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Analysis of Conventional Beam Column System over RC Structural Wall System in Multi Storey Building

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ABSTRACT:
In the recent years there are vital changes in the construction process. In old days building are constructed with concept of load bearing and then RCC frame construction invented. Now RC structural wall construction in metropolitan cities is widely used. The latest technique is invented for the modern construction is called as Aluform technique or Mivan technique. In this technique whole building is design with RC structural wall i.e. shear wall. It is specially design to allow rapid construction on all types of architecture layout. This work having the scope of comparative analysis of conventional beam column system over RC structural wall system in G+30, G+20, G+10 storey building models and its advantages as a structural point of view. For this, design software ETABS is used for analysis. Analysis is carried out considering the various seismic and wind load condition for both system of framing. Beam column conventional system and RC structural wall will be compared on the basis of various structural parameters. Concluding remark will be given with respective high structural performance.

1.Introduction:
Construction of high rise building is highly complex and required advanced construction technology and equipment. Mivan technology, climbing formwork, Aluform technologies are the new developments in the formwork and latest one. In Beam Column System of buildings reinforced concrete frames are provided in both principal directions to resist vertical loads and the vertical loads are transmitted to vertical framing system i.e. columns and foundations. This type of system is effective in resisting both vertical & horizontal loads. In RC Structural wall system the lateral and gravity load-resisting system consists of reinforced concrete walls and reinforced concrete slabs. RC structural walls are the main vertical structural elements with a dual role of resisting both the gravity and lateral loads.

Wall thickness varies from 150 mm (as per clause 9.1.2 of IS 13920:1993) to 500 mm, depending on the number of stories, building age, and thermal insulation requirements. In general, these walls are continuous throughout the building height however, some walls are discontinued at the street front or basement level to allow for commercial or parking spaces.

1.1 Objective of the study
The main objective of this study is to analyse the multi storey building with RC Structural wall system over the conventional beam column system. For this design software ETABS is be used. The results are obtained by applying Response Spectrum Analysis to the selected building models.

Basic objectives of the study are:
•To study the relationship between maximum storey displacement and story for selected building models.
•To study the effect of different seismic zones over the maximum story displacements of the building models.
•To study the relationship between storey base shear and storey height for selected building models.
•To study the effects of storey height on inter - storey drift.
•To study the variation of modal period and natural frequency for the modes considered for different building models considered.

2. Required Indian standards
IS 456:2000 As per clause 32, design for wall describes, design of horizontal shear in clause 32.4 given details of how shear wall have to be constructed.

IS 1893-2001 (part1) Criteria for Earth quake resistant design of structures clause 7.8 gives the method of determining the story shears forces due to all modes considered.

IS 13920:1993 it gives the ductile detailing of shear wall as per clause9, where 9.1 gives general requirements,9.2 shear ductile detailing, as per the code IS: 13920:1993 is considered very important as the ductile detailing gives the amount of reinforcement required and the alignment of bars.

IS: 875-1987 Code of Practice for Design loads (Part 1 to 3) (other than Earthquake) for Building and Structures.

3.Linear Dynamic Analysis

Linear Dynamic Analysis is carried out by either Response spectrum method or by Elastic Time History method.

3.1.Response Spectrum Method:

This approach permits the multiple modes of response of a building to be taken into account (in the frequency domain). This is required in many building codes for all except for very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of the forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include following:

•Absolute peak value method
•square root of the sum of the squares (SRSS)
•complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

4. Methodology

4.1 Introduction

The study in this work is based on the analysis of structural models representing multi-story buildings with beam column system and Reinforced structural wall system are presented and discussed in detail. A total of thirty six models have been analysed. Basically there are six types of models G+30, G+20 and G+ 10 with beam column system and RC structural wall system.For each model seismic zones of zone IV, zone III and zone II are considered, for each such building model is considered with two soil types soil I, soil II.

Consequently we will get six basic models and to each such model six conditions are considered. Thus, thirty six structural models are analysed. Earthquake and wind load analysis is done using Response spectrum analysis. Finite element software ETABS is used to carry out this analysis.

