COMPARATIVE ANALYSIS OF R.C. BUILDING USING STEEL BRACING AND R.C. STRUCTURAL WALL IN GROUND STOREY

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Abstract : Open first storey is a typical feature in the modern multistory constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas; this has been verified in numerous experiences of strong shaking during the past earthquakes. Though multistoried buildings with open (soft) ground floor are inherently vulnerable to collapse due to earthquake load, their construction is still widespread in the developing nations like India. Social and functional need to provide car parking space at ground level far out-weighs the warning against such buildings from engineering community. Hence we need to find out an efficient method to provide strength to soft storey in multi-storied buildings. In the proposed work, a comparative analysis was carried out with a Residential R.C. building of six storey (G + 5), located in seismic zone III, modeled with linear elastic dynamic analysis using response spectrum method. Three models of building with open ground storey, RC structural wall and steel bracing in the ground storey were modeled using the software STAAD.Pro V8i. The results were compared on the basis of displacement, shear force, bending moment, axial force and base shear.

IndexTerms - Response Spectrum Method, RC wall, bracing, STAAD.Pro V8i

I. INTRODUCTION

Due to increasing population since the past few years car parking space for residential apartments in populated cities is a matter of major concern. Hence the trend has been to utilize the ground storey of the building itself for parking. These types of buildings having no infill masonry walls in ground storey, but infilled in all upper storeys, are called Open Ground Storey (OGS) buildings. From the past earthquakes it was evident that the major type of failure that occurred in OGS buildings included snapping of lateral ties, crushing of core concrete, buckling of longitudinal reinforcement bars etc. The OGS framed building behaves differently as compared to a bare framed building (without any infill) or a fully infilled framed building under lateral load. A bare frame is much less stiff than a fully infilled frame; it resists the applied lateral load through frame action and shows well-distributed plastic hinges at failure. When this frame is fully infilled, truss action is introduced. A fully infilled frame shows less inter-storey drift, although it attracts higher base shear (due to increased stiffness). A fully infilled frame yields less force in the frame elements and dissipates greater energy through infill walls. The strength and stiffness of infill walls in infilled frame buildings are ignored in the structural modeling in conventional design practice. The design in such cases will generally be conservative in the case of fully infilled framed building. But things will be different for an OGS framed building. OGS building is slightly stiffer than the bare frame, has larger drift (especially in the ground storey), and fails due to soft storey-mechanism at the ground floor. Therefore, we need to find out an efficient method to provide strength to OGS buildings. Following measures can be taken to enhance the strength of the soft storey in ground floor by providing

- Brick masonry infill in ground storey
- Prestressed concrete bracing
- Steel bracing
- R.C. structural wall

II. OBJECTIVE

1. Modeling of R.C. building in STAAD PRO V8i.
2. Analysis of R.C. building with open soft ground storey.
3. Analysis of R.C. building with R.C. structural wall in soft ground storey.
4. Analysis of R.C. building with steel bracing in soft ground storey.

III. STRUCTURAL MODELLING

3.1 Building Description

The building is a G+5 storey building (18.5m high) and is made of Reinforced Concrete (RC) Special Moment Resisting Frames (SMRF). It is located in seismic zone III. Imposed load is taken as 3.5 kN/ m² for all floors except roof. Fig. presents typical floor plans showing different column and beam locations.

