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Comparison Study of Shear Wall and Bracings under Seismic Loading in Multi- Storey Residential Building

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Abstract : During earthquake almost all the structures in that area will experience the seismic force. When a tall building is subjected to lateral or torsional deflections under the action of seismic loads the resulting oscillatory movement can induce a wide range of response in the building occupants. Hence lateral stiffness is a major consideration in the design of multi-storey structures. The improvement of reinforced concrete frame structure against lateral loading can be achieved by providing shear wall and cross bracing. In this study, a G+4 storey residential RC building with soft storey has to be analysed with cross bracings and shear wall. This analysis was made as per IS 1893:2002 codal provision by using ETABS software[1]. The cross bracings such as X bracing are to be provided at the outer periphery of the column and the shear walls are provided at the corners of the buildings. The building model are analysed by equivalent stiffness method using ETABS software. The main parameters compared are lateral displacement, base shear, storey drift, axial force, shear force and time period.
Keywords : Shear wall, Bracing, Lateral Stability, Seismic loading.

1.0 Introduction

Nowadays the objectives of civil engineering is to design a building's lateral resistance to wind and earthquake forces are to provide a system of shear walls, diaphragms, and interconnections to transfer lateral loads and overturning forces to the foundation, to prevent building collapse in extreme wind and seismic events and to provide adequate stiffness to the structure for service loads experienced in moderate wind and seismic events.

In frame construction, the lateral force-resisting system comprises shear walls, diaphragms, and their interconnections to form a whole-building system that may behave differently than the sum of its individual parts. In fact, shear walls and diaphragms are themselves subassemblies of many parts and connections. In part, the challenge results from the lack of any single design methodology or theory that provides reasonable predictions of complex, large-scale system behaviour in conventionally built or engineered light-frame buildings[2,3].

This article focuses on methods for evaluating the lateral resistance of individual sub-assemblies of the lateral force-resisting system (i.e., shear walls and diaphragms) and the response of the whole building to lateral loads (i.e., load distribution). The real behaviour of light-frame buildings is highly dependent on the performance of building systems, including the interactions of structural and non-structural components. For example, the non-structural components in conventional housing (i.e., sidings, interior finishes, interior partition walls, and even windows and trim) can account for more than 50 percent of a building's lateral resistance[4,5].

In this study the multi storey residential building with soft storey which is present at highly seismic area has been analysed. Generally both shear wall and bracings will provide an effective lateral stiffness. In this the performance of the shear wall and bracings are to be compared for better results between them. For this the equivalent static method of analysis has to be performed with the help of ETABS software. And the results of bare frame, shear wall and bracings are to be compared for better performance in lateral stiffness.

In construction, cross bracing is a system utilized to reinforce building structures in which diagonal supports intersect. Cross bracing can increase a building's capability to withstand seismic activity. Bracing is important earthquake resistant building because it helps keep a structure standing. Cross bracing is usually seen with two diagonal supports placed in an X shaped manner; these support compression and tension forces. Depending on the forces, one brace may be in tension while the other is slack. It helps make buildings sturdier and more likely to withstand lateral forces. Cross bracing can be applied to any rectangular frame structure, such as chairs and bookshelves. In steel construction, steel cables may be used due to their great resistance to tension (although not resistant at all to compression). The common uses for cross bracing include bridge (side) supports, along with structural foundations[6,7,8,9]. This method of construction maximizes the weight of the load a structure is able to support.Braced frames are a very common form of construction, being economic to construct and simple to analyze. Economy comes from the inexpensive, nominally pinned connections between beams and columns. Bracing, which provides stability and resists lateral loads, may be from diagonal steel members or, from a concrete 'core'. In braced construction, beams and columns are designed under vertical load only, assuming the bracing system carries all lateral loads.

Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter the effects of lateral load acting on a structure. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces[10,11,12]. Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants; create powerful twisting (torsional) forces. These forces can literally tear (shear) a building apart. Reinforcing a frame by attaching or placing a rigid wall inside it maintains the shape of the frame and prevents rotation at the joints. Shear walls are especially important in high-rise buildings subjected to lateral wind and seismic forces[13,14,15].

