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Effect of seismic response on a multi storey vertical irregular soft storey structure strengthened using R.C.shear wall

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ABSTRACT: This paper is an analysis study on the effect of vertical irregular soft storey configuration in the building and rectifying it by using RC shear wall. RC Shear walls are structural elements provided in the Multistorey structure to avert the damages caused due to earthquake. The object of providing shear wall is to prevent the total collapse of the structure due to the movement of earth. Therefore the ideal location of shear wall in a building is most important to with stand the seismic response of the structure. The linear dynamic analysis is adopted for various structural models having 15 storey high rise structure. The results of responses obtained from all models, such as Storey displacement, storey drift, storey shear, torsion and bending moment are tabulated and compared with different configurations. Thus, It is often effectively concluded that the supply of shear walls can reduce the consequences of sentimental storey to a way greater extend in an Irregular structure. RC Shear walls play an inevitable role in reducing the soft storey effect in the buildings, as the height of the building increases, the factors evaluated in this paper exert a major impact on the building's stiffness and stability, thus necessitating the need for in depth study in this area.

KEYWORDS: Soft storey, Irregular structure, Linear Response Spectrum analysis and RC Shear wall.

I. INTRODUCTION

A Soft storey is storey in which whose lateral stiffness [6]is less than the storey above. Here in this study the ground floor of structure is fully open for parking facilities, therefore the buildings with open ground storey configurations have shown higher tendency for collapse during earthquakes due to the soft storey properties. This effect is mainly due to increased flexibility of soft storeys as compared to normal floors. And since of this, large bending moments and shear forces act at that storey. In such buildings, major percentage of the base shear is required to be resisted by the beam-column joints of the ground storey. So it is very important to relieve the effect of soft storey in buildings to a greater extend. In order to realize this, various structural arrangements are often provided within the buildings. The most commonly adopted method is providing shear walls.

In the present study, hypothetical RCC buildings of medium rise (G+14) building having open ground floor storey with floating column at the centre bay in X direction both sides of its longer length, considered for providing shear wall structural arrangements incorporated in them. Also the present study explores the seismic evaluation of a soft story at ground floor with and without shear wall at various ideal location is determined using Response spectrum analysis and the comparison is made to reveal the differences.

II. Methodology

Linear dynamic analysis shall be performed to obtain the design lateral force for all buildings, in this study dynamic analysis is performed by Response Spectrum method using STAAD Pro V8i software. The analysis of model for dynamic analysis of buildings should be such that the Presenceof vertical irregularity in this structure is classified as stiffness irregularity (soft storey) as defined in IS code: 1893-2002(part 1) table 6. [2]. Dynamic Analysis shall be performed to get the planning seismic force, and its distribution in several levels along the peak of the building, and within the various lateral loads resisting elementfor the buildings.

III. Modeling of building

The models of the building under study are analyzed through Linear Dynamic analysis. [2] (RESPONSE SPECTRUM METHOD) using STAAD Pro v8 analysis package. For modeling the structure following assumptions are taken such as beams and columns as frame elements, floor slab as rigid horizontal plane, RC shear wall as vertical plane element and infill walls are considered as negligible and foundation of the structure as rigid.Mostly in Residential buildings, floor plan will be same for all floors. So the buildings were considered with same plan altogether floors. Shear walls of same section were used for same height of buildings throughout the peak.

3.1Description of the building frame

The building consists of fifteen storey high rise structure. All columns in all models are assumed to be fixed at the base. The ground floor is open for car parking and there are No in-fill walls. The floor to floor height is 3.5 m at Ground floor and all other floors are 3m height. Slab is modeled as rigid plane element of 0.15m thickness for all stories considered. Live load on floor is taken as 5 kN/m^2 and Dead load on roof is 4 kN/m^2. Weathering course on roof is 1.0 kN/m^2. The seismic weight is calculated as per IS code provision. The unit weight of RCC is taken as 25 kN/m^3. The concrete used is M-30 grade and the building is SPMR (Special Moment Resisting Frame) type and situated in seismic zone five having medium soil and intended for residential use.

