Comparison of Storey Drift, Storey Displacement & Base Shear for Different Structural Systems

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Abstract - **In the current age, with the development of skyscraper buildings, earthquake engineering has a vital role to play in designing. In skyscraper structural design, lateral load ((i.e. wind or earthquake loads) are mainly responsible for storey drift & base shear. Shear wall & bracing system are provided as a structural element used to resist lateral forces parallel to the plane of the wall. Shear wall & bracing have highly in plane stiffness and strength which can be used to simultaneously resist the base shear and storey displacement. The main objectives of this study are to compute the; a) Storey drift & storey displacement for different models. b) Lateral load & base shear for different models. In this research analysis of G+9 & G+19 RC-frame with and without shear wall & bracing structures are taken into considerations using the STADD Pro. The various parameters are taken as storey drift, storey displacement & base shear.**

keywords - **Skyscraper, Shear Wall, Bracing, Storey Drift, Storey Displacement, Base shear**

I. Introduction

In general, as the height of a structure increases, with simultaneously lateral load (such as wind and earthquake) increases. When these type of response becomes sufficiently great that the effect of lateral load must be explicitly taken into consideration in designing, a skyscraper structure. The lateral load effects on skyscraper buildings can be resisted by using Shear walls & bracing system. Shear wall is a structural system composed of shear panels to counter the effects of lateral load acting on the structure. Depending upon the zone wind and seismic loads are the most common loads for which the shear walls are designed. The basic function of shear wall is to increase the rigidity for lateral load resistance along with providing adequate stiffness and strength to the structure. A braced frame is a structural system designed primarily to oppose the wind and earthquake forces. In braced frames, members are designed to work in tension and compression, just like truss. The braced frames are generally always made up of steel members. When Shear wall and bracing system are used in skyscraper structure then increases the stiffness of structure and reducing to storey drift, storey displacement & thus minimizing the probability of collapse.

Storey drift is the difference of displacements between two consecutive storey's divided by the height of that story. And Story displacement is the absolute value of displacement of the storey under action of the lateral forces. The importance of story drift is in design of partitions/ curtain walls.

II. Methodology

In this study a building having regular plan is considered for analysis as shown in fig. All storeys including ground storey having 3.5 m floor to floor height is considered for the analysis. Area of plan of building is 480 m2. Structures are having 5-bay in X-direction and each bay is having a length of 6 m and in Z-direction number of bays are 3 with different length two bays are having length of 6 m and middle bay is having a length of 4 m. Three types of columns are considered in this study. Some columns are rectangular and some columns are square as per structure requirement. Two types of beams having different cross sections are used. Sizes of beams are 230 mm × 450 mm and 300 mm × 450 mm. Slabs with a thickness of 200 mm are used. A floor finishing of 50 mm is provided. Supports of the structure are made fix at the bottom. Three types of walls are used – main wall, partition wall and parapet wall. The thickness of wall varies as main wall is having a thickness of 230 mm, partition wall and parapet walls are half of the main wall thickness. Height of main wall and partition wall is same as the height of storeys. Parapet wall is considered with a height of 1m. Shear walls are provided in some models and the thickness of shear wall is taken 230 mm. In some other models cross bracings are provided these bracings are having steel-I section ISMB-100. Building is located in two types of earthquake-zones (Zone-III and in zone-V). Soil condition are considered medium stiff and a damping ratio of 5% and importance factor is taken1. Dead loads and live loads are applied accordingly. Earthquake loads are applied as per IS 1893 (Part -1) 2016.

In this study use G+9 & G+19 skyscraper structure are analysed with or without shear wall and bracing system using with the STAAD Pro. Also, compare the storey drift, storey displacement & base shear among 12 models in zone-3 & zone-5.

