A COMPARATIVE STUDY ON EFFECT OF OPEN GROUND STOREY BUILDING ON SEISMIC PERFORMANCE OF HIGH RISE BUILDING BY USING DIFFERENT PROVISION OF INFILL

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Abstract: **This paper study on effect of open ground story on seismic performance of high rise building parking space for residential apartments in populated cities is a matter of major concern. Hence the trends has been to utilize the ground story of the building itself for parking. "Open Ground Story building are those type of building in which the ground story is free of any infill masonry walls. These types of building are very common in India for parking provisions. In generally open ground story column were either damaged severely or failed completely, there by damaging the building due to sudden reduction in lateral stiffness and mass in the ground story result in higher under seismic loading. To prevent the soft story failure a multiplication factor by static nonlinear analysis considering infill stiffness and strength.**

Keywords: **Soft Story, Infill Masonry.**

1. INTRODUCTION

Open Ground Story buildings (Also known as Soft Story buildings) are commonly used in the urban environment nowadays since they provide parking area. According to IS 1893- 2002, Soft story is defined as story which has less than 70 percent lateral stiffness than story above or less than 80 percent of the average lateral stiffness of the three story above. From past earthquakes, this type of building shows comparatively higher tendency to collapse during earthquake due to soft story effect. For example, during the 1999 Turkey, 1999 Taiwan, 2001 Bhuj , India, 2005 Jammu and Kashmir, India and 2003 Algeria earthquakes, maximum damaged buildings were found to have open ground story. A reason behind collapse is hinge formation developed at ground story column due to large lateral displacement. Large lateral displacement at ground story column is due to stiffness of Infill wall during earthquake in actual behavior & building act as a Inverted Pendulum.

For simplification in analysis, bare frame is considered without infill walls & all column is fixed for hard soil and hinged for soft soil. This neglects stiffness of infill walls and flexibility of soil below footing which gives inaccurate result than exact behavior during earthquake. To overcome this soft story effect IS 1893:2002 gives multiplication factor 2.5 to shear force & bending moment calculated under seismic force in bare frame for ground story elements(Column, Beam, Shear wall) in clause 7.10.3(a) without considering aspect

Ratio of building, No. of bay, stiffness of infill walls & soil flexibility. The value of magnification factor suggested in various literatures is vary from 1.0 to 4.8, Yet there is no proper justification about this magnification factor.

Fig 1: Pendulum Effect in Building & Pendulum Effect in Actual Building

2. EFFECT OF INFILL STIFFNESS

Most of the Structure Engineer uses bare frame in analysis without infill walls which neglects stiffness of infill wall, But in actual structure Infill wall plays an important role in seismic behavior. Infill wall alters the natural time period of building, seismic behavior of building and finally alters the base shear and affects the multiplication value 2.5. Stiffness of Infill wall depends on percentage opening and location of opening provided in wall for ventilation. Indian code IS 1893(Part- I): 2000 does not

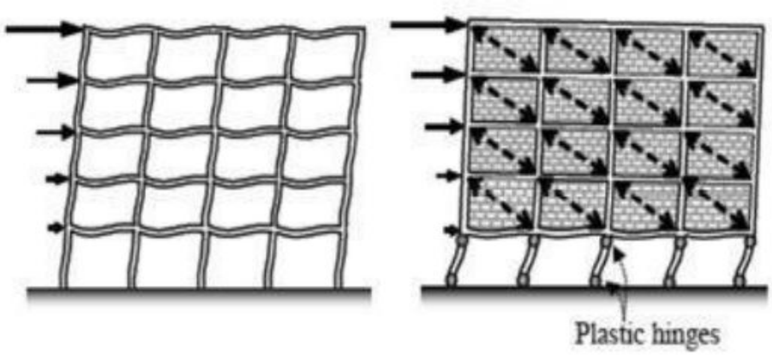

Fig 2: Behavior between bare frame and OGS Building

Include provision of taking into consideration the effect of infill. If the effect of infill is taken into account in the analysis and design of frame, the resulting structure behavior may be significantly different.