4 .2 Description of the building models Building model IDs with beam column system:

Case 1:
G30Z4S1BC system - G+30 Beam column model in Seismic Zone IV with soil type II.
Case 7:
G20Z4S2BC system - G+20 Beam column model in Seismic Zone IV with soil type II.
Case 13:
G10Z4S2BC system - G+10 Beam column model in Seismic Zone IV with soil type II.

Table 4.1: Building Model IDs with Beam Column System

Sl.no.	MODEL ID	No. of stories	Seismic zone	Soil type
1	G30Z4S2BC	30	IV	II
2	G30Z4S1BC	30	IV	I
3	G30Z3S2BC	30	III	II
4	G30Z3S1BC	30	III	I
5	G30Z2S2BC	30	II	II
6	G30Z2S1BC	30	II	I
7	G20Z4S2BC	20	IV	II
8	G20Z4S1BC	20	IV	I
9	G20Z3S2BC	20	III	II
10	G20Z3S1BC	20	III	I
11	G20Z2S2BC	20	II	II
12	G20Z2S1BC	20	II	I
13	G10Z4S2BC	10	IV	II
14	G10Z4S1BC	10	IV	I
15	G10Z3S2BC	10	III	II
16	G10Z3S1BC	10	III	I
17	G10Z2S2BC	10	II	II
18	G10Z2S1BC	10	II	I

Building Model IDs with shear wall system:
Case 19:
G30Z4S2SW system - G+30 RC Structural wall model in Seismic Zone IV with soil II.
Case 25:
G20Z4S2SW system - G+20 RC Structural wall model in Seismic Zone IV with soil II.

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Case 31:
G10Z4S2SW system- G+10 RC structural wall model in Seismic Zone IV with soil II.

Table 4.2: Building model IDs with shear wall /RC structural wall system

Sl.no.	MODEL ID	No. of stories	Seismic zone	Soil type
19	G30Z4S2SW	30	IV	II
20	G30Z4S1SW	30	IV	I
21	G30Z3S2SW	30	III	II
22	G30Z3S1SW	30	III	I
23	G30Z2S2SW	30	II	II
24	G30Z2S1SW	30	II	I
25	G20Z4S2SW	20	IV	II
26	G20Z4S1SW	20	IV	I
27	G20Z3S2SW	20	III	II
28	G20Z3S1SW	20	III	I
29	G20Z2S2SW	20	II	II
30	G20Z2S1SW	20	II	I
31	G10Z4S2SW	10	IV	II
32	G10Z4S1SW	10	IV	I
33	G10Z3S2SW	10	III	II
34	G10Z3S1SW	10	III	I
35	G10Z2S2SW	10	II	II
36	G10Z2S1SW	10	II	I

For each model Seismic zones of (zone IV, zone III ,zone II) are considered, and for each such building model is considered with Two Soil types (soil1, soil 2).

TOTAL NO. OF MODELS = 36

Case 1: G30Z4S2BC system

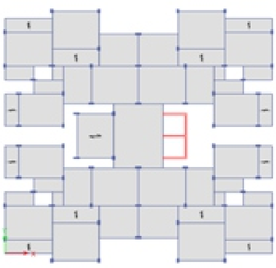

Figure 4.1 Plan View of G30Z4S2BC system model

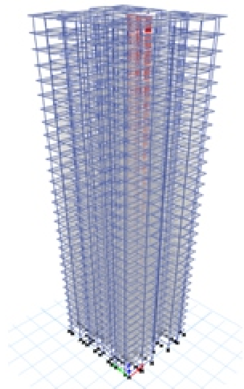

Figure 4.2 Isometric View of G30Z4S2BC system model

Case 19: G30Z4S2RC Structural wall system

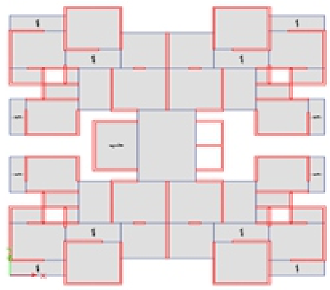

Figure 4.3 Plan View of G30Z4S2SW system model

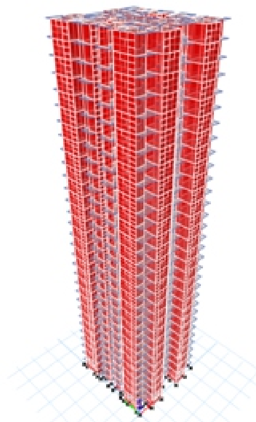

Figure 4.4 Isometric View of G30Z4S2SW system model

7.3 Design Data

Material Properties:

Young's modulus of (M40) concrete, E
 = 31.6227 x 106 kN/m^2
Density of reinforced concrete
= 24.9926 kN/m^3
Density of brick masonry
 = 19 kN/m^3

Young's modulus of (Fe500) Rebar, E
= 200 x 106 kN/m²
Density of rebar = 76.97 kN/m³

Assumed load intensities:

Dead load =2 kN/m²
Live load = 3 kN/m²
On terrace
Dead load = 2 kN/m²
Live load = 1.5kN/m²
On stair case
Dead load = 4kN/m²
Live load = 3kN/m²
Dead load as sunken load in bath & wc
= 6kN/m²
External wall load = 10.49KN/m
Internal wall load = 6.84KN/m

Member Properties:

Thickness of slab = 0.125 m
Thickness of stair case slab = 0.150 m
Column size = (0.900mx1.350m), (0.750mx1.350), (0.750mx1.050), (0.450mx0.750), (0.230mx0.450).
Beam size = (0.300mx0.600m)
Thickness of shear wall = 0.150, 0.200, 0.230, 0.250m.

Table 4.3 Seismic, Time period & wind parameters

Sl. No.	Seismic coefficients as per IS 1893(part1):2000	value
1	Seismic zone	II,III,IV
	Seismic zone factor	0.10,0.16,0.24
	Soil type	I(Hard soil),II(Medium soil).
	Importance factor(I)	1
	Response reduction factor(R)	3
2.	**Wind coefficient as per IS:875**	
	Risk coefficient(K1)	1
	Terrain category , Height, structure size Factor (K2	-
	Topography factor (K3)	1
	Basic wind speed (m/sec)	44

Table 4.4: Time period

Model	Height	Width	Length	Time period in X direction in (sec)	Time period in Y direction In (sec)
G+30	92	21.6	25	1.7815	1.656
G+20	62	21.6	25	1.20	1.116
G+10	32	21.6	25	0.62	0.576

Table 4.5: Wind coefficients

Model	W_x		W_y	
	C_p in wind ward	C_p in Lee ward	C_p in wind ward	C_p in Lee ward
G+30	0.8	0.25	0.8	0.25
G+20	0.8	0.25	0.8	0.25
G+10	0.7	0.25	0.7	0.25

5.Results & Discussions:

A total of thirty six models have been analysed. Basically there are six types of models G+30, G+20 and G+ 10 with beam column system and RC structural wall system ,for each model Seismic zones of zone IV, zone III and zone II are considered, for each such building model is considered with two soil types soil I, soil II. Thus, thirty six structural models are analysed. Earthquake and wind load analysis is done using Response spectrum analysis. Finite element software ETABS is used to carry out this analysis. The results of variation of maximum Storey displacements, variation of story drifts, variation of story shears, variation of time period with mode shapes, variation of natural Frequency with mode shapes for different building models are presented and compared. In the analysis it is observed that the earthquake loads are governing the models considered.

Variation of storey Base shear, Maximum storey displacements & storey drift for G+30 models

It is observed from the present study that the storey base shear is reducing from seismic zone IV to seismic zone II and from soil II to soil I in both type of structural systems in G+30 model. It is also observed that the maximum storey displacement is reducing from seismic zone IV to seismic zone II and from soil II to soil I in both structural systems in G+30 model.

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Table 5.1: Variation of storey Base shear, Maximum storey displacements and storey drift for G+30 models.

