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"ANALYSIS AND COMPARISON OF RCC, STEEL AND STEEL-CONCRETE MULTI-STOREY BUILDING BY RESPONSE SPECTRUM ANALYSIS"

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Abstract - *This project emphasises the study of seismic behaviour and wind analysis in different zones and also comparison of different type of structures in various zones. Due to increase in population there is increase in urbanisation so the construction industry plays important role. Till today we have seen various multi-stories constructions like RCC, Steel and Composite Structures. But this project deals with the combination of RCC and Steel and comparison of this structure with RCC structure and Steel structure. The combination of RCC and Steel is a different type of construction. Below 5 stories is RCC construction and above 5 stories is Steel construction. In this project a multi-storey building of G+10 is modeled for RCC, Steel and Steel-Concrete structures for various different zones like zone II, III and IV in ETABS software. Totally 9 models are prepared such that 3 models for each structure and are compared.*

The results concluded that Base shear for Steel-Concrete structure is less in both X and Y directions compared with RCC structure but when compared with Steel structure the base shear is less in X-direction and more in Y-direction. Steel-Concrete has less storey shear compare to RCC but more than Steel in X-direction but the storey shear is less in Y-direction compared to both the structures. The Storey displacement for Steel-Concrete is less in X-direction but more in Y-direction compared to Steel. Hence we can say that seismic behaviour of Steel-Concrete structure is better than seismic behaviour of RCC structure and Steel structure.

Key Words: **Seismic behaviour, RCC structure, Steel structure, Steel-Concrete structure, Base shear, Storey shear, Storey displacement**

1. INTRODUCTION

Construction is the process of constructing a building or infrastructure. Construction which starts with planning, designing, financing and execution, it continues until the project is built and is ready for use. Construction also covers repairs and maintenance work, any works to expand, extend and improve the asset, and its eventual demolition, dismantling or decommissioning. The most widely and commonly used construction is the building construction. If we see the construction of building is been carried out everywhere. The construction of building may be either residential or non-residential. It is divided in 2 parts Single-storey building and Multi-storey building. Single-storey is a building where there is only ground storey is constructed where as a Multi-storey is a building which consists of several multiple stories and contains the vertical movement or circulation in the form of stairs, lifts and ramps. Till today we have seen various multi-stories constructions like RCC, Steel and Composite Structures. Construction of multi-storey buildings is much dependent on the materials available, the level of technology in construction and also the available services such as elevators or lifts which are necessary for the use in the building. The growth in modern multi-storey building construction is intended largely for commercial and residential purposes.

1.1 Objectives

1. To analyze and compare the seismic analysis for RCC, Steel & Steel-Concrete Structures.
2. To analyze and compare the wind analysis for RCC, Steel & Steel-Concrete Structures.
3. To study the effects of different Seismic forces on performance of multi-storey building in terms of seismic responses such as base shear, storey displacement, and storey shear.
4. To study the effects of Seismic forces in different seismic zones such as Zone II, Zone III and Zone IV.
5. To study the advantages of using different materials in construction.

1.2 Methodology

1. This study involves Response Spectrum analysis of RCC, Steel and Steel-Concrete building by using ETABS software.
2. Each structure is modeled and analyzed separately by Response Spectrum analysis.
3. The analysis is conducted for specified combinations of loads.

2. MODELLING AND DETAILS OF STRUCTURE

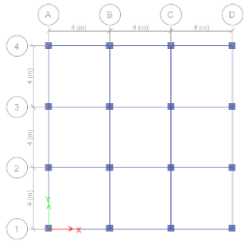

Figure 1: General floor plan

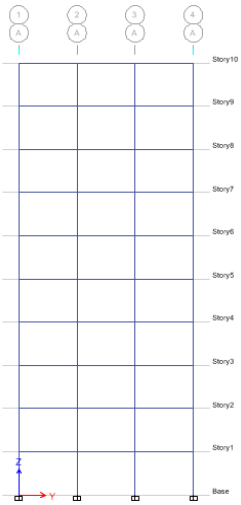

Figure 2: Typical Elevation

Table 1: Material Properties

Concrete Properties	
Grade of concrete	M30
Modulus of elasticity	27386.13MPa
Density of concrete	25 kN/m^3
Poisson's ratio	0.2
Reinforcement Properties	
Grade of steel	Fe500
Modulus of elasticity	200000 MPa
Poisson's ratio	0.3
Masonry Properties	
Density of brick wall including plaster	20 kN/m^3
Poisson's ratio	0.2
Steel Properties	
Grade of steel	Fe250
Modulus of elasticity	210000 MPa
Poisson's ratio	0.3