Out of all hazards, earthquakes have the possibility of having the big damages to the life and structures. Because of earthquake forces are in random manner & unpredictable. Earthquake load is to be carefully modeled so as to judge the material behavior of structure with a clear reason. In this situation pushover analysis, which is an iterative procedure is looked upon as an alternative to the conventional analysis procedures. Pushover analysis of buildings subjected to increasing lateral forces is carried out until the target displacement is reached or building is collapsed. With the increase in the lateral loading, the progressive non- linear behavior of various structural elements is captured, and weakest link and failure modes of the structures are recognized.

Past earthquake shows that the most of damages in open Ground story are occurred in the ground story column and is called soft story collapse. These are due to the sudden lowering stiffness or strength in the open ground story as compared to a typical in filled frame building. Such an OGS frame building, completely collapsed during Bhuj earthquake 2002, due to soft story experience a lesser damage because all upper stories are moves like pendulum

3. BRICK INFILL WALL MODELLING

Infill wall is two- dimensional element that can be model with plate element for analysis of buildings with infill wall. But, two dimensional nonlinear plate element modeling is very difficult to understand. Therefore, for nonlinear analysis of the buildings, the infill wall is modeled as a line element (one- dimensional) for software implementation purpose. So, in this study Infill walls are modeled as equivalent diagonal strut element which is most common method of modeling a infill walls. There are different approaches to model infill. There are four approaches to model the equivalent strut found in literature and are listed below:

- Elastic Analysis Approach
- Approach Based on Finite Element Analysis
- Approach Based on Plastic Analysis
- Ultimate Load Approach

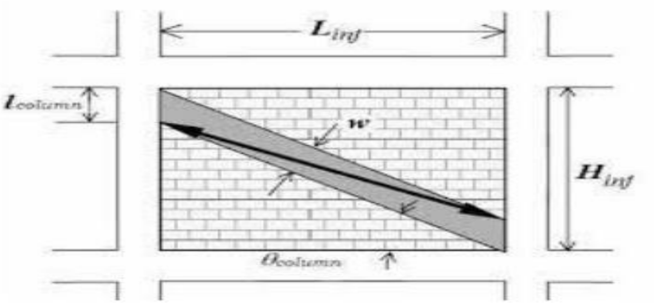

Fig 3: Diagonal strut for infill wall

Table 1: Equation for diagonal strut width by various researchers

Researcher	Strut Width(w)	Remarks
Holmes	0.333dm	dm is length of diagonal
Mainstone	$0.175D(\lambda h\ H)^{-0.4}$	$\lambda h\ H = H\left[\frac{Em\ t\ sin2\theta}{4Ec\ Ic\ Hm}\right]$
Liuw and kwan	$\frac{0.95\ hm\ t\ cos\theta}{\sqrt{\lambda hm}}$	$\lambda h\ H = \left[\frac{Em\ t\ sin2\theta}{4Ec\ Ic\ Hm}\right]^{1/4}$
Paulay and Preisly	0.25dm	dm is length of diagonal
Hendry	$0.5[\alpha h + \alpha l]^{1/2}$	$\alpha h, \alpha l$ are constant

Figure show how the infill panels behave when it is subjected to lateral load designed as equivalent diagonal strut. Smith and carter given the parameter as follows.

$$\lambda h = \sqrt[4]{Es\,t\,\frac{\sin 2\theta}{4\,Ec\,Ic\,h'}}$$

Es = Elastic modulus of the equivalent strut

Ec = Elastic modulus of the column in the bonding frame

Ic = Moment of inertia of the column

h' = clear height of infill wall

h = Height of column between centerline of beams

t = thickness of infill wall

θ = Slope of the infill wall diagonal to the horizontal

4. STRUCTURAL MODELLING

Data of Building	Dimension
No. of Story	G+5, G+9
Plan Dimension	15m x 20m
Story Height	3m
Slab Thickness	130mm
Column Size	600 x 600mm
Beam Size	230 x 500mm
Wall Thickness	230mm
Live Load	3 kN/m^2
Grade of Concrete	M30
Grade of steel	Fe 415

One of the purpose of this working is to test a real life structure under earthquake loads. For that we have selected existing RC Residential building. No special design is performed for building to keep the structure as close to reality as possible. Also the column size, sections and reinforcement are varied along the story same in the case of original real life structure.

In this paper study about G+5 and G+9 Story building with different Provision of Infill like Light weight block, Brick-1 and Brick-2 different masonry properties with Bare Frame, 20% Opening and 10% Opening and check the parameters of Story Displacement, Story Drift and Story Shear. And provide the strut as a equivalent to brick masonry as per Mainstone Equation given in table and make the excel sheet of Mainstone equation and get the strut width (W).