Sl. No.	MODEL	Storey Base shear (KN)	Maximum storey displacement(mm) in X direction	Maximum storey drift
1	G30Z4S2 BC	11768	188.2	0.0023
2	G30Z4S1 BC	8653	138.8	0.0017
3	G30Z3S2 BC	7845	126	0.0015
4	G30Z3S1 BC	5769	93	0.0011
5	G30Z2S2 BC	4903	79.3	0.00096
6	G30Z2S1 BC	3605	58.7	0.00071
7	G30Z4S2 SW	8032	91.1	0.00059
8	G30Z4S1 SW	5906	67.2	0.000407
9	G30Z3S2 SW	5355	61	0.00039
10	G30Z3S1 SW	3937	45.1	0.00027
11	G30Z2S2 SW	3347	38.5	0.0025
12	G30Z2S1 SW	2461	28.6	0.00014

Variation of storey Base shear, Maximum storey displacements & storey drift for G+20 models

It is observed from the present study that the storey base shear is reducing from seismic zone IV to seismic zone II and from soil II to soil I in both type of structural systems in G+20 model. It is also observed that the maximum storey displacement is reducing from seismic zone IV to seismic zone II and from soil II to soil I in both structural systems in G+20 model.

Table 5.2: Variation of storey Base shear, Maximum storey displacements and storey drift for G+20 models.

Sl. No.	MODEL	Storey Base shear (KN)	Maximum storey displacement(mm) in X direction	Maximum storey drift
1	G20Z4S2 BC	10848	130	0.0026
2	G20Z4S1 BC	7977	96.5	0.0019
3	G20Z3S2 BC	7232	87.9	0.0017
4	G20Z3S1 BC	5318	65.6	0.0012
5	G20Z2S2 BC	4520	56.3	0.0010
6	G20Z2S1 BC	3324	42.3	0.00078
7	G20Z4S2 SW	7691	47.3	0.00052
8	G20Z4S1 SW	5655	34.9	0.00036
9	G20Z3S2 SW	5127	31.7	0.00035
10	G20Z3S1 SW	3770	23.4	0.00024
11	G20Z2S2 SW	2356	20	0.00022
12	G20Z2S1 SW	3205	14.9	0.00015

Variation of storey Base shear, Maximum storey displacements & storey drift for G+10 models

It is observed from the present study that the storey base shear is reducing from seismic zone IV to seismic zone II and from soil II to soil I in both type of structural systems in G+10 model. It is also observed that the maximum storey displacement is reducing from seismic zone IV to seismic zone II and from soil II to soil I in both structural systems in G+10 model.

Table 5.3: Variation of storey Base shear, Maximum storey displacements & storey drift for G+10 models.

Sl. No.	MODEL	Storey Base shear (KN)	Maximum storey displacement(mm) in X direction	Maximum storey drift
1	G10Z4S 2BC	9756	87.2	0.0032
2	G10Z4S 1BC	7173	64.6	0.0023
3	G10Z3S 2BC	6504	58.8	0.0021
4	G10Z3S 1BC	4782	43.8	0.0015
5	G10Z2S 2BC	4065	37.5	0.0013
6	G10Z2S 1BC	2989	28.1	0.0009
7	G10Z4S 2SW	7566	14.9	0.00033
8	G10Z4S 1SW	5563	11	0.00024
9	G10Z3S 2SW	5044	10	0.00022
10	G10Z3S 1SW	3709	7.4	0.00016
11	G10Z2S 2SW	3152	6.3	0.00014
12	G10Z2S 1SW	2318	4.7	0.00010

I.Variation of maximum Storey Displacements of Models considered

In multi-storeyed building maximum storey displacement will observe at top stories, as the height is increasing the storey displacement will have maximum value, from output of both the system it is observed that maximum storey displacement is occur for beam column system. Figure 8.1 shows maximum storey displacement is at top storey then goes on reducing up to first storey for both systems. The variation of maximum storey displacements of models considered in zone IV and soil I is shown in figure 8.1. It is found that at top storey maximum storey displacement in the case of G10Z4S1 beam column system is 82.97 per cent greater than RC structural wall system, in the case of G20Z4S1 beam column system is 63.83 percentage greater than RC structural wall system and in the case of G30Z4S1 beam column system is 55.58 percentage greater than RC structural wall system.

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From story data it is observed that the difference between the story displacement values of both the systems decreasing with increasing the number of stories.

