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COMPARATIVE ANALYSIS OF RCC AND STEEL-CONCRETE COMPOSITE MULTISTORIED BUILDING

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ABSTRACT— The majority of building structures are designed and constructed in reinforced concrete which are mainly depends upon availability of the constituent materials and the level of skill required in construction, as well as the practicality of design codes. R.C.C is no longer economical because of their increased dead load, hazardous formwork. However composite construction is a new concept for construction industry. The present comparative study deals with inelastic behavior of RCC and composite structures. The pushover analysis is carried out using E-tab 15 and compare the various parameters like story drift, displacements etc. The reviews shows that, the composite structures are best suited for high rise buildings compared to that of steel and reinforced concrete structures.

KEYWORDS—*steel-concrete composite; SRC; CFT; equivalent linear static analysis; story drift ; story displacement,*

I INTRODUCTION

Now a days, in India; to fulfill the need of high rise building, composite is best suited for infrastructural growth rather than RCC and Steel. Reviews and studies shows that composite construction considerably reduces the gravity load as compare to RCC .composite is compatible and complimentary to each other; they have ideal combination as, steel in tension and concrete in compression, concrete protect the steel from corrosion as well as it gives thermal insulation to embedded steel; though they have almost same thermal expansion. Although the compressive strength and unit cost of reinforced concrete is less than that of structural steel, the use of modern composite systems, allowing the erection of multi-story structural frames to proceed at pace, can make it economically prohibitive to delay the construction of each floor while concrete columns are cast. In Japan, however, the superior earthquake resistant properties of composite beam-columns have been long recognized and have become a commonly used for construction in that region. It was therefore necessary to develop seismic design criteria for typically used Indian structural systems, to advance the use of this efficient type of mixed construction.

II. OBJECTIVE

The purpose of this work is to introduce the steel concrete composite members in high rise building construction.

1. Inelastic (Pushover) analysis of both RCC and Composite building frame are carried out using E-tab 15
2. For composite column, Encased rolled steel section in concrete (SRC) and concrete filled steel tube (CFT) are used.
3. The beams are made up from RCC and rolled steel section.
4. Compare the parameters like story drift, displacement etc. of RCC and Composite frame.
5. Suggest the suitability of composite construction as compare with RCC.

III. LITERATURE REVIEWS

Dr. D. R. Panchal In **(2014)** present the simplified method of design of composite slabs, beams and columns and software is developed with pre- and post- processing facilities in VB.NET. All principal design checks are incorporated in the software. The full and partial shear connection and the requirement for transverse reinforcement are also considered.

D. R. Panchal and P. M. Marathe (2011) make the comparative analysis of steel concrete composite, steel and R.C.C. for of G+30 storey commercial building in earthquake zone IV. Equivalent Static Method is used. For modeling of Composite, Steel and R.C.C. structures, ETABS software is used and the results are compared; and it is found that composite structure is found to be more economical. In all the options the values of story displacements are within the permissible limits as per code limits. Steel and composite structure gives more ductility to the structure as compared to the R.C.C. which is best suited under the effect of lateral forces.

LIU Jingbo and LIU Yangbing (2008) creates the CL-CFST (composite beam-concrete filled square tubular column), SL-CFST (steel beam-concrete filled square tubular column), CL-ETRC (composite beam-equivalent stiffness RC column), SL-ETRC (steel beam-equivalent stiffness RC column) and RC frame structures. Then the response spectrum and the inelastic analysis under rare earthquakes are carried out. The results illustrate that, compared with the SL-CFST frame, the integral stiffness of the CL-CFST frame is enhanced; natural periods are shortened; the top deflection of and the storey-drift-angle are decreased, after considering the composite effect of RC floor slabs. According to the comparisons, as a whole, the CFST frame structure has qualified a seismic performance.

A. S. Elnashai & B. M. Broderick (1993) gives experimental confirmation of the highly ductile behavior and the availability of a truly 'predictive' analytical model, generation of seismic design criteria for partially encased composite beam-columns can proceed with confidence and a high degree of exactitude configuration should make composite beam-columns more attractive, when compared to steel and reinforced concrete alternatives.

