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Seismic Analysis of Moment Resisting Frame Building with Steel Shear Walls and with Bracing System

Vivek Singh[1] and Anjali Rai[2]

[1]*Student (M. Tech Structural Engineering) Civil Engineering Department, Institute of Engineering and Technology, Lucknow*
[2]*Assistant Professor, Civil Engineering Department, Institute of Engineering and Technology, Lucknow*

Abstract—*The structures in seismic areas are generally susceptible to the severe damage. Along with the gravity loads structures has to withstand the lateral loads too which has the tendency to develop high stresses. Generally shear walls and bracings are installed in the structure to enhance their lateral stiffness and ductility and minimize its lateral displacements to provide safety to the structures. The critical issues in seismic design are mainly story drifts and lateral displacements. Four different types of frame building models are developed and evaluated with the help of ETABS. In present work G+21 multi story moment resisting frame building models are considered using steel shear walls and two types of bracings. The plan considered for all models is 20mX20m and method use for analysis is response spectrum analysis method. All members were designed as per IS456:2000, IS800:2007 and load combination for seismic force were considered as per IS1893 (part-1):2016. Comparison between all four models was performed on the basis of following parameters i.e. Displacement, Stiffness and Natural time period. The result is expressed in the form of graphs, and figures and comparison is done as per IS1893 (part-1):2016. The main focus of this study is to find the optimised model.*

Keywords: *Seismic analysis, displacement, stiffness, Steel shears wall, inverted V- bracing, ETABS, Lateral loads.*

1. INTRODUCTION

In present scenario, the population and industrialization are increasing at a very rapid rate with the passage of time. The engineers are approaching to work on the vertical development in the field of construction of mainly high-rise and skyscraper buildings. But it's not easy to increase the height of building. For the buildings, there are many parameters play important roles in which some of them is lateral loads (i.e. wind and seismic loads). The task of the structural designer is to design such types of buildings having greater stability over whole the span. The steel building altogether accounts as long as tall buildings because of its greater strength to weight ratio, easy in installation and transportation. Usually steel buildings are considered for tall buildings because of its high strength-weight ratio and availability of wider sections. Different structural systems are also available for resisting lateral loads of high-rise buildings such as rigid frame, shear wall frame, braced frame, outrigger and tubular systems. In this study two types of frame systems were used.

Steel Shear Wall Framed System: These type of system is used in both reinforced concrete as well as composite buildings. The steel shear walls can be considered as vertical cantilever beams that can resist lateral wind and seismic loads on the buildings. Within structures shear walls can be used to shape elevator ducts and service corps and also provides extreme stability.

Braced Framed System: These structures are generally used in steel buildings. The braced frame method makes the construction of the rigid frame structures more efficient by reducing the column and girders bending by using more bracings. While on the other hand it is the inexpensive and effective mechanism of horizontal load resistance which functions as a vertical truss made up of columns and girders to carry gravity load.

2. OBJECTIVE OF WORK

a) To study the behaviour of Moment resisting frames structure under the effect of gravity and seismic loads.
b) To study the performance of different arrangements of bracing, steel shear wall, without steel shear wall and without bracing in multi story steel frame building.
c) To compare the different parameters of seismic analysis like natural time period, stiffness, displacement of moment resisting frame

building with different types of bracing i.e. (V, Inverted V), without bracing, without steel shear wall and with steel shear wall.

d) To find the optimized model from the analysed result.

3. DESCRIPTION OF BUILDING

Building type- Residential building

Plan area- 20mx20m
Number of story- G+21

Total height of building- 63m

Height of each story- 3m

No of bays in x & y direction- 6No@4m

Steel section used for beam-ISMB250

Steel section used in secondary beam-ISMB200

Steel section used for column-ISMB600

Steel section used for brace-ISMB300

Concrete grade used for core- M30

Concrete grade used in deck slab-150mm

Grade of steel- Fe250

Dead load as per IS-875(PART-1)

Live load 4KN/m^2 as per IS-875(PART-2) Shear wall thickness-6mm

SEISMIC DATA:

Seismic zone-III

Zone factor (Z) =0.16(table 3 clause 6.4.2)

Importance factor (I) =1.2 (table 8, clause 7.2.3)

Response reduction factor I=5 (SMRF) (table9, clause 7.2.6)

Soil type-II (medium soil)

Density of steel- 7850 kg/m^3

Young's modules (E)- 2.1X10^5 N/mm^2

Shear modules-80000 N/mm^2

Poisson's ratio- 0.3

4. MODELLING

MODEL-1 WITHOUT BRACING AND WITHOUT STEEL SHEAR WALL

MODEL-2 V- BRACING (CORE)

MODEL-3 INVERTED V- BRACING (CORE)

MODEL-4 STEEL SHEAR WALL (CORE)

Modelling is done with the help of ETAB'S 2017 software.

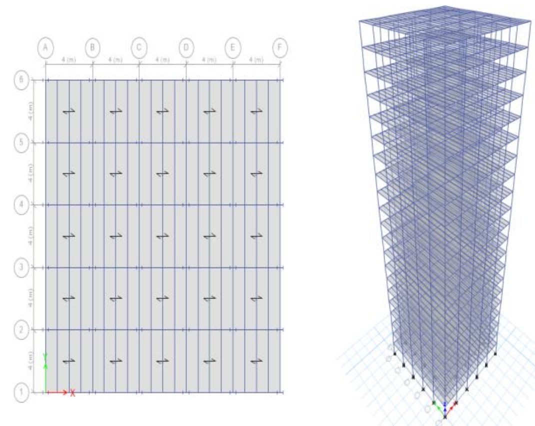


Fig. 1: Plan and 3D view of Model 1

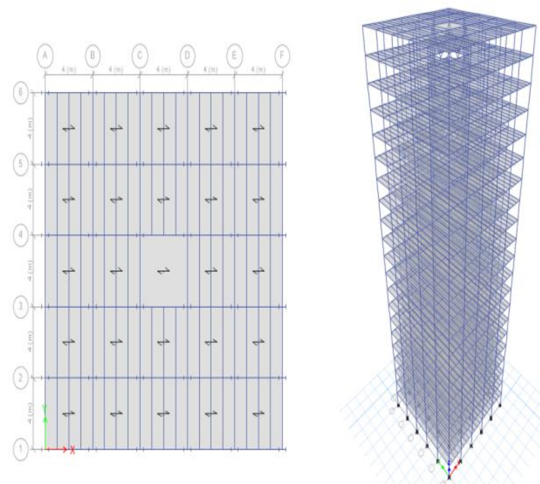


Fig. 2: Plan and 3D view of Model 2

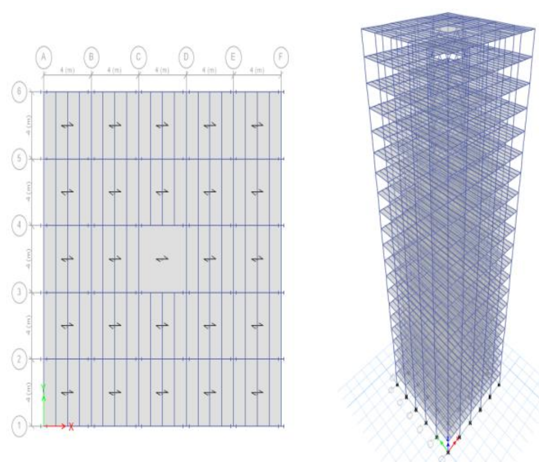


Fig. 3: Plan and 3D view of Model 3

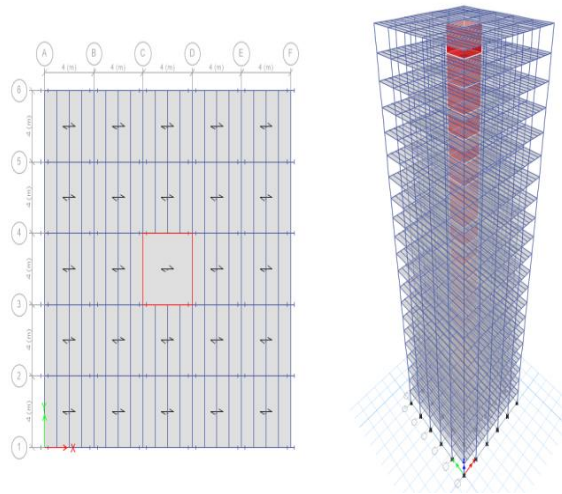
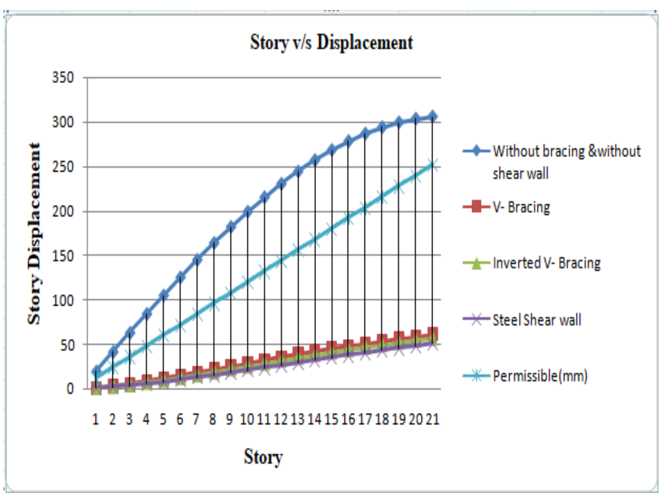


Fig. 4: Plan and 3D view of Model 4

