COMPARATIVE STUDY OF RCC AND HYBRID BUILDING STRUCTURESIN DIFFERENT SEISMIC ZONES

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ABSTRACT

Earthquake is always led to destruction especially when it comes to structure the destruction is more vulnerable to damage. Because of high shear forces acting at beam-column- slab connection it is one of the most critical region in the structure. There are many factors for the damage during earthquake. From this paper, the methodology and result will be concluded. The work is divided in two phase.In first phase sample of low, medium and high rise building is taken according to IS 456:2000 (LSD), model and analyses using STAAD Pro V 8i.This phase concludes that with increase in height, shear demand also increases. In Second phase concrete beam is replaced by steel beam i.e. a composite structure is prepared and also the deformed rebar used in column is replaced by high tensile pre-stress steel. This phase concludes that this will lead to heavy design of structure but decrease destruction.

Keywords: Hybrid building structure, seismic zones, STAAD Pro, Shear force, bending moment.

1. INTRODUCTION

Past is witness to many destruction and devastation of building due to connection failures due to earthquake. There are many researches on beam- column joint but there are several connection failure identified due to slab adjacent to joint. The contribution of slab in the beam- column joint was first considered in ACI 352-02. Beam- column- slab connection becomes problem when we talk about lateral load i.e. seismic load it becomes a critical problem. As we know practically it is very uneconomical and impossible to construct a building seismic proof but we can reduce the effect to a great extant by making structures ductile, this problem can be solved. Ductility can be the solution but beam- column- slab connection shear failure is also the reason of destruction during earthquake which will be studied further in this paper.

1.1 Beam- Column- Slab Connection:

A beam- column- slab connection is the combination of joint and beam, column, slab adjacent to the joint. And a joint is defined as that portion of column within the depth of deepest beam that frames into the column.

Following are the three type of connections:

i) Corner beam- column- slab connection
ii) Interior beam- column- slab connection
iii) Exterior beam- column- slab connection

1.2 Connection failure of the structure can be classified as:

i) Bond failure due to excess tension in reinforced bar. (T)
ii) Material failure at connection. (M)
iii) Shear failure before formation of plastic hinge in the beam. (P)

From many literatures survey it was interpreted that the above cited beam- column- slab connection failure are depend on following parameter:

Table 1 Factor affecting connection failure

S. No.	T	M	P
1	Type of connection	Type of connection	Type of connection
2	Grade of material	Grade of material	Grade of material
3		Height of storey building	
4		Width of bay	Width of bay
5	Size of column	Size of column	Size of column
6	Size of beam	Size of beam	Size of beam
7	Diameter of bar	Diameter of bar	
8	Lateral Loading	Lateral Loading	Lateral Loading

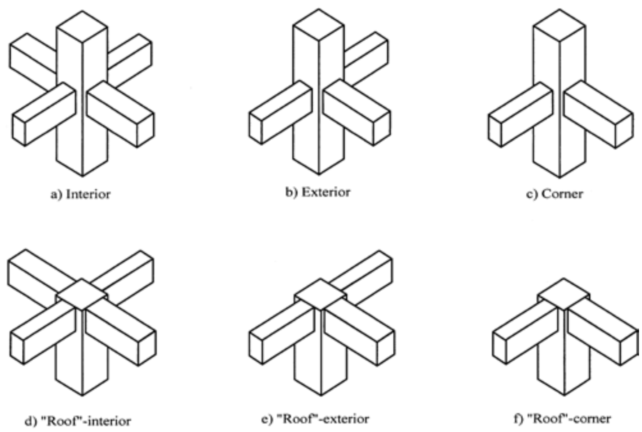


Fig: 1 Typical beam- column- slab connections (slabs not shown for clarity) (ref: ACI 352-02)

1.3 Hybrid Structure

In the last thirty years, the use of hybrid structure has gained popularity. One of the basic hybrid system used is RCS frame which consist of reinforced concrete (RC) column, slab and steel (S) beam. Now days, the use of RCS frame system provide us advantage of time and cost effective type of construction. RC columns are more cost effective in terms of axial strength and stiffness than steel columns [Sheikh et al. 1987]. Despite of many advantages of RCS structures, because of lack of design provision their use has been restrained in moderate earthquake regions.

