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THE EFFECT OF GEOMETRICAL CONFIGURATION OF SHEAR WALL ON BEHAVIOR OF RC BUILDING UNDER SEISMIC LOADS

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***Abstract –** The decision regarding provision of shear wall to resist lateral forces play an important role in choosing the appropriate structural systems. Shear walls are vertical stiffening elements designed to resist lateral forces exerted by wind or earthquake. The shape and location of shear wall have significant effect on their structural behavior under lateral loads. In this study 3D structural modelling based software Midas-GEN was used to generate and analyze three-dimensional building models for assessment of relative lateral load resisting systems. Four models were used, one moment resisting frame and 3 models each, for lateral load resisting system. Each model consisted of G+12 storey frame structure having total height of 36.0 m. Each building model was subjected to three-dimensional analysis for the determination of both displacement at roof level and interstorey drifts.*

***Keywords –** Moment frame, shear wall, roof displacement, interstorey drift, seismic loads*

I. INTRODUCTION

In the last few decades, structural walls have been used extensively in countries especially where high seismic risk is observed. The major factors for inclusion of structural walls have ability to minimize lateral drifts, simplicity of design and excellent performance in past earthquakes. Recent earthquakes were beneficial in better understanding the behavior and observing the seismic performance of structural walls. As a matter of fact, the term "Shear wall" is incomplete to define the structural attributes of the walls since they resist not only the shear force but also provide lateral load resistance during a seismic action. Therefore, the term "Structural wall" is used interchangeably with the term "Shear wall" throughout the study.

Structural walls are designed to resist gravity loads and overturning moments as well as shear forces. They have very large in-plane stiffness that limit the amount of lateral drift of the building under lateral loadings. Structural walls are intended to behave elastically during wind loading and low to moderate seismic loading to prevent non-structural damage in the building. However, it is expected that the walls will be exposed to inelastic deformation during less frequent, severe earthquakes. Therefore, structural walls must be designed to withstand forces that cause inelastic deformations while maintaining their ability to carry load and dissipate energy. Structural and non-structural damage is expected during severe earthquakes; however, collapse prevention and life safety is the main concern in the design. Structural walls are very effective at limiting damage according to the post-earthquake evaluations. Observed damage is typically dependent on the building and wall configuration.

II. SPECIFICATIONS

2.1 Problem definition

A residential building having foot print of 21m × 21m is taken for the study. This building is considered in the seismic Zone III. In this case the earthquake force is predominant than the calculated wind pressure, hence the structure is analyzed for seismic loading only.

Further using Midas GEN, different structural systems with shear walls are prepared. Preliminary element sizes are designed as per IS 456:2000. The load combinations are taken as per IS 875 (Part I to V).

Midas provides membrane element for modeling shear wall as wall element, which retains the shape of a rectangular or square. The elements retain in-plane tension/compression stiffness in the vertical direction, in-plane stiffness in the horizontal direction, out of plane bending stiffness and rotational stiffness about vertical direction.

2.2 Preliminary Data

Table 1. Preliminary data

Dead load	: 2.0 kN/m^2 at typical floor : 2.0 kN/m^2 on terrace
Live load	: 2.0 kN/m^2 at typical floor : 1.0 kN/m^2 on terrace
Floor finish	: 1.0 kN/m^2
Water proofing	: 1.0 kN/m^2
Zone	: Seismic zone - III
Earthquake load	: As per IS-1893 (Part 1) - 2002
Type of soil	: Type II, Medium as per IS: 1893
Storey height	: Typical floor: 3 m : Ground Floor: 3 m
Floors	: G + 12
Beams	: 230 mm × 250 mm
Column	: 400 mm × 400 mm
Walls	: 230 mm thick brick masonry walls at Periphery. : 150 mm thick internal brick Masonry walls. : Density of masonry = 20 kN/m^3
Material Properties (1) Concrete ⇒All components unless specified in design: M25 grade all: f_{ck} = 25 N/mm^2 $E_c = 5000\times\sqrt{f_{ck}}$ = 25000 N/mm^2 (2) Steel ⇒ HYSD reinforcement of grade Fe 415 confirming to IS: 1786 is used throughout. f_y = 415 N/mm^2	

2.3 Load Combinations

The analysis results are based on the load cases given below. As per IS-875 the combinations given below produces the most unfavorable effects in the buildings and structural members. The analysis results are carried out for each of them in each directions.

