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Analysis And Design Of Steel Building over Reinforced Cement Concrete Building

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Abstract— Structural engineers are facing the challenge of most efficient and economical design with accuracy in answer whereas ensuring that the ultimate design of a building should be safe and serviceable over its life – time. Nowadays, structural needs for high rise buildings are changing and expansion of planning is becoming more significant. In the present work, comparative study of purely reinforced cement concrete, purely steel and lower floors of reinforced cement concrete with above floors of steel (G+7) residential building which is situated in earthquake zone-III for earthquake loading and wind zone V for wind loading to achieve different use in height direction and great public atrium in lower stories that provides attractive free space. ETABS is incorporated with all the main analysis engines that's static, dynamic, Linear and non-linear, etc. This software is used to analyze and design of buildings. Taking the horizontal loading effects of wind & seismic forces are according to IS 1893:2000 (part 1) and IS 875(part 3), linear static analysis and response spectrum analysis are performed using ETABS 2014. Comparison of steel building over reinforced cement concrete building, purely steel building and purely reinforced cement concrete building is made by considering story displacement, story drift, story shear, story stiffness, time period of seismic response and wind response and it is found that hybrid structure is found to be more economical where horizontal expansion is restricted.

Keywords— Residential building, Hybrid structure, Seismic effect, Wind effect, ETAB.

I INTRODUCTION

The conventional system of reinforced cement concrete modeling is unable to fulfill large demand of shelter in brief house of contemporary world. To provide the shelter in available space in metropolitan cities in India, the construction industry is looking forward to a newly developed and economic system of hybrid steel-concrete modeling for high rise structures. In recent ultra-high-rise buildings, there are many cases where large spans are required to gain special freedom on typical floors and wide atria to allow continuity with the external spaces on the lower floors. In order to attain these areas, it's necessary to produce high strength within the structural members that represent the building structure, notably the columns. It is potential to avoid overly massive volume columns by victimization applicable combos of high strength materials. As we all known, super high-rise building is complex engineering system, which involving beauty, safety and economy. However, there's another structural kind, all-steel structure, which has better structural performance. According to the site condition of the region where building is situated, and considering each performance and engineering cost, we decide the hybrid structure system, earthquake forces may be necessary in design in high earthquake zones of the country. Seismic response of hybrid buildings is totally different from alternative structural systems as there's separation, both in the lateral and vertical load transfer mechanisms. The response below lateral masses becomes complicated thanks to specific strength and stiffness discontinuities ensuring from the utilization of various structural systems. The hybrid structure includes the hybrid floors, hybrid beams and hybrid columns used individually or in varying combinations to make the design cost-effective and efficient to the desired performance and service requirements. The most commonly used sections are steel beam anchored to concrete slab by means of shear connectors of rigid, flexible or bearing types like studs, cut channels etc. and steel column enclosed within the reinforced cement concrete.
The innovative and revolutionary new ETABS is that the final integrated software system package for the structural analysis and style of buildings. CAD drawings are often directly regenerate into ETABS models. Design of steel and concrete frames, hybrid beams, hybrid columns, concrete and masonry shear walls, as give the capability check for steel connections and base plates.

