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Dynamic Analysis on RCC and Composite Structure for Uniform and Optimized Section

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Abstract: ***This study examines the composite structure that is increasing commonly in developing countries. For medium-rise to high-rise building construction, RCC structures is no longer economical due to heavy dead weight, limited span, low natural frequency and hazardous formwork. The majority of commercial buildings are designed and constructed with reinforced concrete, which largely depends on the existence of the constituent materials as well as the quality of the necessary construction skills, and including the usefulness of design standards. Conventional RCC structure is not preferred nowadays for high rise structure. However, composite construction, is a recent development in the construction industry. Concrete-steel composite structures are now very popular due to some outstanding advantages over conventional concrete and steel structures.***

In the present work, RCC and steel-concrete composite structure are being considered for a Dynamic analysis of a G+25-storey commercial building of uniform and optimized section, located at in seismic zone IV. Response Spectrum analysis method is used to analyze RCC and composite structure, CSI ETABS v19 software is used and various results are compared such as time period, maximum storey displacement, maximum storey stiffness. Maximum storey shear and maximum stoey overturning moment.

Keywords: RCC Structure, Composite Structure, Uniform Section, Optimized Section, Shear Connector, Time Period, Storey Displacement, Storey Shear, Storey Stiffness, Response Spectrum method, ETABS

I. INTRODUCTION

In India, most building structures fall into the low-rise building category. Therefore, reinforced concrete structure are increasingly used in these constructions because of their very convenient and economical construction. However, urban populations are growing exponentially and land is limited, requiring buildings to grow vertically in these cities. To this end, many mid-to-high-rise buildings are currently being built. For these skyscrapers, using composite components for construction has been found to be more effective and economical than using reinforced concrete components. The popularity of composite structure in cities is due to their advantages over traditional reinforced concrete structures. Reinforced concrete frames are used in low rise buildings due to their light load. However, traditional reinforced concrete structures cannot be used in medium and high-rise buildings due to their increased weight, limited span, low stiffness and vulnerable to hazards framing system. Steel is rarely used in the Indian construction industry compared to other developing countries such as China and UK. With the development in India, there is an urgent need to do more research in the field of construction and develop new and improved technology of steel composite as a building material in an economical construction. Reinforced concrete composite frames use more steel and have proven to be an economical approach to solving mid-to-high building structural problems.

A. Why Composite

1) High flexibility in design and ease of manufacturing.
2) Ideal material in earthquake prone locations due to its high strength, stiffness and ductility.
3) The size of the elements can be reduced, thus increasing the strength-to-weight ratio.
4) Facilitate faster project construction.
5) Meet the demand for long span construction, a modern trend in architectural design.
6) Allows easy structural repair and modification.
7) Precisely designed concrete and steel composite members prevent brittle fracture of reinforced concrete members and have high ductility.
8) Encased steel frame can be used as a shoring system during construction process.

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B. Objectives

In this thesis two RCC model, one is uniform section type another is optimized section type and two composite model, one is uniform section type another is optimized section type are taken. Dynamic analysis (Response Spectrum method) is done using CSI ETBAS v19 software.

The objectives of this paper are: -

1) To understand the effect of optimized section in base reaction, base moment, time period, base shear, overturning moment, storey deflection, storey drift and stiffness.
2) To understand the behavior of RCC and composite structure in Response Spectrum analysis.
3) To understand the seismic performance of RCC and composite structure in case of uniform and optimized section.
4) To compare the result for RCC and composite structure of G+25 storey.

II. COMPOSITE STRUCTURE

A composite member is defined as consisting of a rolled or a built-up structural steel member covered with reinforced concrete or a structure bound to reinforced concrete. The composite structural elements are constructed so that the shapes of the steel structure and concrete act together to resist axial compression, flexure and torsion.

Component of composite structure: -

1) Composite column
2) Composite beam
3) Composite deck slab
4) Shear connector

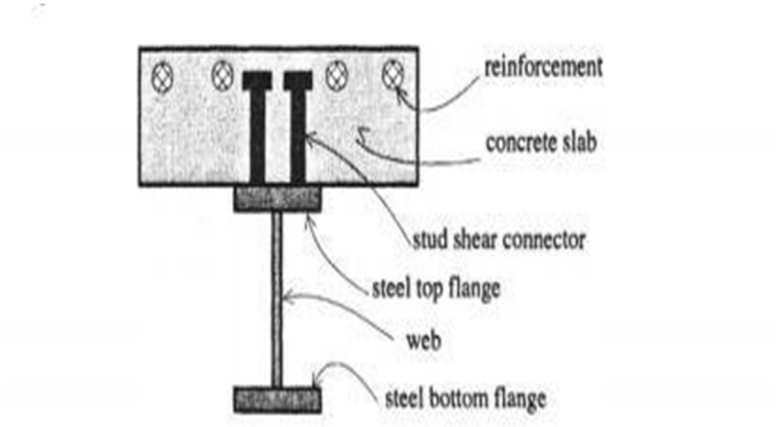


Figure-2.1-Cross Section of a typical composite member

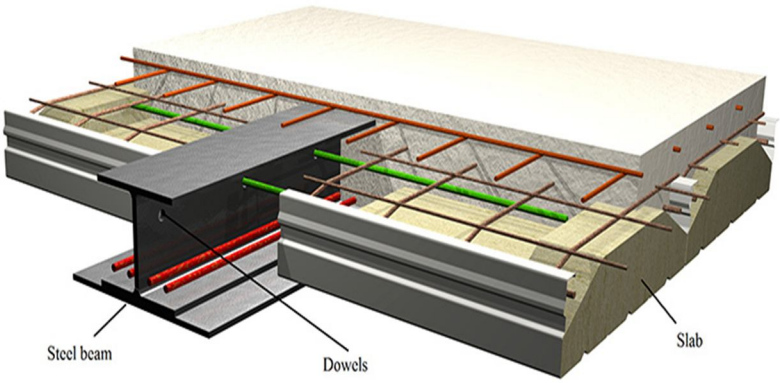


Figure-2.2-Flexural Joint between Beam and Slab

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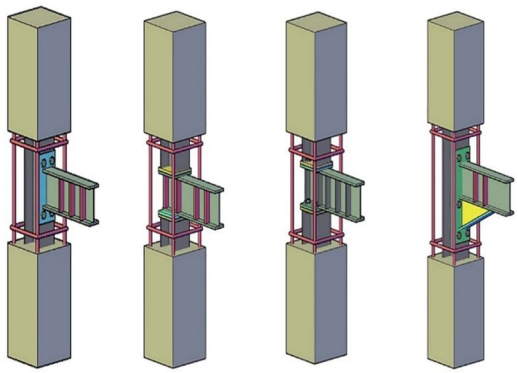


