Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 7, Issue 2; April-June 2020, pp. 170-173

http://www.krishisanskriti.org/Publication.html

SEISMIC ANALYSIS OF STEEL FRAME BUILDING WITH STEEL SHEAR WALLS AND BRACING SYSTEM

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Abstract—*Earthquake is a natural calamity which produces strong ground motions and affects the structures. 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 steel frame building is considered using steel shear wall and bracing. 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 were performed using different parameters i.e. Natural time period, Drift and base shear were analysed .The result were expressed in form of graph, table and figures while comparison was done with the limitation as per IS1893(part-1):2016. The main focus of this study is to find the optimised model.*

Keywords: *Steel shear wall, V- bracing, ETABS, lateral loads*

1. INTRODUCTION

In developing cities, the main problems are population growth, due to the large number of buildings, there is not enough space to accommodate the growing population. High-rise buildings address this problem as one of the solutions for megacities in developing countries. In addition, high-rise buildings add aesthetics to cities, they are a sign of modern development. Relatively low-rise buildings (approximately 8–20 story) are more common worldwide than high-rise buildings (usually more than 30 story).

The structural behaviour of two buildings can be learned, including their seismic parameters. High-rise buildings exhibit much more complex dynamic properties that require careful study and full understanding before they can become self-sufficient. Parameters have been analysed Moment frames are rectangular assemblies of column & beams, the beams are rigidly connected to the columns. Resistance to lateral forces is provided mainly by the action of a rigid frame, i.e., by the development of a bending force at the moment of bending in the joints of the frame elements. Due to rigid beam-column connections, the frame cannot momentarily move sideways without bending the beams or columns, depending on the geometry of the connection.

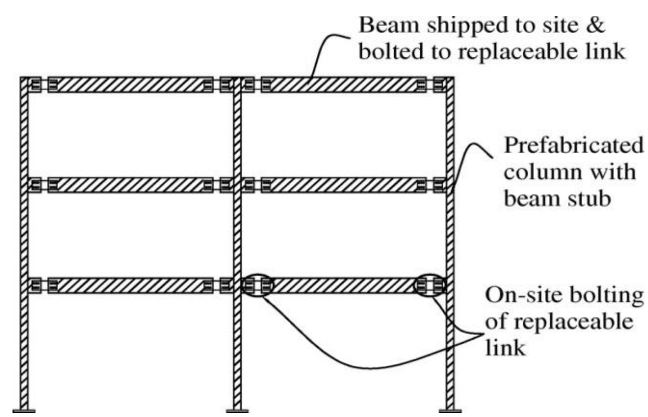


Fig.1 Performance of Steel Moment Resisting Frame

Shear wall:

During construction, a rigid vertical layer capable of transferring shear forces from external walls, floors, and roofs to the ground in a direction parallel to their planes**.** There are various types of shear walls follows as

- Reinforced Concrete Shear Wall.
- Concrete Block Shear Wall.
- Steel Shear Wall.
- Plywood Shear Wall.
- Mid-Ply Shear Wall.

Bracing:

A bracing is a method used in a building structure to withstand seismic forces. The members in a braced frame were designed to work as a truss structure of tension or compression. The bracing withstands the lateral load caused by the action of inclined rods. Links act as forces on the displayed frame; they passed through columns of beams, which look like key stressed intersections. Clamps are more effective because diagonal fasteners work with axial stress therefore, the smaller the size of the elements, the greater the stiffness strength against horizontal shear. There are two types of links: concentric link and eccentric link.

2. OBJECTIVE OF WORK

a) To study the behaviour of steel 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, base shear, story drift of steel 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- 20m*20m
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.