1.4 Advantage and Disadvantage

- **Advantages:** High-strength concrete resists loads that cannot be resisted by normal-strength concrete. It also increases the strength per unit cost, per unit weight, and per unit volume as well. The hybrid structures consisting of RC columns and steel beams are suitable for use in high seismic risk zones. RCS moment-resisting frame systems, consisting of Reinforced Concrete (RC) columns and Steel (S) beams, take advantage of the inherent stiffness and damping, as well as low-cost of concrete, and the lightweight and construction efficiency of structural steel.
- **Disadvantages:** Increased quality control is needed in order to maintain the special properties desired and high-strength concrete must meet high-performance standards consistently in order to be

effective. Allowable stress design discourages the use of high-strength concrete. And minimum cover over reinforcement or minimum thickness of members may restrict the realization of maximum benefits.

2. METHODOLOGY:

1. Selection of types of structures.
2. Modeling of the selected structures.
3. Performing dynamic analysis on selected building models and comparison of the analysis results.
4. Ductility based design of the buildings as per the analysis results.

When a building is subjected to seismic force, it responds by vibrating. A seismic force is resolved in three mutually perpendicular directions and the predominant direction of shaking is horizontal. This force is called as the seismic design base shear. To find out the base shear, the analysis of structure is carried out using FEM software's named STAAD Pro. The program calculates the base shear that resists the design lateral loads at connection. It also calculates the moments, center of mass and rigidity of the building. Work is divided into 2 phases. In first I have analyzed the low, mid and high story buildings having same strength of component of building to find out the location of maximum shear force. And in Second phase the concrete column is replaced by steel column to see the change in economy of building.

In the following table 2, different parameters have been selected which are supposed to affect the shear demand of beam- column- slab connection in phase one and phase two.

Table 2 Building Model Detail

S. No.	Parameter	First Phase	Second Phase
1	**Material Properties**		
A	Column	M25	M30
B	Beam	M25	Steel
C	Slab	M25	M25
2	**Size**		
A	Column	400	ISWB300
B	Beam	400	400
C	Slab	150	150
3	**Load**		
A	Dead Load	20 KN/m	20 KN/m
B	Live Load	5 KN/m	5 KN/m
C	Earthquake Load		
II	**Soil Type**	II	II
III	**Response Reduction**	5	5
IV	**Importance Factor**	1	1

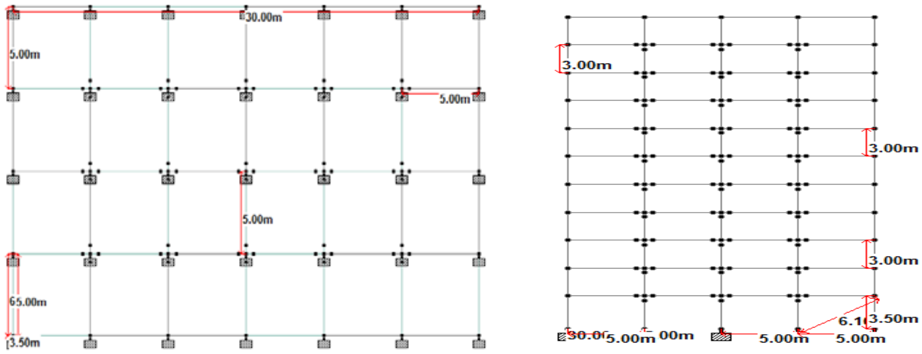
In the following table 3, parameters of earthquake load were considered as:

Table 3Earthquake parameters

Description	Factor/Value
Earthquake Parameters Zone (Z)	IV
Response Reduction factor (RF)	1
Importance factor (I)	1
Rock and soil factor (SS)	1
Type of structures	1
Damping ratio (DM)	0.05
Time Period	$Ta=0.075h^{0.075}$

3. MODELING AND ANALYSIS:

The structure is modeled through below steps of different story of RCC and composite is made and analysis can be done using STAAD pro software.