Figure-2.3-Flexural joint between Column and Beam

A. Advantages Of Composite Structure

1) Increase strength for a given cross-sectional dimension.
2) Increased stiffness, resulting in reduced slenderness and increased resistance to warping.
3) Good fire resistance in case of encased concrete.
4) Corrosion protection in coated elements.
5) Outstanding seismic performance for lateral loads.
6) Substantial economic advantage over alternatives to purely steel or reinforced concrete structures.
7) This allows the external dimensions of the column to be kept fixed over several floors of the building, thus simplifying construction and architectural details.
8) Build a high-rise building in an extremely efficient way.
9) No formwork is required for the concreting tubular section. Economical for high-rise buildings.

III. MODELLING AND ANALYSIS

This chapter explained that the 3D building model is analyzed using the Response Spectrum method. The commercial building models G+25 RCC and Composite are analyzed using ETABS 19 software. The seismic codes are unique to a particular region of the country. In India, Indian Standard for Design of Seismic Structures IS 1893:2016 is the main standard that provides the outline for the calculation of seismic design forces.

1) Model 1: G+25 RCC Structure of Uniform Section
2) Model 2: G+25 RCC Structure of Optimized Section
3) Model 3: G+25 Composite Structure of Uniform Section
4) Model 4: G+25 Composite Structure of Optimized Section

A. Optimization

The process of finding the best economic structural outcomes with maximum benefit at minimum material or cost is called optimization. Due to recent advances in structural design, it is very easy to obtain a safe design, but difficult to find an economical design, so optimization techniques are needed to obtain most economically efficient design.
This is beneficial in many ways such as saving materials, reducing concrete usage. Therefore, optimization has gained momentum in structural engineering. In this project, optimization of columns and beam is carried out.

B. Step Of Section Optimization

1) First define various section of column and beam both for RCC and composite structure.
2) Start assigning from minimum section to the column or beam and run analysis, after analysis check for design if design check meets the demand capacity ratio, then section is safe for structure, if not then increase the section and repeat the process till design check satisfy the demand capacity ratio.
3) After satisfy demand capacity ratio for uniform section, then check for stress level in each column and beam. Some column and beam just pass the design check and some are under stressed.

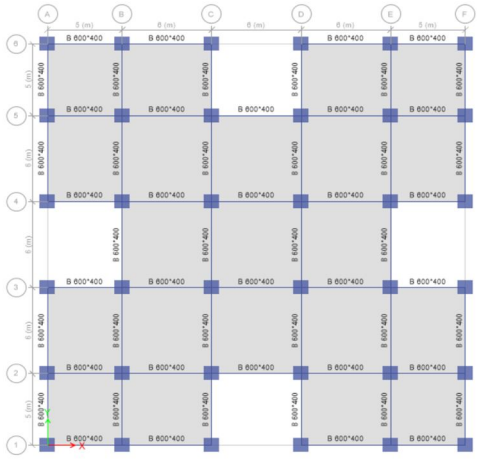
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4) According to stress level in column and beam assign lower section and run analysis, after analysis check for design, if design check meets the demand capacity ratio, then section is safe for structure. If not then repeat this process till stress level meet the demand capacity ratio.

5) After all the column and beam match the approximate same demand capacity ratio, the section come out by this iterative process is now optimized section for structure.

Table 3.1: Data for Analysis of R.C.C. Structure

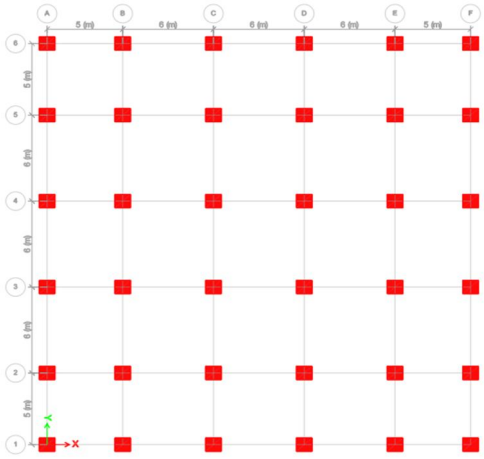
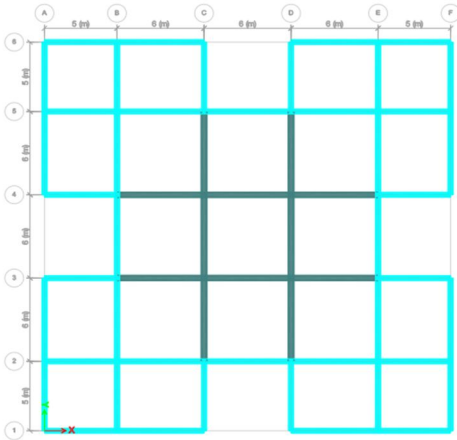
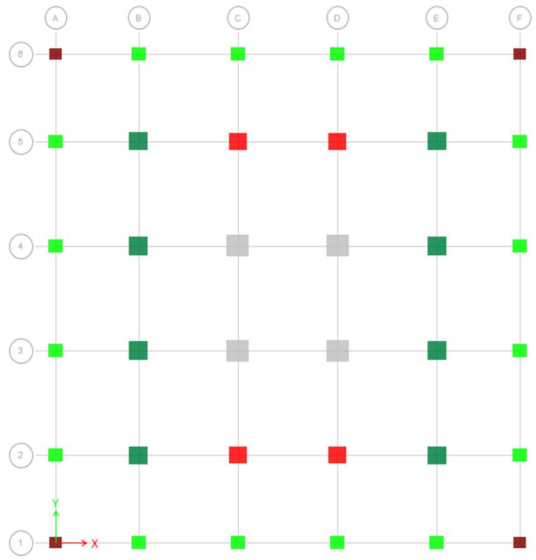
S.I No	Particulars	Dimension/Value
1	Plan Dimension	28x28 m
2	Total height of the building	75.6 m (G+25)
3	Height of base storey Height of each storey	3.6 m 3 m
4	Height of parapet	1.2 m
5	Thickness of slab Thickness of walls Dimension of Beam	150mm 230mm 600x400mm
6	Seismic zone Importance factor Zone factor Damping ratio	IV 1.5 0.24 5%
7	Floor finish Live load at all floors Wall load Parapet wall Density of concrete Density of brick	2.0kN/m2 3.0 KN/m2 8KN/m 3.75 KN/m 25 KN/m3 20 KN/m3
8	Grade of concrete column Grade of concrete Beam Grade of concrete Slab Grade of reinforcing steel Grade of tie steel Soil condition	M35 M35 M20 HYSD500 Fe250 Medium soil

