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COMPARATIVE STUDY ON THE SEISMIC BEHAVIOUR OF RCC AND STEEL-CONCRETE COMPOSITE FRAME STRUCTURES

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Abstract - *Composite construction has gained a very wide acceptance because of its many advantages i.e. faster to erect, lighter in weight, better quality control, reduced time of construction, has better ductility and hence superior lateral load resisting behaviour. Moreover, this type of outlook is a modern idea in the field of construction. Use of the RCC are no longer the economical because of the higher dead loads, longer construction time and hazardous formwork. In the present thesis comparative study on the response of different steel-concrete composite frame structures and RCC structure for 20 storey is carried out. Equivalent static method and response spectrum method are the two analytical methods used in this work. The analysis is performed by making using ETABS2016.Different parameters like bending moment, shear force, time period, storey displacement, storey drift ratio, base shear, have been extracted for various models for zones II and V and are compared to assess the better performing structure.*

Key Words: *Composite beam, Composite column, Shear connectors, Equivalent static analysis, and Response spectrum analysis, etc*

1. INTRODUCTION

Structural engineers in these days are confronting tasks in satisfying the demand of prevailing as well as an efficient design for structures. For low rise structures RCC members are widely utilized in country like India. However, if there would arise an existence of multi-storey structure, then the use of RCC members may not be occasionally suitable due to the increase in the dead load, restraint of span length and a reduction in the amount of stiffness.

Composite Structures are the structures, wherein composite sections are built of two unique type of the materials, for example, for beams and columns steel, concrete are utilized. The composite construction, consolidates improvement in the property of concrete in case of compression as well as tension. The thermal expansion of them are quite similar and results in quicker construction. In this type of construction two distinct materials that are actually tied by the utilization of the shear studs at their interface possessing smaller depth. Composite individuals are comprised of two unique materials, for example, for beams and columns steel and concrete is utilized. The various components of composite structure are composite slab, composite beam, composite column, shear connector.

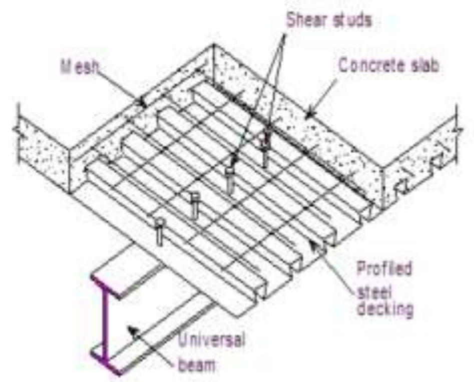

Fig -1: Typical Composite slab section.

1.1 Composite Slab

In case of composite slab steel sheets are associated with the composite bar with the assistance of the shear connectors, at first steel sheets go about as permanent shuttering and furthermore behave as bottom reinforcement for steel deck slab and later it is joined with hardened concrete. It is an another member of composite structure which interfaces the beam and column together and shapes a unit. A trapezoidal deck is placed over beam with profiled sheets, reinforcement bars are laid and concreting is done over that. It gives a smooth working stage since profiled sheets are laid before concreting. There are essentially 2 sorts of decks accessible, for example, trapezoidal and Re-entrant steel deck.

1.2 Composite Beam

A composite beam is a steel beam or partially encased beam which is predominantly subjected to bending and it supports the composite deck slab. A composite beam is also a part which connects both slab and column together to form a single united structure. The load from slab can be equally distributed to the beam. Composite beam can be produced by incorporating steel section in beam mould and reinforcing the same with certain grade of concrete. Shear connectors are main element in composite beam which acts same like shear reinforcement. The steel section can be kept inside the beam mould or filling material can be filled inside the steel section.

1.3 Shear Connectors

These are utilized for the association of concrete as well as structural steel to provide adequate strength as well as the stiffness for composite members. It's a principle component that responsible for improvement of composite action between concrete slab and steel beam by the transfer of shear. It is in turn is helpful for the composite system in order to bear a lot of flexural stresses and for the transfer of horizontal loads to lateral load resisting system. Reason for shear connectors provision is elimination of partition of concrete slab and steel beam and to transfer horizontal shear present in the concrete & steel interface. Numerous sorts of shear connectors can be utilized based on the requirement.

1.4 Composite Column

Compression member comprising of steel and concrete elements can be named as steel concrete composite columns. Two kinds of composite columns are.

- Concrete section with an embedded steel section.
- Hallow steel section with the concrete infill.