EUROCODE 4 provides buckling curves for steel columns which is given by in Eurocode 3 (CEN, Eurocode 3 : Design of steel structures, European Committee for standardization, 2004).The Eurocode 4 column design assumes that concrete and steel interact fully with each other until failure. Design by the Eurocode method uses the full plastic axial and moment capacity of the cross-section and then reduces those values based on the column slenderness and other factors. The Eurocode composite design considers all material properties of the cross-section, including partial safety factors for the different materials.

The **AISC** and Load and Resistance Factor Design [AISC 1999] procedure introduced in the Manual of Steel Construction, it intended to be the compromise between necessity of practical approach and the need to reflect the complex behavior of composite columns. The AISC design method provides the modified approach for the composite cross-sections, like columns.

IV. ELEMENTS OF COMPOSITE MULTISTORIED BUILDINGS

The primary structural components used in composite construction consists of

A. Composite deck slab

B. Composite beam

C. Composite column

D. Shear connector

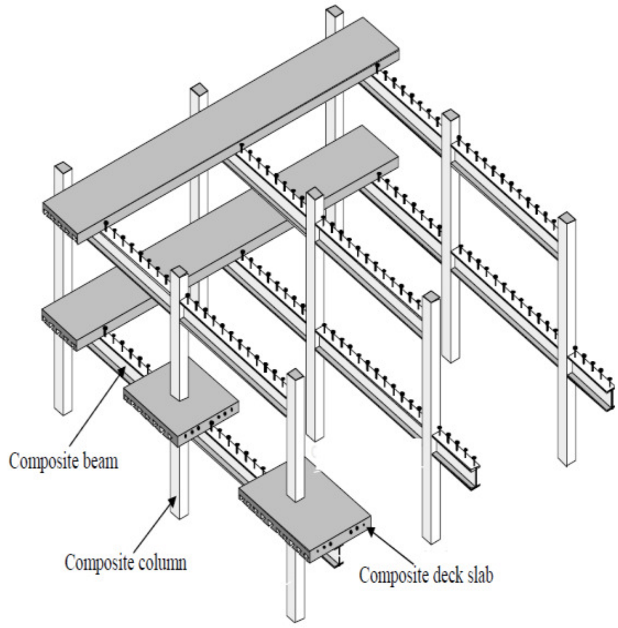

Fig .1. Typical Composite Frame

A. COMPOSITE DECK SLAB

Recently in western countries, profiled deck sheeting is much popular in composite floor construction. Composite deck slabs are more suitable where the concrete floor has to be completed quickly and where medium level of fire protection to steel work is sufficient. But , composite slabs with profiled decking are unsuitable when there is heavy concentrated loading or dynamic loading in structures such as bridges. A typical composite floor system using profiled sheets is shown in Fig.2. There is presently no Indian standard covering the design of composite floor system using profiled sheeting.

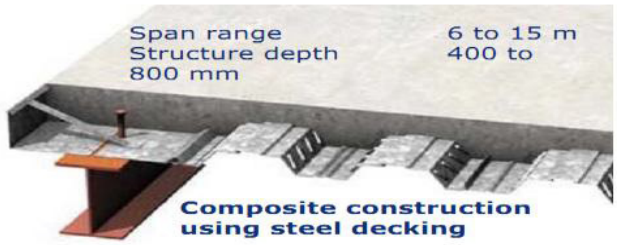

Fig. 2. Typical Composite Slab

B. COMPOSITE BEAM

Conventionally in composite construction, concrete slabs rest over steel beams and are supported by beams. Under loading condition these elements act independently if there is no any interface connection. Hence providing the interface connection both elements act as a monolithically. In this case the steel beam and the slab act as a "composite beam" and their action is similar to that of a monolithic Tee beam. By the composite action between these two elements, we can utilize their respective advantage to the fullest extent. Typical composite beam is shown in fig.3.

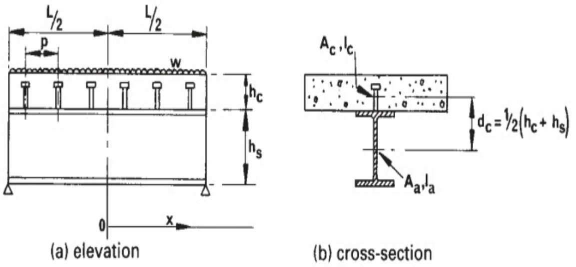

Fig. 3. Typical Beam Cross Sections

2.1 Advantages of composite beams-

1. Comparing with conventional construction keeping span and load unaltered composite sections are more economical.
2. Encased steel beam sections improve fire resistance and corrosion.
3. It also satisfies the requirement of long span construction.
4. Composite construction provides speed in work due to use of rolled steel sections.
5. Composite sections have higher stiffness than the corresponding steel sections and thus the deflection is lesser.
6. Permits easy structural repairs or modification.
7. Provides flexibility in design and ease in fabrication.
9. Considerable reduction in overall weight of the structure and hence reduces foundation cost.
10. Suitable to resist repeated earthquake loading which requires high amount of resistance and ductility.