Table 2: Gravity Loads on Structure

Live Load	
Floor	3 kN/m^2
Roof	3 kN/m^2
Dead Load	
Masonry Wall Load	13 kN/m

Table 3: Section Properties on each storey

Members	Storey	RCC	Steel	Steel-Concrete
Beam	1 to 5	230mm x 450mm	ISLB 600	230mm x 450mm
	6 to 10	230mm x 450mm	ISLB 600	ISLB 600
Column	1 to 5	450mm x 450mm	ISHB 450	450mm x 450mm
	6 to 10	450mm x 450mm	ISHB 450	ISHB 450
Slab	1 to 5	150mm	-	150mm
	6 to 10	150mm	-	-
Deck Slab	1 to 5	-	150mm	-
	6 to 10	-	150mm	150mm

Table 4: Seismic parameters

Parameters	Zone II	Zone III	Zone IV
Zone Factor	0.1	0.16	0.24
Soil Type	II	II	II
Importance Factor	1.5	1.5	1.5
Reduction Factor	5	5	5
Damping	5%	5%	5%

3. RESULTS AND COMPARISON

3.1 Comparison of Base Shear

Table 5(a): Base shear comparison for different models (Static Analysis)

Zones	RCC Structure		Steel Structure		Steel-Concrete Structure	
	EQX	EQY	EQX	EQY	EQX	EQY
II	304.474	304.474	153.681	338.003	242.823	304.045
III	487.161	487.161	245.890	540.804	388.517	486.472
IV	730.741	730.741	368.835	811.207	582.776	729.709

Table 5(b): Base shear comparison for different models (Response Spectrum Analysis)

Zones	RCC Structure		Steel Structure		Steel-Concrete Structure	
	RSX	RSY	RSX	RSY	RSX	RSY
II	309.488	309.488	168.855	313.228	264.827	304.350
III	495.180	495.180	270.167	501.165	423.723	486.960
IV	742.773	742.773	405.252	751.747	635.584	730.441

Table 5(c): Base shear comparison for different models (Wind Analysis)

Zones	RCC Structure		Steel Structure		Steel-Concrete Structure	
	WLX	WLY	WLX	WLY	WLX	WLY
II	703.846	703.846	703.846	703.846	703.846	703.846
III	703.846	703.846	703.846	703.846	703.846	703.846
IV	703.846	703.846	703.846	703.846	703.846	703.846

3.2 Comparison of Storey Shear

Table 6(a): Storey shear comparison for different models in X-direction (Zone II)

Storey	Load Case	Zone II		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-X	67.931	38.976	63.929
9	RS-X	128.119	68.443	109.106
8	RS-X	162.188	87.403	134.121
7	RS-X	189.682	102.149	149.515
6	RS-X	210.651	115.566	162.874
5	RS-X	229.861	127.836	176.842
4	RS-X	250.419	138.608	203.209
3	RS-X	272.435	148.518	229.669
2	RS-X	292.529	158.960	252.821
1	RS-X	304.474	168.855	264.827

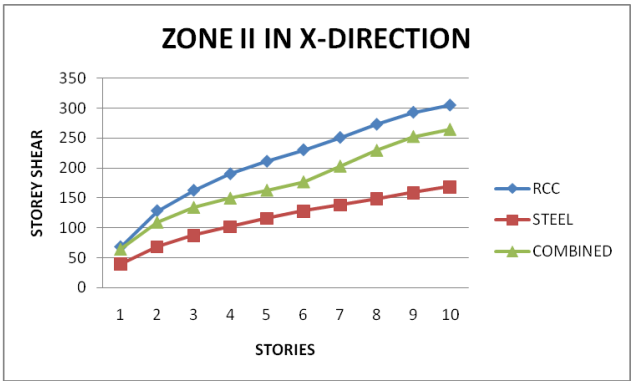

Chart 1(a): Storey Shear variation along storey height in X-direction for Zone II

Table 6(b): Storey shear comparison for different models in Y-direction (Zone II)