In case of composite columns friction and bond are the parameters due to which steel as well as concrete act together as solitary unit. The common procedure of construction for the construction of the composite type of column incorporates assembly of hollow steel section or even I section which takes primary construction loads, after that its loaded with concrete or concrete is casted around I beam. The lateral deflections, also buckling of the steel members are avoided due to the concrete member. Along with this composite column possess lesser area of cross section as well as lighter in weight in comparison to the RCC columns. Because of which serviceable floor area increments in case of composite structures, also cost of the foundation likewise gets diminished.

2. OBJECTIVES

- To analyze a 20 storey RCC regular structure for zone II and V.
- To analyze a 20 storey regular structure in the zone II and V, for various steel-concrete composite frame structures.
- To study the efficiency of composite structures and RCC structures with respect to storey drift ratio, story displacement, time period, base shear, axial forces.

3. BUILDING DETAILS

In the present work five structural system has been considered i.e., one RCC and four composite buildings. In this work the columns and beams are composite in nature (RCC beam+RCC column), (Compst:1 Steel with fully encased concrete beam + steel with fully encased concrete column), (Compst:2 Steel with fully encased concrete beam + steel with partially encased concrete column), (Compst 3: Steel with fully encased concrete beam + rectangular concrete filled steel column), (Compst 4: Steel beam + circular concrete filled steel column). All models were analyzed using equivalent static and dynamic response spectrum method as per IS1893-2016 specifications using ETABS software.

Table -1: Detailed data for the example building

Structure	RCC structure. Steel-concrete composite Structure.
Plan dimension	32m x24 m along X and Y directions
Grid Spacing	4m both along X and Y directions.
No of storey	G+20
Storey Height	3.0 m
Type of building use	Commercial
Grade of concrete	M25,M40
Grade of steel	Fe345,HYSD500
Column	600 x 600mm : RCC column, steel with fully encased concrete, steel with partially encased concrete, concrete filled steel column rectangular shape and circular shape.
Beam	300mm x450mm: RCC beam, steel with fully encased concrete beam, steel beam of ISMB450,secondary beam of ISLB250.
Slab	Slab-150,Deck-100mm
Floor finishes	1.50 KN/m2
Glazing load	2 KN/m2
Live load	3.0 KN/m2
Wind speed	50m/sec
Terrain category	2
Zone	II , V
Importance factor	I=1
Response reduction factor	R=5
Soil type	medium

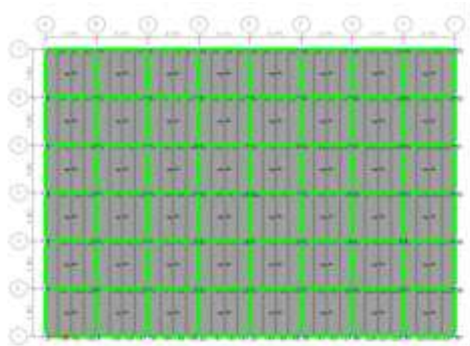

Fig -2: Plan View of typical composite building

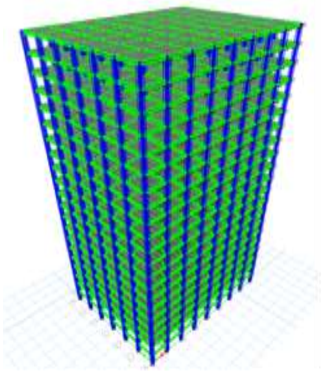

Fig -3: 3D view of typical composite building

4. RESULTS

4.1 Time Period

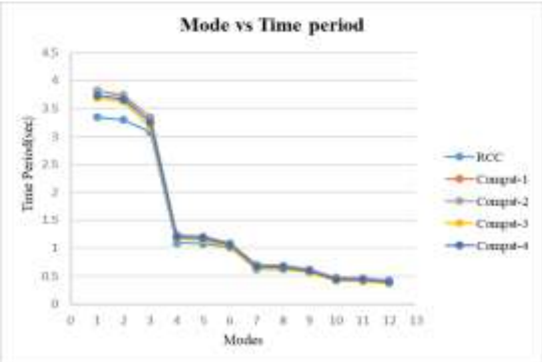

Fig -6: Modes vs Time period

The maximum time period obtained is 3.382 sec for compst - 1. The time period is 3.81, 3.68, 3.74 seconds for **compst-2,** compst-3, compst-4 respectively, which is lesser than compst-1. Whereas, the least time period obtained is 3.346 sec for RCC model compared to all the other models