C. COMPOSITE COLUMN

It is a compression member consisting either concrete encased hot rolled steel section or a rolled steel section embedded in concrete. At present there is no Indian standard code covering the design of composite column. The design method follows largely follows Euro code 4, which provides latest research on composite construction. IS 11384-1985 does not make any specific provisions to composite columns. This method adopts the European buckling curves for steel columns as a basic of column design.

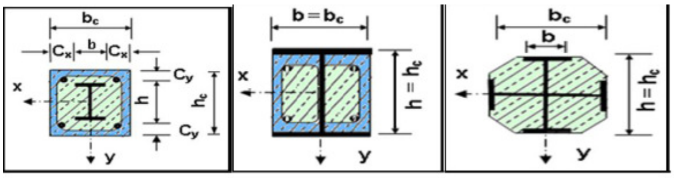

Fig.4 .Cross Section of Fully and Partially Concrete Encased Columns

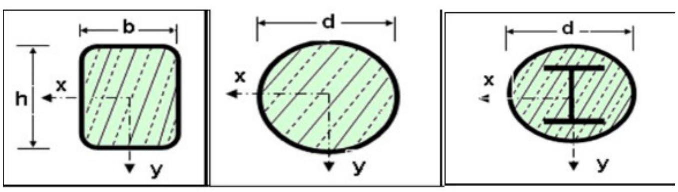

Fig.4. Typical column Cross Sections

The advantages of composite columns are-

1) Increased strength for a given cross sectional dimension.
2) Increased stiffness and buckling resistance, leading to reduced slenderness.
3) Good fire resistance in the case of encased section.
4) Good Corrosion protection in encased section.
5) Identical cross sections with different load and moment resistances can be obtained by varying steel thickness, grade of concrete and reinforcement. This makes the outer dimensions of a column to be constant over a number of floors in a building, which simplifying the construction and architectural detailing.
6) Minimizing formwork cause of steel section may itself resist erection and construction load.

D. SHEAR CONNECTORS

The total shear force at the interface between concrete slab and steel beam is approximately eight times the total load carried by the beam. Therefore, mechanical shear connectors are required at the steel-concrete interface. These connectors are designed to (a) transmit longitudinal shear along the interface, and (b) Prevent separation of steel beam and concrete slab at the interface.

Types of shear connectors:-

1. Rigid type

These connectors are very stiff and they sustain only a small deformation while resisting the shear force. They derive their resistance from bearing pressure on the concrete, and fail due to crushing of concrete. Shear connectors are essential for steel concrete composite construction as they integrate the compression capacity of supported concrete slab with supporting steel beams to improve the load carrying capacity as well as overall rigidity

2. Flexible type

Headed studs, channels come under this category. These connectors are welded to the flange of the steel beam. They derive their stress resistance through bending and undergo large deformation before failure. These types of stud connectors are used extensively. The shank and the weld collar adjacent to steel beam resist the shear loads whereas the head resists the uplift.

3. Bond or anchorage type:-

It resist horizontal shear and prevent separation of girder from the concrete slab from the interface through bond action. These connectors derived from the resistance through bond and anchorage action.

V. METHODOLOGY

A thirteen storey R.C and composite moment resisting frames is analyzed by the Performance based Plastic design method. Then the frames are analyzed and evaluated by the nonlinear static analysis (Pushover Analysis) using ETABS-2015, which is the major part of this study. And compare the parameter of both RCC and Composite.

VI. RESULTS AND DISCUSSION

1. Inelastic response analysis of the R.C and composite moment resisting frame.

The R.C and Composite MRFs are designed using lateral force distribution along the height of the building for the Performance Based Plastic Design method and then nonlinear static i.e. pushover analysis is carried out by using E-tab 15. And find out probable failure of structure from the location of hinges in building component.