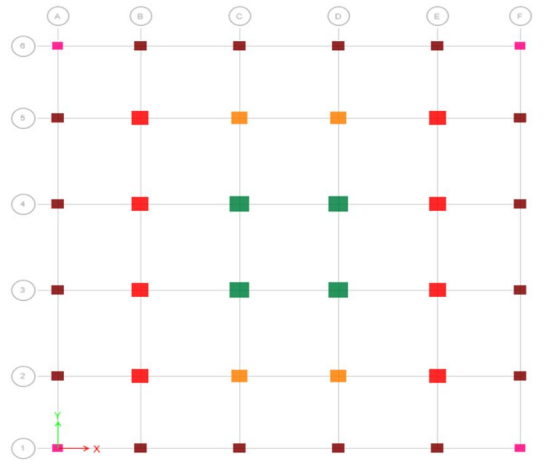
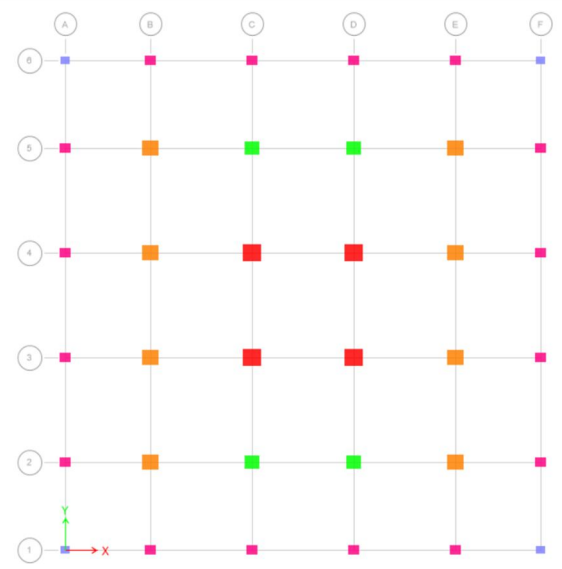
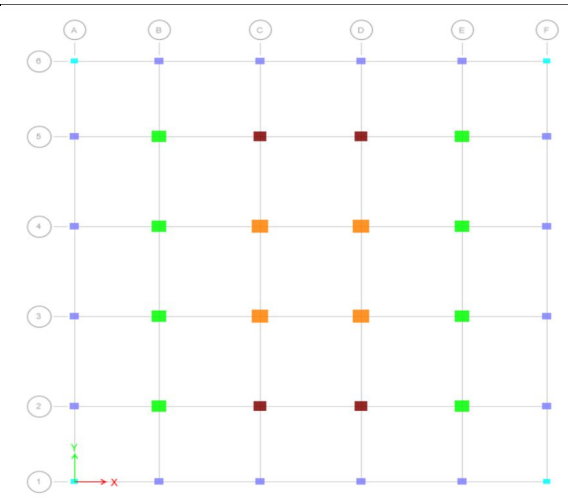


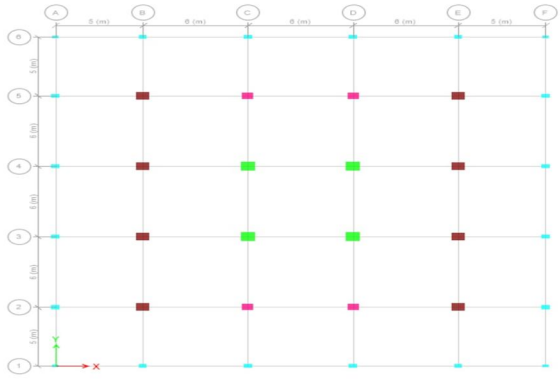
Minimum Uniform section of Beam which satisfy the demand/capacity ratio.

The dimension of Beam is 600x400 mm.

Total plan area is 28x28 m.