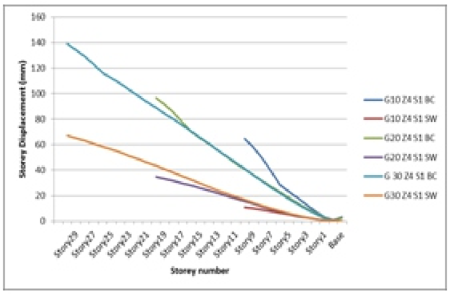

Figure 5.1: Variation of maximum storey displacements of models considered in zone IV, soil I.

Similar percentages of variation observed in zone III soil I, zone II soil I, zone IV soil II, zone III soil II, zone II soil II models. From story data it is observed that the difference between the story displacement values of both the systems decreasing with increasing the number of stories.

II. Variation of maximum storey displacements in beam column system

The variation of maximum storey displacements in beam column system for models considered in seismic zones IV, III, II is shown in figure 8.2.The maximum displacement for 30, 20, 10 storied building is compared with Zone-IV, Zone-III and Zone-II are considered with soil I and soil II types. It is found that maximum displacement is reduced by 57.86percentage in G30S2 system, 57.52percentage in G30S1 system, 56.69percentage in G20S2 System, 56.16percentage in G20S1 system, 56percentage in G10S2 system, 56.50percentage in G10S1 System for zone II when compared with zone IV. The maximum reduction in displacement of 57.86 percentage is observed in G30S2 system from zone IV to zone II.

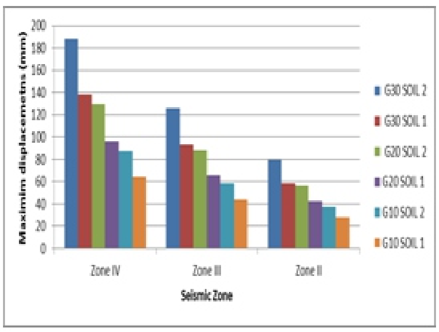

Figure 5.2: Variation of maximum storey displacements in beam column system for models considered in seismic zone IV,III ,II.

III. Variation of maximum storey displacements in shear wall system

The variation of maximum storey displacements in beam RC structural wall system for models considered in seismic zones IV, III and II is shown in figure 8.3.The maximum displacement for 30, 20, 10 storied building is compared with Zone-IV, Zone-III and Zone-II are considered with soil I and soil II types. It is found that maximum displacement is reduced by 57.73percentage in G30S2 System, 57.44percentage in G30S1 System, 57.71percentage in G20S2 System, 57.30percentage in G20S1 System,57.71 percentage in G10S2 System,57.27percentage in G10S1 System for zone II when compared with zone IV. The maximum reduction in displacement of 57.73 percentage is observed in G30S2 system from zone IV to zone II.

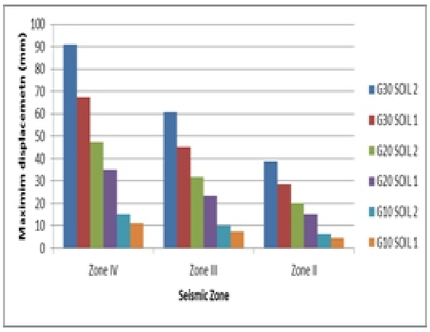

Figure 5.3: Variation of maximum storey displacements in shear wall system for models considered in seismic zone IV,III,II.

IV. Variation of storey drifts of models considered

Storey drift is relative displacement between any two levels of storey between the floor above and below the under consideration. For beam column system storey drift is greater than the RC structural wall system. As per the IS1893-2002 story drift shall not exceed 0.004 times the storey height. All storey drift are within permissible limit.

Variation of storey drifts of models considered in zone IV for soil type I is shown in figure 8.4.It is observed that at top storey G30Z4S1 beam column system is having 62.27 percentage greater storey drift than RC structural wall system, G20Z4S1 beam column system is having 67.97 percentage greater storey drift than RC structural wall system and G10Z4S1 beam column system is having 80.15 percentage greater storey drift than RC structural wall system.