2. PROJECT DETAILS

TABLE NO I- Particulars of Project Work

Particulars	RCC structure	Composite structure
Plan dimension	30mx48m	30mx48m
No of story	13	13
Height of each story	3.97m	3.97m
Total height	49.64m	49.64m
Depth of footing	2m	2m
Size of beam	300x750	300x750
Size of column	600mmx600mm	Encased I section (SRC)
	750mmx750mm	
	900mmx900mm	
Slab thickness	150	150
Dead load	2kn/m2	2kn/m2
Live load	4kn/m2	4kn/m2
Seismic zone	III	III
Soil condition	Medium	Medium
Response reduction factor	5	5
Importance factor	1	1
Zone factor	0.16	0.16
Grade of concrete	M30	M30
Grade of reinforcing steel	Fe500	Fe500
Grade of structural steel	-----	Fe250
Density of concrete	25 kn/m3	25 kn/m3
Density of brick masonry	20 kn/m3	20 kn/m3
Damping ratio	5%	5%

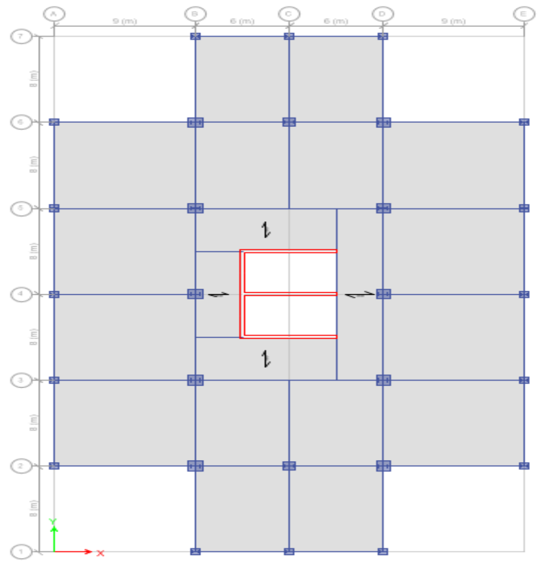