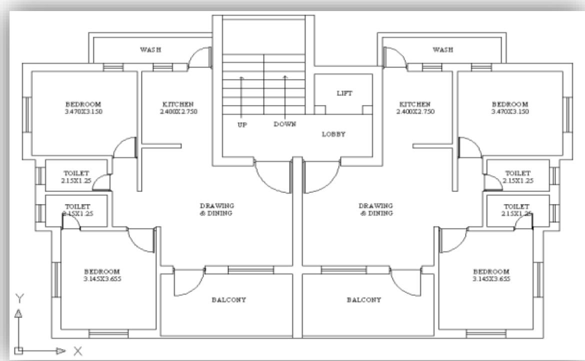

Fig.3.1: Plan of the building

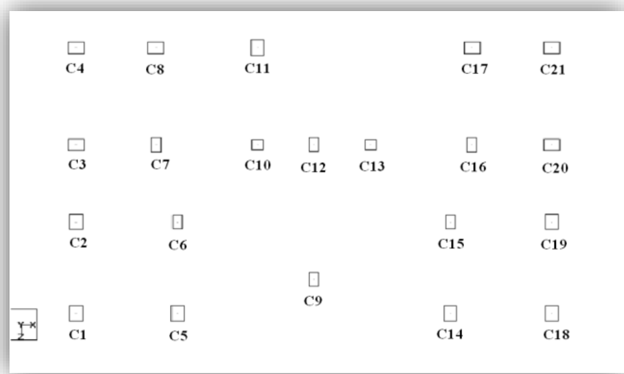

Fig.3.2: Column notations

3.2 MATERIAL PROPERTIES

M-25 grade of concrete and Fe-415 grade of reinforcing steel are used for all the frame models used in this study. Elastic material properties of these materials are taken as per Indian Standard IS 456: 2000. The short-term modulus of elasticity (E_c) of concrete is taken as: $Ec=5000\sqrt{f_{ck}}$ MPa is the characteristic compressive strength of concrete cube in MPa at 28-day (25 MPa in this case). For the steel rebar, yield stress (f_y) and modulus of elasticity (E_s) is taken as per IS 456:2000.

Table 3.1: Structural properties

External wall thickness	230mm
Internal wall thickness	115mm
Thickness of slab	150mm
Thickness of shear wall	180mm
Steel cross bracing	ISMB 250
Sizes of columns used	450mm x 500mm 300mm x 450mm 350mm x 350mm
Sizes of beams used	300mm x450mm 230mm x 300mm

The cross sections of the structural members (columns and beams) are equal in all frames and all stories.

3.2 CALCULATION OF LATERAL FORCES

3.2.1 DEAD LOAD

(As Per IS 875:1987- Part I)

Ground floor:

DL on external wall=0.23 x 19 x 3.5= 15.295 KN/m²

DL on internal wall= 0.115 x 19 x 3.5 = 7.65 KN/m²

1st to 5th floor:

DL on external wall=0.23 x 19 x 3= 13.11 KN/m²

DL on internal wall= 0.115 x 19 x 3= 6.56 KN/m²

- Weight of slab= 0.15 x 1 x 25= 3.75 KN/m²

Floor finish = 1.0 KN/m² *(As Per IS 875:1987- Part I, page 29, Asphalt flooring)*

Parapet wall= 1.2 x 0.115 x 19= 2.622 KN/m²

3.2.1 LIVE LOAD

(As Per IS 875- Part II, cl. No. 3.2.1, page no. 12)

1. Ground floor = 3.5 KN/m2
2. 1st floor = 3.15 KN/m2
3. 2nd floor = 2.8 KN/m2
4. 3rd floor = 2.45 KN/m2
5. 4th & 5th floor =2.1 KN/m2
6. Live load is not considered on roof *(As Per cl. no. 7.3.2, IS 1893:2002- PART I)*

3.2.2 EARTHQUAKE LOAD *(AS PER IS 1893-PART 1:2002):*

Z= Zone factor= 0.16(for zone III)
(***As per IS 1893(PART I):2002, Table 2)***

Table 3.2 Zone factor

Seismic Zone	**II**	**III**	**IV**	**V**
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.1	0.16	0.24	0.36

I= Importance factor=1
(As per IS 1893 (PART I): 2002, Table 6)
R= Response reduction factor=5 (for SMRF)
(***As per IS 1893 (PART I): 2002. Table 7)***
Damping ratio=0.05

The load combinations that were considered as per IS 1893:2002-

1. 1.5DL+1.5LL
2. 1.2(DL+LL+EQX)
3. 1.2(DL+LL-EQX)
4. 1.2(DL+LL+EQZ)
5. 1.2(DL+LL-EQZ)
6. 1.5(DL+EQX)
7. 1.5(DL-EQX)
8. 1.5(DL+EQZ)
9. 1.5(DL-EQZ)
10. 0.9 DL +1.5 EQX
11. 0.9 DL -1.5 EQX
12. 0.9 DL +1.5 EQZ