Table 1. Various structural system models

Sl.No.	**Building Configuration Cases**	**Abbreviation**
1	Normal Structure with open Ground floor without shear wall.	**A**
2	Open Ground floor structure with shear wall at outer perimeter on all four sides.	**B**
3	Open Ground floor structure with shear walls at all four corners of building perimeter.	**C**
4	Open Ground floor structure with shear wall at lift.	**D**
5	Open Ground floor structure with 'C' type shear wall along shorter side of the building perimeter.	**E**
6	Open Ground floor structure with plane shear wall along shorter side of the building perimeter.	**F**

3.2 Model diagrams

Information about Model

For Modeling, We have taken Special moment resisting RC frame of 15 storey with each bay length of 3m along X and Y direction in which total number of bays were 3bays along Z direction and 6 bays along X direction. Moreover, the base story height is 3.5m at ground floor and 3m at all other floors. For analysis of the structure under seismic effect, six models have been considered. The selected models which are bare frame with rigid slab. The Ground floor bay is fully open for parking space and there is a floating column bay at the centre of the outer perimeter of the building in X dirction both sides.

Table 2. Datas

Building parameters	Assumed Data
Seismic Zone	Five
Response Reduction Factor	Five
Property of the Material	concrete
Soil type	Medium soil
Importance Factor	1
Floor to Floor height at G.F.	3.5m
Floor to Floor height all others	3m
Total building height	45.5m
Beam sizes	600 x 550 (G.F), 300 x 450 (other floors)
Column sizes	600 x 550, 300 x 300(floating column)
Floor Slab thickness	150 mm
RC Shear wall thickness	150 mm
R C Building with special moment resisting frame (SMRF)	R=5

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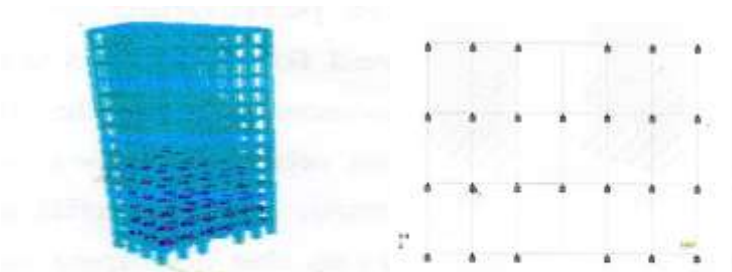
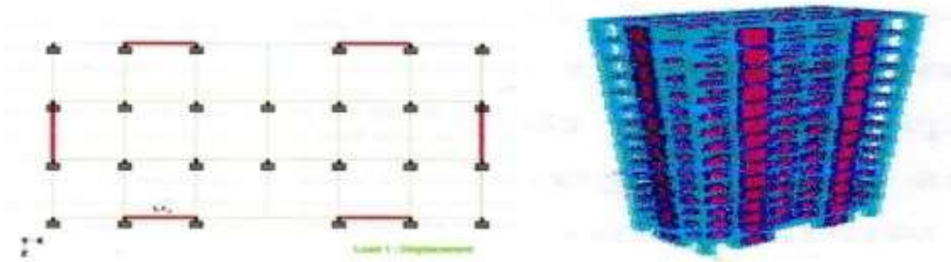
Natural period Ta	0.09h/d^0.5

