FLOWCHART:

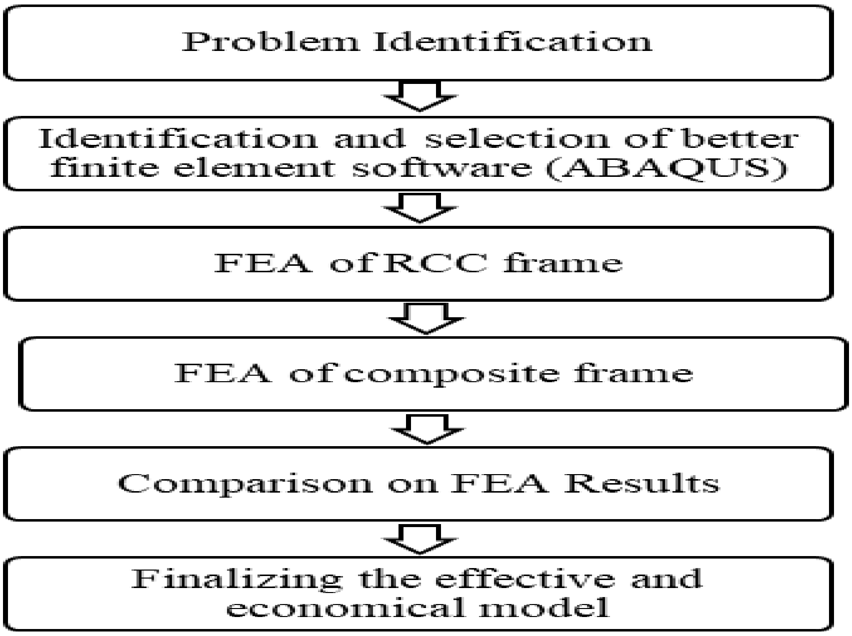

Fig. 1. Flowchart for the design of effective composite member

4. PARAMETRIC STUDY OF RCC SYSTEM:

The design process is completely carried out with ABAQUS software where primarily three different RCC specimens were designed and they are subjected to common deflection and fixed support conditions. The material properties of all the specimens were the same at concrete density =2400kg/m3, Young’s modulus is provided as 20GPa, and Poisson’s ratio at 0.18. For steel the density is provided at 7850 kg/m3, Young’s modulus at 210GPa, and Poisson’s ratio at 0.3 respectively for all three specimens. Primarily the frame is designed with two columns supporting a beam which are rested over a fixed support condition The steel and concrete elements are assembled as Both the base of the columns are fixed by using the option ENCASTRE in the Load tab. The uniform distribution load is applied on the top face of the beam. A representative view of loading has been attached below, the interaction between steel and concrete is applied in the interaction. For this case, the embedded region is applied. To find more accuracy of the results, the size of the mesh is 10mm for all the

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components The specimen details are listed in the form of a table where column and beam details are listed with variations in steel sizes and detailing properties in various forms which are compared with their bending, defection, and displacement properties.

	Specimen 1	Specimen 2	Specimen 3
Length (mm)	3000	3000	3000
Breadth (mm)	230	230	230
Width (mm)	300	300	300
Main reinforcement (mm)	12	16	16
Stirrups (mm)	8	8	10
Minimum cover (mm)	25	25	25

Table 1. Column details for different specimen samples

	Specimen 1	Specimen 2	Specimen 3
Length (mm)	3000	3000	3000
Breadth (mm)	230	230	230
Depth (mm)	300	300	300
Main reinforcement (mm)	12	16	16
Stirrups (mm)	8	8	10
Minimum cover (mm)	25	25	25
Reinforcement at joints (mm)	12	12	12
Reinforcements at middle (mm)	12	12	12

Table 2. Beam details for different specimen samples

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5.PICTORIAL REPRESENTATION AND OUTCOME OF THE DESIGN PROCESS:

Fig. 2. Reinforcement placement in t rame

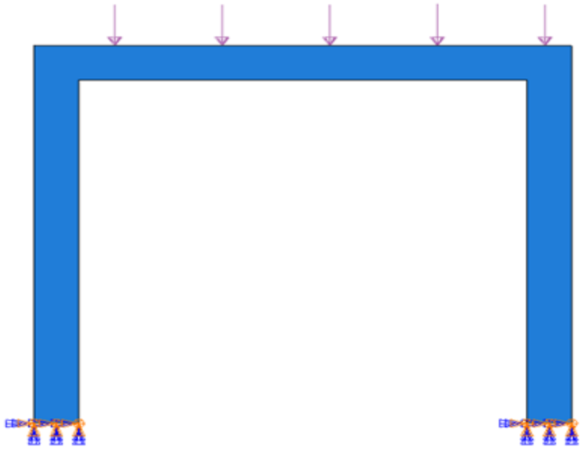

Fig. 3. RCC frame with loading

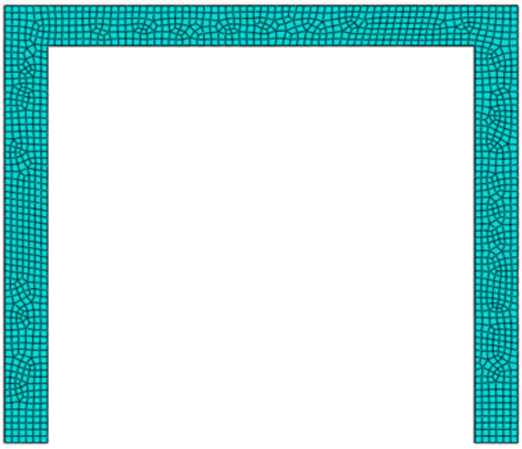

Fig.4. Meshing details

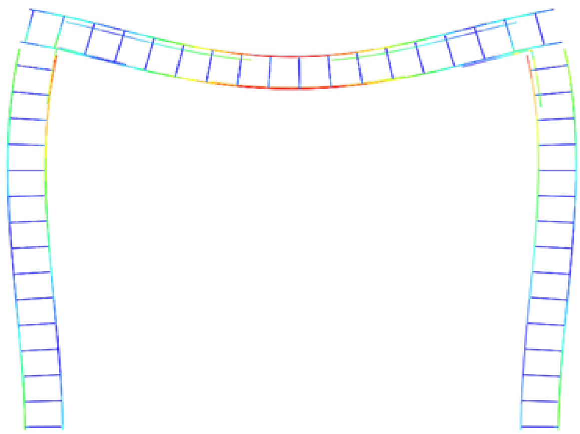

Fig.5.Loaded frame

The nodal analysis and graphical analysis are done for all three specimens available and results are concluded with an equal amount of deflection values. It was found that specimen 3 with an area of steel in a higher percentage performs well with loading conditions than the other two specimens. Hence it is well noted that the increase in a higher amount of area of steel results in better loading

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capacities but the difficulty in this process is we can't continuously increase the amount of steel as it increases the dead load, steel congestion in member and increase in amount of the structure

S.No	Specimen1 Load (kN)	Specimen2 Load (kN)	Specimen Load (kN)	Deflection (mm)
1.	7.19	7.34	7.55	10
2.	10.79	11.17	11.42	15
3.	21.58	22.02	22.66	30
4.	35.96	36.71	37.76	50
5.	57.54	58.73	60.42	80

Table 3. Deflection of RCC sections for different loading

6.BEAM AS REINFORCEMENT:

6.1 Design Process:

The conventional RCC system proves to carry more load with an increase in the percentage of steel, but it seems to be uneconomical so with the advancement of structure steel concrete composite structures are used, where steel is made to be available as precast sectional members. Here ISMB250 has been used for the analysis where overall depth = 250mm, Width of the Flange = 125mm, Thickness of the Web = 6.9 mm, Thickness of the Flange = 12.5 mm. Refer to Specimen 1 for the concrete section. As web part of the I-section is pretending to buckle and cause failure. To overcome this, by changing the web thickness in the frame analysis is carried out for the effective thickness of the web. Hence, three different types of thickness have been studied in this case (I-Beam). Thickness 1 = 6.9 mm, Volume of steel = 0.705m3.Thickness 2 = 6.9 mm, Volume of steel = 0.710m3, Thickness 2 = 6.9 mm, Volume of steel = 0.714m3.

6.2Results for different kind of I section :

S.No	Specimen Load (kN)	Specimen 2 Load (kN)	Specimen Load (kN)	Deflection (mm)
1	6.44	9.88	10.32	10
2	19.32	29.65	30.96	30
3	32.20	49.41	51.60	50
4	51.52	79.05	82.57	80

Table 4. Deflection of composite I section for different loading

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COMPOSITE SECTION WITH MODIFIED COLUMN :

Iteration I:

I sectional composite sections are by far the well-known economical form of system, yet little modification in those structures makes this a versatile form of structure. The modification is carried out by replacing different column sections and comparing their buckling characteristics, where the beam member (I sectional) is not changed and fixed with a standard cross-section from the previous iteration, The sectional reinforcement is selected as hollow circular, hollow rectangular and channel section which is placed face to face are varied as column members. Throughout this process the analysis is carried out with fixed buckling values with serviceability criteria and corresponding load-carrying capacities are obtained and the deflection is not studied here as the beam member is completely fixed throughout the process. Here the study leads to a point where I sectional column is compared over a sectional reinforced section, where it can be replaced by a circular sectional column member at 1/3rd of the concrete section where the major load-carrying region in the column is concentrated and performs better among all the other section in terms of both load carrying capacities and less usage of steel. For rectangular cross-section columns, when the load is placed within the middle third of the depth or width of the section then there will be no tension produced in the column and the column is said to resist most of its load through the region. This is called the middle third rule. The rule is covered by various standard texts in the field of civil engineering, for instance.Cross section of Circular beam are Diameter = 150mm, Thickness = 20mm, Volume of steel = 0.705m3.