0.9 DL -1.5 EQZ

IV. ANALYSIS OF MULTISTORIED STRUCTURE

STAAD-PRO MODEL OF BUILDING

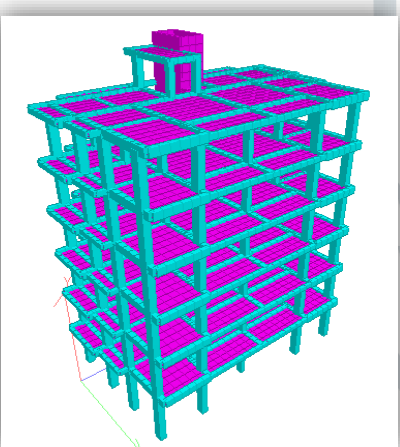

Fig.4.1 STAAD-PRO model of the building with soft ground storey

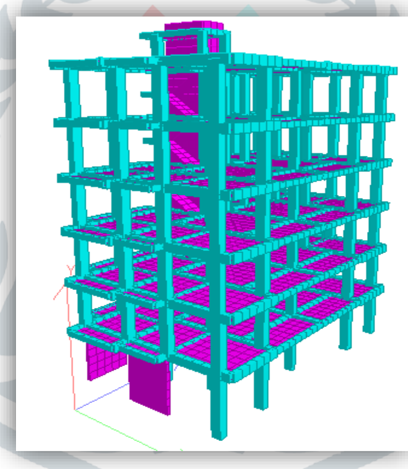

Fig. 4.2 STAAD-PRO model of the building with shear wall in ground storey

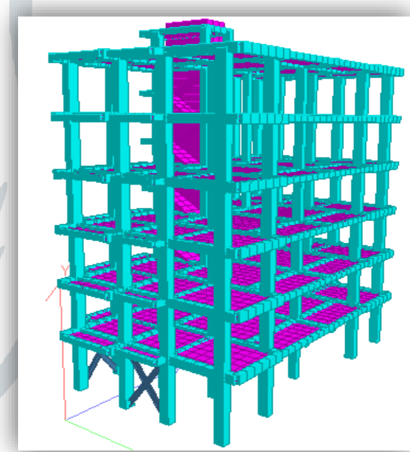

Fig.4.3 STAAD-PRO model of the building with bracing in ground storey

V. RESULTS AND DISCUSSION

The analysis of multistoried building (G+5) with soft storey in ground floor, shear wall in ground floor and steel bracing in ground floor using response spectrum method modeled in STAAD-Pro V8i gave following results:

5.1 Comparison of Displacement

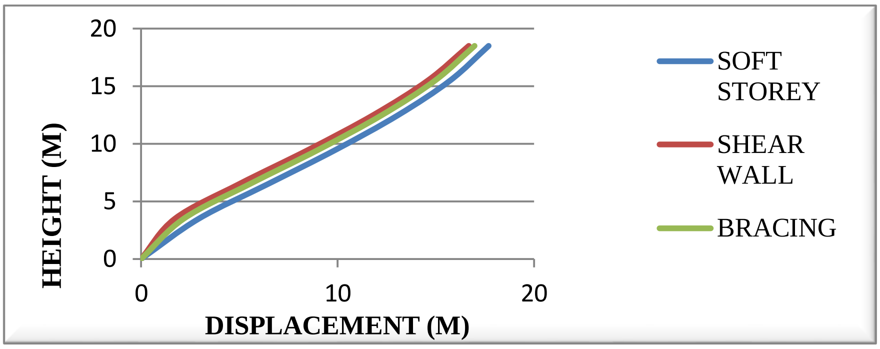

Fig.5.1 Graph of Displacement (M) for different models for load combination 0.9DL+1.5EQX

5.2 Comparison of Shear Force

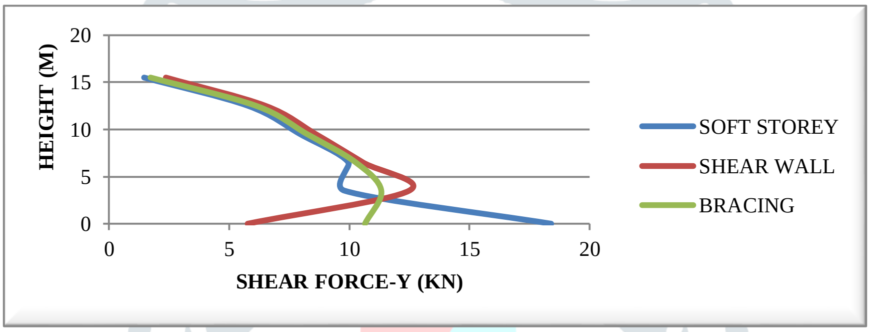

Fig.5.2 Graph of Shear Force-Y (KN) for different models for load combination 0.9DL+1.5EQX

