



# Comparative Analysis Of Hybrid Rc Beam-To-Steel Column Connections Under Seismic Loads

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**Abstract:** The steel-and-concrete structure is a contemporary design that combines the benefits of both steel and concrete. It is used extensively worldwide these days. Understanding and putting this kind of organization into effect requires a thorough understanding of its genesis and development history. The analysis of shear-key hybrid connections between steel columns and RC beams is the focus of this paper. This study addresses six models in total: the entire reinforced concrete structure, the relationship of reinforced concrete beams to steel columns, and the steel structure of two distinct seismic zones, Zone II and Zone V. Considering the 36 x 36 m plan size of the G+21 building for each of the six types. Complete RC and steel structures are generic models that do not take replacements into account, but in RC beam to column structure by installing shear keys at every RC beam to steel column connection, we are swapping out all of the peripheral concrete columns for steel ones. Comparing the drift, displacement and stiffness parameters of the models under consideration at two distinct seismic zones is the primary objective of the research. Response spectrum analysis is used to analyze the Base shear, which is then compared to the structures. ETABS-2021 is utilized in this project for entire model design and analysis. The analysis is done as per IS 456:2000 code and for seismic analysis IS 1893:2016 (part 1) code. M30 grade of concrete and FE-550 grade of steel is adopted. Based upon the results as plotted on the graphs it is clear that RC beam to steel column connection structure performing better compared to RC and Steel Structure in terms of Storey Drift and Storey Displacement values in both the zones II and V. The base shear is little high in RC structure compared to RC Beam to steel column structure but, it doesn't affecting much in structural aspects. RC Beam to Steel Column Structure is Stiffer as well as Economical.

**Index Terms** - Hybrid connections, steel columns, reinforced concrete beams, shear-keys, Bracings

## I. INTRODUCTION

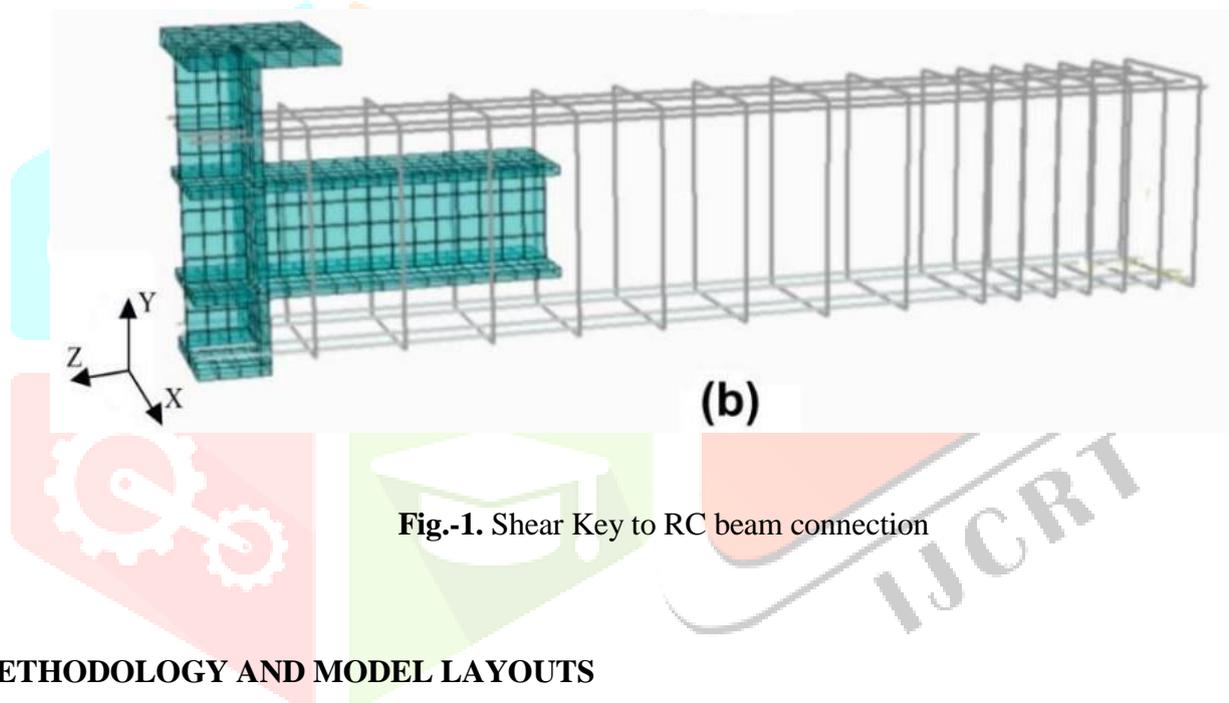
When compared to the steel and reinforced concrete counterparts, composite steel-concrete systems may exhibit improved performance characteristics. Currently defined regulations cover the reaction and design of numerous types of composite steel-concrete members, which are generally well understood. Unconventional hybrid structural forms that blend two or more components made of different materials may fall under this category. Using such hybrid arrangements can result in significant economic savings in addition to better structural efficiency. While individual steel columns wrapped in concrete to increase fire resistance may be viewed as an early hybrid, this type of composite member is now widely utilized in practice and covered by design rules. Numerous research have also evaluated the force transfer mechanisms between structural steel and concrete along the length of composite members.