	Minimum Uniform section of Column which satisfy the demand/capacity ratio. The dimension of Column is 1050x950 mm. Total plan area is 28x28 m.
	After iterative process the optimized dimension which satisfy the demand/capacity ratio. Inner Beam is 600x400 mm Outer Beam is 450x350 mm which is shown by different color in figure. Total plan area is 28x28 m.
	After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 1 to storey 5. Different types of column section are used, which is shown by different color. 4 RCC columns of 1350x1250 8 RCC columns of 1150x1050 4 RCC columns of 1050x650 16 RCC columns of 850x750 4 RCC columns of 750x650

	After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 6 to storey 10. Different types of column section are used, which is shown by different color. 4 RCC columns of 1150x1050 8 RCC columns of 1050x950 4 RCC columns of 950x850 16 RCC columns of 750x650 4 RCC columns of 650x550
	After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 11 to storey 15. Different types of column section are used, which is shown by different color. 4 RCC columns of 1050x950 8 RCC columns of 950x850 4 RCC columns of 850x750 16 RCC columns of 650x550 4 RCC columns of 550x450
	After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 16 to storey 20. Different types of column section are used, which is shown by different color. 4 RCC columns of 950x850 8 RCC columns of 850x750 4 RCC columns of 750x650 16 RCC columns of 550x450 4 RCC columns of 450x350



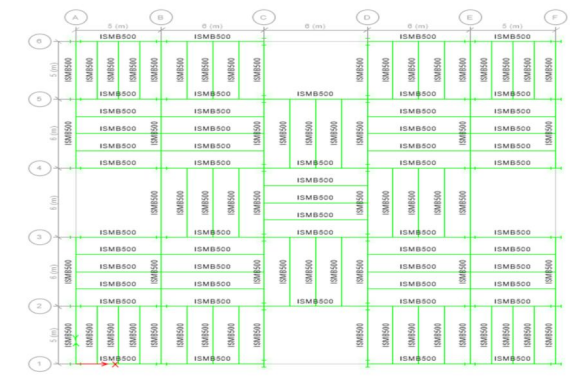
After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 21 to storey 25.

Different types of column section are used, which is shown by different color.

4 RCC columns of 850x750
8 RCC columns of 750x650
4 RCC columns of 650x550
20 RCC columns of 450x350

Table 3.2: Data for Analysis of Composite Structure

S.I NO	Particulars	Dimension/value
1	Plan Dimension	28x28 m
2	Total height of the building	75.6 m
3	Height of each storey	3 m
4	Height of parapet	1.2 m
5	Thickness of slab Thickness of profiled deck Thickness of walls	140 mm 75-100 mm 230 mm
6	Seismic zone Importance factor Zone factor Damping ratio	IV 1.5 0.24 5%
7	Floor finish Live load at all floors Wall load Parapet wall Density of concrete Density of steel Density of brick	2.0 KN/m2 3.0 KN/m2 8 KN/m 3.75 KN/m 25kN/m2 7850 kg/m3 20 KN/m3
8	Grade of concrete in column Grade of deck Grade of reinforcing steel Soil condition	M35 M20 HYSD500 Medium soil

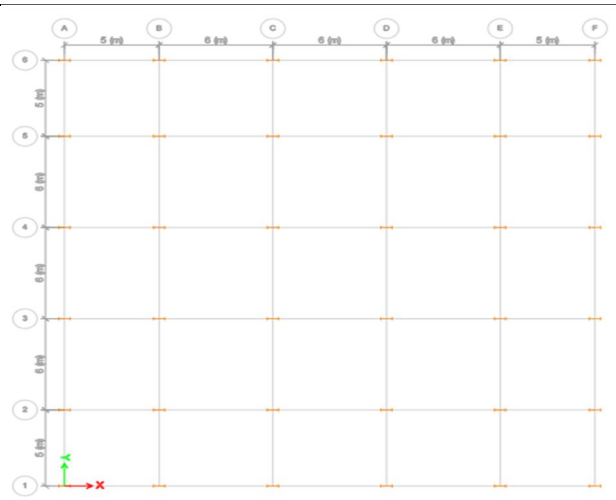
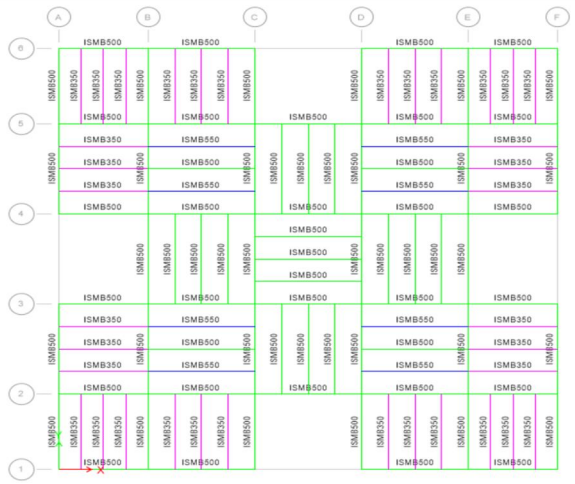
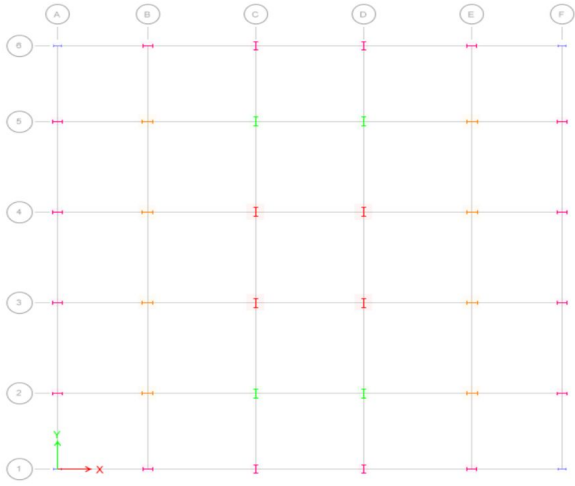