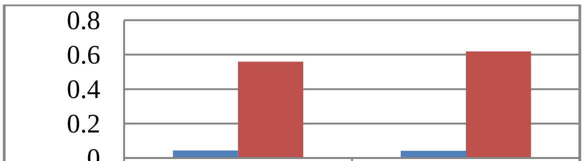
(a) (b)

Fig: 2(a) Plan of different story RCC and composite multistoried structure, (b)Elevation of 10 story RCC and composite multistoried structure

4. RESULT:

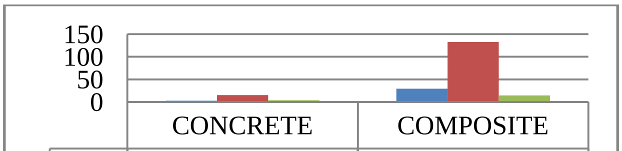
The normal RCC and composite structures of different multistoried structures are analyzed and the results of shear and bending moment of different multistoried structures using STAAD PRO software are mentioned in below work.

Analysis of shear stress and bending moment in5-story structure for Zone 5:



	RCC	COMPOSITE
SQX	0.044	0.042
SQY	0.559	0.619

Fig: 4 Shear Stress Graph for Zone 5

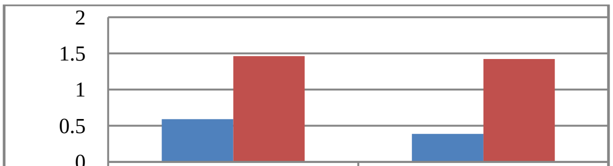


	CONCRETE	COMPOSITE
MX	2.896	29.437
MY	15.127	132.746
MZ	3.808	14.639

Fig:5 Bending Moment Graph for Zone 5

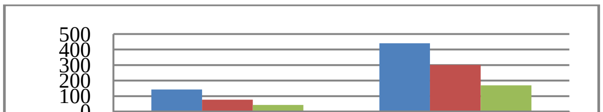
The normal RCC and composite structures of 5-story structure is analyzed for Zone 5 and the results of shear, membrane and bending moment are shown in figure 4 and figure 5. The shear stress graph for zone 5 is represented in figure 4; shear stress in x-direction and shear stress in y-direction are shown by blue and red colors respectively. The values for RCC and Composite in both directions are the results of 5-story structure for Zone 5. The Bending Moment graph for zone 5 is represented in figure 5; bending moment in x-direction, bending moment in y-direction and bending moment in z-direction are shown by blue, red and green colors respectively. The values for RCC and Composite in all three directions are the results for Zone 5 represented by the graphs.

Analysis of shear stress and bending moment in 5-story structure for Zone 2:



	CONCRETE	COMPOSITE
SQX	0.591	0.388
SQY	1.463	1.423

Fig:6 Shear Stress Graph

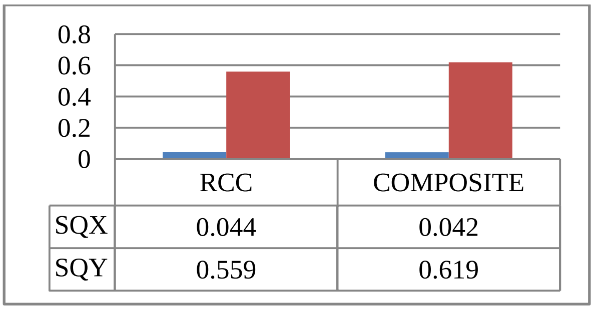


	CONCRETE	COMPOSITE
MX	143.067	440.057
MY	77.276	300.724
MZ	43.559	169.795

Fig:7 Bending Moment of 5 Story Building for Zone 2

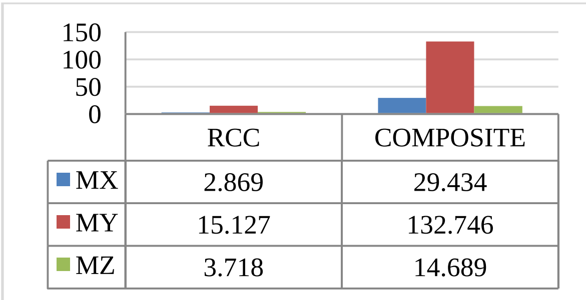
The normal RCC and composite structures of 5-story structure is analyzed for Zone 2 and the results of shear, membrane and bending moment are shown in figure 6 and figure 7. The shear stress graph for Zone 2 is represented in figure 6; shear stress in x-direction and shear stress in y-direction are shown by blue and red colors respectively. The values for RCC and Composite in both directions are the results for Zone 2. The Bending Moment graph for zone 5 is represented in figure 7; bending moment in x-direction, bending moment in y-direction and bending moment in z-direction are shown by blue, red and green colors respectively. The values for RCC and Composite in all three directions are the results for Zone 2 represented by the graphs.

Analysis of shear stress and bending moment in 20-story structure for Zone 5:



	RCC	COMPOSITE
SQX	0.044	0.042
SQY	0.559	0.619

Fig:8Shear Stress Graph

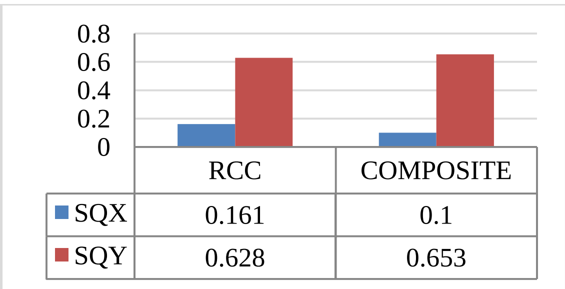


	RCC	COMPOSITE
MX	2.869	29.434
MY	15.127	132.746
MZ	3.718	14.689

Fig:9Bending Moment Graph

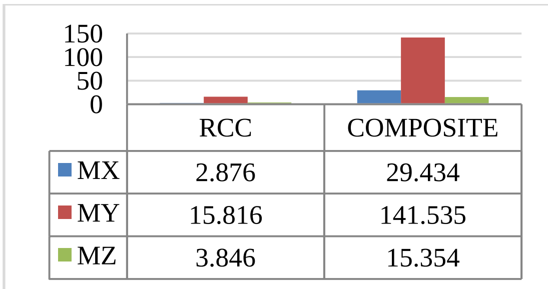
The normal RCC and composite structures of 20-story structure is analyzed for Zone 5 and the results of shear, membrane and bending moment are shown in figure 8 and figure 9. The shear stress graph for 20-story structure in Zone5 is represented in figure 8; shear stress in x-direction and shear stress in y-direction are shown by blue and red colors respectively. The values for RCC and Composite in both directions are the results for 20-story structure in Zone 5. The Bending Moment graph for zone 5 is represented in figure 9; bending moment in x-direction, bending moment in y-direction and bending moment in z-direction are shown by blue, red and green colors respectively. The values for RCC and Composite in all three directions are the results for Zone 5 represented by the graphs.

Analysis of shear stress and bending moment in 10-story structure for Zone 5:



	RCC	COMPOSITE
SQX	0.161	0.1
SQY	0.628	0.653

Fig:10Shear Stress Graph



	RCC	COMPOSITE
MX	2.876	29.434
MY	15.816	141.535
MZ	3.846	15.354

Fig:11Bending Moment Graph

The normal RCC and composite structures of 10-story structure is analyzed for Zone 5 and the results of shear, membrane and bending moment are shown in figure 10 and figure 11. The shear stress graph for 10-story structure in Zone5 is represented in figure 10; shear stress in x-direction and shear stress in y-direction are shown by blue and red colors respectively. The values for RCC and Composite in both directions are the results for 10-story structure in Zone 5. The Bending Moment graph of 10-story structure for zone 5 is represented in figure 11; bending moment in x-direction, bending moment in y-direction and bending moment in z-direction are shown by blue, red and green colors respectively. The values for RCC and Composite in all three directions are the results for Zone 5 represented by the graphs.