Case I – 1.5(DL+EQXN)

Case II – 1.5(DL+EQYN)

Denotations

DL: Dead load

EQXN: Earthquake in X-ve direction

EQYN: Earthquake in Y-ve direction

2.4 Geometrical Configuration

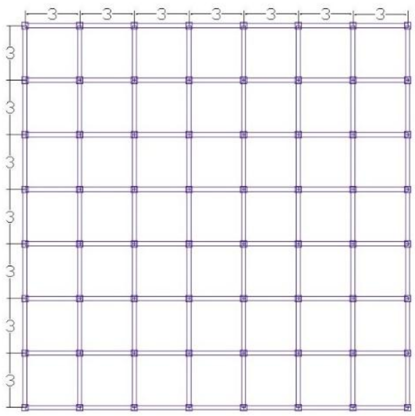

Figure 1. P0_BF

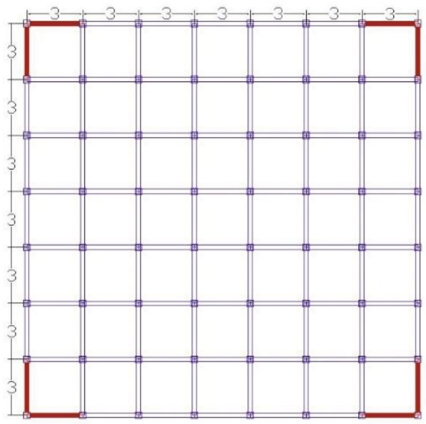

Figure 2. P1_SCo

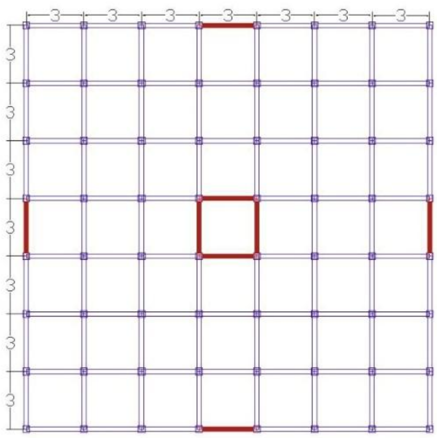

Figure 3. P1_SCeE

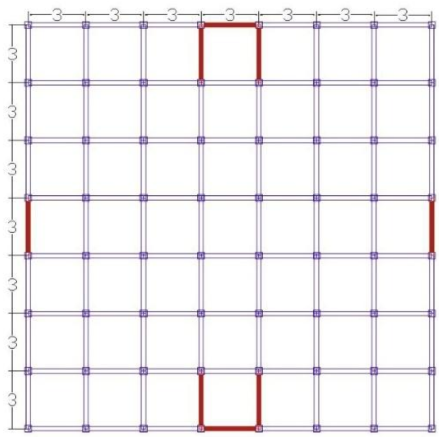

Figure 4. P1_SE(C)

III. RESULTS & DISCUSSION

3.1 Displacement

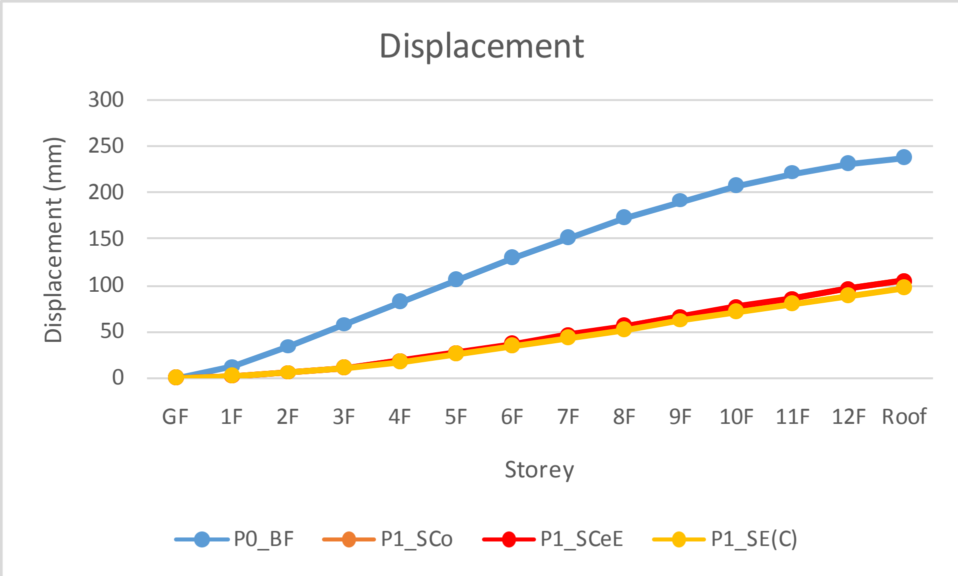

Figure 5. Displacement →Storey (Case – I)