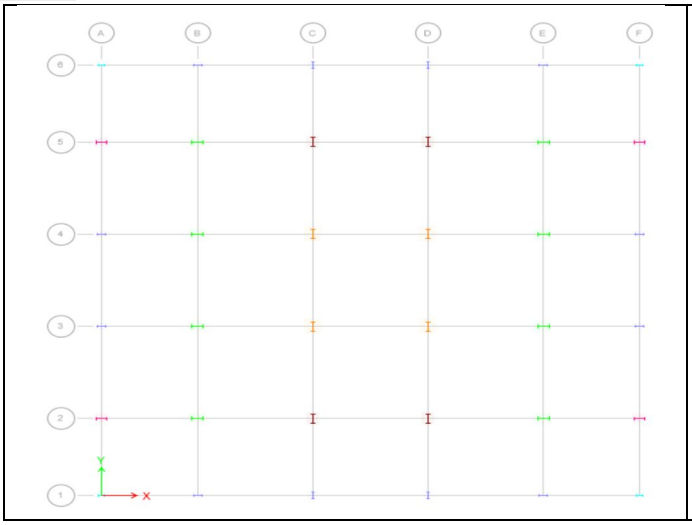
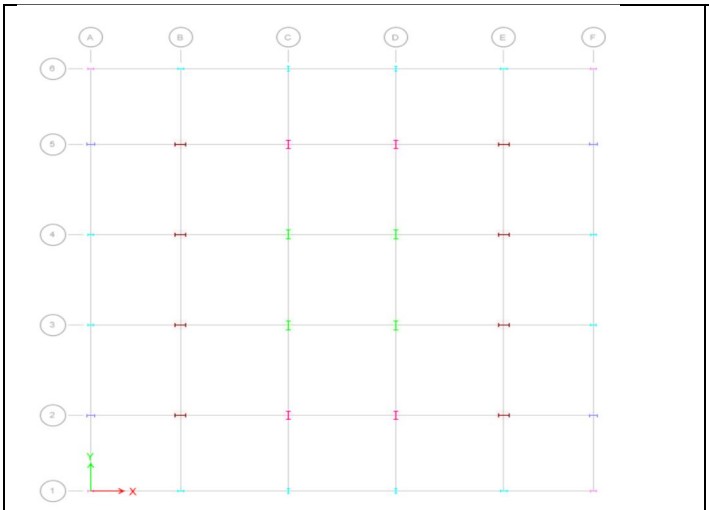
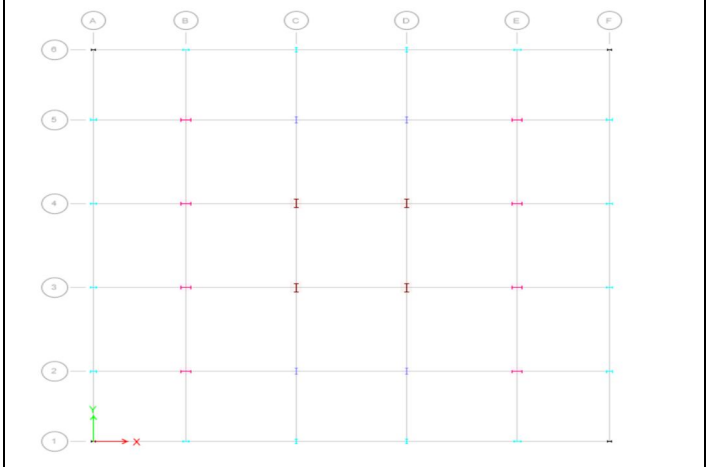
Minimum Uniform section of Beam which satisfy the demand/capacity ratio.

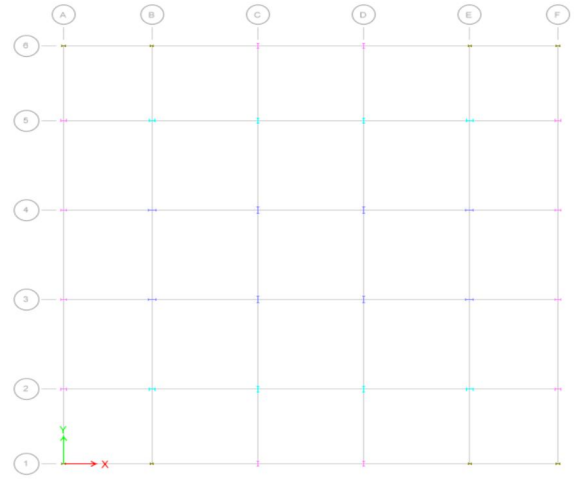
The dimension of Beam is ISMB500.

Total plan area is 28x28 m.

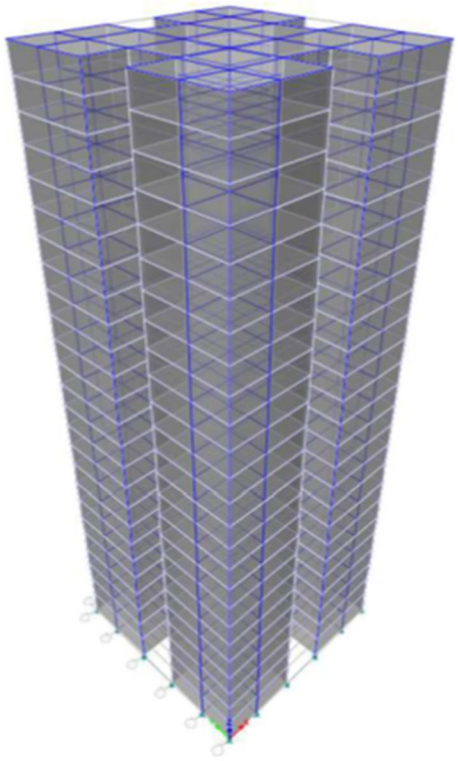
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	Minimum Uniform section of Column which satisfy the demand/capacity ratio. The dimension of Column is 950x850 mm. Total plan area is 28x28 m.
	After iterative process the optimized dimension which satisfy the demand/capacity ratio. Inner Beam is ISMB500 outer Beam is ISMB350 which is shown by different color in figure. Total plan area is 28x28 m.
	After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 1 to storey 5. Different types of column section are used, which is shown by different color. 4 composite columns of 1050x850 8 composite columns of 950x850 4 composite columns of 850x750 16 composite columns of 650x550 4 composite columns of 550x450