4.2 Storey Displacements

4.3.1 Equivalent Static Analysis

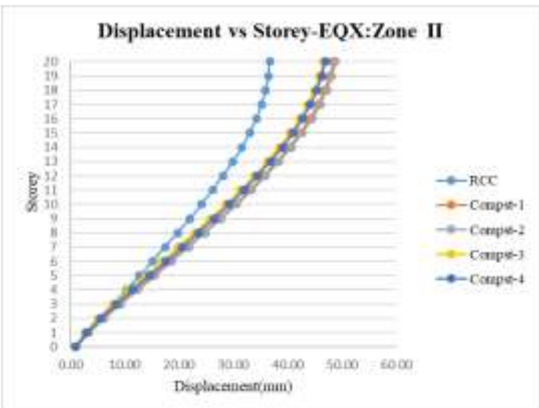

Fig -7: Displacements vs storey along EQX direction for zone II

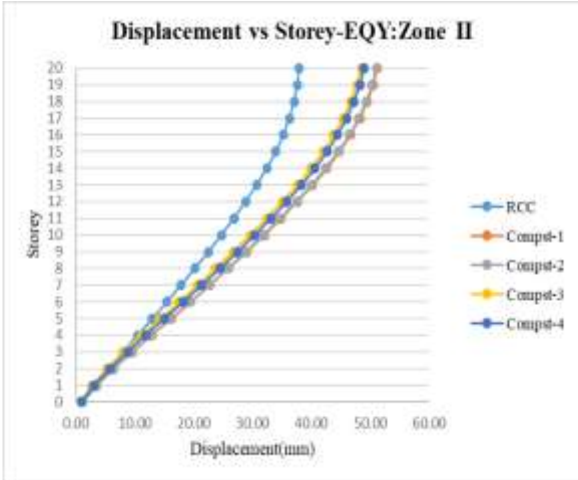

Fig -8: Displacements vs Storey along EQY direction along zone II

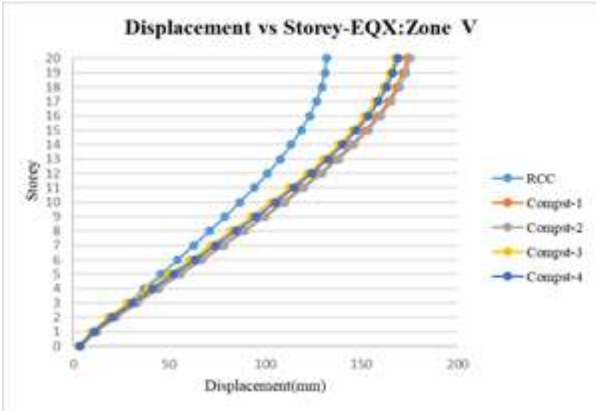

Fig -9: Displacements vs storey along EQX direction for zone V

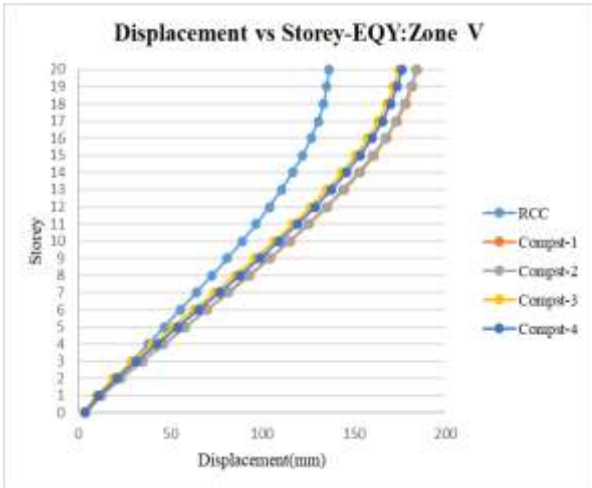

Fig -10: Displacements vs Storey along EQY direction along zone V

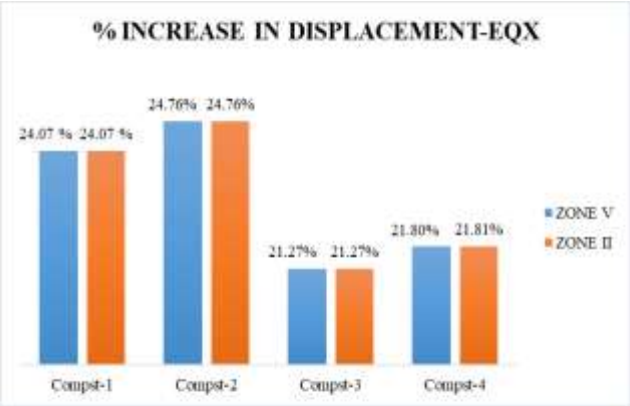

Fig -11: Increase in Displacement along EQX for zone V and II w.r.t model 1(RCC).