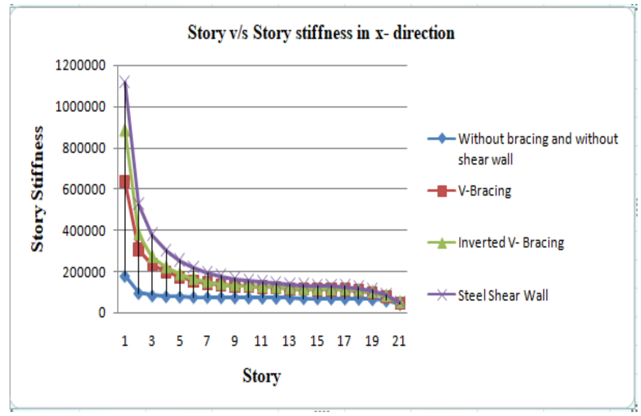
5. ANALYSIS AND RESULT

Story Displacement: The total displacement of the floor with respect to the ground due to the lateral forces acting on the building is termed as lateral displacement. The story displacement is the displacement of the particular story with respect to the ground. The displacement as per **IS 1893 (Part I):2016** is limited to H/250.

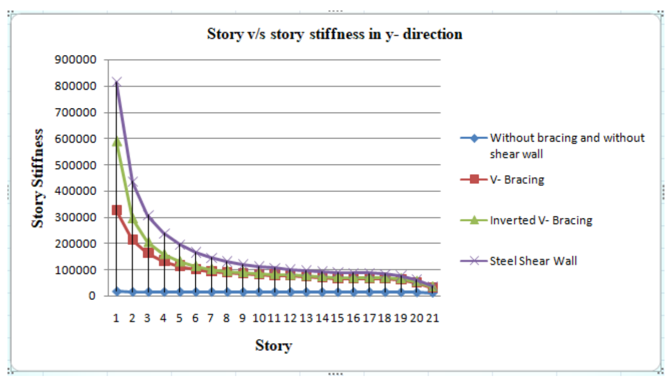


From the above graph, we can see that in all the models the displacement value is under permissible limit but model-4(steel shear wall) have the minimum value than other three models so model-4 (steel shear wall) is much efficient then other model. Hence we conclude that story displacement model-1(without bracing and without steel shear wall) 5.1172 times more than model-2(V bracing), 5.7975 times more than model-3(Inverted V bracing), and 7.02739 times more than model-4(steel shear wall).