Storey	Load Case	Zone II		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-Y	67.931	63.851	55.049
9	RS-Y	128.119	119.234	107.151
8	RS-Y	162.188	160.550	147.229
7	RS-Y	189.682	191.552	177.699
6	RS-Y	210.651	216.370	203.029
5	RS-Y	229.861	238.711	227.372
4	RS-Y	250.419	260.826	250.000
3	RS-Y	272.435	282.663	273.042
2	RS-Y	292.529	301.652	294.048
1	RS-Y	304.474	313.228	304.350

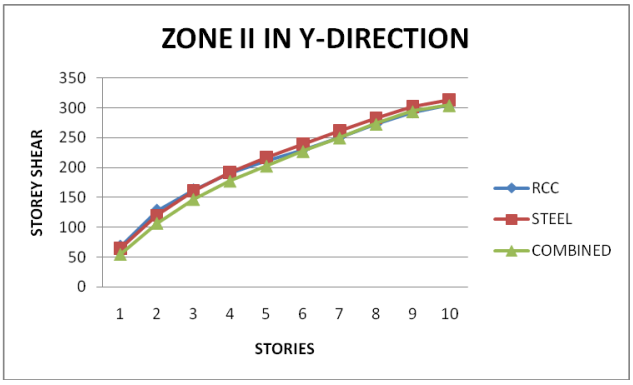

Chart 1(b): Storey Shear variation along storey height in Y-direction for Zone II

Table 7(a): Storey shear comparison for different models in X-direction (Zone III)

Storey	Load Case	Zone III		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-X	108.690	62.362	102.287
9	RS-X	196.991	109.508	174.569
8	RS-X	259.500	139.844	214.593
7	RS-X	303.491	163.438	239.224
6	RS-X	337.042	184.906	260.598
5	RS-X	367.778	204.538	282.948
4	RS-X	400.670	221.773	325.135
3	RS-X	435.896	237.628	367.470
2	RS-X	468.046	254.337	404.514
1	RS-X	487.158	270.168	423.723

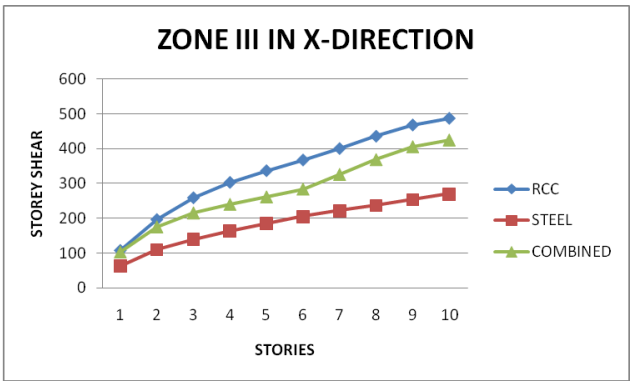

Chart 2(a): Storey Shear variation along storey height in X-direction for Zone III

Table 7(b): Storey shear comparison for different models in Y-direction (Zone III)

Storey	Load Case	Zone III		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-Y	108.690	102.161	88.079
9	RS-Y	196.991	190.774	171.441
8	RS-Y	259.500	256.880	235.566
7	RS-Y	303.491	306.483	284.319
6	RS-Y	337.042	346.192	324.846
5	RS-Y	367.778	381.938	363.795
4	RS-Y	400.670	417.321	400.000
3	RS-Y	435.896	452.261	436.867
2	RS-Y	468.046	482.644	470.477
1	RS-Y	487.158	501.165	486.961

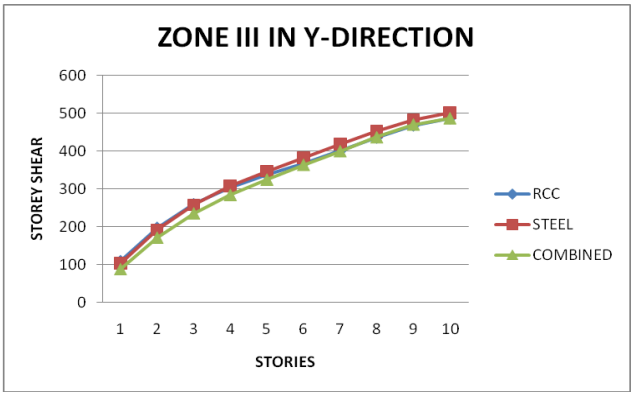

Chart 2(b): Storey Shear variation along storey height in Y-direction for Zone III

Table 8(a): Storey shear comparison for different models in X-direction (Zone IV)