For high-rise buildings or heavily loaded structures in particular, the requirement for increased capacities and improved ductility prompted experimental research on hybrid steel-concrete systems, such as hybrid RC walls with multiple encased steel profiles or RC floors supported by steel columns using shear-keys. Coupling beams are one type of hybrid steel-concrete system. For instance, it has been demonstrated via much research that the seismic design and detailing of steel/composite coupling

beams and their connections to RC walls offer major advantages over traditional RC coupling beams. In contrast to the brittle shear failures that prevail at the beam-wall joints of traditional RC coupling beams, these hybrid forms help to produce a ductile response that is favourable. In RC beam to steel column structure all the peripheral columns are replaced by steel columns with shear key joints at junctions.

### 1.1 SHEAR KEY

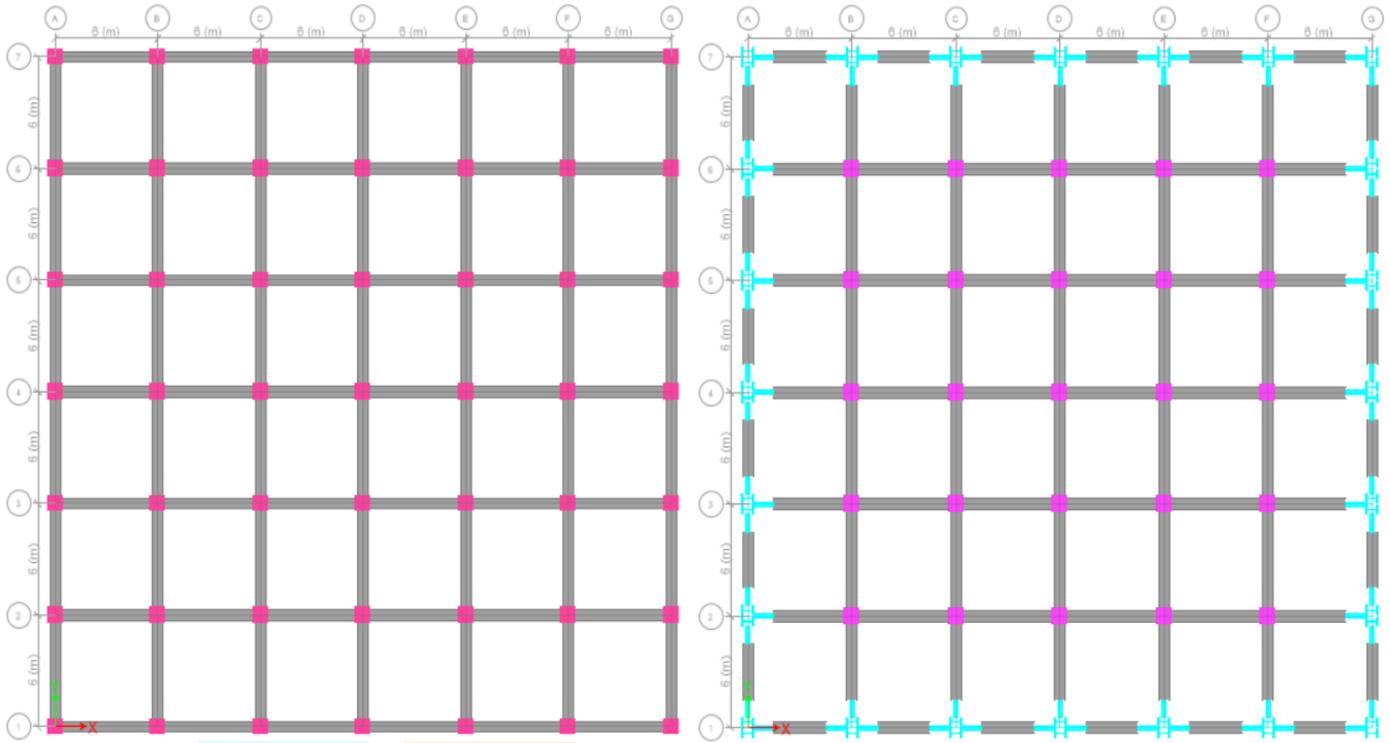
Shear keys are beam-to-column junctions in structural engineering. In order to control forces and strengthen the bond between a beam and a column, it is an essential component of design. Shear keys facilitate the movement of shear pressures from the column to the beam and vice versa. Making sure the load is distributed appropriately and the structure performs as expected depends on this. Shear keys increase the joint's stability by offering a firm grip. Their assistance in preserving the relative locations of the column and beam under load adds to the structure's overall stability. Shear keys ensure effective load transfer and reduce potential gaps that could compromise structural integrity by limiting relative movement or slippage between the beam and column. Shear keys are useful in seismic design because they can assist absorb and dissipate energy, allowing the building to flex in a controlled way during an earthquake without collapsing.