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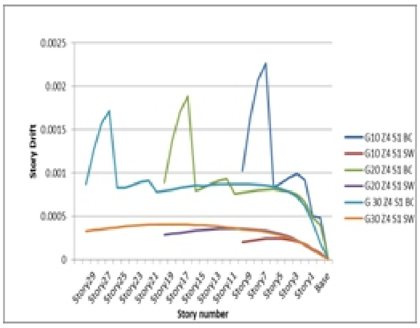

Figure 5.4: Variation of story drifts of models considered in zone IV, soil I

•Similar variation observed in zone III soil I, zone II soil I, zone IV soil II, zone III soil II, zone II soil II models.

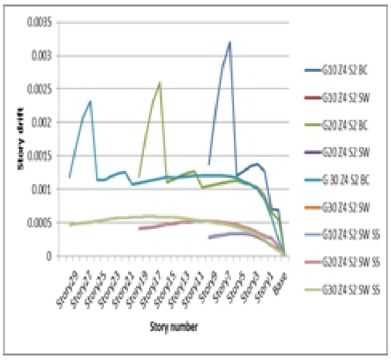

Figure 5.5: Variation of story drift of models considered in zone IV, soil II including Stilt story model.

V. Variation of storey shears of models considered

The variation of storey shears of models considered in zone IV, soil I is shown in figure 8.6. It is found that base storey shear in G30Z4S1 beam column system is 31.75 percentage greater than the RC structural wall system, in G20Z4S1 beam column system is 29.11percentage greater than the RC structural wall system and in G10Z4S1 beam column system is 22.44percentage greater than the RC structural wall system.

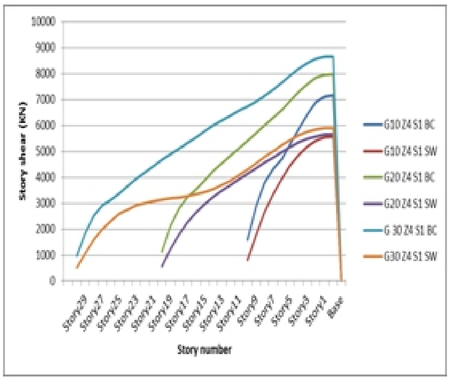

Figure 5.6: Variation of story shears of models considered in zone IV, soil I

Similar variation observed in zone III soil I, zone II soil I, zone IV soil II, zone III soil II, zone II soil II models. The percentage change in storey shear in beam column and RC structural system is almost same for different soil types (I,II) and seismic zones (II,III,IV) considered.

VI. Variation of storey base shears in beam column system for models considered

The variation of maximum storey base shears in beam column system for models considered in seismic zones IV, III, II is shown in figure8.7. The base shears for 30, 20, 10 storied building is compared with Zone-IV, Zone-III and Zone-II are considered with soil I and soil II types. It is found that the base shears is reduced by 58.33 percentage in G30S2 system, 58.33 percentage in G30S1 system, 58.33 percentage in G20S2 system, 58.33 percentage in G20S1 system, 58.33 percentage in G10S2 System, 58.33 percentage in G10S1 system for zone II when compared with zone IV. Maximum reduction in displacement of 58.33 % is observed from zone IV to zone II.

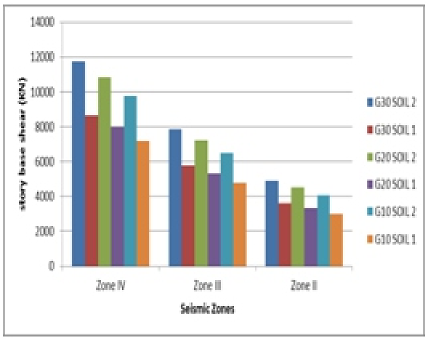

Figure 5.7: Variation of maximum storey base shears in beam column system for models considered in seismic zone I, III, II.

VII. Variation of storey base shears in RC structural wall system for models considered

The variation of maximum storey base shears in RC structural wall system for models considered in seismic zones IV, III, II is shown in figure 8.8. The base shears for 30, 20, 10 storied building is compared with Zone-IV, Zone-III and Zone-II are considered with soil I and soil II types. It is found that the base shears is reduced by 58.33 percentage in G30S2 System, 58.33 percentage in G30S1 System, 58.33

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percentage in G20S2 System, 58.33 percentage in G20S1 System, 58.33 percentage in G10S2 System and 58.33 percentage in G10S1 System for zone II when compared with zone IV. Maximum reduction in displacement of 58.33 % is observed from zone IV to zone II.