MODELS



MODEL A : NORMAL STRUCTURE WITH OPEN GROUND FLOOR WITHOUT SHEAR WALL**.**



MODEL B : OPEN GROUND FLOOR STRUCTURE WITH SHEAR WALL AT OUTER PERIMETER ON ALL FOUR SIDES**.**

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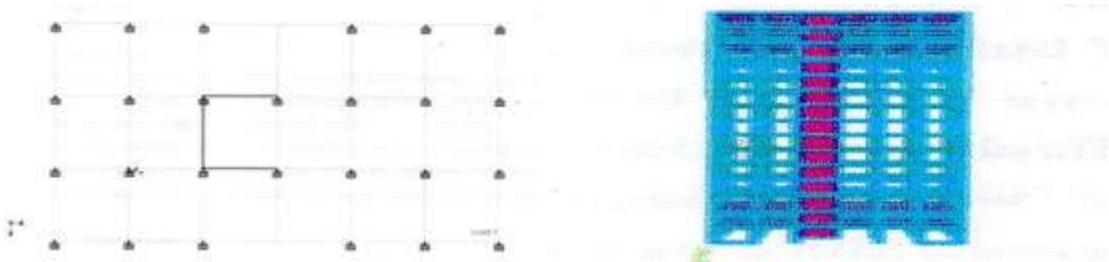
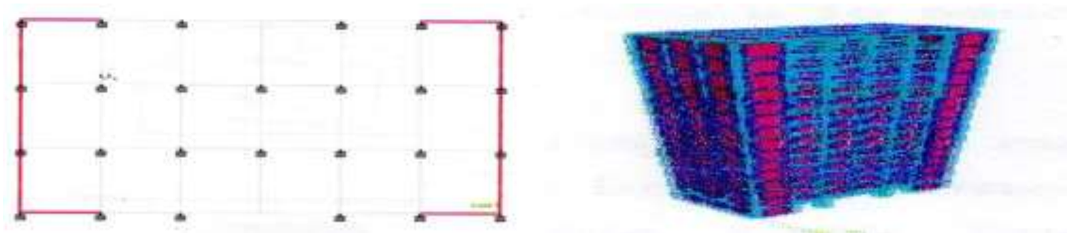
MODEL C : OPEN GROUND FLOOR STRUCTURE WITH SHEAR WALLS AT ALL FOUR CORNERS OF THE BUILDING PERIMETER.



MODEL D : OPEN GROUND FLOOR STRUCTURE WITH SHEAR WALL AT LIFT.



MODEL E : OPEN GROUND FLOOR STRUCTURE WITH "C" TYPE SHEAR WALL ALONG SHORTER SIDE OF THE BUILDING PERIMETER.

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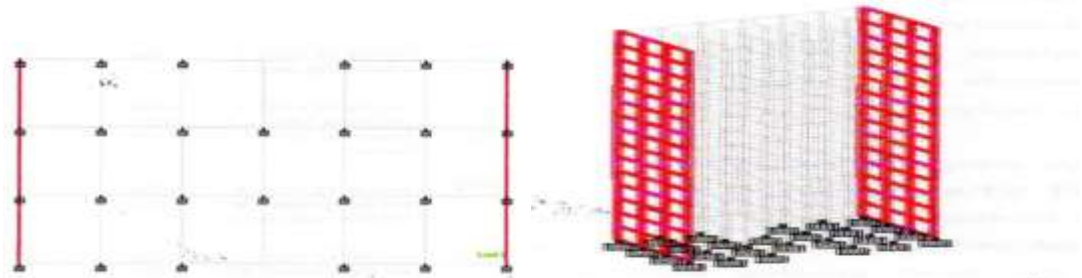

MODEL F : OPEN GROUND FLOOR STRUCTURE WITH PLANE SHEAR WALL ALONG SHORTER SIDE OF THE BUILDING PERIMETER.

IV. Results and discussion

The five models were analysed . The various parameters were identified. The parameters are maximum nodal displacements, maximum bending moment, maximum torsional moment, maximum shear force and storey drift.

Table: 3Maximum nodal displacements at joints in x and z direction

CASE	X- DIRECTION(In mm)	Z – DIRECTION(In mm)
A	23.09	30.36
B	14.25	15.76
C	17.22	20.44
D	15.01	21.80
E	14.27	11.07
F	17.10	13.23