**Fig.-1.** Shear Key to RC beam connection

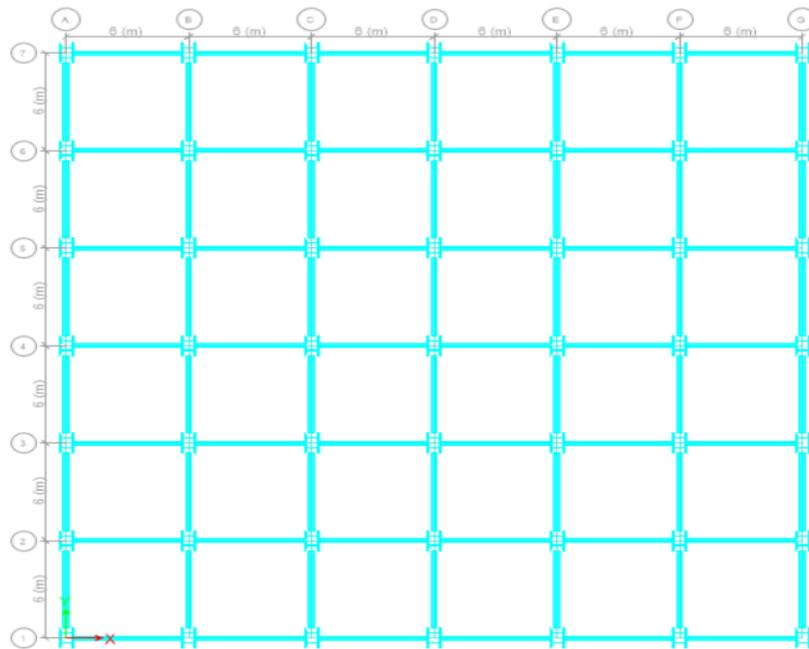
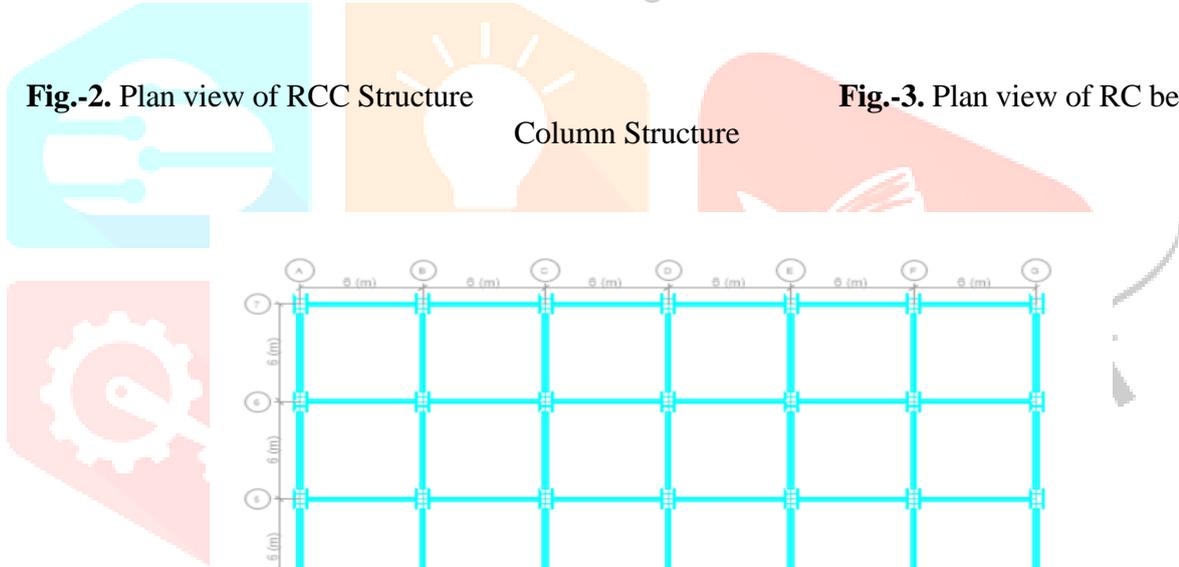
## 2. METHODOLOGY AND MODEL LAYOUTS

The present objective of the project is to compare the behaviour of RC beam to steel column structure with both RCC and steel structure for both the seismic zones II and V as per IS 1893:2016. The parametric studies comprise of storey drift, storey displacement and Base shears generated in the frames for all seismic zones. ETABS models on RCC, RC Beam to Steel Column, Steel Structures are executed with G+21 floors with fixed sections and material properties. Response spectrum analysis was considered for analysis in ETABS software. Lateral stability for RCC, RC Beam to Steel Column, Steel Structures is assessed for lateral displacement, storey drift and Base shear for seismic zones II and V as per IS1893:2016. Lateral stability for RCC, RC Beam to Steel Column, Steel Structures are compared to know the suitability of structures in both the seismic zones. Review of results of all the structures in two different zones are plotted in graphs and tables.



**Fig.-2.** Plan view of RCC Structure

**Fig.-3.** Plan view of RC beam to Steel Column Structure

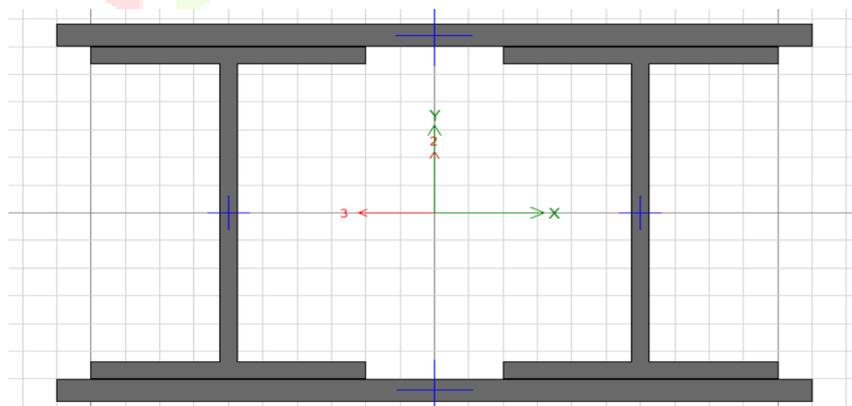


**Fig.-4.** Plan View of Steel Structure

**Fig.2,3,4** represents the plan view of RCC, RC beam to steel column structure and Steel structures of both the zones II & V