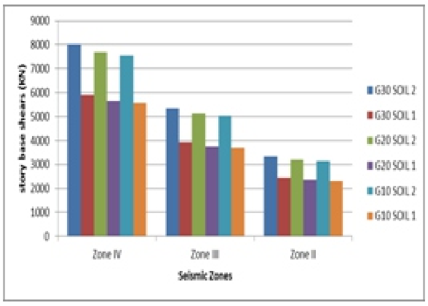

Figure 5.8: Variation of maximum storey base shears in shear wall system for models considered in seismic zone I, III, II.

VIII. Variation of Time period with mode shapes

The variation of time period with mode shapes for G30S1 models is shown in figure 8.9, from storey data it is observed that time period for beam column system is greater than RC structural wall system. The time period is reduced by 25.69% for structural wall system when compared with beam column system for mode 1 and reduced by 70.02% for structural wall system when compared with beam column system for mode 12.

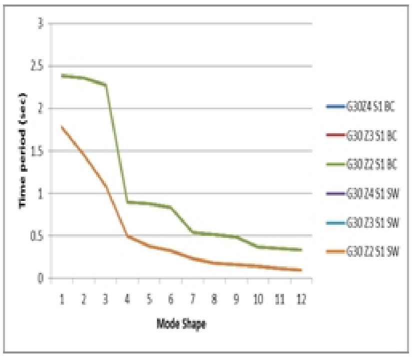

Figure 5.9: Variation of time period with mode shapes for G30S1 models.

IX. Variation of natural frequency with mode shapes

The variation of natural frequency with mode shapes for G30S1 models is shown in figure8.11. . It is seen that natural frequency for RC structural wall system is greater than the beam column system.

The natural frequency is increases by 25.70% for structural wall system when compared with beam column system for mode 1 and increased by 69.88% for structural wall system when compared with beam column system for mode 12. Mode 12 gives maximum natural frequency (HZ).

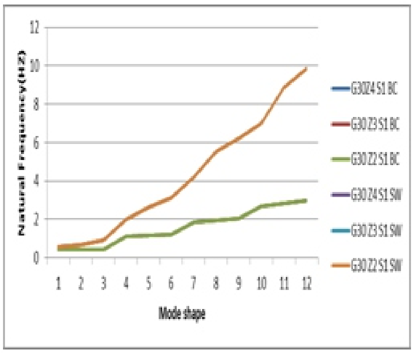

Figure 5.11: Variation of natural frequency with mode shapes for G30S1 models.

6.Conclusion

The overall thirty nine building models are analysed. Finite element software ETABS is used to carry out the Response spectrum method of analysis. On the basis of the results of the analytical investigation carried out on the building models the following conclusions are drawn.

1.The percentage change in maximum storey displacements in beam column system and RC structural wall system is almost same for different soil types (I, II) and different seismic zones (II, III, IV) considered.

2.The percentage increase of maximum story displacements in beam column system comparing with RC structural wall system is reducing by increasing the number of stories.

3.Average decrease in maximum storey displacements in beam column system from seismic zone IV to zone II for the models considered is 56.78%.

4.Average decrease in maximum storey displacements in shear wall system from seismic zone IV to zone II for the models considered is 57.53%.

5.The percentage change in storey shear in beam column and RC structural system is almost same for different soil types (I,II) and seismic zones (II,III,IV) considered.

6.The percentage increase in storey base shears in beam column system comparing with RC structural wall system is reducing by decreasing the number of stories.

7.Average decrease in story base shears in beam column system & RC structural wall system from seismic zone IV to zone II is 58.33%.

8.Difference in both systems time period for different modes is decreasing by reducing number of stories.

9. Difference in both systems natural frequency for different modes is increasing by decreasing the number of stories.

10.RC structural wall System has high structural performance to worst loading than conventional beam column system.

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