Fig. 5. Plan of existing building in E-tab 15

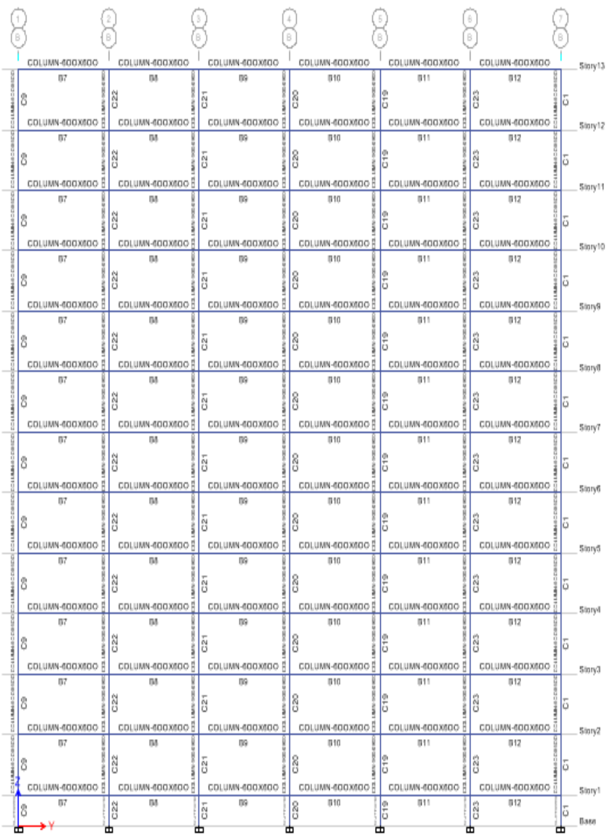

Fig.6. Elevation of building in E-tab 15

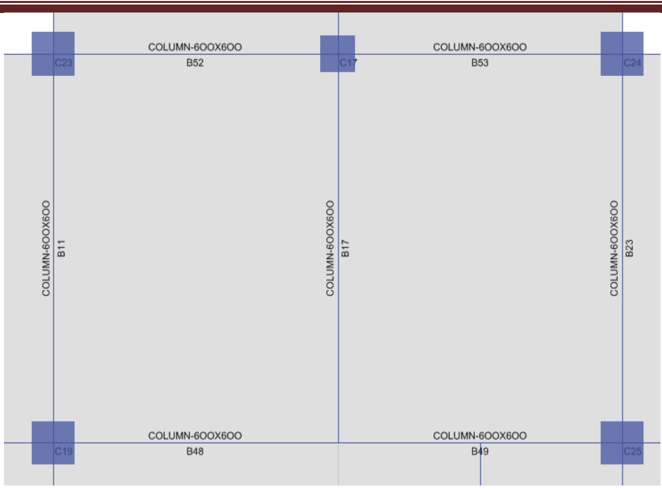

fig.7. Floor plan showing RCC section in E-tab 15

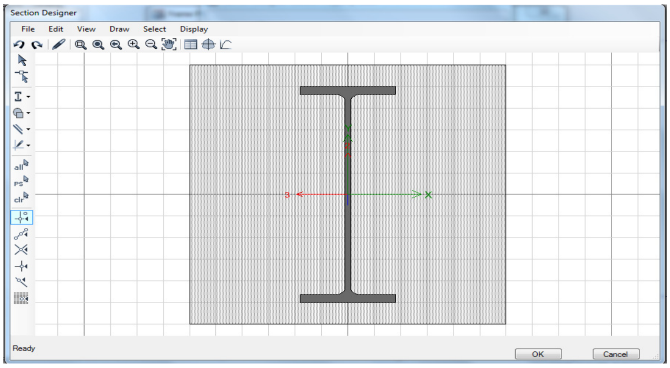

Fig. 8. Modelling of Composite column (SRC) in E-tab 15

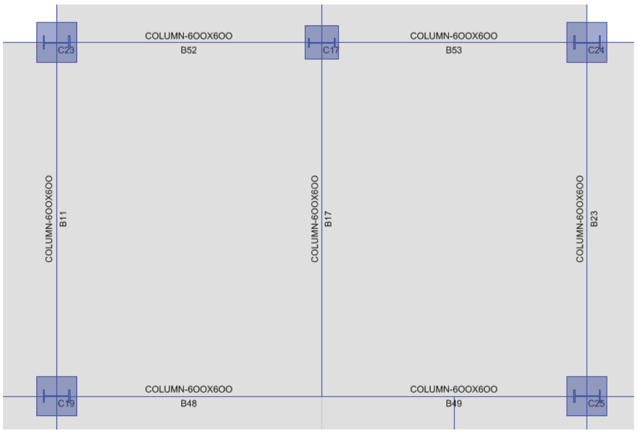

Fig.9. modelling of composite plan in E-tab 15

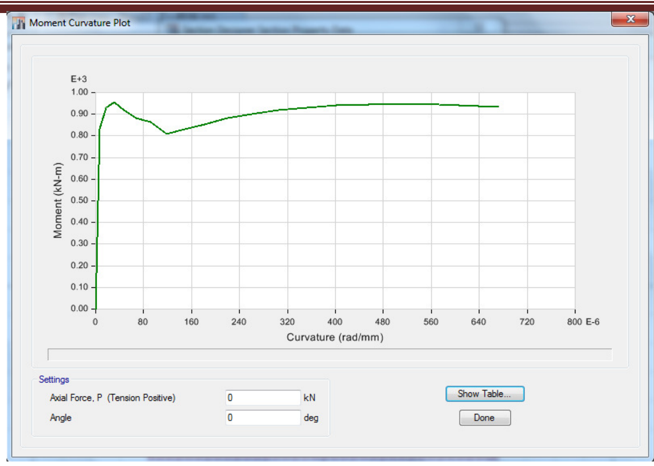

Fig.10. Moment curvature plot in E-tab 15

We are performed the equivalent linear static anlysis of both the RCC and composite structures, from which we are come to know the comparative performance of composite and RCC structure, which shows the composite structure gives better performance as compared with RCC.