A Description Of Building

Plot area = 900 m^2
Floor space ratio = 0.8
Allowable built up area = 700 m^2

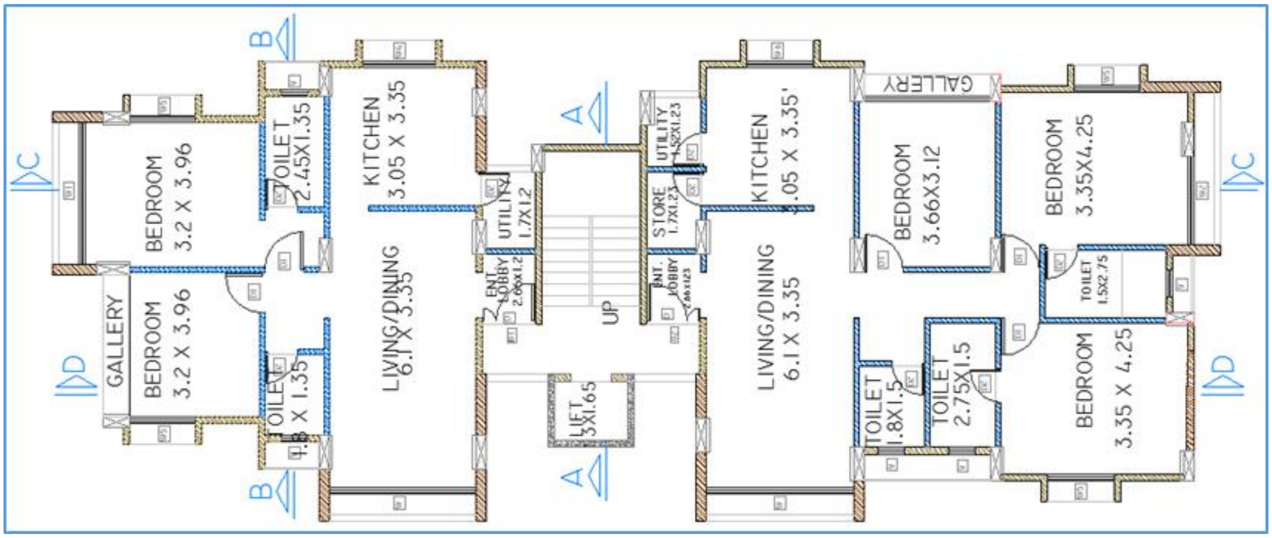


Figure.1**:** Plan of building,

B Modeling Of Structural Systems In ETAB

Fundamental to ETABS modeling is the generalization that multi-story buildings usually include identical or similar floor plans that repeat within the vertical direction. Modeling options that streamline analytical-model generation, and simulate advanced unstable systems, are listed as follows:

a) Templates for global-system and local-element modeling
b) Customized section geometry and constitutive behavior
c) Grouping of frame and shell objects
g) Editing and assignment features for plan, elevation, and 3D views

Once modeling is complete, ETABS automatically generates and assigns code-based loading conditions for gravity, seismic, wind, and thermal forces. Users could specify an infinite variety of load cases and combos. Analysis capabilities then offer advanced nonlinear methods for characterization of static-pushover and dynamic response. Dynamic considerations may include modal, response-spectrum analysis.

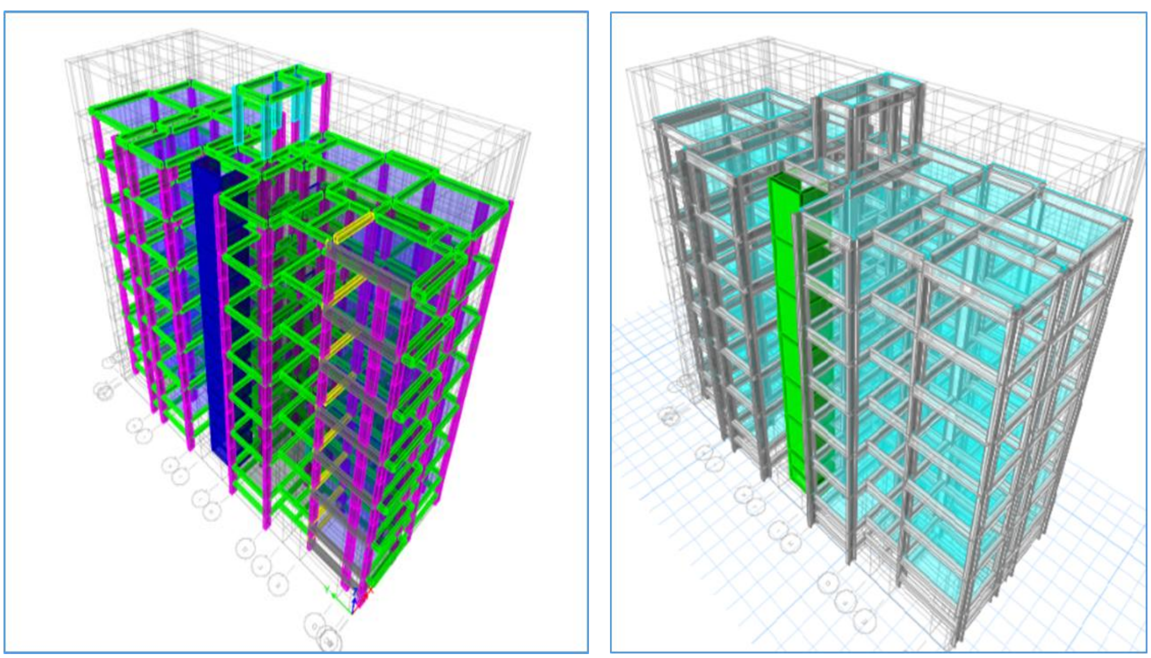
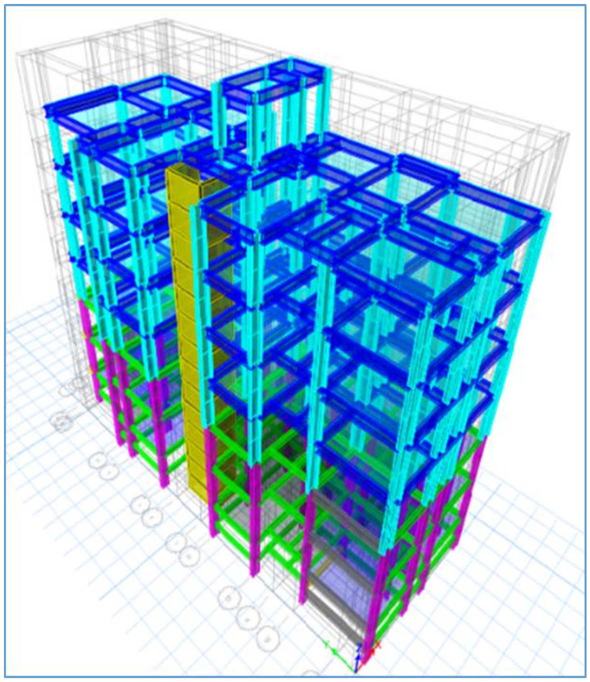