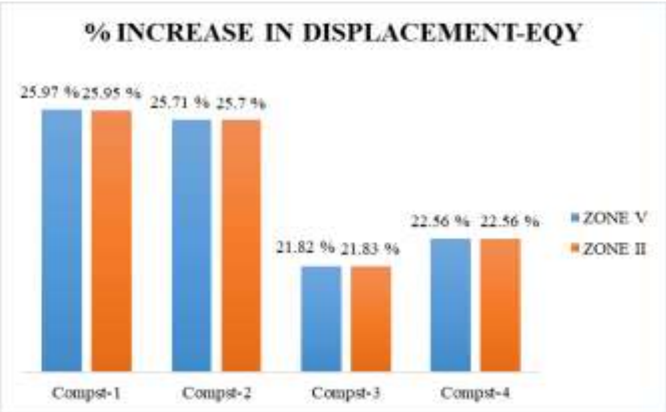

Fig -12: Increase in Displacement along EQY for zone V and II w.r.t model 1(RCC).

The percentage increase in displacement along X direction is 24.07%, 24.76%, 21.27%, 21.81% respectively for compst-1, compst-2, compst-3, compst-4 w.r.t RCC model as shown in the fig 11. The percentage increase in displacement along Y direction it is 25.97 %, 25.71%,21.82 %,22.56% respectively for compst-1, compst-2, compst-3, compst-4 w.r.t RCC model as shown in the fig 12.