2.0 Methodology

The equivalent static lateral force method is a simplified technique to substitute the effect of dynamic loading of an expected earthquake by a static force distributed laterally on a structure for design purposes. The total applied seismic force V is generally evaluated in two horizontal directions parallel to the main axes of the building.

In this paper, a multi- storey residential building is designed under high seismic loading. That building is considered to be located at bhuj, which is one of the high seismic area (zone v) located in india. To improve the building's stability against lateral loading an additional structural member such as shear wall and bracings are placed in the structure and analysed. These additional elements are placed separately in two different identical models and analysed, to compare its individual performance against lateral loading. This was modelled and analysed by using ETABS software.

3.0 Specification

Type of building	**residential building with soft storey**
Plan area of the building	381sq.m
Number of storey	G+4
Height of each storey	3m
As per IS 1893:2002	
Location of the building	zone V area-Bhuj
Zone factor	0.36

Size of column	230X460 mm
Size of beam	230X350mm
As per IS 875(part III):1987	
Basic wind speed	50m/s
Structure Class	Class B
Terrain Category	3
Windward coefficient	1.2
Leeward coefficient	0.75

4.0 Result and Discussion

The base shear was obtained for both x and y direction is 4606.95kN. For this value of base shear the lateral force applied in each storey of the building was given in the figure below.

Similarly the lateral force acting because of wind was calculated with the design wind speed value of 47.8 m/s^2 and it was given in the figure below.

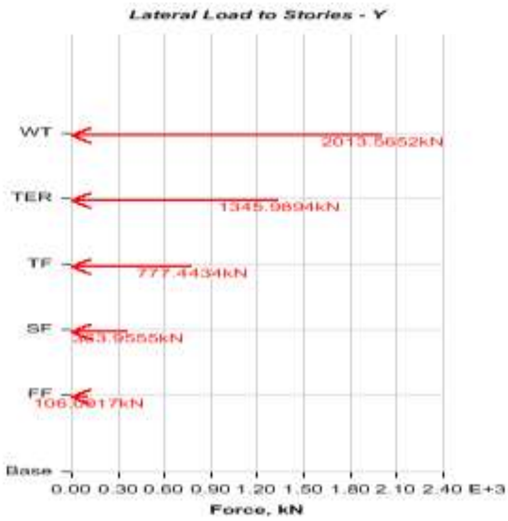

Fig1: lateral load acting on building because of seismic action

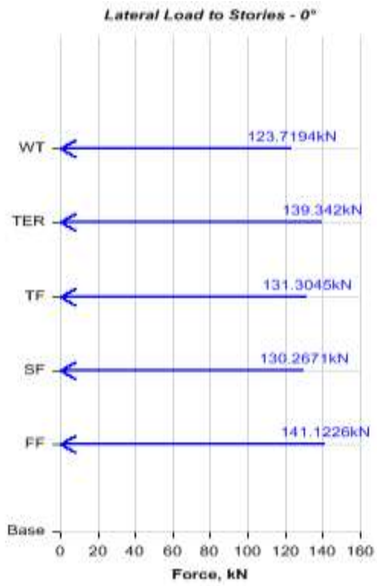

Fig2: lateral load acting on building because of wind action

By comparing both the images it is clear that the effect of seismic action is far more than that of wind. Since both provides lateral loading it is enough to consider the maximum lateral force. Therefore, the seismic action alone is considered for further works.

Table. No: 2 lateral force on the building

Height of the floor	Bare frame	Frame with shear wall	Frame with bracing
15.5m	2013.5	2114.29	2016.84
12.5m	1345.98	1464.7	1350.04
9.5m	777.44	846.03	779.78
6.5m	363.95	396.03	365.05
3.5m	106.09	116.07	106.32