Figure.2**:** a) Modeling of Reinforced Cement Concrete building, b) Modeling of Steel building,



c) Modeling of steel building over reinforced cement concrete building

C Load Calculations Used For Result

Table 1: Dead Load Calculations

Dead load on external beams due to external walls		
Story 1-story 6	20x0.23x3	13.8 kN/m
plinth	20x0.23x3	13.8 kN/m
Dead load on internal beams due to internal walls		
Plinth –storey6	20x0.0.115x3	6.9 kN/m
Dead load on cantilever beams of 130mm thick		
Gallery 1	25x0.13x0.6	2kN/m
Lift	25x0.2x1.5	6kN/m
Staircase with floor finish of 2kN/M	Total no. of riser of 150mm Total no. of tread of 240mm 25x0.24x0.15x10x2	20 No. 18 No. 20 kN/m
Landing of 200mm thick	25x2.44x0.2	12 kN/m
Headroom(water tank load)		17 kN/m
Dead loads on slab		
Story 1-Headroom		1 kN/m^2

Table 2: Live Load Calculations

Live load on beams	No live loads
Live load on slabs	
Story 1-Headroom	2 kN/m

Table 3: Seismic Loads

Zone	III
Zone factor	0.16
Importance Factor	1
Response Reduction Factor	5

Table 4: Wind Loads

Wind Speed	50 m/s
Windward Coefficient(Cp)	0.8
Leeward Coefficient(Cp)	0.5

Terrain Category	3
Structure Class	c
Risk Coefficient Factor (k1)	1
Topography Factor (k3)	1

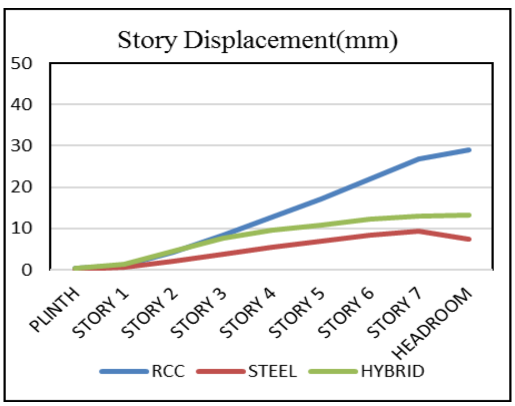
D Load Combinations Used For Results

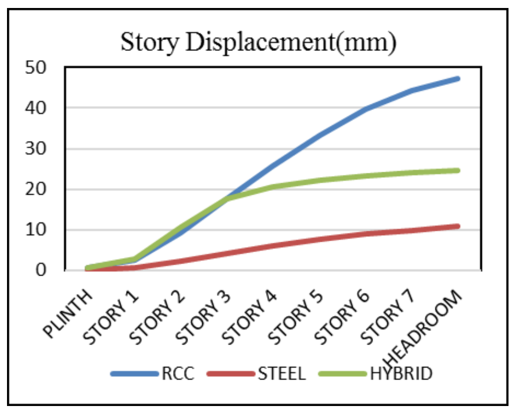
1)1.5(DL+/-EX)
2)1.5(DL+/-EY)
3)1.5(DL+/-WX)
4)1.5(DL+/-WY)
5)1.2(DL+LL+/-EX)
6)1.2(DL+LL+/-EY)
7)1.2(DL+LL+/-WX)
8)1.2(DL+LL+/-WY)

E Compaison Of Analysis Results

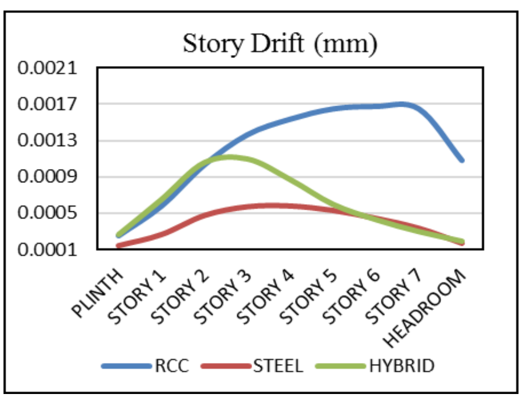
1 Linear Static Analysis due to seismic loads