A. Building Model Detailing

Size of Plan	:	30 m x 16 m
No of bays in X-direction	:	5

Length of each bay in X-direction	:	6 m
No of bays in Z-direction	:	3
Length of bays in Z-direction	:	6m, 4m, 6m
Height of each storey	:	3.5 m
Height of Parapet wall	:	1 m

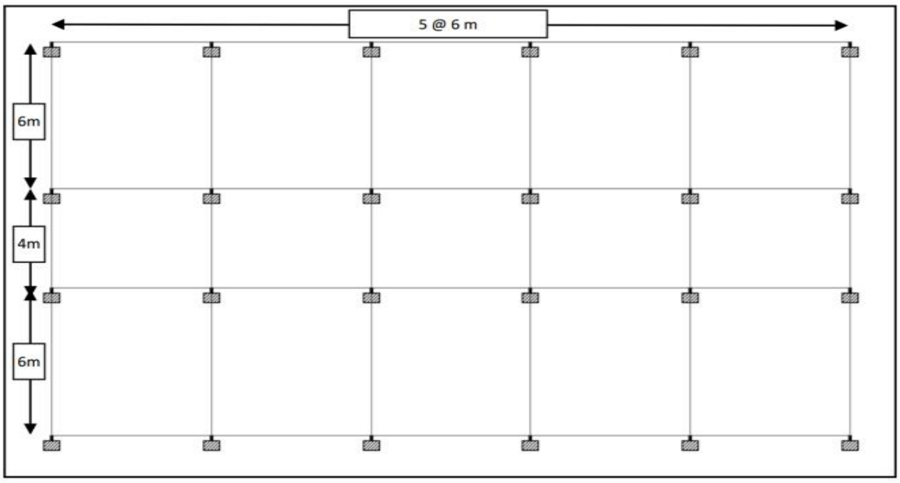


Fig 2.1: Plan of Model

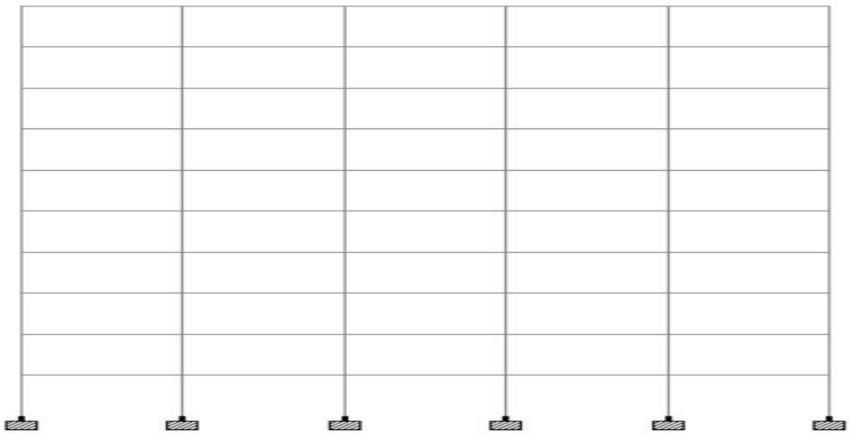


Fig 2.2: Elevation of Model

TABLE 2.1: COLUMN SIZE FOR G+9 (10 STOREY)

Type	Size (mm)
Outer corner column	450 mm x 450 mm
Outer mid column	450 mm x 600 mm
Inner mid column	600 mm x 450 mm

TABLE 2.2: COLUMN SIZE FOR G+19 (20 STOREY)

Type	Size (mm)
Outer corner column	600 mm x 600 mm
Outer mid column	600 mm x 750 mm
Inner mid column	750 x 600 mm

TABLE 2.3: THICKNESS OF VARIOUS TYPES OF SYSTEM

Property	Thickness (mm)
Main wall	230
Partition wall	115
Parapet wall	115
Slab	200

Floor	50
Shear wall	230

B. Other Parameter of Building:

Soil type : Medium, stiff
Damping ratio : 5%
Importance factor : 1
Building Type : SMRF
Zone type : III & V
Unit weight of RCC : 25 kN/m^3
Unit weight of brick : 19 kN/m^3

C. Materials Used

This structure is made of concrete grade M-30 with steel reinforcement of Fe-500. Bracings which are used in model are made of steel.