Story Stiffness: The term story stiffness is defined as capability of resisting force/load acting on any story. It is depending on material property, if the story is stiffer it means lessflexible. Stiffness in x direction and stiffness in y direction were analysed which are as follows:



From the above graph, we can see that steel shear wall model having maximum Story stiffness value then other three models. We can say that steel shear wall model is more efficient in X-dir. from all three models. Hence we conclude that story stiffness in model-1(without bracing and without steel shear wall) is 0.717196 times less than model-2(V bracing), 0.797978 times less than model-3(Inverted V bracing), 0.839721 times less than model-4(steel shear wall).

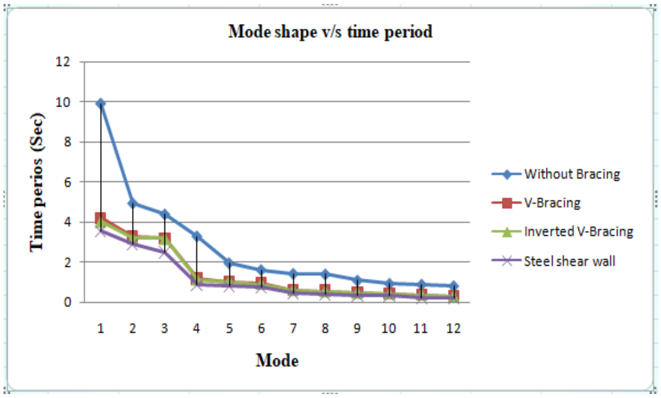


From the above graph we can find that model-4 have the maximum stiffness value in both the direction X&Y. We can say that steel shear wall model is more efficient in Y-dir. from all three models. Hence we conclude that story stiffness in y-direction for model-1(without bracing and without steel shear wall) is 0.945362 times less than model-2(V bracing), 0.96988 times less than model-3(Inverted V bracing),and 0.97826 times less than model-4(steel shear wall).

Time period: The natural period T_n of a building is the time during which it completes one complete cycle of fluctuations. This is an integral property of a building, which is determined by its mass (m) rigidity (k).

$$T_n = 2\pi\sqrt{m/k}$$

Its unit is second. Buildings that are heavy and flexible have more natural period than light and stiff buildings.



From the above graph, we can see that steel shear wall structure having less time period value then V-Bracing and Inverted-V bracing, at all faces and maximum value of time period can been seen in model-1(without bracing and without steel shear wall). We can say that steel shear wall structure is more efficient in all four models. Hence we conclude that model-1(without bracing and without steel shear wall) has natural time period 1.3523 times more than model-2 (V bracing), 1.458 times more than model-3 (Inverted V bracing), 1.7829 time more than model-4 (steel shear wall).

6. CONCLUSIONS

From the above analysis and result we can conclude the following:

i. Story Displacement of model-1 has maximum displacement and model-4(steel shear wall) has minimum displacement value then the other three models because moment of inertia is more so flexural rigidity is also more, when flexural rigidity is more than there will be less deformation or less displacement.model-1 has minimum lateral stiffness while model-4 has maximum stiffness.

ii. So it can be concluded that the steel shear wall model is most efficient model and story displacement of steel shear wall is 12.457% of model-1.

iii. Story Stiffness of model-1 has minimum stiffness and model-2 and model-3 shows the stiffness in the increasing order.

iv. Steel shear wall has maximum stiffness value because more is the stiffness, less is the deformation it means when there is the minimum displacement or deformation the stiffness will have maximum value.

v. So we can conclude that steel shear wall is most efficient model.

vi. Natural time period is maximum in first mode, and time period decrease as the mode move further i.e. second mode third mode and so on respectively.

vii. Model-1 shows maximum time period and steel shear wall model shows minimum time period and model-2 and model-3 shows respectively in decreasing order. It can be concluded that model-1 have minimum stiffness where as steel shear wall shows maximum stiffness.

viii. Hence we can say that steel shear wall is more efficient model and natural time period of steel shear wall model is 35.933% of without bracing and without steel shear wall.

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