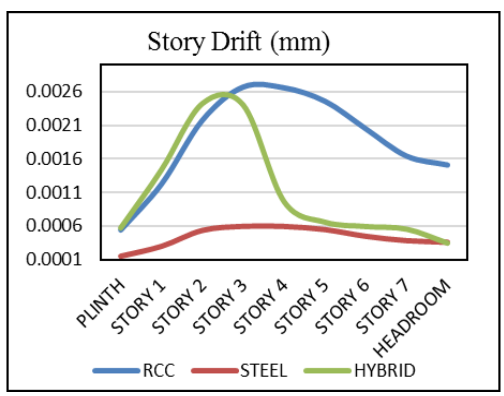
Graph 1 Comparison of Maximum Story Displacement Along Both Direction





Graph 2 Comparison of Story Drift Along Both Direction





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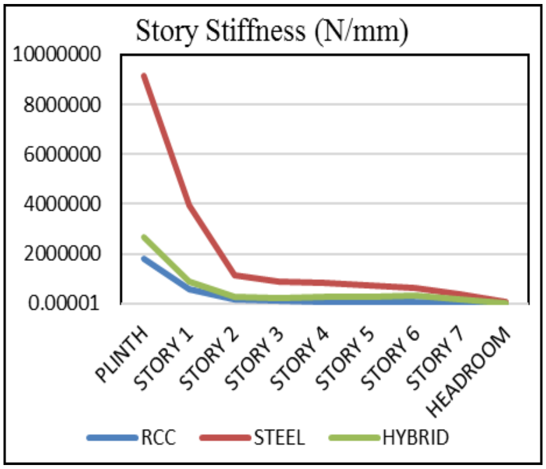
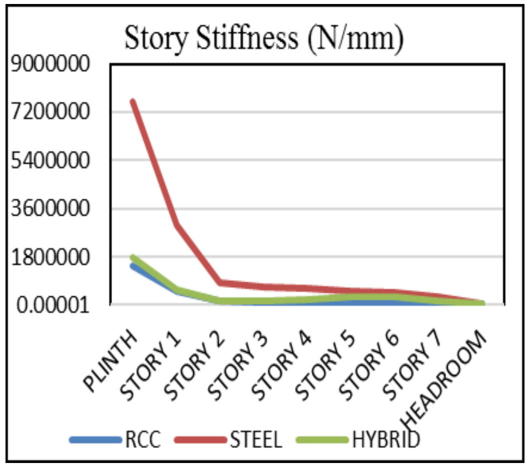
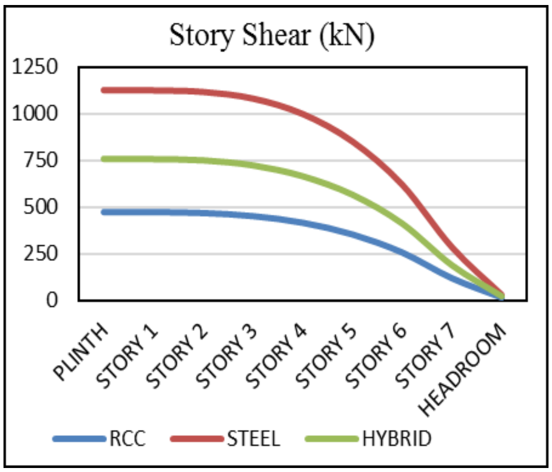
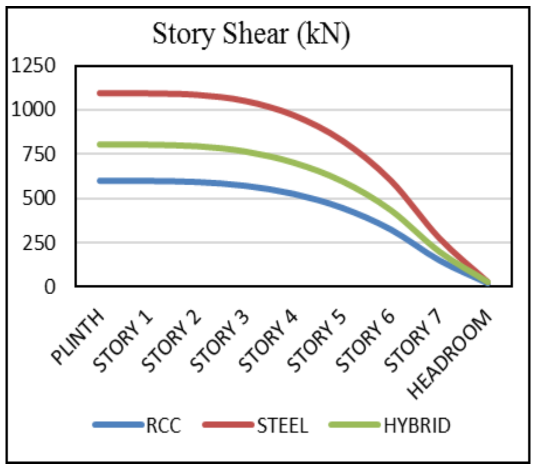
Graph 3 Comparison of Story Stiffness Along Both Direction





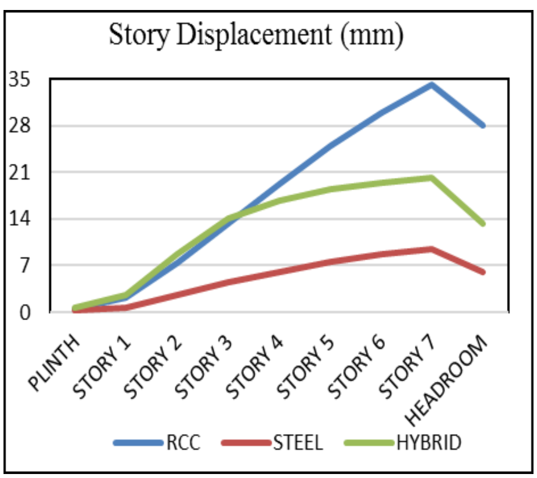
Graph 4 Comparison of Story Shear Along Both Direction