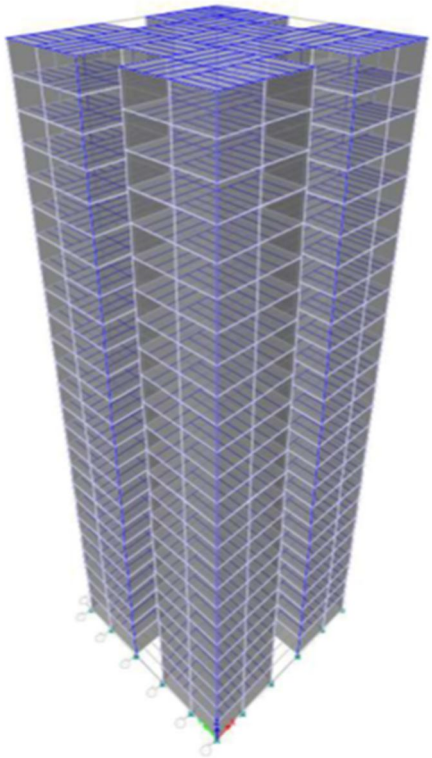
	After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 6 to storey 10. Different types of column section are used, which is shown by different color. 4 composite columns of 950x850 8 composite columns of 850x750 4 composite columns of 750x650 4 composite columns of 650x550 12 composite columns of 550x450 4 composite columns of 450x350
	After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 11 to storey 15. Different types of column section are used, which is shown by different color. 4 composite columns of 850x750 8 composite columns of 750x650 4 composite columns of 650x550 4 composite columns of 550x450 12 composite columns of 450x350 4 composite columns of 400x300
	After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 16 to storey 20. Different types of column section are used, which is shown by different color. 4 composite columns of 750x650 8 composite columns of 650x550 4 composite columns of 550x450 4 composite columns of 550x450 12 composite columns of 450x350 4 composite columns of 350x250

	After iterative process the optimized dimension which satisfy the demand/capacity ratio for storey 21 to storey 25. Different types of column section are used, which is shown by different color. 8 composite columns of 550x450 8 composite columns of 450x350 12 composite columns of 350x250 8 composite columns of 300x200