Analysis of shear stress and bending moment in 10-story structure for Zone 2:

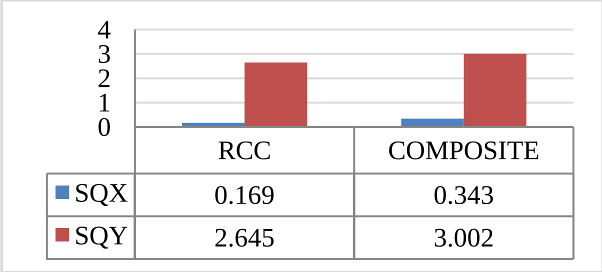


Fig12:Shear Stress Graph

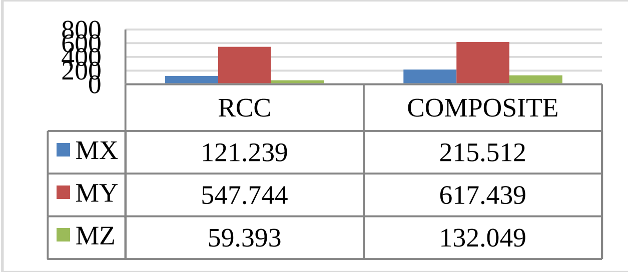


Fig:13Bending Moment Graph

The normal RCC and composite structures of 10-story structure is analyzed for Zone 2 and the results of shear, membrane and bending moment are shown in figure 12 and figure 13. The shear stress graph for 10-story structure in Zone2 is represented in figure 12; shear stress in x-direction and shear stress in y-direction are shown by blue and red colors respectively. The values for RCC and Composite in both directions are the results of 10-story structure for Zone 2. The Bending Moment graph of 10-story structure for zone 2 is represented in figure 13; bending moment in x-direction, bending moment in y-direction and bending moment in z-direction are shown by blue, red and green colors respectively. The values for RCC and Composite in all three directions are the results for Zone 2 represented by the graphs.

CONCLUSION:

- For 10 story zone 5, the shear stress along X axis of RCC and composite structure of 10 story building zone 5 is 72.22% and similarly along Y axis is 65.21%. Since shear stress in X direction is more than shear stress in Y direction. The bending moment along X axis of R.C.C and composite structure of 10 story building zone 5 is 44.32% and similarly along Y axis is 41.03% and in z direction the percentage of variation is 50.99%. So, we can conclude that BM in Z direction is maximum.
- For 10 story zone 2, the shear stress along X axis of R.C.C and composite structure of 10 story building zone 2 is 20.73% and similarly along Y axis is 1.38 %. Since shear stress in X direction is more than shear stress in Y direction. The bending moment along X axis of R.C.C and composite structure of 10 story building zone 2 is 60.68% and similarly along Y axis is 47.45% and in z direction the percentage of variation is 62.75%. So, we can conclude that BM in Z direction is maximum.
- For 20 story zone 5, the shear stress along X axis of R.C.C and composite structure of 10 story building zone 5 is 67.96% and similarly along Y axis is 12.65%. Since shear stress in X direction is more than shear stress in Y direction. The bending moment along X axis of RCC and composite structure of 10 story building zone 5 is 55.93% and similarly along Y axis is 11.93% and in z direction the percentage of variation is 75.99%. So, we can conclude that BM in Z direction is maximum.
- For 5 story zone 5, the shear stress along X axis of R.C.C and composite structure of 5storey building zone 5 is 4.65% and similarly along Y axis is 11.18%. Since shear stress in X direction is more than shear stress in Y direction. The bending moment along X axis of RCC and composite structure of 5storey building zone 5 is 57.32% and similarly along Y axis is 35.03% and in z direction the percentage of variation is 60.99%. So, we can conclude that B.M in Z direction is maximum.
- For 5 story zone 2, the shear stress along X axis of R.C.C and composite structure of 5storey building zone 5 is 11.65% and similarly along Y axis is 9.18%. Since shear stress in X direction is more than shear stress in Y direction. The bending moment along X axis of R.C.C and composite structure of 5storey building zone 5 is 67.32% and similarly along Y axis is 68.03% and in z direction the percentage of variation is

88.99%. So, we can conclude that B.M in Z direction is maximum.

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