D. Models Considered for Analysis

In this particular study we have considered 12 types of different model. In this study, firstly it has been analyzed and design for 10-Storey building with RC-frame, Bracing and Shear wall in zone-3 and zone-5 respectively. Secondly, it has been analyze and design for 20 storey buildings in same manner.

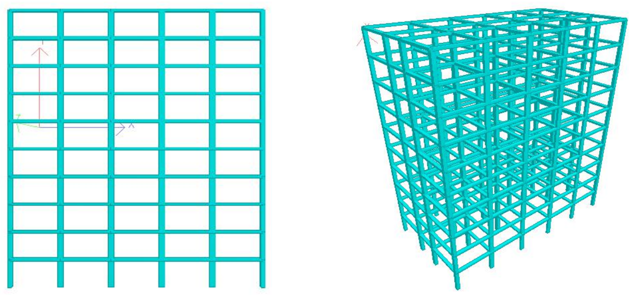


Fig. 2.3 Elevation & Isometric View of 10-Storey RC-Frame

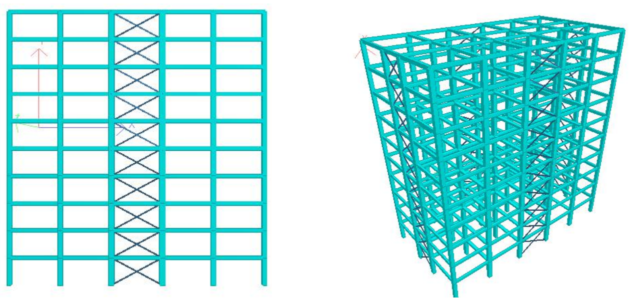


Fig. 2.4 Elevation & Isometric View of 10-Storey with Braced Frame

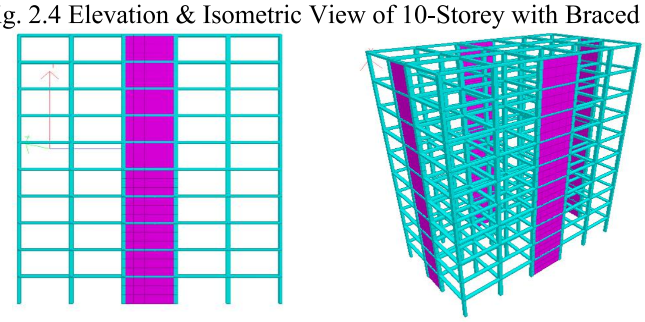


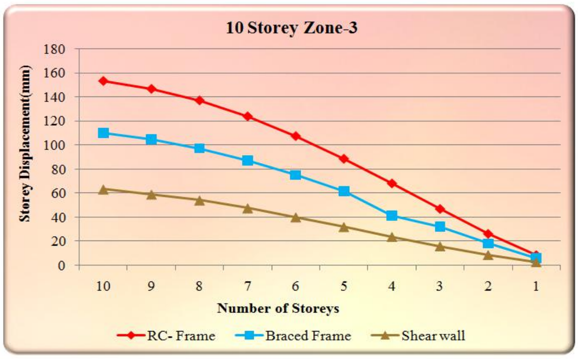
Fig. 2.5 Elevation & Isometric View of 10-Storey with Shear Wall

Similar models are considered for 20 storey buildings & all 12 models show different variation in storey drift, displacement & base shear in zone-3 & zone-5 respectively.