C. Analysised Model Of Rcc And Composite Structure Of G+25 Storey



RCC Structure

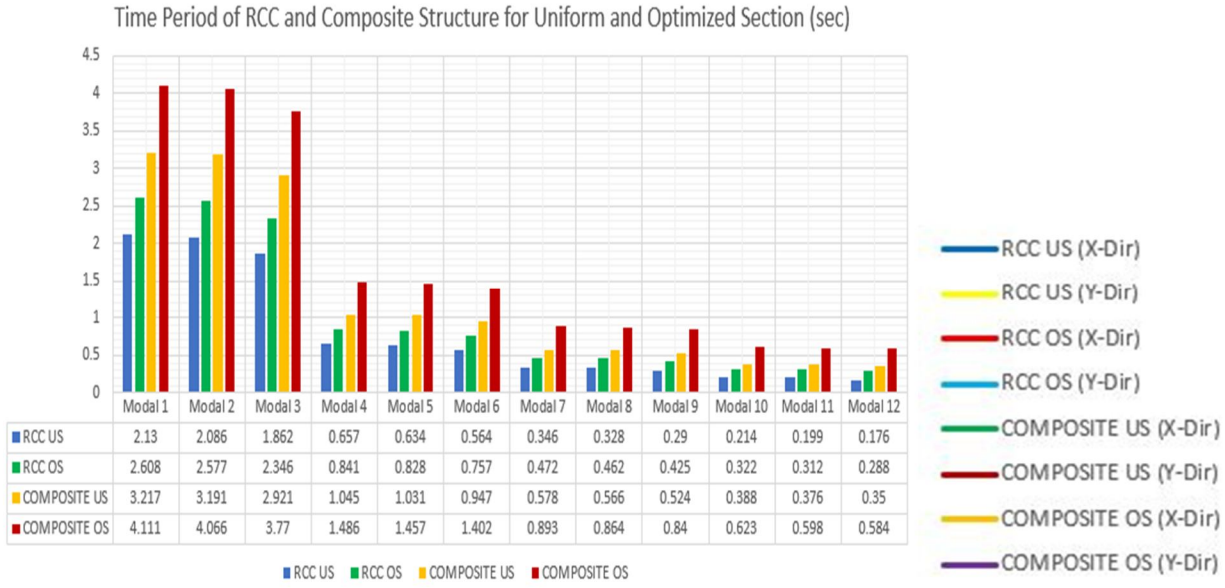


Composite Structure

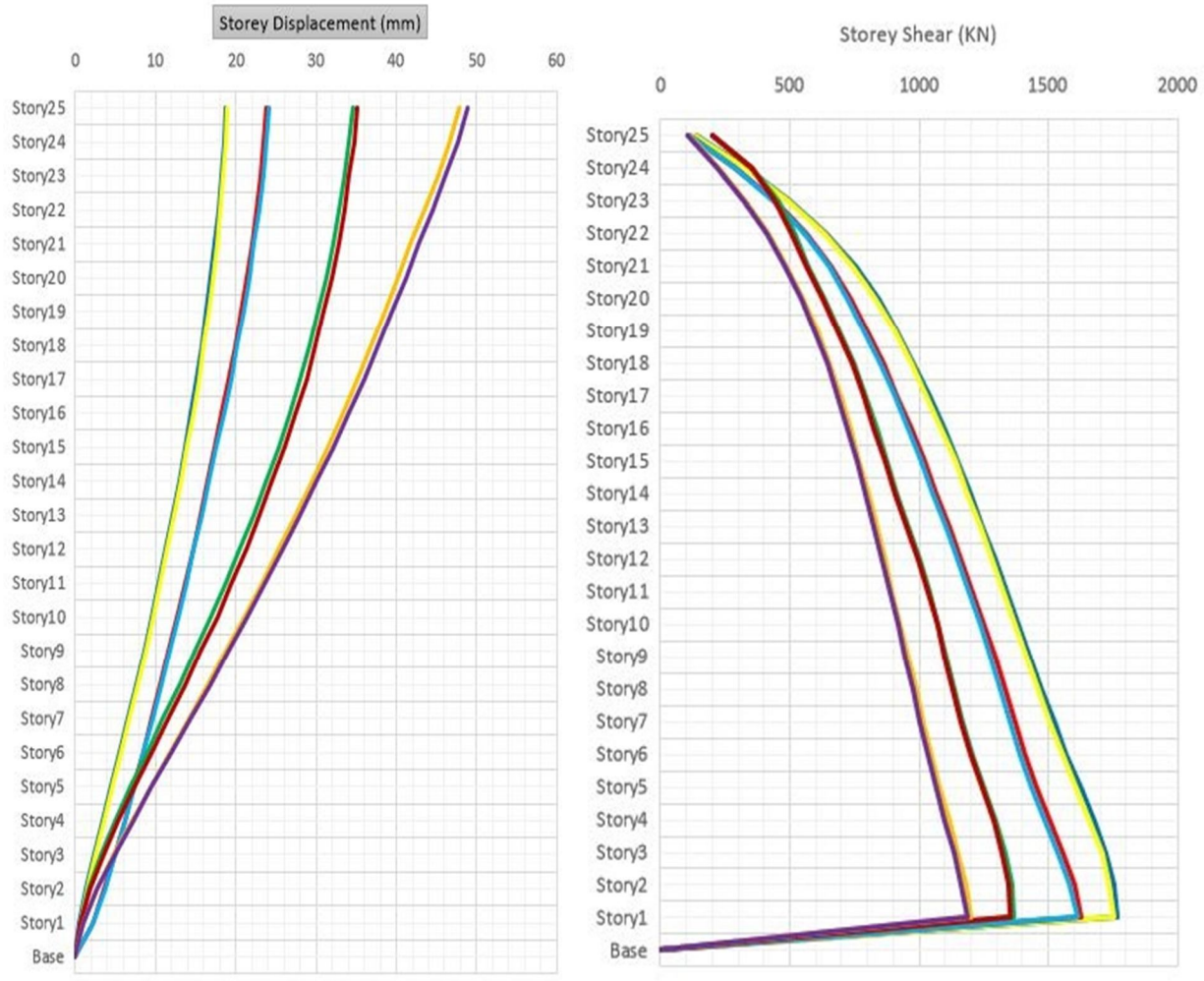
IV. RESULT

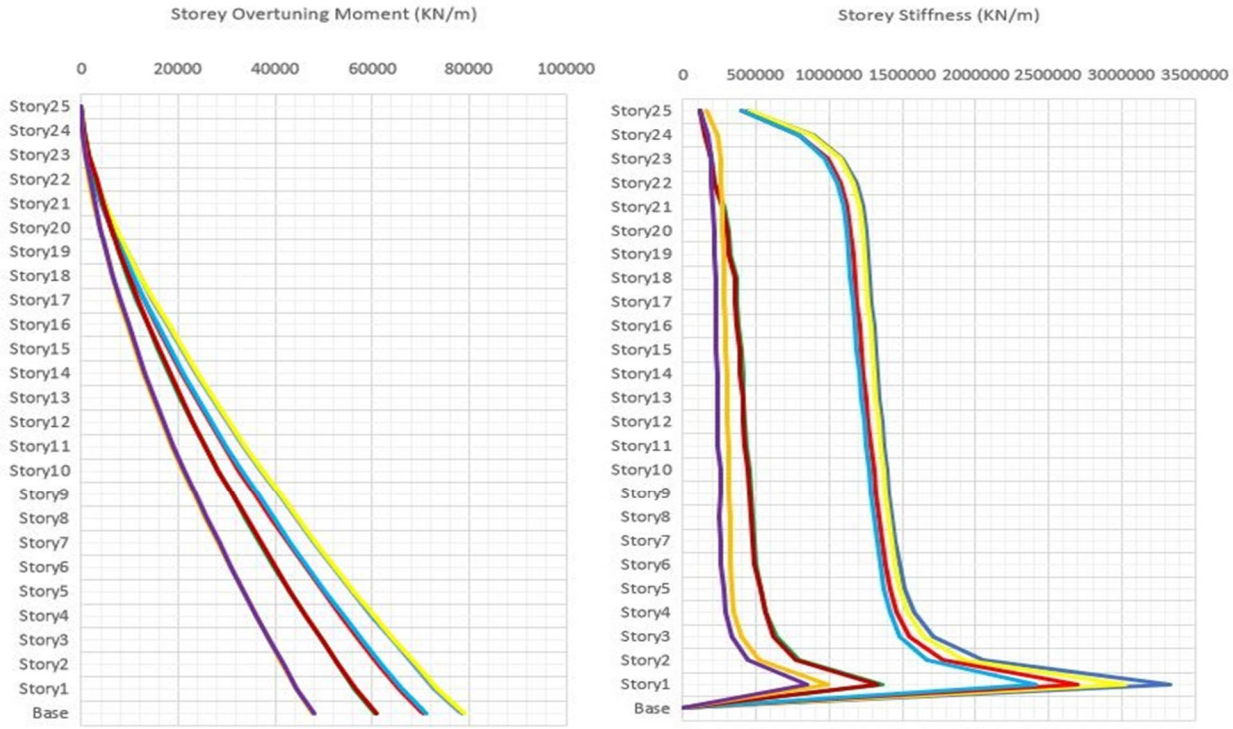
The Dynamic Analysis is conducted on two different model using CSI ETABS19, several values of model were found out from RCC and Composite Structure. IS 1893-2016 guidelines is used for the Dynamic Analysis of four model of G+25 storey. these structures are analyzed for RCC and Composite Structure of uniform and optimized section.

Therefore, total four models are used for analyzing the response of the building. The result of frequency, time period, displacement, drift, storey shear, storey overturning moment and storey stiffness are compared for both RCC and Composite structure of uniform and optimized section.