Storey	Load Case	Zone IV		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-X	163.035	93.543	153.431
9	RS-X	295.488	164.263	261.854
8	RS-X	389.252	209.766	321.890
7	RS-X	455.239	245.157	358.835
6	RS-X	505.565	277.358	390.896
5	RS-X	551.670	306.807	424.422
4	RS-X	601.008	332.660	487.703
3	RS-X	653.847	356.442	551.205
2	RS-X	702.073	381.505	606.771
1	RS-X	730.741	405.252	635.584

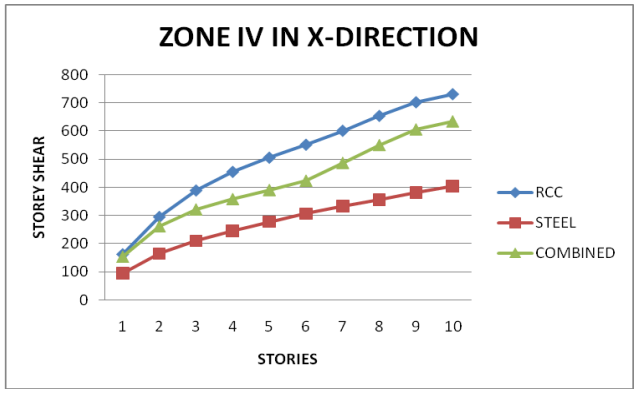

Chart 3(a): Storey Shear variation along storey height in X-direction for Zone IV

Table 8(b): Storey shear comparison for different models in Y-direction (Zone IV)

Storey	Load Case	Zone IV		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-Y	163.035	153.242	132.119
9	RS-Y	295.488	286.161	257.162
8	RS-Y	389.252	385.320	353.350
7	RS-Y	455.239	459.724	426.478
6	RS-Y	505.565	519.288	487.268
5	RS-Y	551.670	572.907	545.692
4	RS-Y	601.008	625.981	600.000
3	RS-Y	653.847	678.392	655.301
2	RS-Y	702.073	723.966	705.715
1	RS-Y	730.741	751.747	730.441

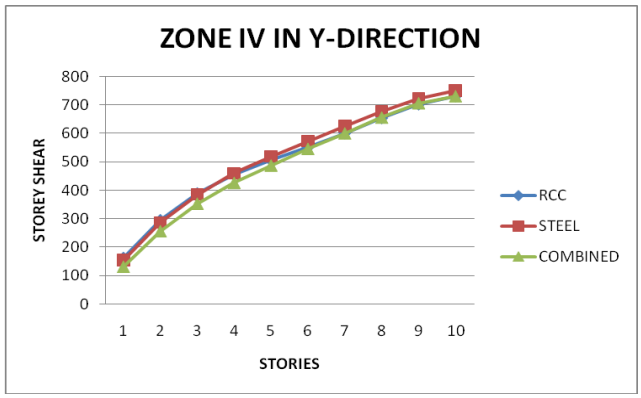

Chart 3(b): Storey Shear variation along storey height in Y-direction for Zone IV

3.3 Comparison of Storey Displacement

Table 9(a): Storey displacement comparison for different models in X-direction (Zone II)

Storey	Load Case	Zone II		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-X	16.099	24.691	19.995

9	RS-X	15.535	23.954	18.909
8	RS-X	14.64	22.695	17.032
7	RS-X	13.431	20.986	14.600
6	RS-X	11.951	18.879	11.736
5	RS-X	10.226	16.413	8.241
4	RS-X	8.27	13.625	6.750
3	RS-X	6.094	10.546	5.035
2	RS-X	3.744	7.191	3.122
1	RS-X	1.42	3.573	1.190

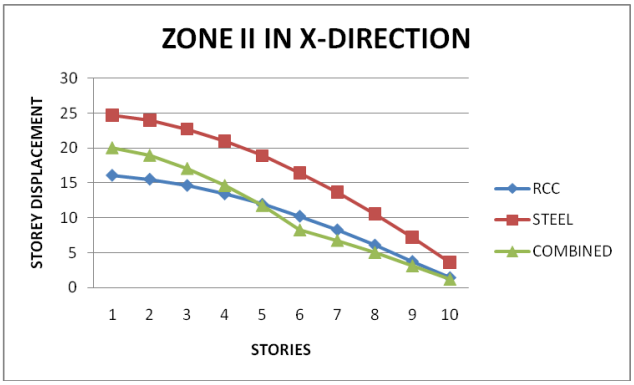

Chart 4(a): Storey displacement variation along storey height in X-direction for Zone II