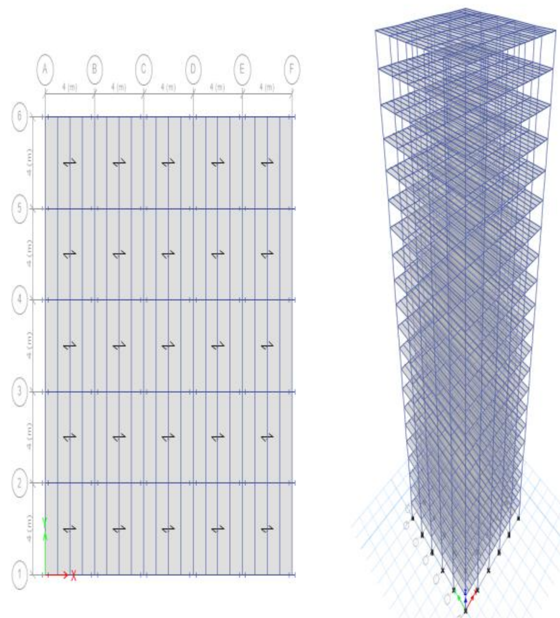


Fig. 2: Plan & 3D view of Model 1

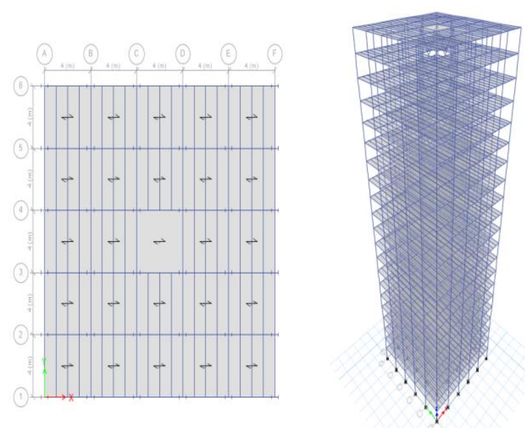


Fig. 3: Plan & 3D view of Model 2

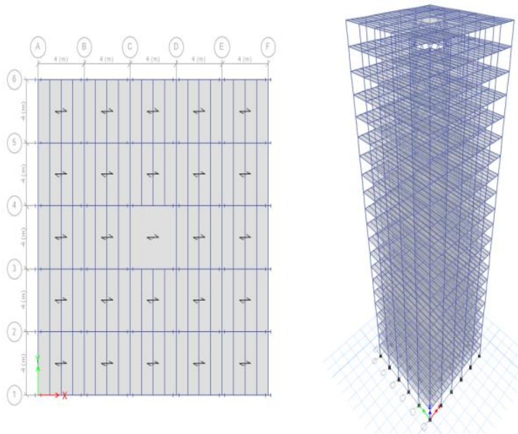


Fig. 4: Plan & 3D view of model 3

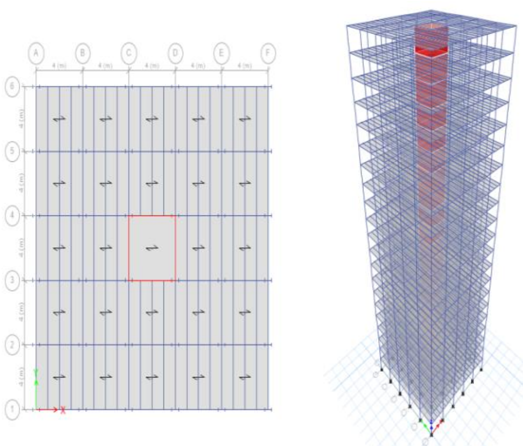


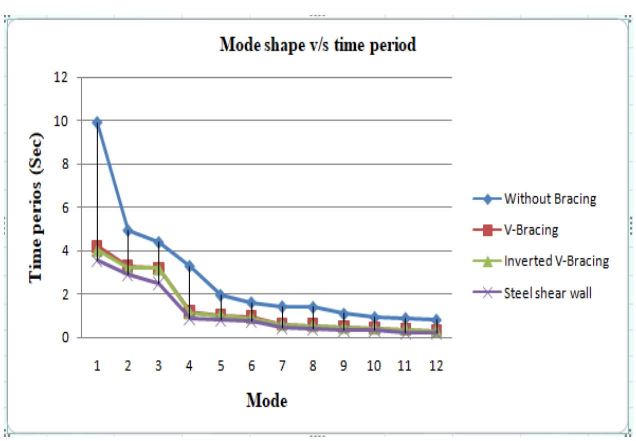
Fig. 5: Plan & 3D view of Model 4

5. ANALYSIS AND RESULTS

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).

