

MONO COLUMN MULTI-STOREY STRUCTURAL SYSTEM USING COMPOSITE MATERIAL

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Abstract — Due to urbanization and scarceness of land multi-storey structures has been constructed using modern construction technology. Stability of structural system depends upon loading and supporting conditions. Due to the requirement of large service spaces, mono column structural system has been gained popularity. Structural system will be more stable when all the components balance static and dynamic loads. Fulfilling the criteria of stability conditions for a mono column will be a complicated. Mono column multi-storey structural system involves designing of structure using software which includes geometric modelling, providing material properties, sectional properties, fixing supports, imposing loads and boundary conditions using CSI ETABS. Seismic analysis has been performed and maximum values of stresses, shear forces, bending moments, deflection, storey drift and displacements are studied. Mono column multi-storey structural system using composite material has been compared with conventional RCC mono column structural system. It is found that composite material in mono column structure makes structure more serviceable as compare to conventional RCC mono column structure.

Keywords — Mono column structure, Multi- Storey Structure, Seismic response, Structural response, ETABS

I. INTRODUCTION

Structure supported only on single column is known as mono column structural system. Mono column structures will be a complicated one, compare with the structures supporting in all the sides depends upon their configuration, since mono column is supporting whole structure, all other members will act as cantilevers and mono column structure is a critical one. Eccentric loading will cause the structure to twist in any direction and may cause failure of structure is very critical condition. Mono column structure has supported on a single column which provides large serviceable area as compare to conventional RCC frame structure. Such type of structures provides more proper spaces for offices and parking. Mono column provides maximum serviceability due to maximum space utilization. In this study planning, structural analysis and design aspects of mono column building using composite materials has been compared with similar RCC building.

II. MODELLING

Different modelling parameters related to structure and materials are calculated. Modelling and analysis has been done in ETABS V16.2 FEM software. For static loading as per IS 875 (part I & II):1987, for dynamic loading as per IS 875 (part III & IV):1987 & IS 1893 -2002 with different material conforming to IS: 456-2000 & IS: 800-2007. It is analysed using Etabs by different steps involved in designing of structure supported on mono column using software are geometric modelling, providing loads & combinations of loading, providing properties of material and sectional properties, fixing supports and boundary Conditions, Special Commands, analysis specification and design command. The influence of plan geometry has a significant role in static analysis. Maximum values of bending moments, shear forces, stresses, deflection, storey drift and displacements are presented. In these two cases the floor load applicable almost vertical downward to the structure and dynamic load such as wind load & earthquake load are acting horizontal to the structure. Comparison of single column multi storey structural system with conventional RCC has done.

A. Structural Modelling

FEM based modelling approach ,multi-storey mono column structure with composite material and multi storey conventional RCC structure are compared for structural element & material used In these two models parameter for analysis are Maximum values of stresses, bending moments, shear forces, deflection, storey drift and displacements are common and properties of structure such as floor area, loading condition, load cases and number of storey in modelling is same exclusive of material & structure element property given in table I and typical modelling detail illustrated in Figure 1 to Figure 4.

TABLE I
STRUCTURE SPECIFICATION

S. No.	Structural component	Conventional RCC structure	Mono column composite structure
1	Column specification	300 mm X 300 mm (M-25 / FE-500)	Column 1800mm diameter (0 to 3.5 m) CFT 900mm-12mm (3.5 m to 26.25m) ISMB300 (3.5 m to 24.5 m) (M-50/ FE-250)
2	Beam Specification	200mm x 300mm (M-25 / FE-500)	Tee-Beam Non prismatic D =500 to 650mm (M-50 / FE-500)
3	Slab Specification	150 mm thick (M-25 / FE-500)	200 mm thick (M-30 / FE-500)
4	Struts	Not provided	8 strut at base 8 strut at top
5	Specification of strut	Not provided	Base - 500mm X 500mm (M-50 / FE500) Top – ISHB 450-2 (FE-250)