Table 9(b): Storey displacement comparison for different models in Y-direction (Zone II)

Storey	Load Case	Zone II		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-Y	16.099	13.314	15.301
9	RS-Y	15.535	12.716	14.865
8	RS-Y	14.64	11.872	14.179
7	RS-Y	13.431	10.804	13.257
6	RS-Y	11.951	9.550	12.102
5	RS-Y	10.226	8.136	10.416
4	RS-Y	8.27	6.583	8.458
3	RS-Y	6.094	4.910	6.228
2	RS-Y	3.744	3.142	3.817
1	RS-Y	1.42	1.351	1.443

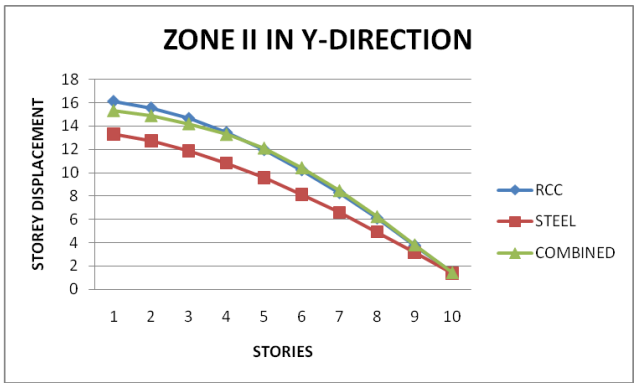

Chart 4(b): Storey displacement variation along storey height in Y-direction for Zone II

Table 10(a): Storey displacement comparison for different models in X-direction (Zone III)

Storey	Load Case	Zone III		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-X	25.758	39.506	31.993
9	RS-X	24.856	38.327	30.255
8	RS-X	23.424	36.312	27.252
7	RS-X	21.490	33.577	23.359
6	RS-X	19.121	30.206	18.777
5	RS-X	16.362	26.261	13.186
4	RS-X	13.232	21.801	10.8000
3	RS-X	9.750	16.874	8.056
2	RS-X	5.991	11.505	4.995
1	RS-X	2.273	5.716	1.905

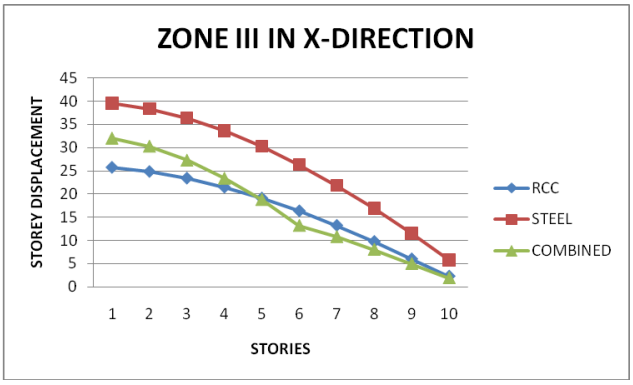

Chart 5(a): Storey displacement variation along storey height in X-direction for Zone III

Table 10(b): Storey displacement comparison for different models in Y-direction (Zone III)

Storey	Load Case	Zone III		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-Y	25.758	21.302	24.481
9	RS-Y	24.856	20.346	23.784
8	RS-Y	23.424	18.994	22.686
7	RS-Y	21.490	17.287	21.212
6	RS-Y	19.121	15.279	19.363
5	RS-Y	16.362	13.017	16.685
4	RS-Y	13.232	10.533	13.533
3	RS-Y	9.750	7.856	9.965
2	RS-Y	5.991	5.028	6.107
1	RS-Y	2.273	2.162	2.308

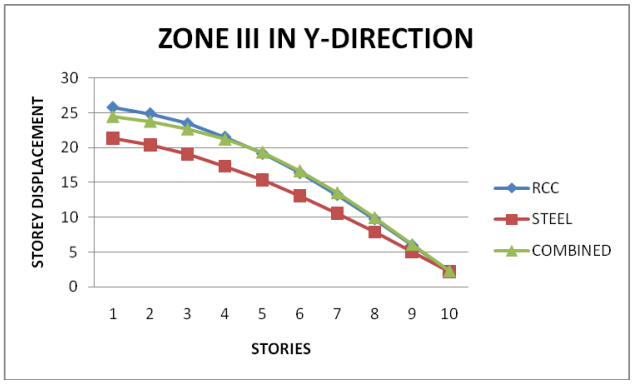

Chart 5(b): Storey displacement variation along storey height in Y-direction for Zone III