Try for Different Masonry's Modulus of elasticity in Mainstone Equation. In this paper Elasticity is taken for Light weight Block (22340Mpa), Brick-1 (5300Mpa), and Brick-2 (6095Mpa) respectively and input in Mainstone Equation to get the strut width in all different zones.

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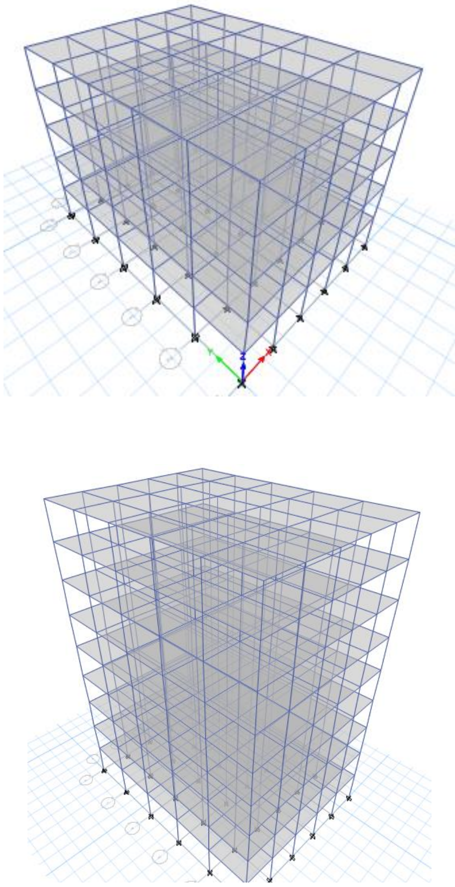


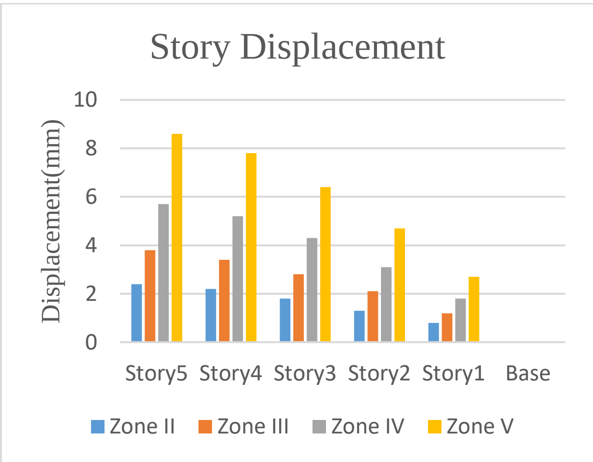
Fig 4: G+5 and G+9 Story Building

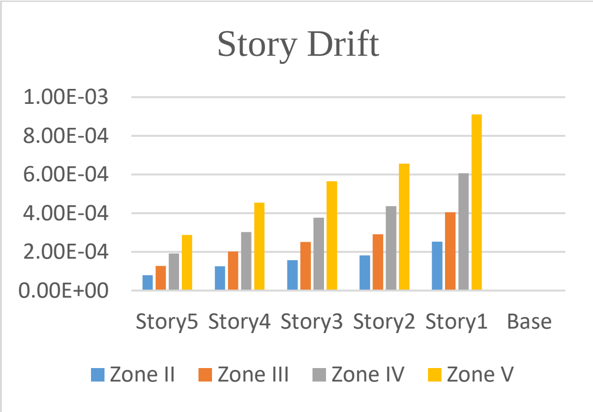
5. ANALYSIS AND RESULT

As the name suggests this procedure is essentially a static analysis, in which the static loads are applied in an incremental fashion until the ultimate state of the structure is attained. The non-linear designation comes from the fact that the various components/elements are modeled using a non-linear mathematical model. This section is dedicated to describe the main steps of this procedure, in a general manner. This is

Followed mainly because the concept of the non-linear static procedure is still relatively new and is the topic for discussion in this study. The various concepts and possible

Methodology in its application are referred at various location of this paper.