**TABLE: 1**  
**SPECIFICATIONS OF RCC, RC BEAM TO STEEL COLUMN AND STEEL STRUCTURES**

Column to Column spacing in x direction	6m
Column to Column spacing in y direction	6m
No. of bays in x direction	6 no's
No. of bays in y direction	6 no's
Floor height	3m
Ground floor height	3m
Slab thickness	150mm
Column sizes	900 mm X 900mm
Beam sizes	600mm X 600mm
Steel Column	ISWB 600-2
Steel Beam	ISLB 600
Build-up Section	peripheral
Grade of concrete	M40
Grade of steel	FE 550



**Fig.-5.** Built-up Column for RC beam to steel column structure and Steel structure.

**Table -2:** Specifications provided for Built-up Column including plate

Height (mm)	600
Top Width (mm)	400
Top Thickness (mm)	30
Web Thickness (mm)	25
Bottom Width (mm)	400
Bottom Thickness (mm)	30
Width (mm)	1100
Thickness (mm)	40

**Table -3:** Seismic parameters considered for RCC, RC beam to steel column and Steel Structures of zone II

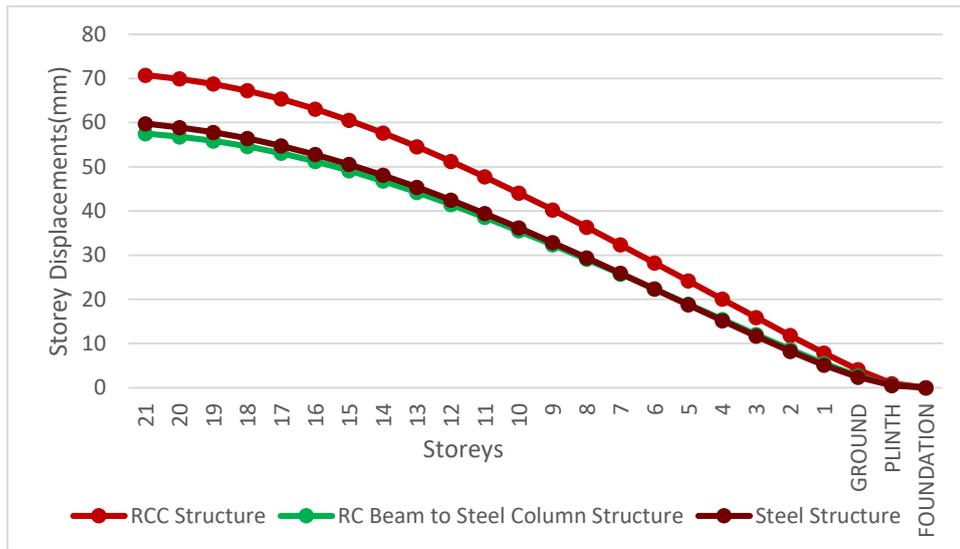
Type of structure	OMRF
damping ratio	5%
zone factor	0.10
importance factor	1
type of soil	type 2(medium soil)
reduction factor	3

**Table -4:** Seismic parameters considered for RCC, RC beam to steel column and Steel Structures of zone V

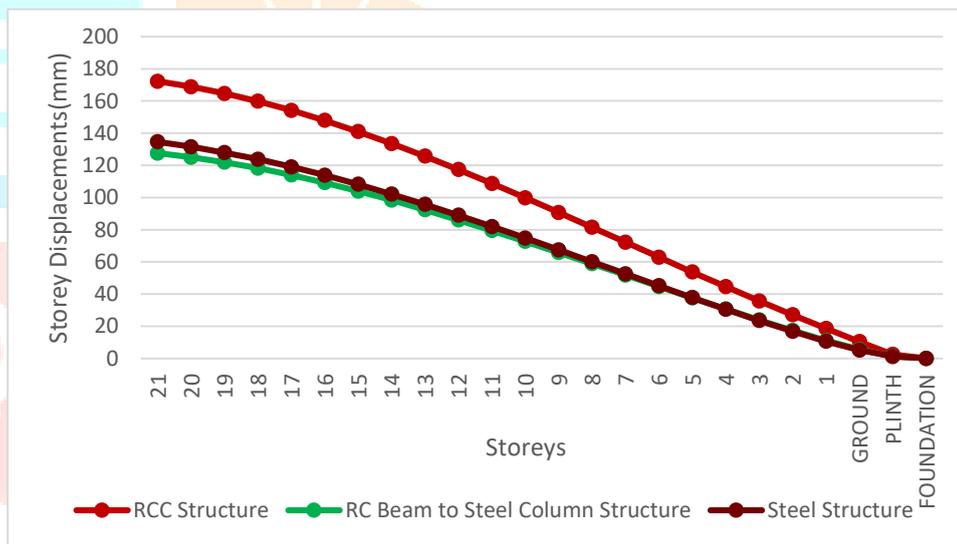
Type of structure	SMRF
damping ratio	5%
zone factor	0.36
importance factor	1
type of soil	type 2(medium soil)
reduction factor	5