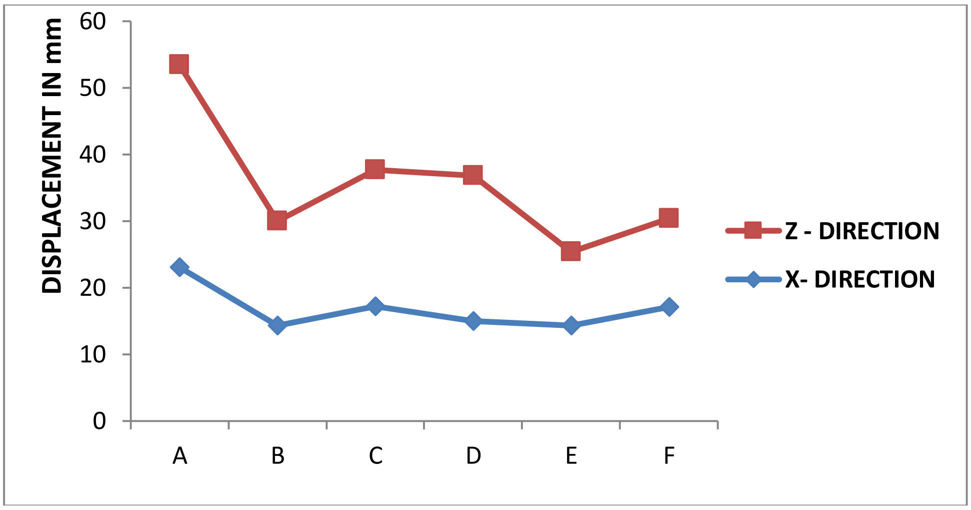

Figure 1 Maximum storey displacement at x and z direction

Table 3 and Figure1 Show the displacement value of various models . Result shows the maximum Storey displacement in Model A and Minimum displacement in Model E.

Table:4 Maximum bending moment of beam in x direction

CASE	**MOMENT Y (kN –m)**	**MOMENT Z((kN –m)**
A	812	782
B	376	512
C	318	679
D	966	886
E	202	486
F	218	812

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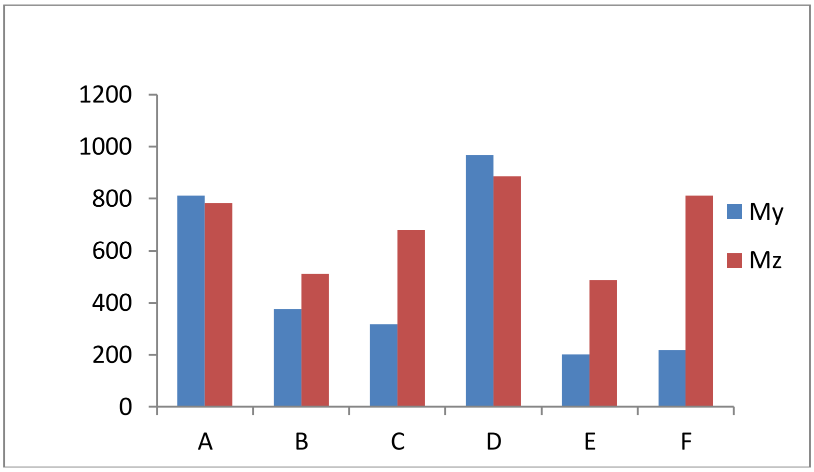

Figure 2 Maximum bending moment in beam at y and z direction

Table 4 and Figure 2showthe maximum Bending moment in beam along x direction is at model A and the minimum at Model E.

Table 5 : Maximum Torsional moment (kNm)

CASE	TORSION (kNm)
A	35.50
B	31.39
C	16.00
D	82.00
E	13.70
F	35.00

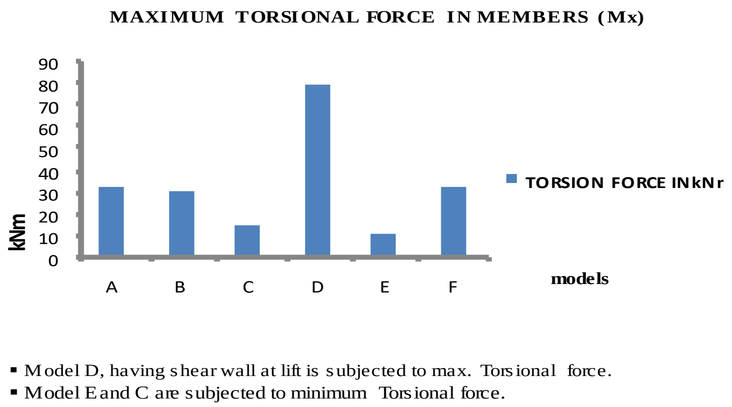

Figure 3 Maximum Torsional moment in column

Table 5 and Figure 3, show the Maximum torsion moment at Model D and Minimum torsion moment At Model E.