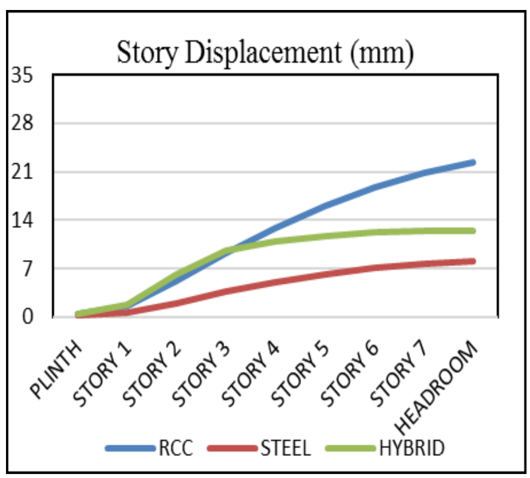




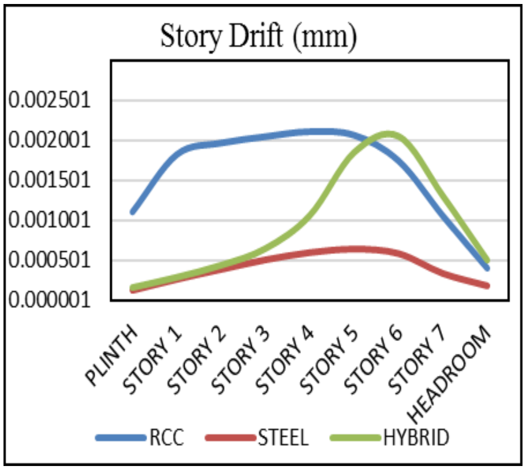
2 Response Spectrum analysis due to seismic load

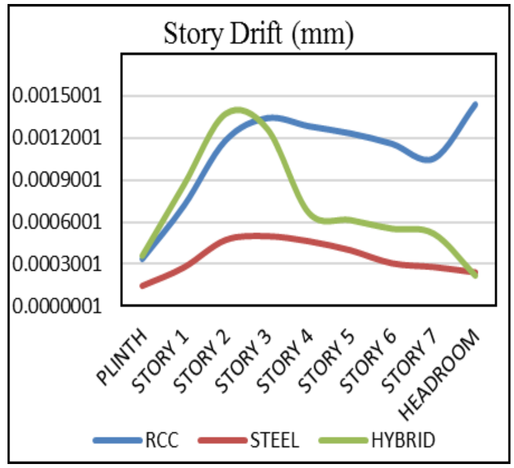
Graph 5 Comparison Of Maximum Story Displacement Along Transverse Direction



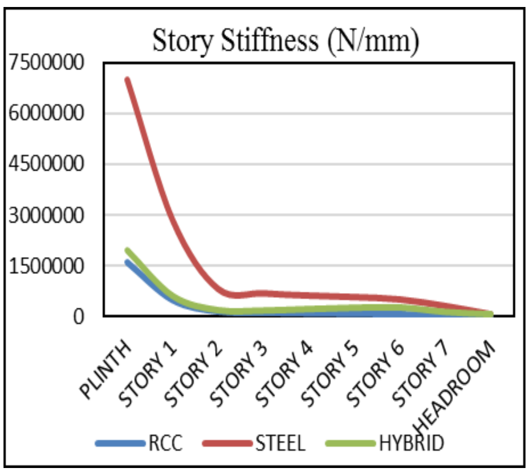


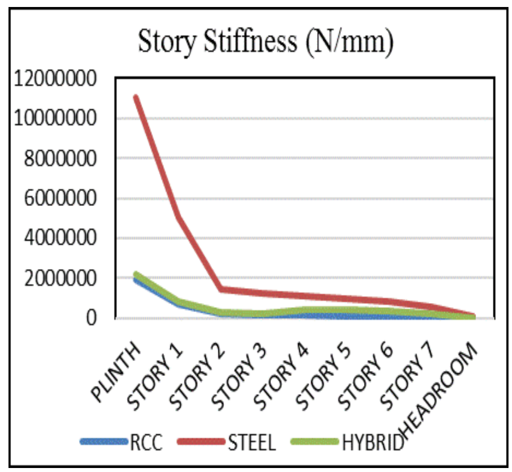
Graph 6 Comparison Of Story Drift Along Longitudinal Direction