7.2 Iteration II:

In this comparison, we consider the channel section, where the channel section face-to-face is designed, which is completely symmetrical and tends to perform well during seismic loads. The problem here with this type of section is production and construction, where it includes a delayed construction process owing to its design, the member is tested with various buckling conditions and its corresponding load-carrying capacities, and the cross-section of the channel section is as follows

The cross-section of the Channel beam is length = 150mm, Breadth = 100mm, Thickness = 10mm.

7.3 Iteration III:

The sectional reinforcement is also studied by replacing hollow rectangular composite sections. Where it is symmetrical to the column section and performs better. The limitation of this design is that the edges of the section are highly stressed making it a weaker section, the rectangular hollow sectional column member is also made at 1/3rd of the concrete section where they are the major load-carrying region in the column. The buckling characteristics of this section are observed with the load-carrying capacities and they are tabulated below

The cross-section of the Rectangular hollow beam is length = 150mm, Breadth = 100mm, Thickness = 10mm.

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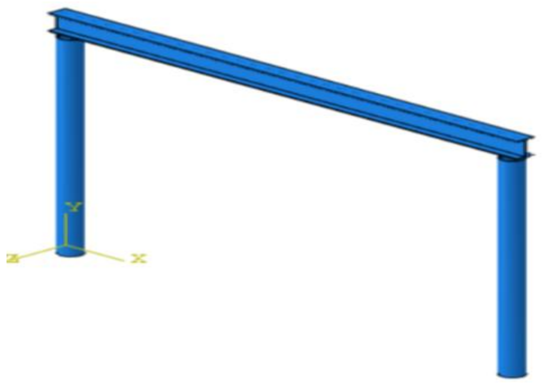

Fig. 6. Reinforcement details for circular olumn with I sectional beam

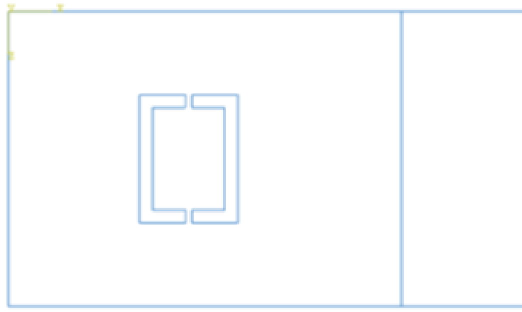

Fig. 7. Cross-sectional view of channel colur n composite section

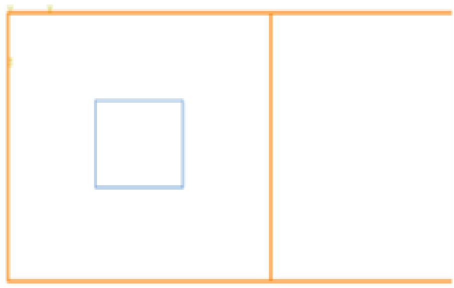

Fig.8. Cross-sectional view of t ectangular column in the composite section

Fig.9. Stress pattern observed in composite ection column

7.4 Outcome and results :

S.no .	S1 Load (kN)	S2 Load (kN)	S3 Load (kN)	Buckling in I column (mm)	Buckling in Circular column (mm)	Buckling in rectangular column section (mm)	Buckling in channel section column (mm)
1	6.4	9.8	10	9.59	8.91	8.51	9.13
2	19	29	30	28.79	27.89	26.32	27.01
3	32	49	51	47.98	46.20	44.86	45.36
4	51	79	82	76.79	75.34	71.93	72.65

Table:5 Buckling behaviour in the composite section

From the results and data obtained it is well known that the modified form of composite frame i.e, circular column in place of I section in column performs well with load carrying capacities and most importantly uses a very low amount of steel in various aspects. The buckling behaviour of the modified composite section is compared with the native form and it is found that both sections performed similarly in terms of buckling, so it provides the conclusive statement of replacement of circular sectional steel column in the place of I sectional steel column provided better economical usage of steel in the composite structure

8. CONCLUSION :

The primary aim of this paper is to establish where the modification of composite framed structure leads to effective load-carrying capacity with an economical form of steel usage. Where it is noted that rather than placing I sectional reinforcement in the column the circular sectional reinforcement acts as the effective form, As per the 1/3rd middle rule for the column, the middle 1/3rd part of the column is effectively used in load distribution to the underneath member so rather than placing I section which has weaker web placed at the middle, circular form of column act as an effective member among the composite framed structures. A graphical comparison of both steel usage and load-carrying capacities explains about economical use of this design from its earlier form of construction. The objectives are made clear with the evolution of the I section from the earlier form of RCC structure, where the load-carrying capacities are increased by increasing the amount of steel in the member which directly increases the cost of production in RCC frames. Hence it finds a way to prove the effective and economical form of usage of composite frame.

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