4.3.2 Response Spectrum Analysis

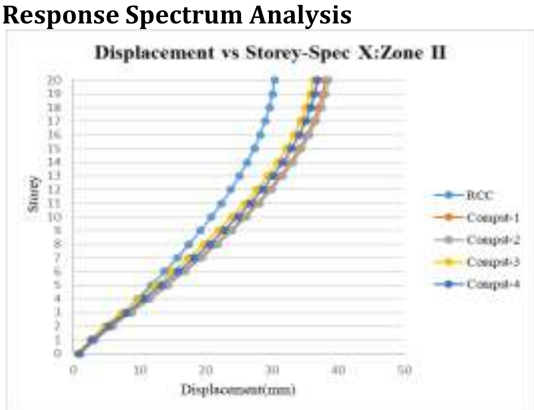

Fig -13: Displacements vs storey along Spec-X direction for zone II

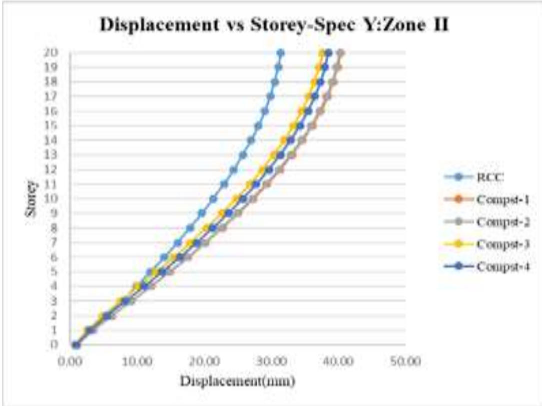

Fig -14: Displacements vs storey along Spec-Y direction for zone II

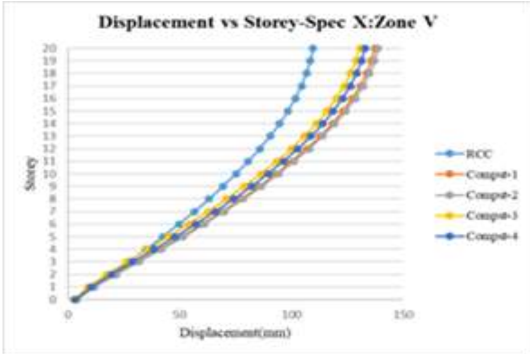

Fig -15: Displacements vs storey along Spec-X direction for zone V

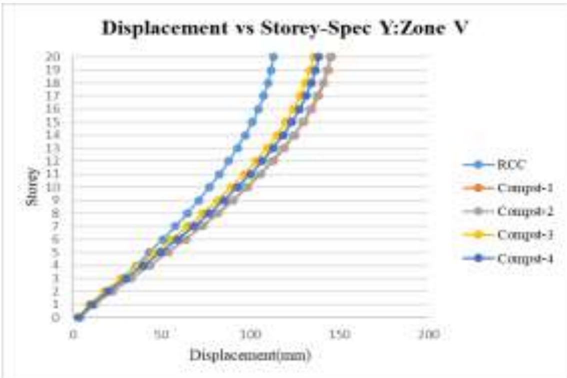

Fig -16: Displacements vs Storey along Spec-Y direction along zone V

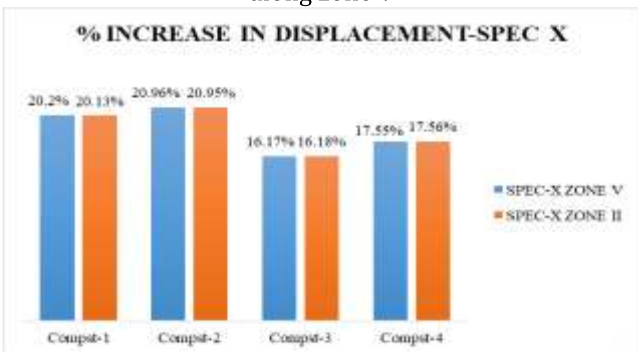

Fig -17: Increase in Displacement along Spec -X for zone V and II w.r.t model 1(RCC)

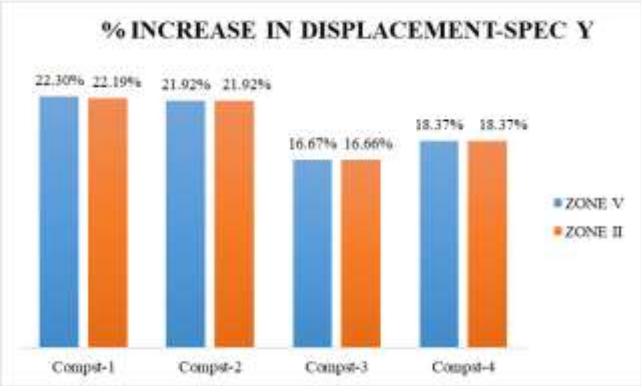

Fig -18: Increase in Displacement along Spec-Y for zone V and II w.r.t model 1(RCC).

The percentage increase in displacement along X direction is 20.2%, 20.96%, 16.18%,17.56% for compst-1, compst-2, compst-3, compst-4 respectively, w.r.t RCC model as shown in the fig 17. The percentage increase in displacement along Y direction 22.30%, 21.92%, 16.67 % and 18.37% respectively for compst-1, compst-2, compst-3, compst-4 respectively, w.r.t RCC model as shown in the fig4.15.