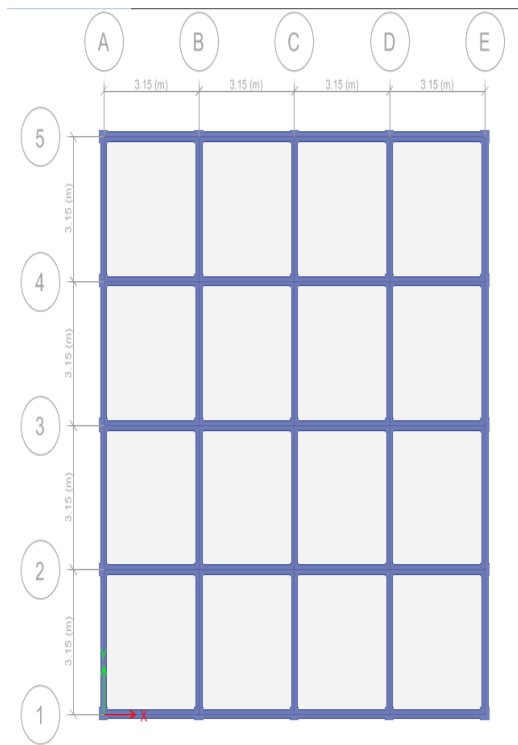


Fig. 1 Plan of Conventional RCC Building

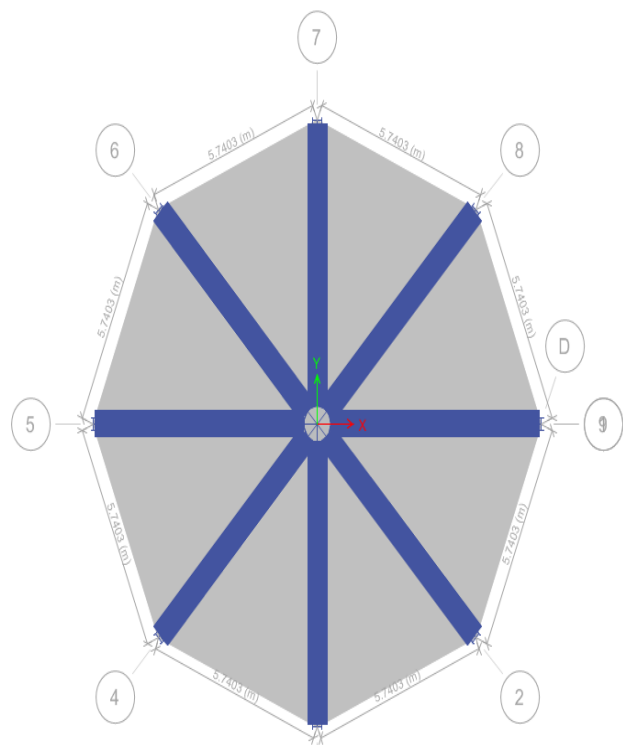


Fig. 2 Plan of Mono-Column Composite Building

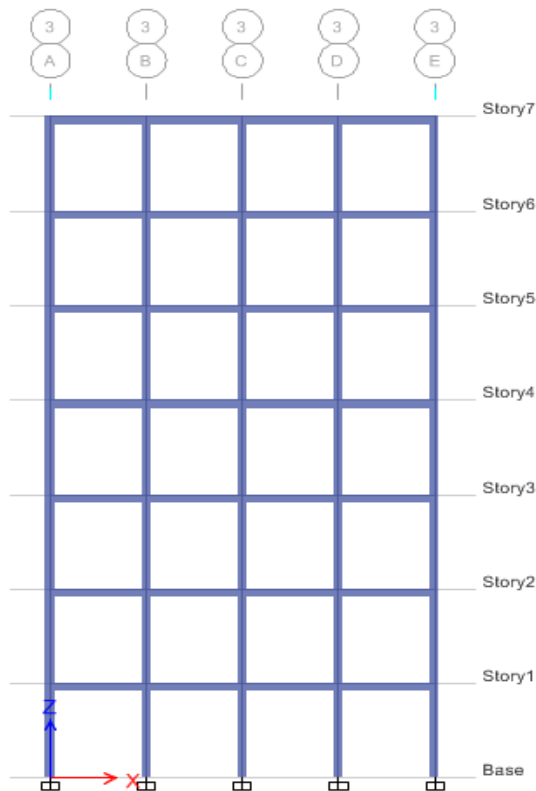


Fig.3 Conventional RCC Building

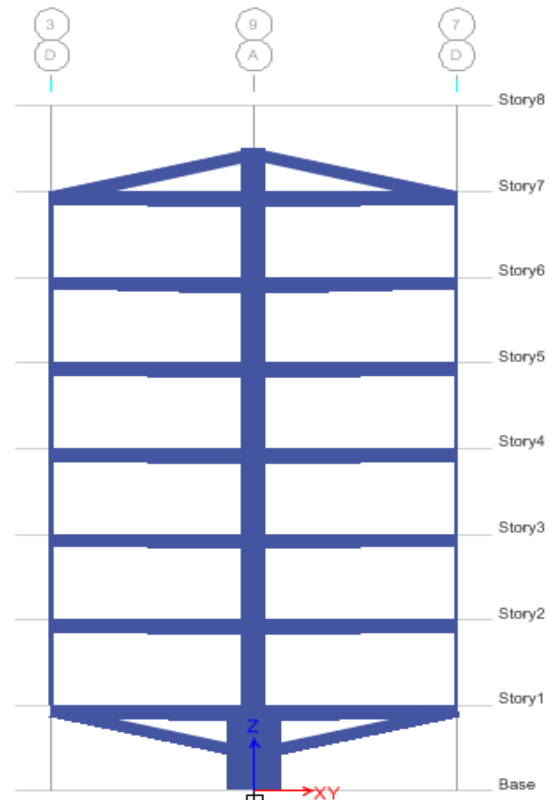


Fig.4 Mono-Column Composite Building

B. Structural Analysis

After FEM based modelling approach, multi-storey mono column structure with composite material and multi storey conventional RCC structure are compared for structural element & material used. Linear static and dynamic analysis done in ETABS V16.2 FEM software under various loading conditions according to IS 875-1987 & IS 1893-2002. Results are carried out for multi storey mono column structure and conventional RCC structure. In this research static analysis is performed to determine the displacements, stresses, strains, and forces in structures and their components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. After analysis of two models, seismic response like storey drift, joint displacement, maximum axial load on column and deflection of primary beam due to effect of static loads has been studied.

III. RESULTS AND DISCUSSION

In this research linear static analysis carried out in ETABS V16.2 FEM software considering various loading conditions. Results are compared for similar multi-storey mono column composite structures and conventional reinforced cement concrete structure.

A. Maximum Storey Drift

In the Fig.5 graph shows comparison OF maximum storey drift between multi storey mono column structure and conventional RCC structure and it is observed that storey drift in multi storey mono column structure is more than conventional RCC structure but storey drift is less than the permissible limit mentioned in IS 1893-2002.

B. Joint Displacement

In the Fig. 6 graph represents value of maximum displacement due to effect of earthquake loading at each floor for both models and it is found that joint displacement in multi storey mono column structure is more than conventional RCC structure. Joint displacement at storey first in mono column composite structure is less as compare to joint displacement in conventional reinforced concrete structure but as height increases joint displacements in mono column composite structure is more as compare to joint displacement in conventional reinforced concrete structure.