The results of equivalent linear static analysis are given as below-

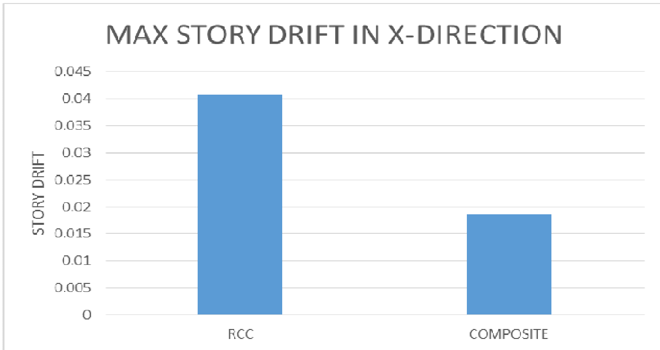

Fig.11. Max story drift in X-direction

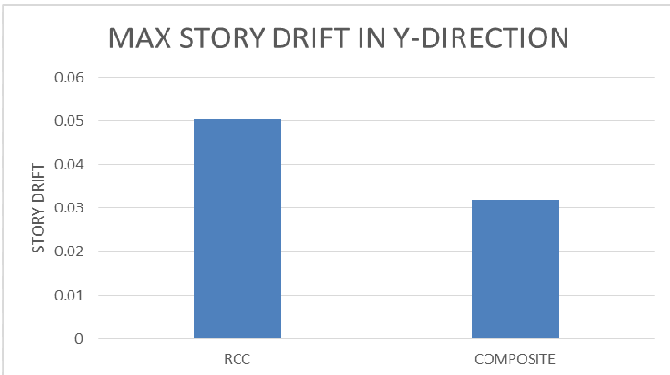

Fig.12. Max story drift in Y-direction

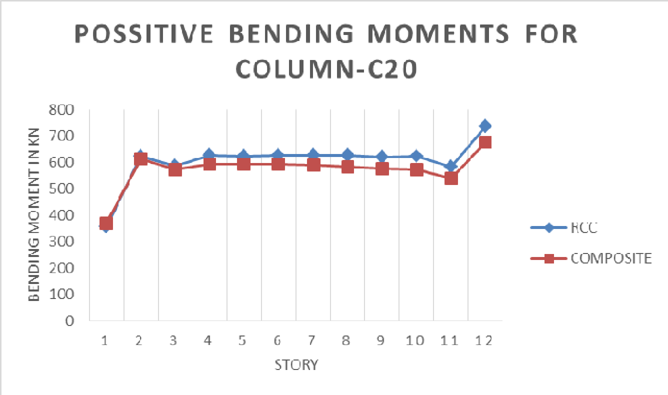

Fig. 13. Positive Bending Moment for Column C20

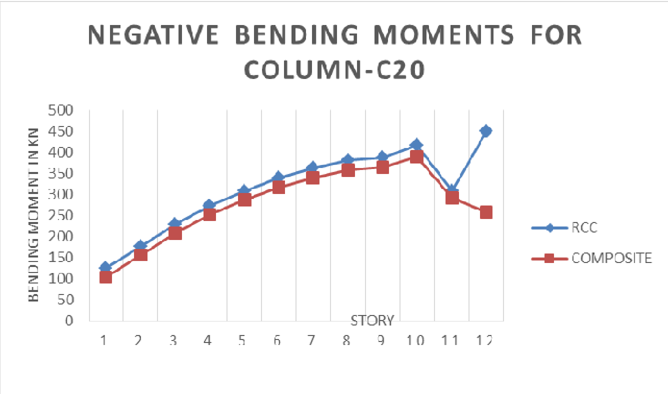

Fig.14.Negative Bending Moment for Column C20

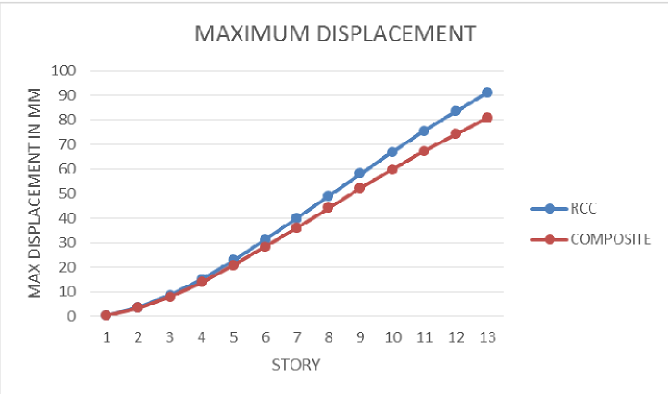

Fig. 15. Maximum story displacement in RCC and SRC-composite

The pushover analysis is performed on RCC and steel-concrete composite (SRC) section using E-tab 15. The comparative story displacement graph is drawn as below.