4.3 Storey Drift Ratio

4.4.1 Equivalent Static Analysis

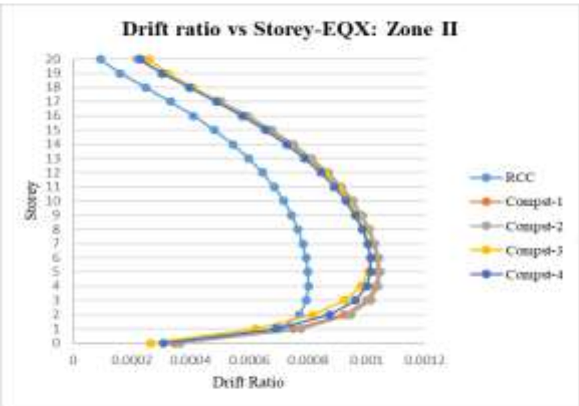

Fig -19: Drift ratio vs story along EQX direction for zone II

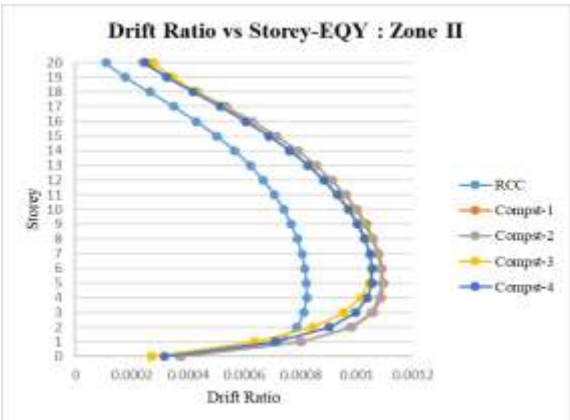

Fig -20: Drift ratio vs story along EQY direction for zone II

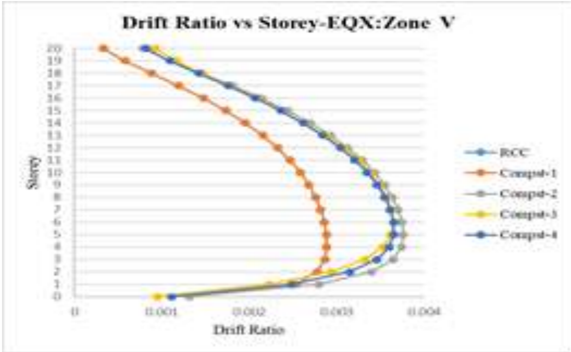

Fig -21: Drift ratio vs story along EQX direction for zone V

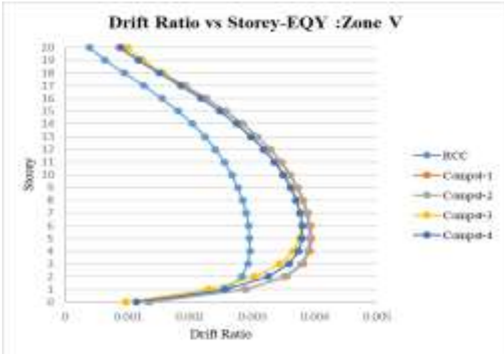

Fig -22: Drift ratio vs story along EQY direction for zone V

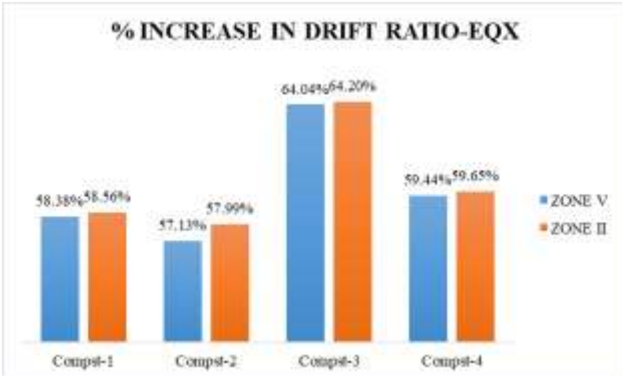

Fig -23: Increase in Drift ratio along EQX for zone V and II w.r.t model 1(RCC)

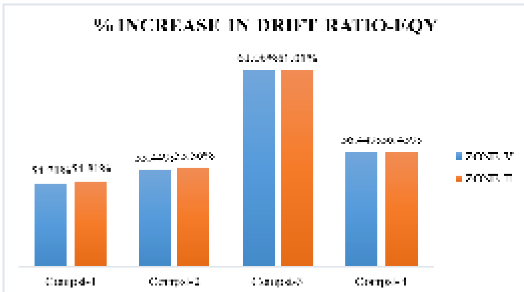

Fig -24: Increase in Drift ratio along EQY for zone V and II w.r.t model 1(RCC).

The percentage increase in drift ratio along X direction is 58.38 %,57.13 %, 64.20%, 59.44%, and along Y direction is 54.71%,55.56%,61.01%,56.45% for compst-1, compst-2, compst-3, compst-4 respectively, w.r.t RCC model as shown in the fig 23 and fig 24.