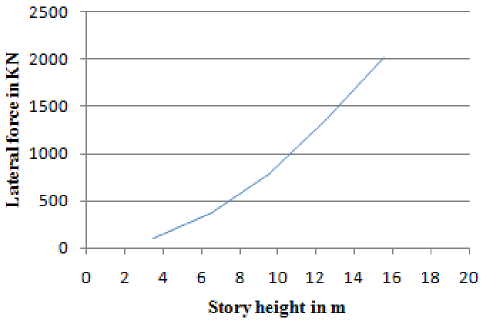

Fig 3: lateral force at bare frame

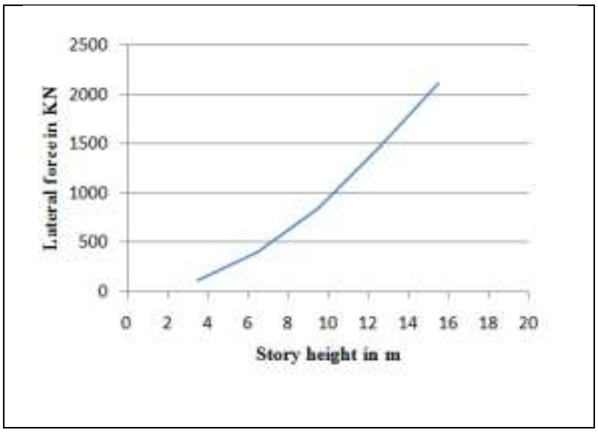

Fig 4: lateral force at shear wall frame

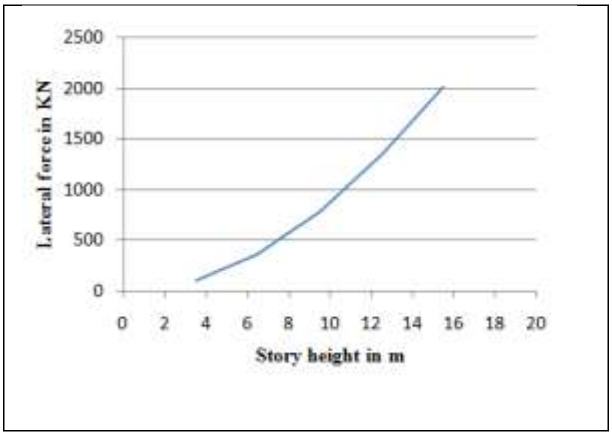

Fig 5: lateral force at bracing frame

The lateral forces of the building acting in empty frame and with shear wall and with bracing are given in the table and graph above.

Table.no:1 base shear

Type of building	Base shear (kN)
Bare frame	4606.95
Building with shear wall	4937.13
Building with bracing	4618.05

As per the above table the value of base shear has got improved of building with shear wall and bracings.