As shown in ***Figure 5. Displacement →Storey (Case – I)***, the roof displacement is reduced by 56.29 % for model P3_SCo, 56.17 % for model P3_SCeE & 59.23 % for model P3_SE(C) in reference to model P0_BF. Also, the roof displacement for model P1_SCe is 0.28 % & 6.29 % for model P3_SE(C) less for than that of model P3_SCeE.

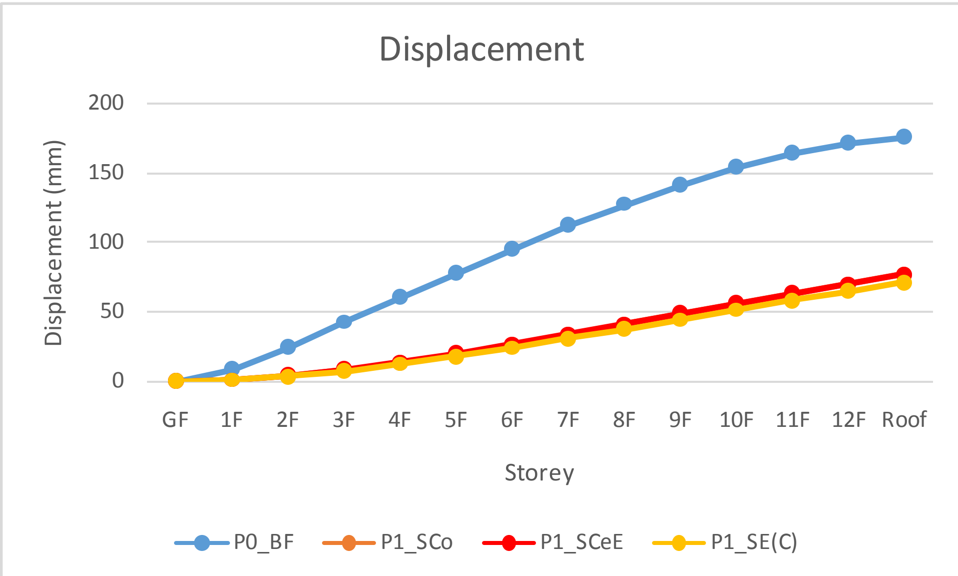

Figure 6. Displacement →Storey (Case – II)

As shown in ***Figure 6. Displacement →Storey (Case – II)***, the roof displacement is reduced by 56.27 % for model P3_SCo, 56.16 % for model P3_SCeE & 59.45 % for model P3_SE(C) in reference to model P0_BF. Also, the roof displacement for model P1_SCe is 0.25 % & 7.51 % for model P3_SE(C) less for than that of model P3_SCeE.