4.4.2 Response Spectrum Analysis

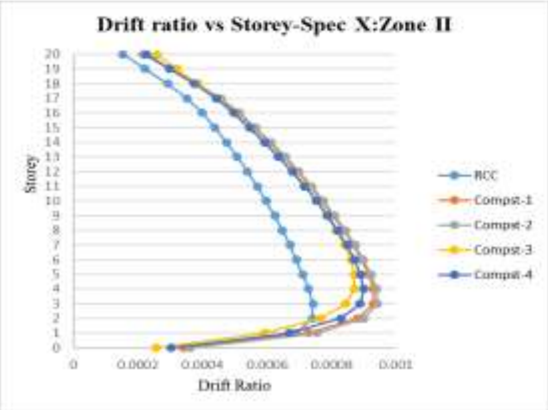

Fig -25: Drift ratio vs story along Spec-X direction for zone II

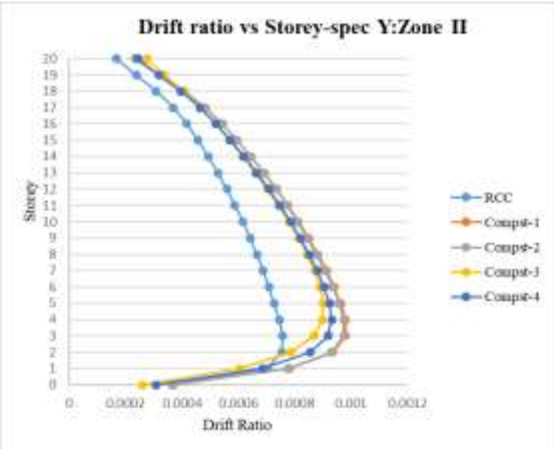

Fig -26: Drift ratio vs story along Spec-Y direction for zone II

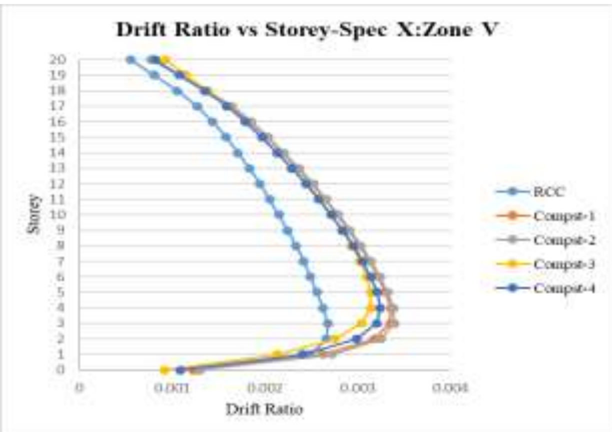

Fig -27: Drift ratio vs story along Spec-X direction for zone V

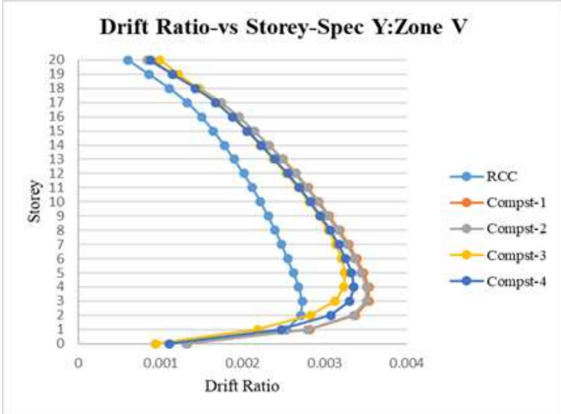

Fig -28: Drift ratio vs story along Spec-Y direction for zone V

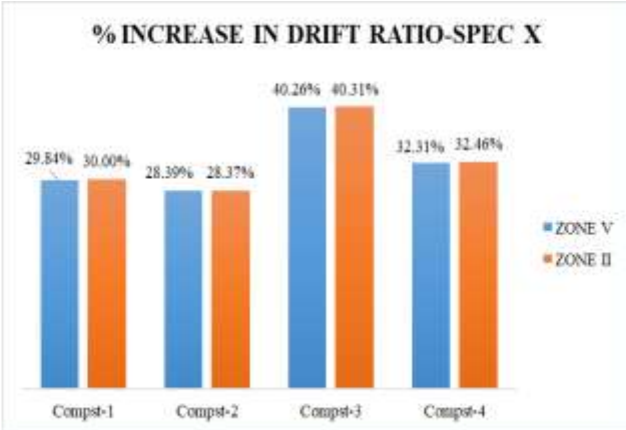

Fig -29: Increase in Drift ratio along Spec-X for zone V and II w.r.t model 1(RCC)

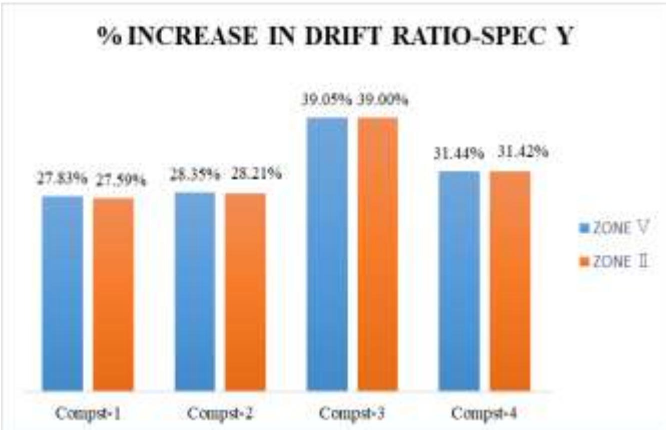

Fig -30: Increase in Drift ratio along Spec-Y for zone V and II w.r.t model 1(RCC)

The percentage increase in drift ratio along X direction is 30.00%, 28.39%, 40.31%, 32.46%, and along Y direction is 27.83%, 28.35%, 39.05%, 31.42% for compst-1, compst-2, compst-3, compst-4 respectively, w.r.t RCC model as shown in the fig 29 and fig 30.