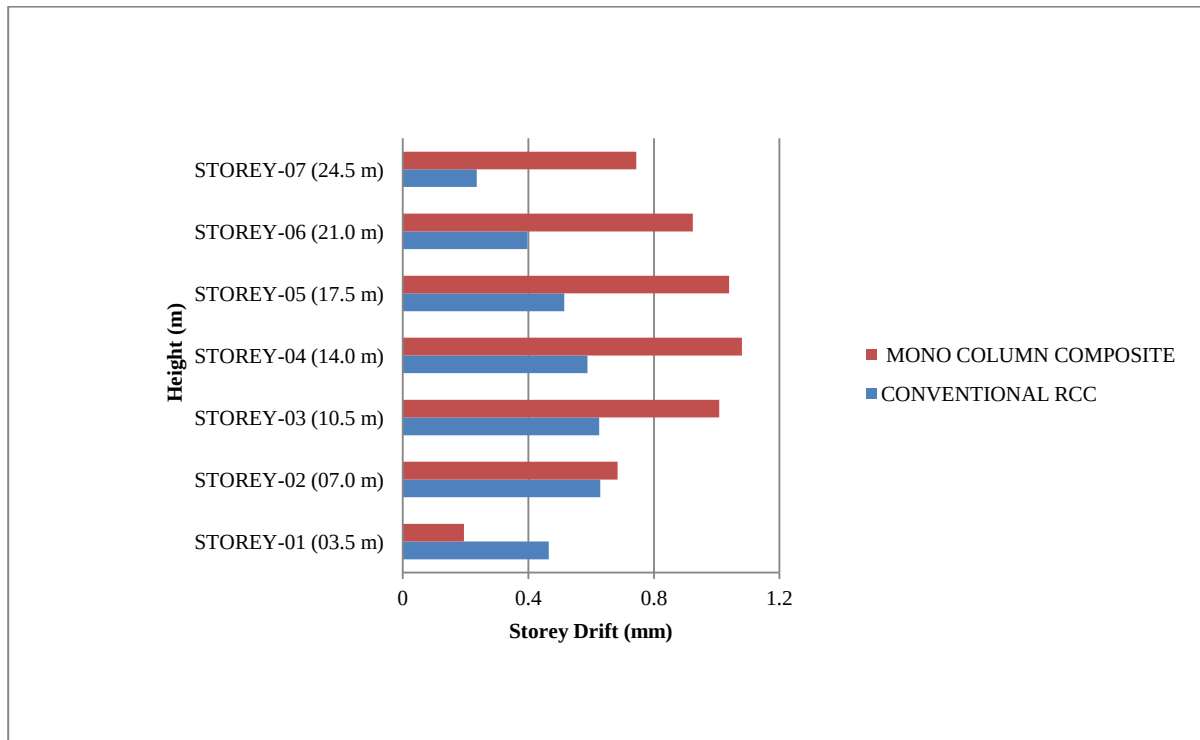


Fig.5 Storey Drift in Mono Column and Conventional RCC Structure

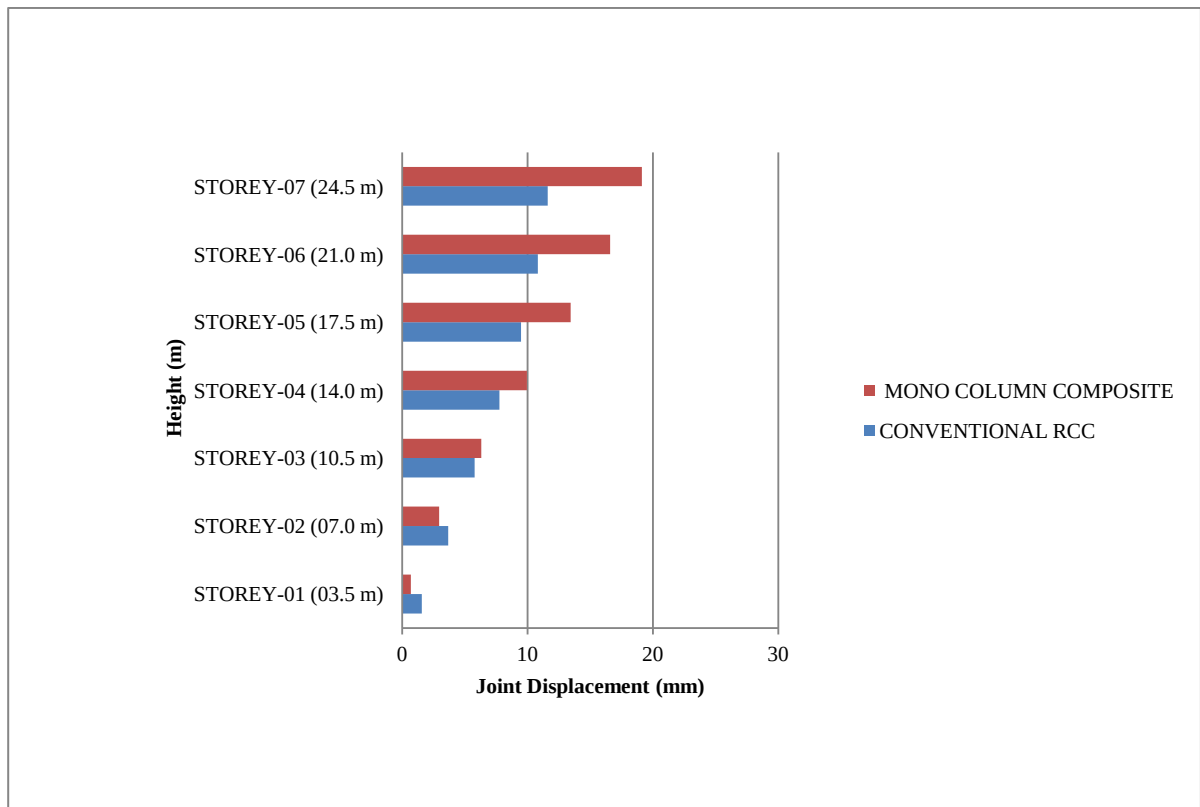


Fig.6 Joint Displacement in Mono Column and Conventional RCC

C. Displacement in Beams

In the table II value of maximum deflection under beam due to effect of static loading on different models and beams in structure model deflection in both models of beams in permissible limit.

TABLE III
DEFLECTION IN PRIMARY BEAM

Model	Material	Grade / Strength (N/mm ²)	Deflection in Primary Beam (mm)	Max Storey Drift (mm)
I	RCC	M25 HYSD500	5.567	0.629
II	Mono Column Composite	M50 HYSD500 FE250	19.050	1.080

IV. CONCLUSIONS

Mono column structure with composite material and multi storey conventional RCC structure are analysed for static and dynamic loading for different parameters.

1. On comparing the results it is found that composite material in mono column structure makes structure more serviceable as compare to conventional RCC mono column structure.
2. It is concluded from the study that storey drift in composite material mono column is large as compare to conventional RCC building although the results are under the permissible limit as per IS 1893:2002.
3. Deflection in primary members of mono column structure is under the given limit with reference to IS 456:2000.
4. In conventional RCC structure storey drift is maximum at second storey where as in mono column composite structure storey drift is maximum at fourth storey.
5. In mono column multistorey structure joint displacement increases with height of structure.
6. Mono column structure with composite material is providing large column free space as compared to conventional RCC building comprising with safe design criteria.

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