3.2 Interstorey drift

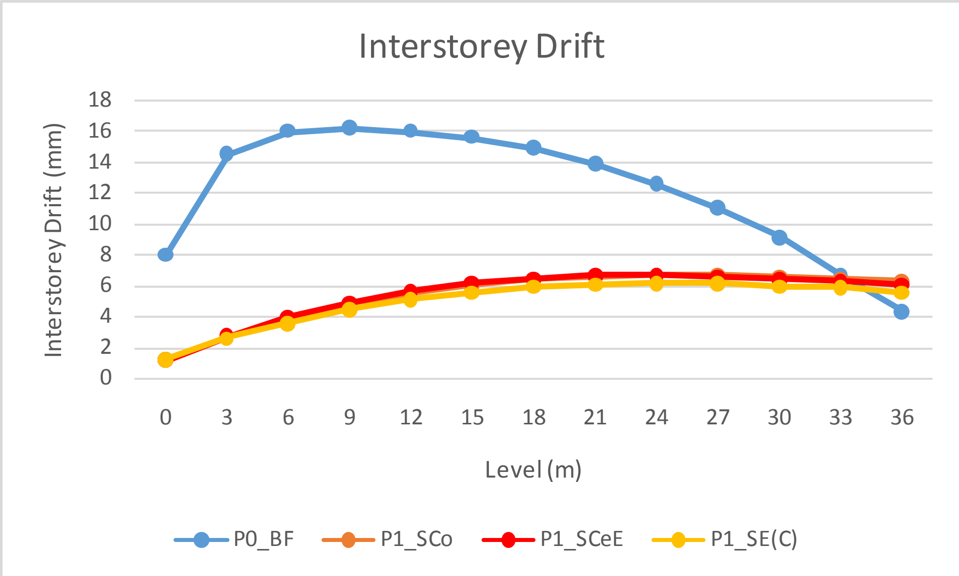

Figure 7. Interstorey drift → Level (Case – I)

As shown in ***Figure 7. Interstorey Drift → Level (Case – I)***, the maximum interstorey drift is reduced by 58.64 %, 58.64 % & 61.72 % in reference to bare frame for model P3_SCo, P3_SCeE & P3_SE(C) respectivly. Also the maximum interstorey drift is reduced by 0 % & 7.46 % for model P3_SCo & 14.28 % for model P3_SE(C) compared to model P3_SCeE.

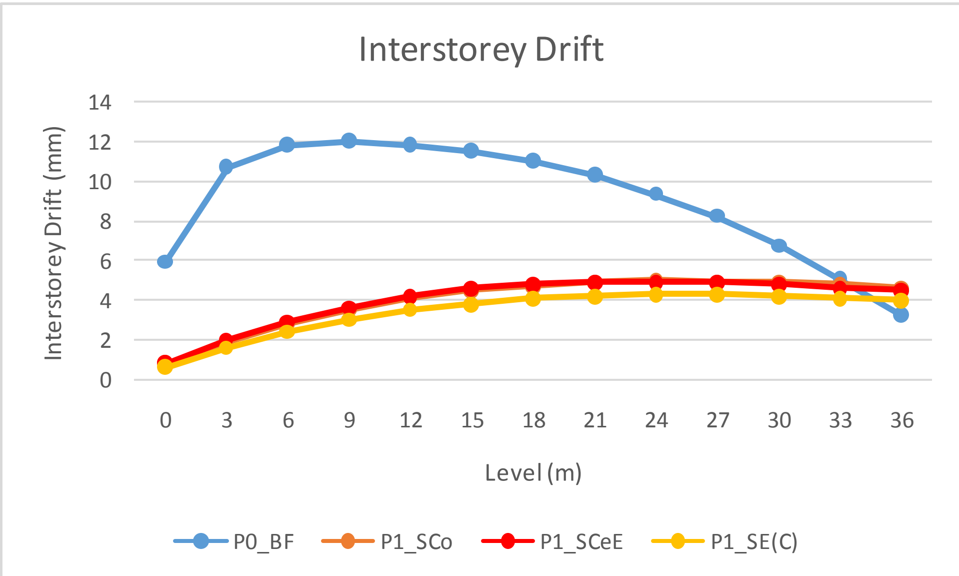

Figure 8. Interstorey drift → Level (Case – II)

As shown in ***Figure 8.Interstorey drift → Level (Case – II)***, the maximum interstorey drift is reduced by 58.33 %, 59.16 % & 64.16 % in reference to bare frame for model P3_SCo, P3_SCeE & P3_SE(C) respectively. Also the maximum interstorey drift is reduced by 2.0 % & 14.0 % for model P3_SCo & 14.28 % for model P3_SE(C) compared to model P3_SCeE.

IV. CONCLUSION

The aim of this study was to evaluate the effect of geometrical configuration shear on the behavior of RC building with and without shear walls. The analysis of G+12 building are carried out with shear wall ratio 1.25 % using Midas-GEN. The results of analysis were used to investigate the parameters like Roof Displacement, Interstorey Drift.

- The behaviour of model buildings were dominated by the shear wall ratio.
- Interstorey drift is the greatest in bare frame and least in P3_SE(C) in both directions.
- Among the building frames studied, the greatest interstorey drift in case of bare frame occurred near mid height of the building. For all other configurations with shear walls, the greatest interstorey drift occurred in upper half of the building.
- Shear wall configuration of model P3_SE(C) with C type shear walls at center of two edges on opposite faces with other two walls on the remaining edges, is found better and effective in seismic behaviour than other models with same percentage shear wall ratio.

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