### 3. RESULTS AND DISCUSSIONS

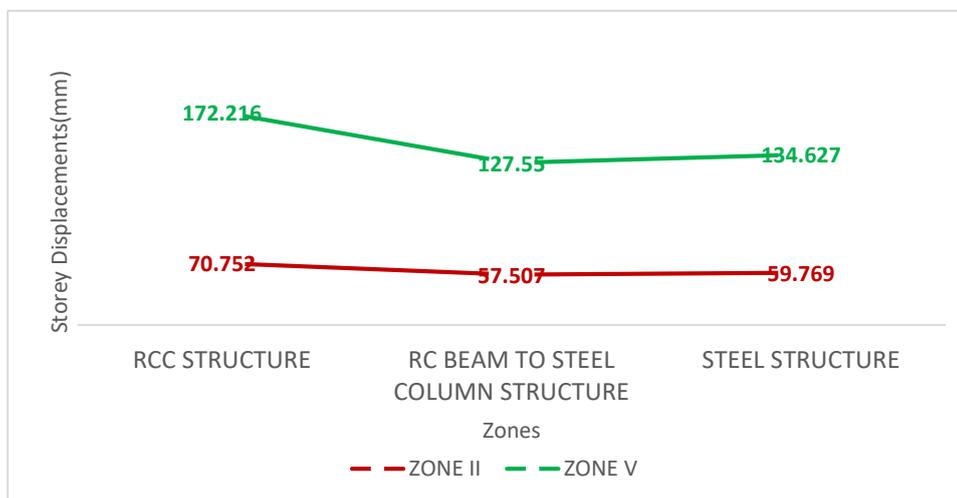
The study of results has been described below of the above specified specifications of the structure



**Fig.-6.** Comparison of displacements of RCC, RC beam to steel column and Steel Structures of zone II



**Fig.-7.** Comparison of displacements of RCC, RC beam to steel column and Steel Structures of zone V

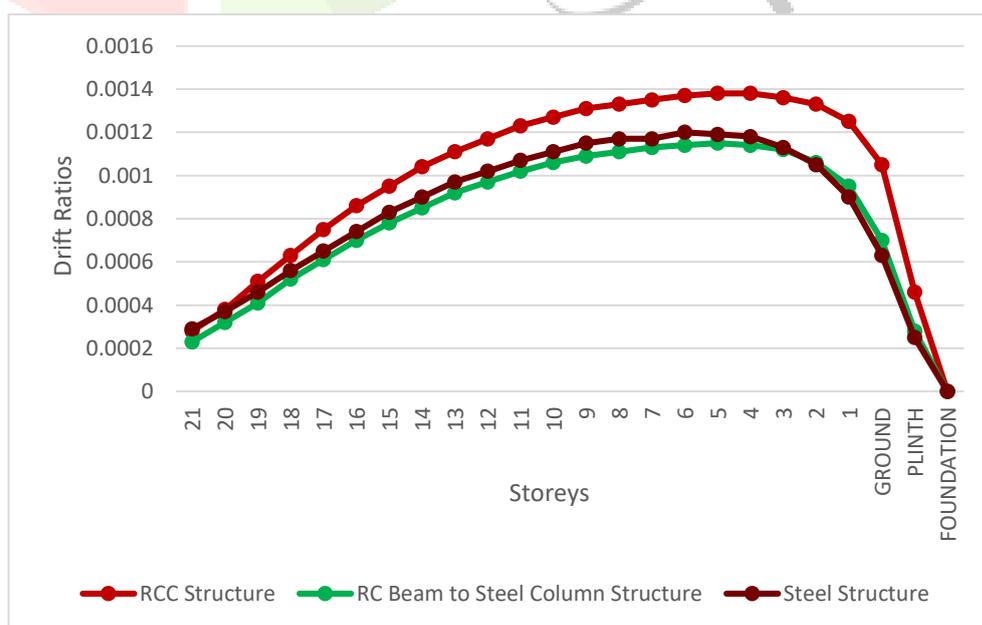


**Fig.-8.** Comparison of displacements of RCC, RC beam to steel column and Steel Structures of both the zone II & V.

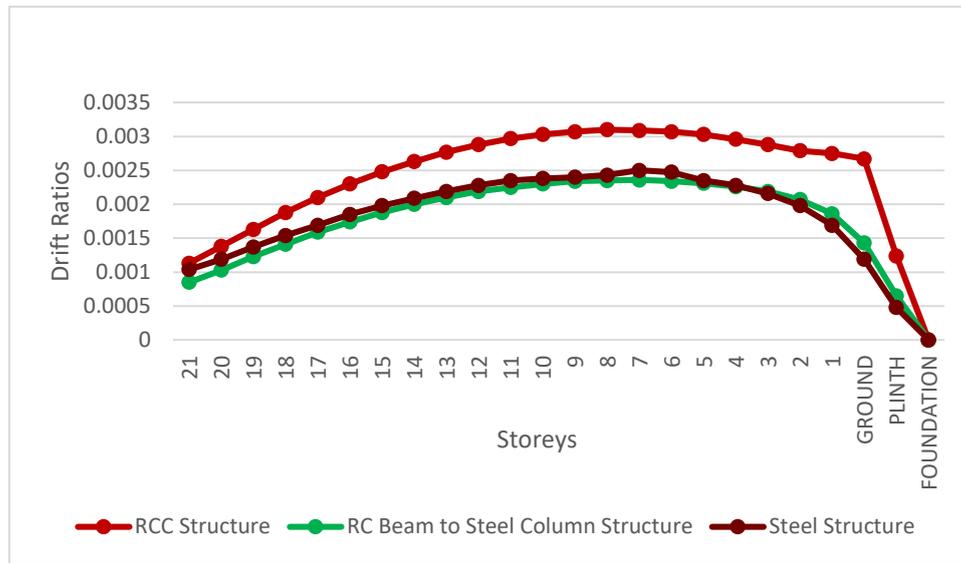
In Fig.-6, which represents the comparison of displacements of RCC, RC beam to steel column and Steel Structures of zone II we can clearly see that there is increase in displacement for RCC structure compared to RC beam to steel column structure and Steel structure and displacements of steel structure is also increased compared to RC beam to steel column structure. The maximum storey displacement is observed at the roof for all the three structures and compared to three structures RC beam to steel column structure has less displacement. The maximum storey displacement for the RCC structure which is observed at the roof is 70.752mm and for the RC beam to steel column structure the observed displacements are 57.507mm and for steel structure the observed displacements at the roof is 59.769. The displacement for the RC beam to steel structure is reduced by 18% compared to RCC structure and reduced by 3% compared to Steel structure.