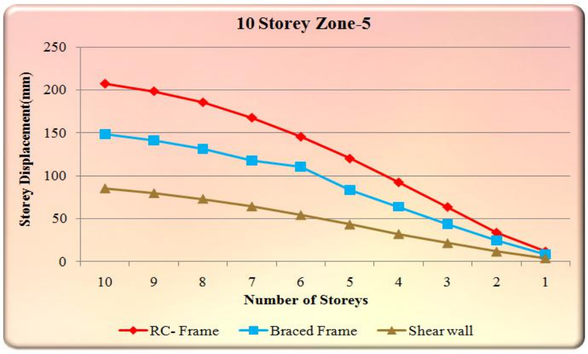
III. Results & Discussions

In this analysis is done for different 12 models, with different heights, in different earthquake zones and with different types of arrangements. Main focus of this study is to control the storey drift and storey displacement & base shear in high rise buildings and make them safe against lateral forces.

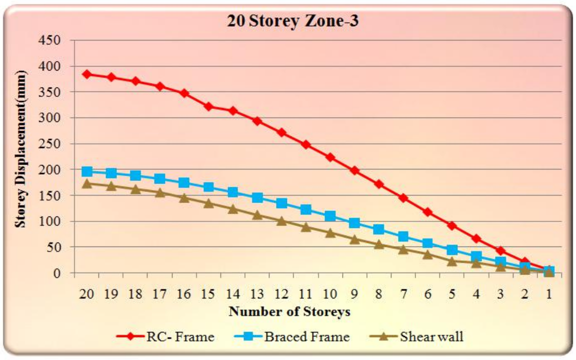
A. Storey displacement Comparison among different models:-



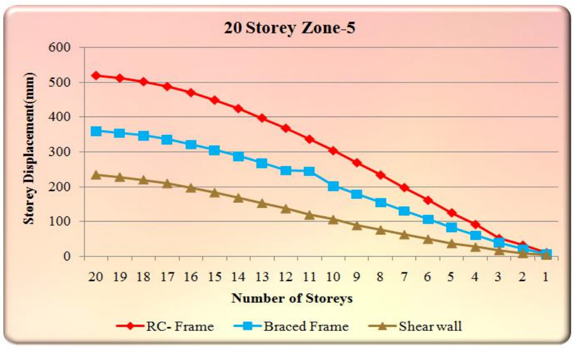
Graph 3.1: Storey Displacement Comparisons with RC-Frame (zone-3)



Graph 3.2: Storey Displacement Comparisons with RC-Frame (zone-5)



Graph 3.3: Storey Displacement Comparisons with RC-Frame (zone-3)



Graph 3.4: Storey Displacement Comparisons with RC-Frame (zone-5)

As shown in the following graph when bracings and shear walls are used at the place of simple framed structure then storey displacement get reduced. It can be seen from the following graphs storey displacements are more reduces in case of shear wall as compare to other frame structure.

B. Storey drift Comparison among different models:-

From the following tables, Storey drift reduces at each floor in braced frame & shear wall structure in zone 3 as well as in zone 5.Finally, it is concluded that the result are highly effective in 20 Storey buildings in zone-5 respectively when shear wall & Bracing structures are used.

TABLE 3.1: STOREY DRIFT IN DIFFERENT MODELS FOR 10 STOREY (ZONE-3)

Storey No.	Height of each Storey (h) (m)	Storey Drift at Different Floor Level (mm)		
		RC-Frame	Braced Frame	Shear Wall
10th	3.5	1.026	1.558	1.230
9th	3.5	2.748	2.154	1.394
8th	3.5	3.792	2.867	1.855
7th	3.5	4.699	3.350	2.162
6th	3.5	5.397	3.867	2.312
5th	3.5	5.870	5.843	2.336
4th	3.5	6.085	2.511	2.269
3rd	3.5	6.787	4.089	2.061
2nd	3.5	5.056	3.488	1.699
1st	3.5	0.000	0.000	0.000

TABLE 3.2: STOREY DRIFT IN DIFFERENT MODELS FOR 10 STOREY (ZONE-5)