Table 11(a): Storey displacement comparison for different models in X-direction (Zone IV)

Storey	Load Case	Zone IV		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-X	38.637	59.258	47.989
9	RS-X	37.284	57.490	45.382
8	RS-X	35.136	54.468	40.877
7	RS-X	32.235	50.366	35.039
6	RS-X	28.682	45.309	28.166
5	RS-X	24.544	39.392	19.779
4	RS-X	19.849	32.701	16.200
3	RS-X	14.625	25.311	12.085
2	RS-X	8.986	17.258	7.493
1	RS-X	3.409	8.574	2.857

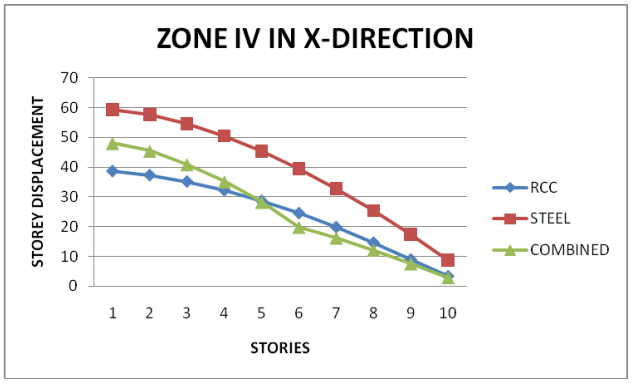

Chart 6(a): Storey displacement variation along storey height in X-direction for Zone IV

Table 11(b): Storey displacement comparison for different models in Y-direction (Zone IV)

Storey	Load Case	Zone IV		
		RCC Structure	Steel Structure	Steel-Concrete Structure
10	RS-Y	38.637	31.953	36.721
9	RS-Y	37.284	30.519	35.676
8	RS-Y	35.136	28.492	34.028
7	RS-Y	32.235	25.930	31.818
6	RS-Y	28.682	22.919	29.044
5	RS-Y	24.544	19.526	24.997
4	RS-Y	19.849	15.800	20.299
3	RS-Y	14.625	11.784	14.948
2	RS-Y	8.986	7.541	9.160
1	RS-Y	3.409	3.243	3.462

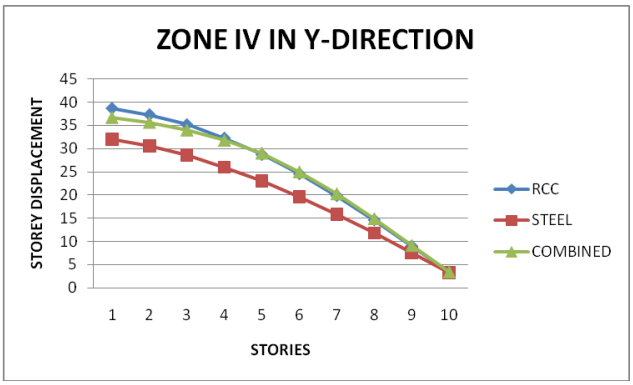

Chart 6(b): Storey displacement variation along storey height in Y-direction for Zone IV

4. CONCLUSIONS

1. Steel-Concrete structure has obtained less base shear compare to RCC structure in both the direction.
2. Steel structure has obtained less base shear in X-direction but more base shear in Y-direction as compared to Steel-Concrete structure.
3. The results obtained for wind analysis are same for all the structures as the height and the parameters are same for all the structure.
4. Steel-Concrete structure has obtained less storey shear compare to RCC structure but more than Steel structure in X-direction.
5. Steel-Concrete structure has obtained less storey shear compare to both RCC structure as well as Steel structure in Y-direction.
6. Steel-Concrete structure has obtained less storey displacement compare to Steel structure in X-direction.
7. Steel-Concrete structure has obtained more storey displacement compare to Steel structure in Y-direction.

5. SCOPE FOR FURTHER STUDIES

1. Design of each structure for the given section properties and also by reducing the section properties is to be studied and compared.
2. Analysis of Composite structure and Steel-Concrete combination and comparing the results.
3. Study the effect of Steel-Concrete at the joint and also to design the connection at that joint.

4. Analysis of the same structures with irregular plan and comparing the results.
5. Estimation of each structure is to be studied and compared.

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