In Fig.-7, which represents the comparison of displacements of RCC, RC beam to steel column and Steel Structures of zone V we can clearly see that there is increase in displacement for RCC structure compared to RC beam to steel column structure and displacements of steel structure is also increased compared to RC beam to steel column structure. The maximum storey displacement is observed at the roof for all the three structures and compared to three structures RC beam to steel column structure has less displacement. The maximum storey displacement for the RCC structure which is observed at the roof is 172.216mm and for the RC beam to steel column structure the observed displacements are 127.55mm and for steel structure the observed displacements at the roof is 134.627. The displacement for the RC beam to steel structure is reduced by 26% compared to RCC structure and reduced by 5% compared to Steel structure.

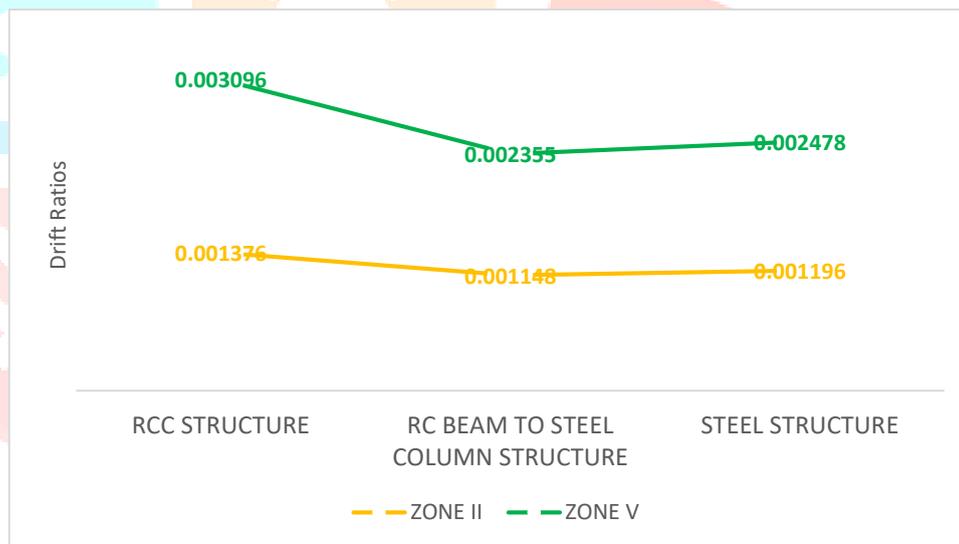
In Fig.-8, which represents the comparison of displacements of RCC, RC beam to steel column and Steel Structures of both the zones II & V we can clearly see that there is increase in displacement for RCC structure compared to RC beam to steel column structure and displacements of steel structure is also increased compared to RC beam to steel column structure in both the zones II & V. The maximum storey displacement is observed at the roof for all the three structures and compared to three structures RC beam to steel column structure has less displacement in both the zones II & V. So, from the displacements graphs it is clear that when the peripheral i.e, uniaxial, Biaxial columns is replaced by steel columns it increases the stiffness as the steel is good in flexure which gradually leads to decrease in the displacement values. RC beam to Steel column structure performs much better compared to RCC structure as the displacement values has huge difference and better compared to steel structure as the displacement values has little difference.so, it is clear that by using steel columns in place of concrete in the peripheral place decreases the displacement values there by increasing the stiffness of the structure.