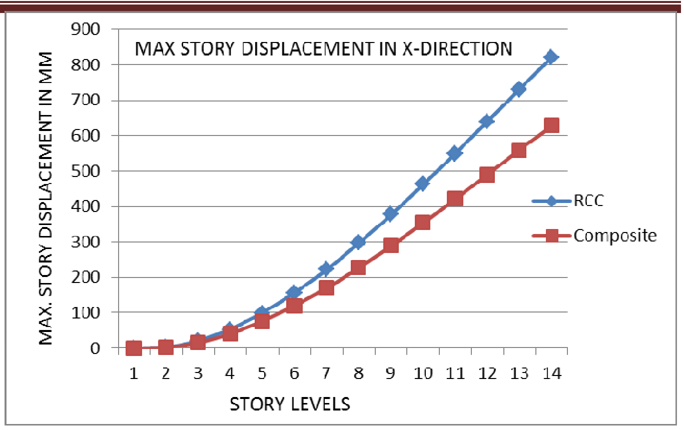

Fig. 16. Maximum story displacement of RCC & SRC composite

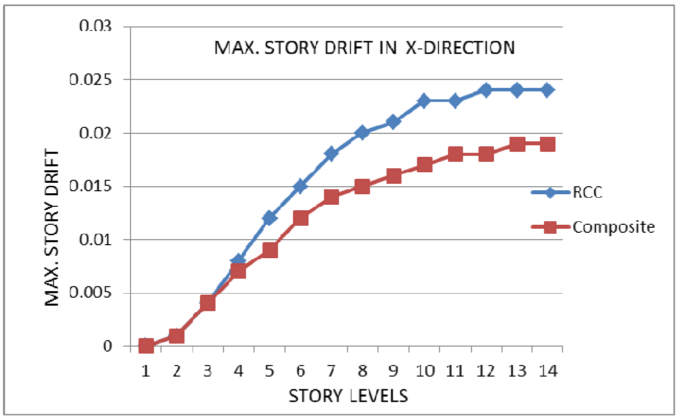

Fig. 17. Maximum story drift of RCC & (SRC) composite

VI. FUTURE WORK

1. Inelastic response analysis of RCC frame and composite frame based on performance based plastic design approach.
2. Formation of plastic hinges at different steps using pushover analysis,
3. Pushover analysis using different types of encased and in filled concrete composite section.

VII. CONCLUSION

1. From the equivalent linear analysis it is seen that the story drift reducess appr. upto 49 %. As Compared with RCC.
2. The story displacement is also reducess appr. upto the 9%. From equivalent linear static analysis.
3. From pushover analysis it is seen that story displacement is decreases as compare to RCC.
4. Also story drift of SRC –composite is considerably reduced as compared wiyh RCC.

Overall response of composite structure is better than RCC structure i.e. composite structure produces less displacement and resists more structure forces.

VIII. ACKNOWLEDGMENT

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IX. REFERANCES

[1] Advanced Design of Composite Steel-Concrete Structural element by Dr. D. R. Panchal -ISSN : 2248-9622, Vol. 4, Issue 7(Version 2), July 2014, pp.124-138

[2] ANSI/AISC 360-05 An American National Standard Specification for Structural Steel Buildings March 9, 2005

[3] Comparative Analysis of RCC and Steel-Concrete-Composite (B+G+ 11 Storey) Building Mr. Nitish A. Mohite, Mr. P.K.Joshi, Dr. W. N. Deulkar IJSR, Volume 5, Issue 10, October 2015 ISSN 2250-3153

[4] Composite Structures of Steel and Concrete (Beams, slabs, columns, and frames) for buildings Third Edition by R.P. JOHNSON (2004)

[5] Eurocode 4: Design of composite steel and concrete structures - Part 1-1: General rules and rules for buildings

[6] Comparative Study Of Performance Based Plastic Design Of R.C And Composite (Cfrst) Moment Resisting Frames Based On Inelastic Response Analysis G.S.Hiremath ,Kushappa M Kabade- IJARSE, Vol. No.3, Issue No.8, August 2014 ISSN-2319-8354(E)

[7] Comparision Of R.C.C. And Comosite Multistoried Buildings by Anish N. Shah , Dr. P.S. Pajgade- Vol. 3, Issue 2, March -April 2013, pp.534-539