	Modal 1	Modal 2	Modal 3	Modal 4	Modal 5	Modal 6	Modal 7	Modal 8	Modal 9	Modal 10	Modal 11	Modal 12
RCC US	2.13	2.086	1.862	0.657	0.634	0.564	0.346	0.328	0.29	0.214	0.199	0.176
RCC OS	2.608	2.577	2.346	0.841	0.828	0.757	0.472	0.462	0.425	0.322	0.312	0.288
COMPOSITE US	3.217	3.191	2.921	1.045	1.031	0.947	0.578	0.566	0.524	0.388	0.376	0.35
COMPOSITE OS	4.111	4.066	3.77	1.486	1.457	1.402	0.893	0.864	0.84	0.623	0.598	0.584





V. CONCLUSION & FUTURE SCOPE

A. *Time Period*

1) After optimization of RCC structure, time period increased by 22.4% as compare to uniform RCC section.
2) In a similar manner, time period increased by 28.6% for optimized section of composite structure as compare to uniform composite section.

B. *Storey Displacement*

1) Maximum storey displacement increased by 28.2%.for optimized RCC section with respect to uniform RCC section.
2) In a similar manner, maximum storey displacement increased by 40.7% for optimized section of composite structure as compare to uniform section.

C. *Storey Stiffness*

1) After optimization of RCC structure, storey stiffness decreased by 27.8% as compare to uniform RCC section.
2) In a similar manner, storey stiffness decreased by 37.9% for optimized section of composite structure as compare to uniform composite section.

D. *Storey Shear*

1) Maximum storey shear decreased by 9.1%.for optimized RCC section with respect to uniform RCC section.
2) In a similar manner, maximum storey shear decreased by 13.2% for optimized section of composite structure as compare to uniform composite section.

E. *Storey Overturning Moment*

1) In case of Uniform Section to optimized section for RCC, maximum storey overturning moment decreases by 10.9%.
2) In a similar manner, Uniform Section to optimized section for composite structure, maximum storey overturning moment decreases by 21.5%.

F. Future Scope

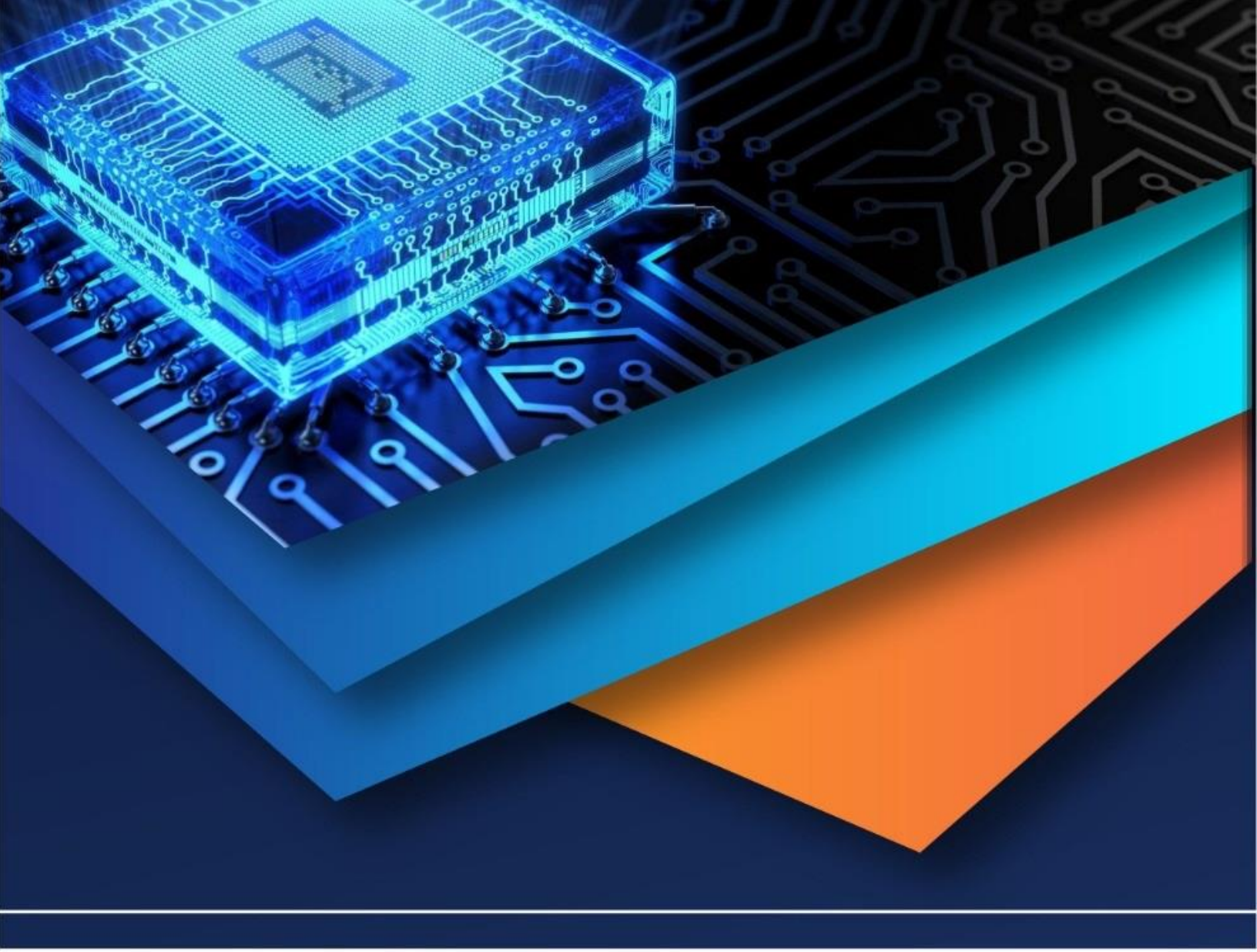
In this paper it is shown that RCC and Composite structures are compared in various aspects under uniform and optimized conditions. But found that Fire protection is very important in case of steel or composite structure. it can lead to change the design criteria such as thickness of slab, nominal cover of composite column etc. and other thing is soil conditions it can be changed other than hard soil and can be compared for worst conditions. in India generally these aspects are not considered fully. But practical applications of these comparison can make structure more safe and more economical. Also, more accurate comparison processes and aspects can be developed.

Study can be held on comparison of RCC structure with sear walls and bracing in deferent locations against Composite structure with sear walls and bracing in same location. The researchers can use deferent software and then compare results and state that which software is more effective.

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