**Fig.-9.** Comparison of drift ratios of RCC, RC beam to steel column and Steel Structures of zone II



**Fig.-10.** Comparison of drift ratios of RCC, RC beam to steel column and Steel Structures of zone V

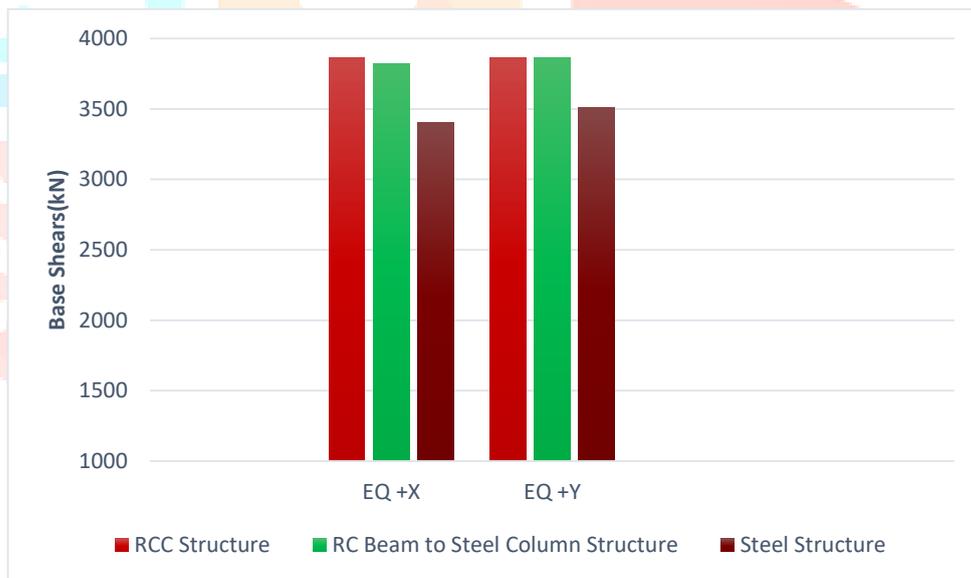


**Fig.-11.** Comparison of drift ratios of RCC, RC beam to steel column and Steel Structures of both the zones II & V

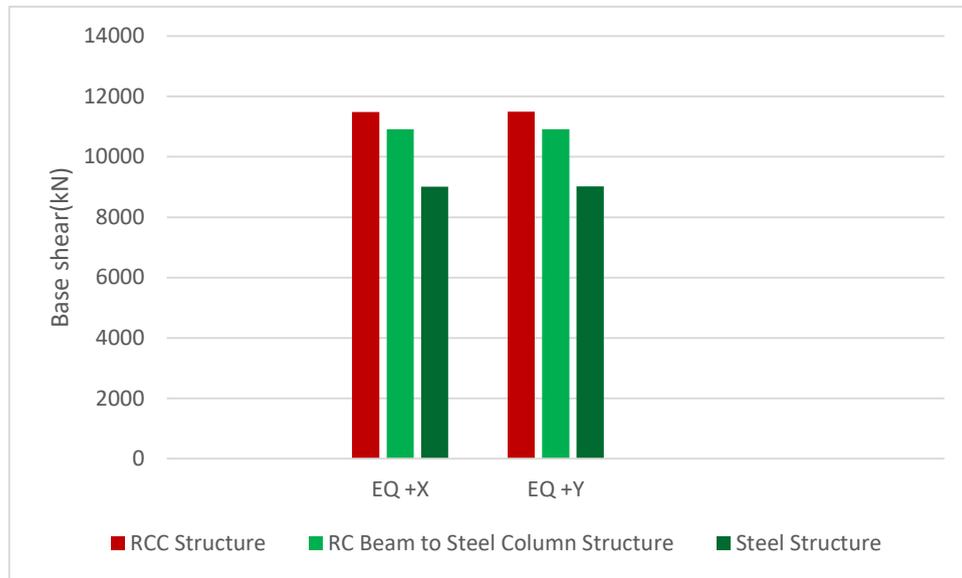
In Fig.-9, which represents the comparison of drift ratios of RCC, RC beam to steel column and Steel Structures of zone II we can clearly see that there is increase in drift ratios for RCC structure compared to RC beam to steel column structure and Steel structure and drift ratios of steel structure is also increased compared to RC beam to steel column structure. The maximum storey drift ratios is observed at the 7<sup>th</sup> floor for all the three structures. when compared to three structures RC beam to steel column structure has less Drift ratio. The maximum drift ratio for the RCC structure which is observed at the 7<sup>th</sup> floor is 0.00137 and for the RC beam to steel column structure the observed drift ratio is 0.001148 and for steel structure the observed drift ratio at the 7<sup>th</sup> floor is 0.001196. The drift ratio for the RC beam to steel structure is reduced by 16% compared to RCC structure and reduced by 4% compared to Steel structure.

In Fig.-10, which represents the comparison of drift ratios of RCC, RC beam to steel column and Steel Structures of zone V we can clearly see that there is increase in drift ratios for RCC structure compared to RC beam to steel column structure and Steel structure and drift ratios of steel structure is also increased compared to RC beam to steel column structure. The maximum storey drift ratios is observed at the 5<sup>th</sup> floor for all the three structures. when compared to three structures RC beam to steel column structure has less Drift ratio. The maximum drift ratio for the RCC structure which is observed at the 5<sup>th</sup> floor is 0.003096 and for the RC beam to steel column structure the observed drift ratio is 0.002355 and for steel structure the observed drift ratio at the 5<sup>th</sup> floor is 0.002478. The drift ratio for the RC beam to steel structure is reduced by 23% compared to RCC structure and reduced by 5% compared to Steel structure.