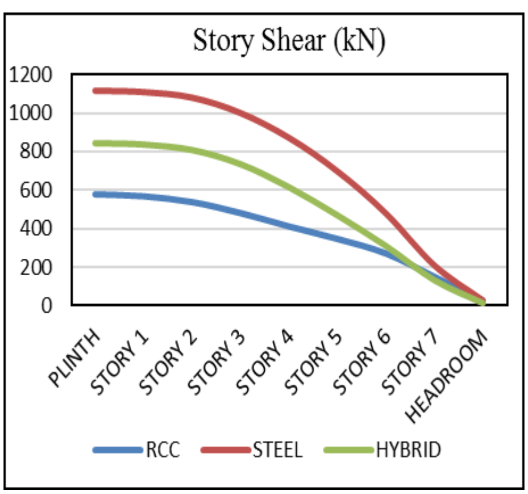


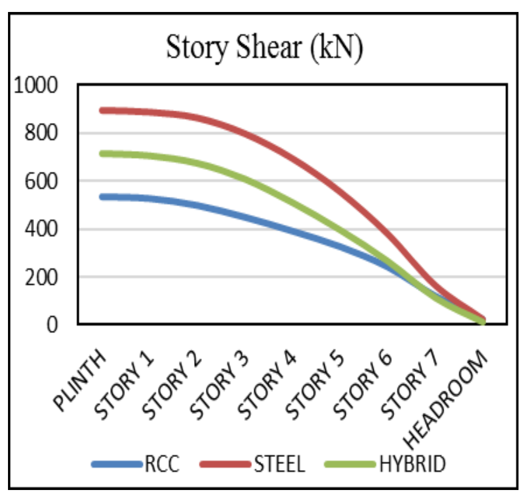
Graph 7 Comparison Of Story Stiffness Along Longitudinal Direction





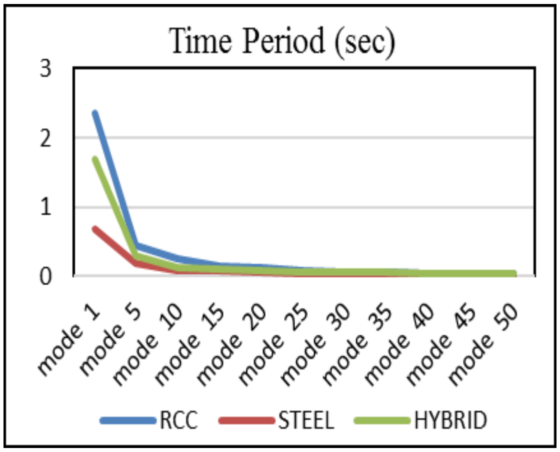
Graph 8 Comparison Of Story Shear Along Transverse Direction