4.4 Base Shear

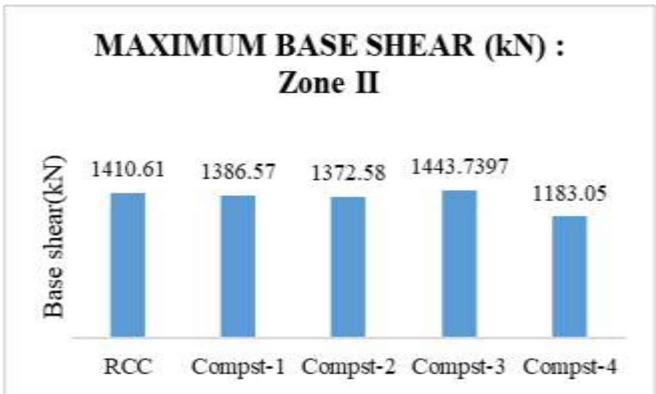

Fig -31: Base shear for zone Ⅱ

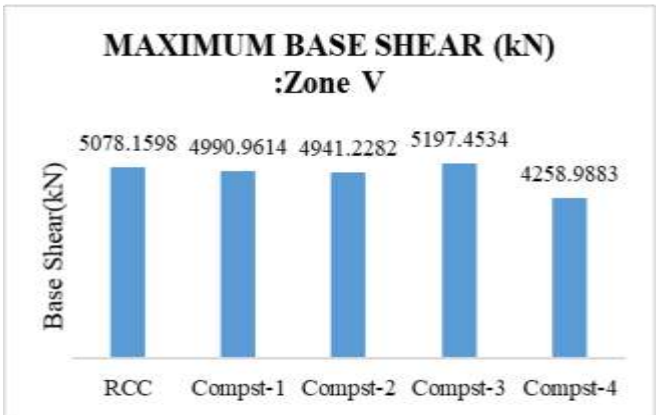

Fig -32: Base shear for zone Ⅴ.

The percentage reduction is found to be similar for both seismic zones Ⅱ and Ⅴ. The percentage reduction in base shear with respect to compst-3 is 2.30%, 3.96%, 4.93%, 18.06% for RCC, compst-1, compst-2, compst-4 respectively.

5. CONCLUSIONS

From the results and discussions following conclusions are made with respect to equivalent static and dynamic response spectrum analysis of RCC and composite steel moment resisting frames.

- The displacement at the top storey for composite models with respect to RCC models is increased in the range of 21%-26% for equivalent static analysis, and 16%-23% for response spectrum method of analysis.
- The displacements in the composite model-3 is less as compared to other composite models.
- The displacement is increased gradually from bottom to top story.
- The drift ratio is reduced in RCC model as compared to composite models.
- The drift ratio at the top storey for composite models with respect to RCC models is increased in the range of 57%-64% for equivalent static analysis, and 27%-39% for response spectrum method of analysis.
- The percentage increment in the displacement and drift ratio is almost the same for both the seismic zones Ⅱ and Ⅴ.
- The time period of RCC model is less as compared to other composite models, indicating that RCC model is stiffer than other composite models.
- Composite model-3 has lesser time period when compared with all the other type of composite models.
- The base shear for the composite model-3 is found to be higher than the other composite models.
- The base shear in the composite model-4 is found to be the least, due to the reduction in the self-weight, since the steel beams are not encased with concrete.
- Composite model-4 is less fire resistant in case of fire hazards since only steel beams are used whereas in all the other composite models, the steel sections are encased with concrete.
- Equivalent static analysis shows comparatively higher values than the response spectrum method of analysis and graphs plotted for response spectrum method of analysis results reveals the behavior of the structure more precisely than static analysis.
- Considering the construction time factor, composite models can be proposed other than RCC models, due to faster erection and placements. However proper workmanship needs to followed for better structural behavior.

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