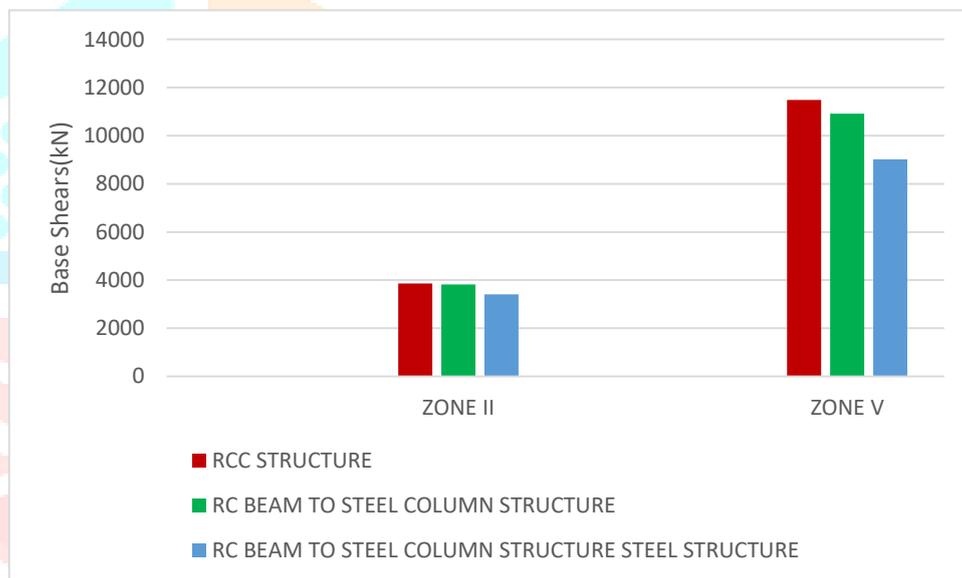
In Fig.-11, which represents the comparison of drift ratios of RCC, RC beam to steel column and Steel Structures of both the zones II & V we can clearly see that there is increase in drift ratios for RCC structure compared to RC beam to steel column structure and drift ratios of steel structure is also increased compared to RC beam to steel column structure in both the zones II & V. The maximum storey drift ratios is observed at the 7<sup>th</sup> floor for all the three structures in zone II and at 5<sup>th</sup> floor in zone V. when compared to three structures RC beam to steel column structure has less drift ratios in both the zones II & V. In both the zones in three models RC beam to Steel column structures drift ratio values are low compared to the RCC structure and Steel structure. So, from the drift ratio graphs it is clear that when the peripheral i.e, uniaxial, Biaxial columns is replaced by steel columns it increases the stiffness as the steel is good in flexure which gradually leads to decrease in the drift ratio values. RC beam to Steel column structure performs much better compared to RCC structure as the drift ratio values has huge difference and better compared to steel structure as the drift ratio values has little difference. so, it is clear that by using steel columns in place of concrete in the peripheral place decreases the drift ratio values there by increasing the stiffness of the structure.



**Fig.-12.** Comparison of Base shears of RCC, RC beam to steel column and Steel Structures of both the zones II



**Fig.-13.** Comparison of Base shears of RCC, RC beam to steel column and Steel Structures of both the zones V



**Fig.-14.** Comparison of Base shears of RCC, RC beam to steel column and Steel Structures of both the zones II & V

In Fig.-12, which represents the comparison of base shears of RCC, RC beam to steel column and Steel Structures of zone II we can clearly see that there is increase in base shear values for RCC structure compared to RC beam to steel column structure and Steel structure. But there is no huge difference in base shear values between RCC structure and RC beam to steel column structure. Steel structure has much difference in Base shear compared to RCC structure and RC beam to steel column structure. In Base shear RCC structure is performing slightly better compared RC beam to steel column structure and better compared to Steel structure. Rc beam to steel column structure. The maximum base shear observed for RCC structure in Y direction is 3863.30 and for RC beam to steel column structure it is observed as 3825.10 and for Steel structure it is observed as 3405.1. The base shear of RC beam to steel column structure is decreased by 1% and compared to Steel structure it is increased by 11%.

In Fig.-13, which represents the comparison of base shears of RCC, RC beam to steel column and Steel Structures of zone V we can clearly see that there is increase in base shear values for RCC structure compared to RC beam to steel column structure and Steel structure. But there is no huge difference in base shear values

between RCC structure and RC beam to steel column structure. Steel structure has much difference in Base shear compared to RCC structure and RC beam to steel column structure. In Base shear RCC structure is performing slightly better compared RC beam to steel column structure and better compared to Steel structure. RC beam to steel column structure. The maximum base shear observed for RCC structure in Y direction is 11490.39 and for RC beam to steel column structure it is observed as 10918.23 and for Steel structure it is observed as 9018.04. The base shear of RC beam to steel column structure is decreased by 5% and compared to Steel structure it is increased by 17%.

In Fig.-14, which represents the comparison of base shears of RCC, RC beam to steel column and Steel Structures of both the zones II & V we can clearly see that there is increase in base shear values for RCC structure compared to RC beam to steel column structure and Steel structure. The dynamic characteristics of the building, including its natural frequency, damping ratio and mode shapes, influence how it responds to seismic ground motion. These properties affect the magnitude and distribution of base shears during an earthquake. As the self-weight of the building increases, it increases the base reactions of the structure. So, from the above graphs it is clear that RCC structure is performing better compared to RC beam to steel column Structure and steel structure. But, there is no much difference between the RCC Structure to RC beam to steel column structure in both the Zones as shown in graphs. So, based upon the Storey Drift and Displacement RC beam to steel structure is preferable even the Base reactions are little low compared to RCC structure. So from all the comparisons we can clearly observed that RC beam to steel column structure is performing better in both the storey displacement and storey shear but in base shear RCC is performing well compared to RC beam to steel column structure and steel structure. But there is no much difference in base shear between the RC beam to steel column structure. Hence it is preferable to use RC beam to steel column structure as it is satisfying the all conditions.

#### 4. CONCLUSIONS.

- 1) The Storey Displacement for RC Beam to Steel Column structure is less compared to RCC Structure and Steel Structure in both the zones II and V.
- 2) The Storey Drift for RC Beam to Steel Column Structure is less compared to RCC Structure and Steel Structure in both the zones II and V.
- 3) The Base Shears for RCC Structure is a slightly high compared to RC beam to Steel Column Structure and high compared to Steel Structure in both the zones II and V.
- 4) RC Beam to Steel Column Structure is recommended in comparison with RCC Structure and Steel Structure as it is performing better in both the zones II and V.

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