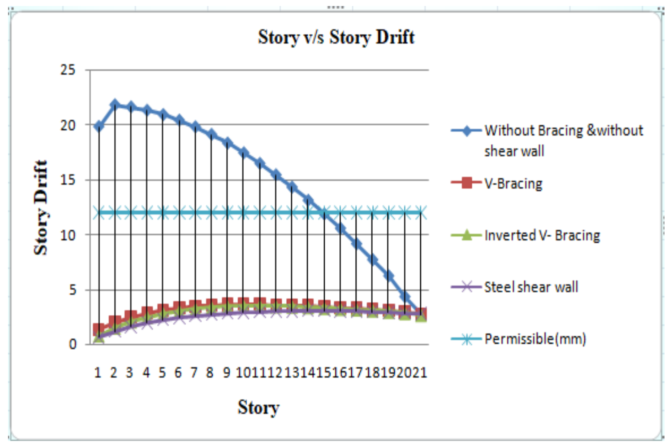
$$T_n = 2\pi\sqrt{m/k}$$

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).

Story drift: This is the displacement of one floor relative to another. The story deviation in any story due to the minimum assumed lateral force with a partial load factor of 1 must not exceed the story height 0.004 times or (h / 250).



From the above graph, we can see that in model-1(without bracing and without steel shear wall) at story-2 it have reached the maximum value of permissible so bracing and steel shear wall is preferred for safety of building. We can see that from the begging steel shear wall having less story drift value then the other 3 models at all faces .So we can say that steel shear wall is most efficient model. Hence we conclude that story drift 4.9533 times more than model-2(V bracing), 5.2736 times more than model-3(Inverted V bracing), and 6.1549 times more than model-4 (steel shear wall).

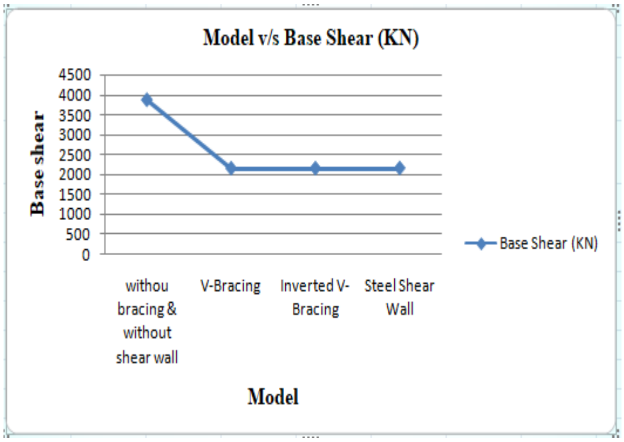
Base shear: Base Shear estimates the maximum expected shear strength of the structure due to seismic activity. It is calculated by means of seismic area, soil material, building codes according to IS 1893:2016.

Vb = Ah x W

Where, Ah= Design horizontal seismic coefficient for structure

TABLE NO-1

Model	Base Shear (KN)
Without bracing & without shear wall	3868.8548
V-Bracing	2141.1421
Inverted V-Bracing	2141.1421
Steel Shear Wall	2145.8143



From the above table and graph, we can see that Model-2(V bracing), Model-3(Inverted V bracing), Model-4(steel shear wall) weight parameter have been considered the same so the base shear value would be almost same for all three model. Model-1 has maximum value of base shear.

6. CONCLUSIONS

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

a) Natural time period of all the models have shown maximum time period in first mode, and time period decrease as the mode move further i.e. second mode third mode and so on respectively.

b) 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.

c) 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.

d) Story Drift of model-1 shows the maximum drift while model-2 and model-3 shows the value of drift in decreasing order and steel shear wall (model-4) has the minimum drift value. Story drift of steel shear wall is 13.976% of model-1.

e) It can be concluded that model-1 has minimum stiffness and model-2 , model-3 have unsupported length where as steel shear wall act as a homogeneous structure and negligible unsupported length has curve like structure due to which drift value is minimum.

f) Hence it can be concluded that steel shear wall is most suitable model in comparison to the other models.

g) Base Shear of model-1 is maximum but other three models have same base shear value this is due to weight of all three models are same

h) But on above conclusion and on basis of result in this we can say steel shear wall is efficient.

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