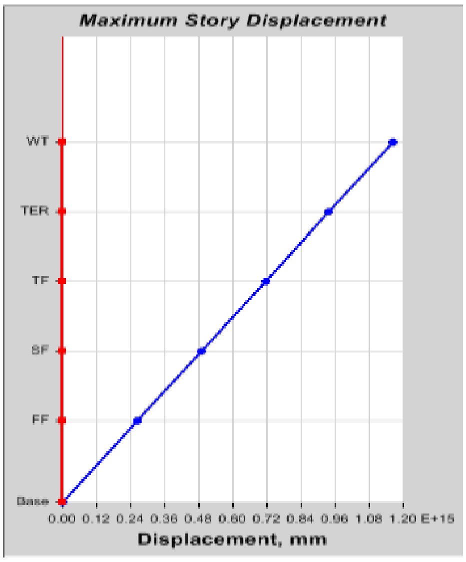

Fig 6: Maximum storey displacement of normal building

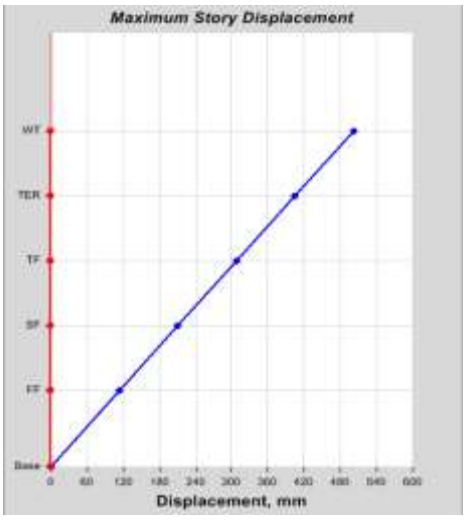

Fig 7: Maximum story displacement of building with shear wall

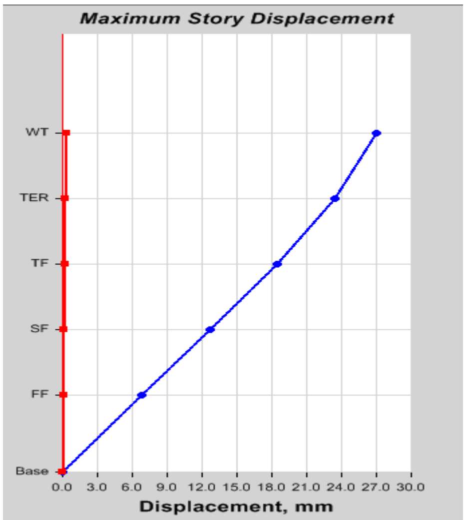

Fig8: Maximum story displacement of building with cross bracing

Table no: 3 lateral displacement on building

Type of building	Lateral displacement (cm)
Bare frame	12.8
Building with shear wall	0.9
Building with bracing	3.8

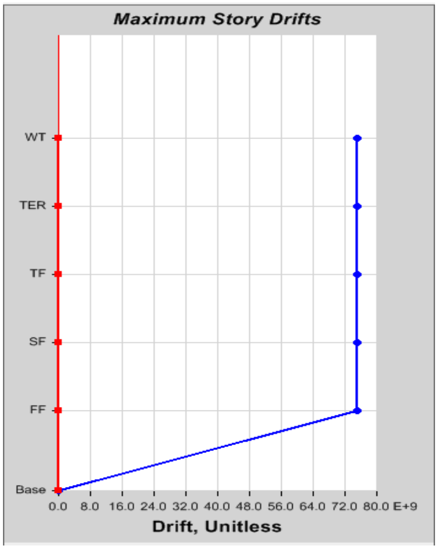

Fig9: Maximum story drift for normal building

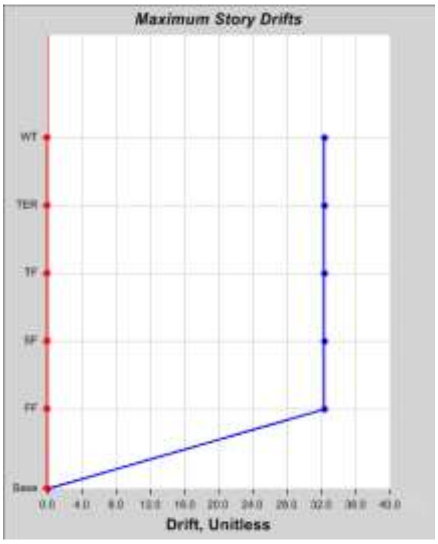

Fig10: Maximum story drift for building with shear wall

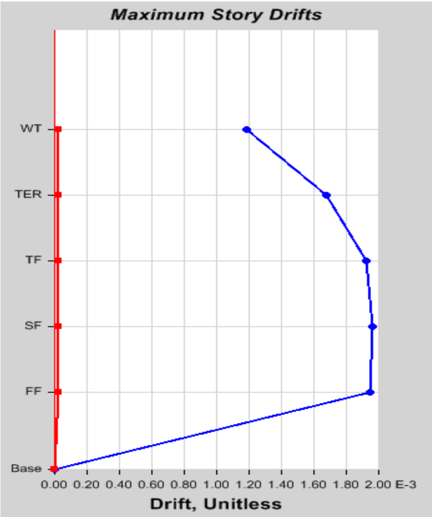

Fig11: Maximum story drift for building with cross bracings

5.0 Conclusion

The base shear of the structure heavily increases and makes the structure more stable against seismic force.

The lateral force resisting system has also been well performed while placing shear wall and bracing.

The natural time period of the structure has highly reduced after placing shear wall than the bracings, which will improve the stability against earthquake and make the structure more stable.

The structure has a minimum lateral displacement with shear wall and bracings compared with bare frame. Structure with shear wall system has a least lateral displacement.

From the above discussion it is concluded that shear wall could improve the lateral stability of the structure more than the bracings.

5.1 Future Work

In this it can be analysed by using different locations of shear wall.

Also different types of bracings such as V shape, inverted V shape and Y shape can be replaced and analysed.

6.0 References

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