Table : 6 Maximum shear force of beam in x direction

MODELS	Fy(kN)	Fz(kN)
A	436	454
B	333	245
C	453	208

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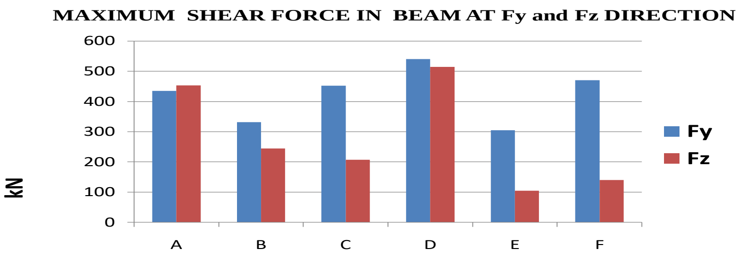
D	542	516
E	306	105
F	472	141



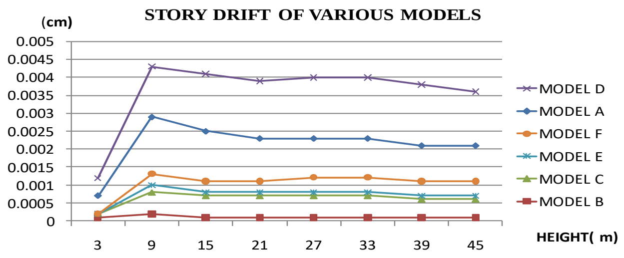
▪ Max. Shear Force in beam occurs in Model D and Min. Value at Model E.

Figure 4 Maximum shear force in beam

Table 6 and Figure 4 , Show the maximum shear force in Model A & D and minimum shear force at Model E.

Table 7 : Storey drift of models at different height

HEIGHT(m)	MODEL A	MODEL B	MODEL C	MODEL D	MODEL E	MODEL F
3	0.0006	0.0002	0.0002	0.0006	0	0
9	0.0017	0.0003	0.0007	0.0015	0.0003	0.0004
15	0.0015	0.0002	0.0007	0.0017	0.0002	0.0004
21	0.0013	0.0002	0.0007	0.0017	0.0002	0.0004
27	O.0012	0.0001	0.0007	0.0017	0.0002	0.0005
33	0.0012	0.0001	0.0006	0.0016	0.0002	0.0005
39	0.0002	0.0001	0.0005	0.0016	0.0001	0.0005
45	0.0002	0.0001	0.0005	0.0015	0.0001	0.0005



▪ **The Min. Story drift observed at models B,C and E.**
▪ **The Max. Story drift occurs at model D.(Lift wall) and A.**

Figure 5 Storey drift of various models

Table 7 and Figure5 , Show the maximum storey drift in Model A and minimum storey drift at Model B,C and E.

The Results of the analysis shows such as storey displacement ,Storey drift, Torsional moment, Bending Moment and Shear Force are presented and variation of these results have been discussed. The variation of these results with respect to all models with shear wall and without shear wall having at different locations are studied . The following Results are observed from this analysis are tabulated as below:

- The maximum storey displacement is observed in Model A and Minimum storey displacement is observed in Model E.
- The Maximum Bending moment in Beam being in Model E.
- Among the Maximum Shear Force in all models the Model E is Least over other Models.
- Among the Storey Drift ratio of all models, bottom floor is having least value and maximum at the top floor
- The Torsional Force is less in Model E among all other models.

V. Conclusions

The effects of vertical irregular soft storey configuration in the buildings are studied and focus is given on the various ideal location of RC shear wall to remedy it. The performance of the building is evaluated in terms of lateral displacement, storey drift, storey shear and bending moment variation. The results for different models are compared with the normal structure without shear wall, it can be concluded that:

1. The Location of shear wall in a structure increases the stiffness and reduces the Lateral displacement and storey drift.
2. It is observed that the storey drift is less in bottom stories and increases towards first, second,Third floor and gradually decreases towards top floor.
3. The Torsional Reaction is comparatively less in C type shear wall.
4. The direction and placement of shear wall in a rectangular high rise structure attract the forces, therefore the shear wall positioning must be in a ideal location.
5. Comparing the results, it is found that providing C type shear wall along the perimeter of the structure in shorter side of the structure as Model E is most efficient over other models in terms stiffness, story drift, nodal displacement, lateral shear, moment distribution and torsional moment consideration

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