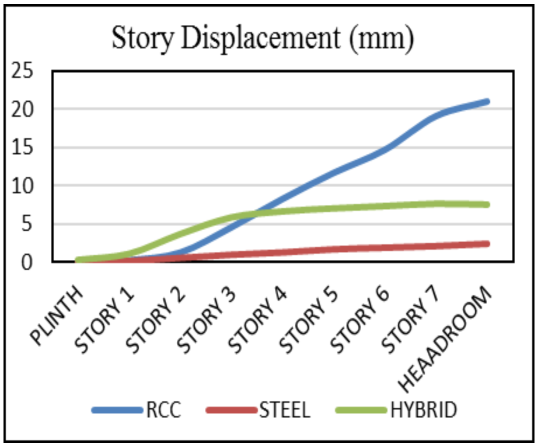
3 Modal Time Periods

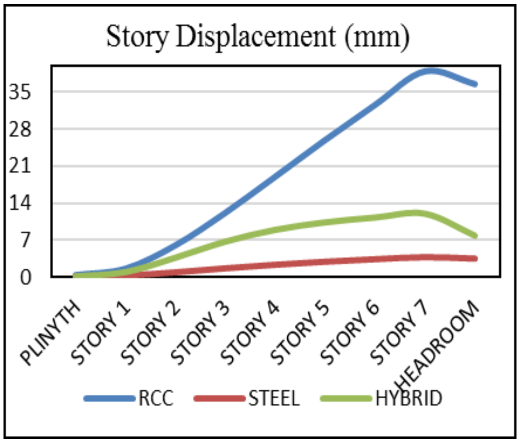
Graph 9 Comparison Of Modal Time Period



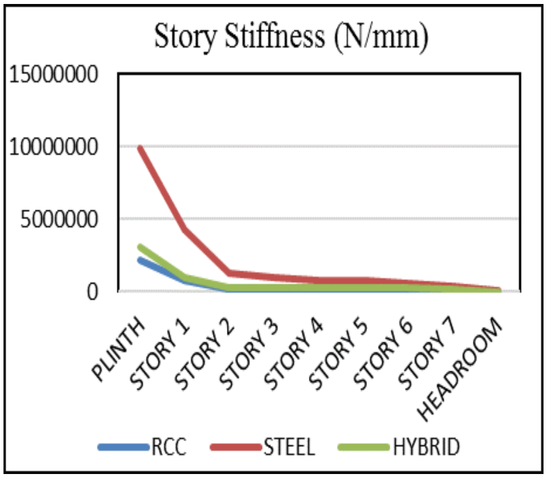
4 Wind loads

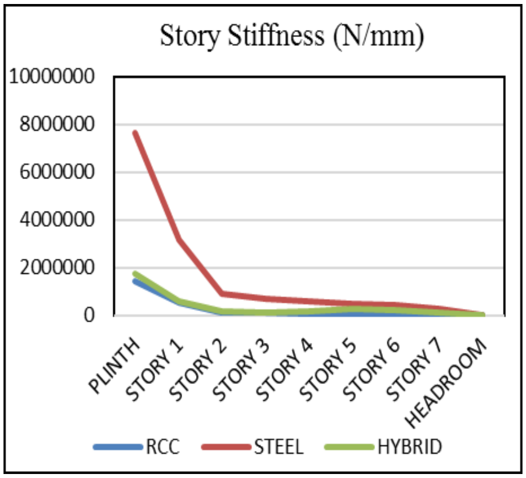
Graph 10 Comparison Of Story Displacement Along Longitudinal Direction



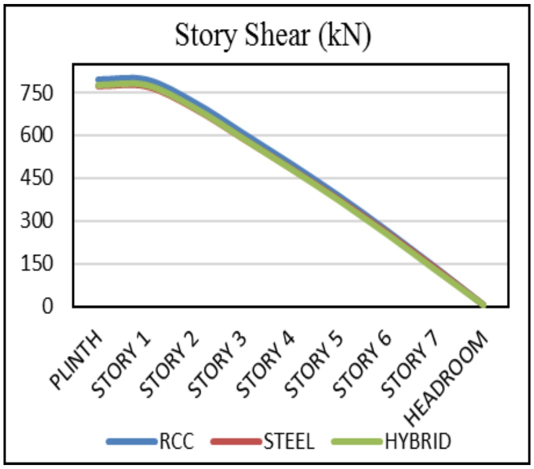


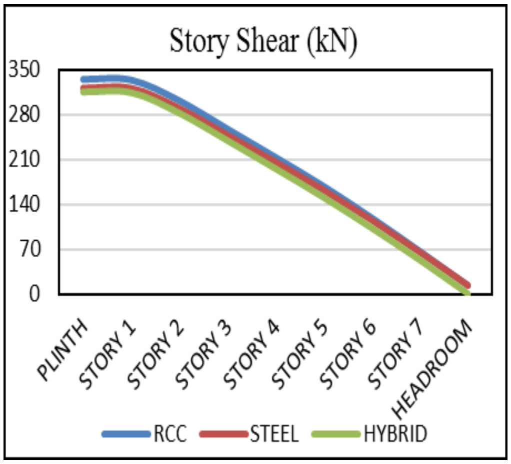
Graph 11 Comparison Of Story Stiffness Along Longitudinal Direction





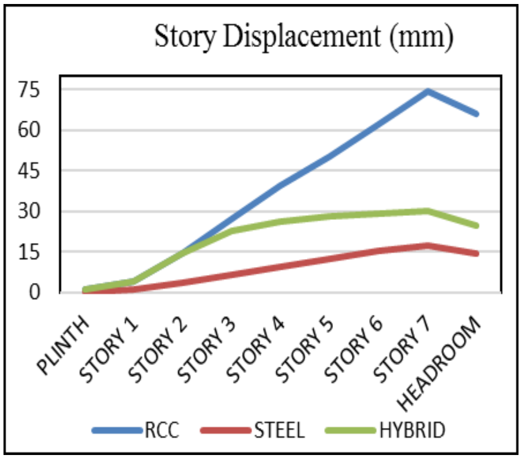
Graph 12 Comparison Of Story Shear Along Longitudinal Direction

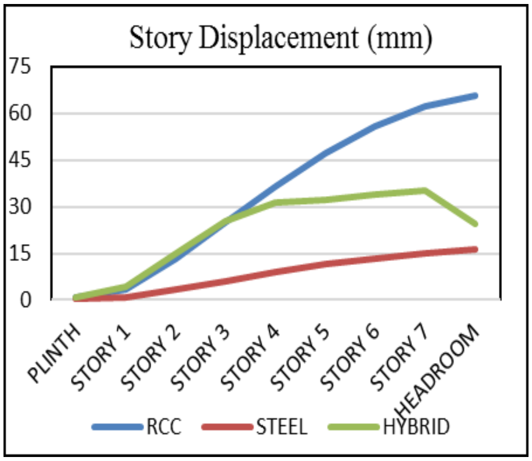




5 Envelope

Graph 13 Comparison Of Story Displacement Along Transverse Direction





F Analysis Results

***1*)Linear Static Analysis Due To Seismic Load**

1) Story displacement of hybrid structure is less as compared to reinforced cement concrete but more as compared to steel building along both longitudinal and transverse direction due to seismic loads.