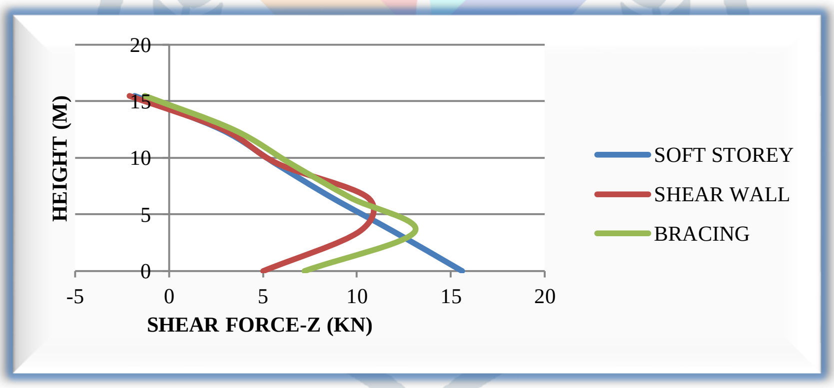

Fig.5.3 Graph of Shear Force-Z (KN) for different models for load combination 0.9DL+1.5EQX

5.3 Comparison of Bending Moment

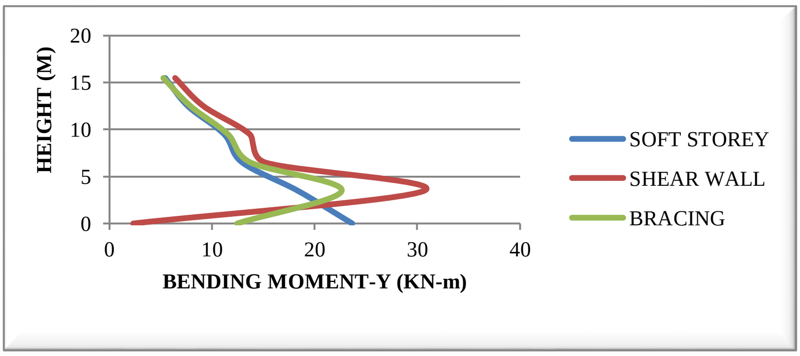

Fig.5.4 Graph of Bending Moment-Y (KN-m) for different models for load combination 0.9DL+1.5EQX

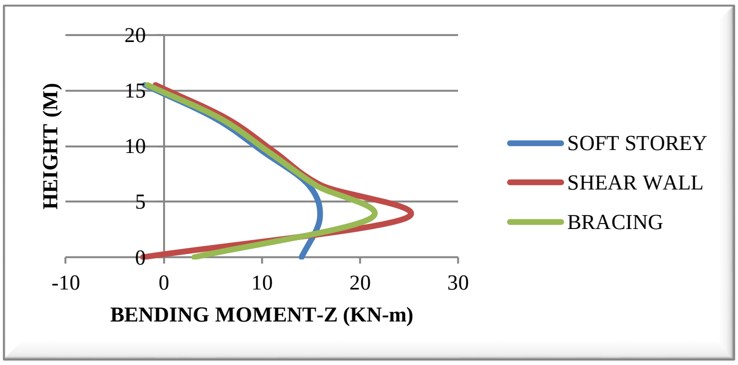

Fig.5.5 Graph of Bending Moment-Z (KN-m) for different models for load combination 0.9DL+1.5EQX

VI. CONCLUSION

With urbanization and increasing unbalance of required space to availability, it is becoming imperative to provide open ground storey in commercial and residential buildings. These provisions reduce the stiffness of the lateral load resisting system and a progressive collapse becomes unavoidable in a severe earthquake for such buildings due to soft storey. Hence the present study is carried out to find an efficient method to strengthen soft ground storey. On the basis of the results of analysis, following conclusions can be made:

i) Among all the load combination, the load combination of 0.9DL+1.5EQX is found to be more critical combination for all the models.
ii) The lateral deflection of column for building with shear wall in ground storey is reduced as compared to bracing in ground storey and soft ground storey.

Thus, it can be concluded that shear wall can be provided in ground storey to strengthen multistoried buildings.

VII. REFERENCES

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