Storey No.	Height of each Storey (h) (m)	Storey Drift at Different Floor Level (mm)		
		RC-Frame	Braced Frame	Shear Wall
10th	3.5	2.511	2.067	1.598
9th	3.5	3.710	2.909	1.903
8th	3.5	5.122	3.871	2.507
7th	3.5	6.343	2.085	2.918
6th	3.5	7.286	7.792	3.121
5th	3.5	7.924	5.573	3.154
4th	3.5	8.215	5.704	3.048
3rd	3.5	8.576	5.521	2.826
2nd	3.5	6.249	4.701	2.260
1st	3.5	0.000	0.000	0.000

TABLE 3.3: STOREY DRIFT IN DIFFERENT MODELS FOR 20 STOREY (ZONE-3)

Storey No.	Height of each Storey (h) (m)	Storey Drift at Different Floor Level (mm)		
		RC-Frame	Braced Frame	Shear Wall
20th	3.5	1.598	0.917	1.396
19th	3.5	2.142	1.263	1.717
18th	3.5	2.959	1.713	1.922
17th	3.5	3.767	2.131	2.960
16th	3.5	7.362	2.492	2.946
15th	3.5	2.307	2.797	3.149
14th	3.5	5.738	3.049	3.272
13th	3.5	6.243	3.255	3.329
12th	3.5	6.663	3.419	3.330
11th	3.5	7.013	3.545	3.285
10th	3.5	7.295	3.640	3.606
9th	3.5	7.511	3.715	2.678
8th	3.5	7.656	3.732	2.921
7th	3.5	7.720	3.751	2.779
6th	3.5	7.600	3.687	3.822
5th	3.5	7.094	3.445	0.923
4th	3.5	6.698	3.265	2.002
3rd	3.5	5.969	2.925	1.736
2nd	3.5	4.585	2.259	1.400

1st	3.5	0.000	0.966	0.000

TABLE 3.4: STOREY DRIFT IN DIFFERENT MODELS FOR 20 STOREY (ZONE-5)

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3rd	3.5	5.969	2.925	1.736
2nd	3.5	4.585	2.259	1.400
1st	3.5	0.000	0.966	0.000

C. Base Shear comparison with RC-frame

As shown in the following tables when bracings and shear walls are used at the place of simple framed structure then Base shear get reduced in case of braced-Frame and in case of shear wall it's approximately same as well as RC-frame

It can be seen from the following results that when think about 20-Storey Braced framed structure then base shear more reduced as compare to 10 Storey's in zone-3 and zone-5.

Hence it can say that braced frame Structure's are more effective for base shear reduction in high rise buildings and critical earthquake zones.

TABLE 3.5: BASE SHEAR COMPARISON WITH RC-FRAME IN ZONE-3

No. of Storey	RC- Frame (kN)	Bracing (kN)	Shear Wall (kN)
10 Storey	2433.538	2374.695	2451.840
20 Storey	3061.509	2166.901	3077.158

TABLE 3.6: BASE SHEAR COMPARISON WITH RC-FRAME IN ZONE-5

No. of Storey	RC- Frame (kN)	Bracing (kN)	Shear Wall (kN)
10 Storey	3285.277	3205.839	3369.001
20 Storey	4133.031	3078.523	4154.154

IV. CONCLUSION

After analyzing and comparing we have observed that:

- Storey displacements are more reduces in case of shear wall as compare to bracing and RC-frame structure.
- Storey drift reduces at each floor in braced frame & shear wall structure in zone 3 as well as in zone 5.Finally, it is concluded that the result are highly effective in 20 Storey buildings in zone-5 respectively when shear wall & Bracing structures are used.
- From the Base shear point of view, it is analyzed that base shear reduction is more in braced frame structure as compare to RC-frame and Shear wall in zone-3 & zone-5.
- Hence it is finally concluded from all the above results that, shear wall and bracing system in the structure is more resilient in the event of the earthquake. From deflection point of view in high rise building shear wall structure is more suitable.

V. ACKNOWLEDGMENT

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