2) Story drift of hybrid structure is less as compared to reinforced cement concrete but more as compared to steel building along both longitudinal and transverse direction due to seismic loads.

3) Story stiffness of hybrid structure is slightly more than reinforced cement concrete building but less as compared to steel building.

***2*)Response Spectrum Analysis Due To Seismic Load**

1) Story drift of hybrid building is nearly equal to reinforced cement concrete building but greater than steel building along both longitudinal and transverse direction.

2) Story stiffness of hybrid building is nearly equal to reinforced cement concrete building but less than steel building along both longitudinal and transverse direction.

3) Story shear of hybrid building is more than reinforced cement concrete building but less than steel building along bot longitudinal and transverse direction.

***3*)Wind Load**

1) Story displacement of hybrid structure is less as compared to reinforced cement concrete but more as compared to steel building along both longitudinal and transverse direction due to wind loads

2) Story shear of hybrid structure is nearly equal to reinforced cement concrete and steel building due to wind loads along both longitudinal and transverse direction.

4) The objective of this research was to study steel building over reinforced cement concrete building and comparing it with purely reinforced cement concrete building and purely steel building. The behavior of building due to seismic loads and wind loads are observed by performing static and dynamic analysis considering seismic zone III and wind zone V. Story displacement, story shear, story drift and story stiffness are the parameters considered for comparison. The results have indicated that improvements in this current design procedures are possible.

G Design Results

Table 5: Reinforced Cement Concrete Building

Beam	150x300,230x400
Column	230x500

Table 6: Steel Building

Beam	ISWB 550
Column	ISWB 500 with (400*25mm) plate on top and bottom flanges
Base Plate	600x440mm having thickness of 25mm
Number of bolts required	8
Beam to column connection bracketed connections	3 per beam
Cleat angle	ISA 90 x 90 x 8
Beam to Beam connection	6 no. of bolts of dia 32mm with 100x550x9.4 mm plate

Table 7: Steel Building Over Reinforced Cement Concrete Building

Beam	ISWB 550
Column	ISWB 500 with (400*25mm) plate on top and bottom flanges
Base Plate	600x440mm having thickness of 25mm
Number of bolts required	8
Beam to column connection bracketed connections	3 per beam
Cleat angle	ISA 90 x 90 x 8
Beam to Beam connection	6 no. of bolts of dia 32mm with 100x550x9.4 mm plate

H Contribution to Present Work

1) Simple reinforced cement concrete building model with all loads is analyzed for seismic and wind loads using ETAB software. To find the story displacement of reinforced cement concrete building due to these loads, linear static and dynamic analysis due to seismic loads is performed. Response spectrum analysis is performed on the same reinforced cement concrete model. Therefore it is recommended in addition to make it more economical.
2) For the same architectural drawing steel building is modelled using steel sections. In addition to modelling same as reinforced cement concrete building, connections are designed for steel beams and columns. In present work bolted connections are used for connection steel members. Then building is analyzed for seismic and wind loads by static linear method and dynamic methods by using ETAB software. For steel building it is suggested to redesign the building by using welded connections and check its resistance to seismic and wind loads.
3) The behavior of steel building over reinforced cement concrete building is observed by analyzing it for seismic and wind loads. In addition to this, connection between steel column and reinforced cement concrete column is designed using bolted connections. Base plates with cleat angles are used for connecting these two columns having different materials. Other steel members connections are designed same as steel building connections.
4) Comparing the analysis results of reinforced cement concrete building, steel building and steel building over reinforced cement concrete building and reached to a conclusion of this project. The parameters considered for comparison are story displacement, story stiffness, story drift and story shear, time period.

I Scope for the Future Work

1) Understanding the behavior of steel building over reinforced cement concrete building, greater area can be achieved at above stories as compared to purely reinforced cement concrete buildings.

2) Entire study is done by keeping column base fixed with base plates with bolted connections. Further studies can be carried out by changing the fixity of column base and check its resistance to seismic and wind loads.
3) Hybrid buildings is designed by using reinforced cement concrete and steel material in this project. In future two different materials can be used for design of such type of hybrid buildings and verify whether they will become safe as per their requirements.
4) Buildings generally fails at joint only. In case of hybrid buildings focus is to be given to joint to make it safer. Modifications of connections between two hybrid members can be made and can develop new techniques of connecting them for getting more resistance at joint.
5) To find cost effectiveness of steel over reinforced cement concrete buildings compared to purely steel building and purely reinforced cement concrete building by making estimates so that hybrid building construction will become more efficient and popular.
6) Various different analysis such as pushover analysis and non-linear static analysis can also be performed to check behavior of hybrid building.

J Acknowledgement

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