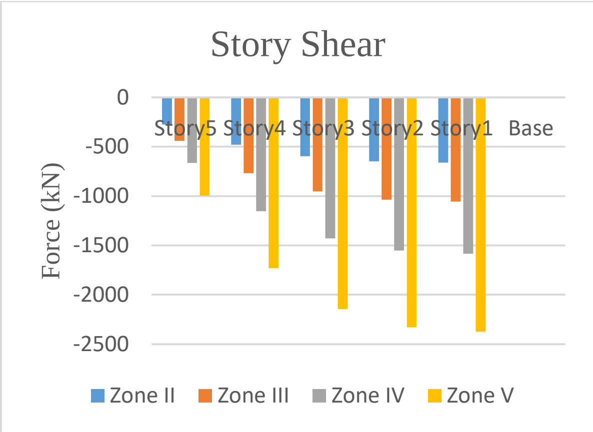
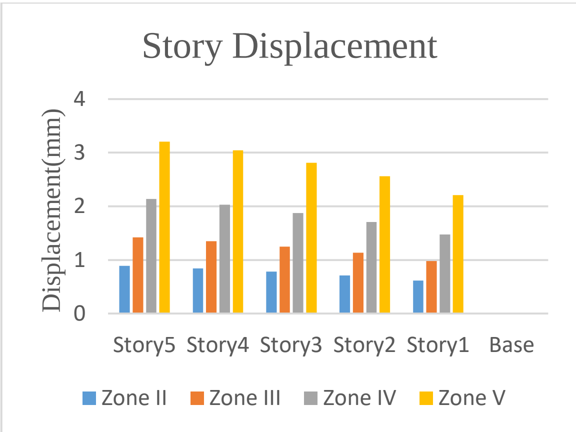
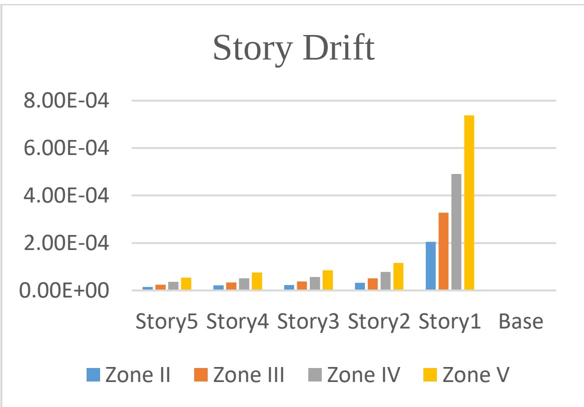


Fig 5: Bare Frame Result of G+5 Story Building. Story Displacement, story Drift and Story Shear





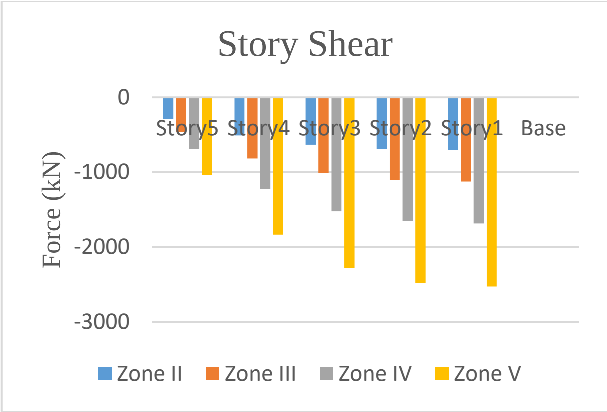
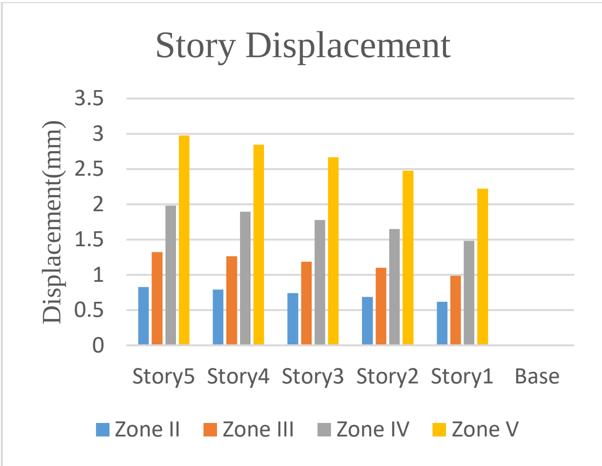
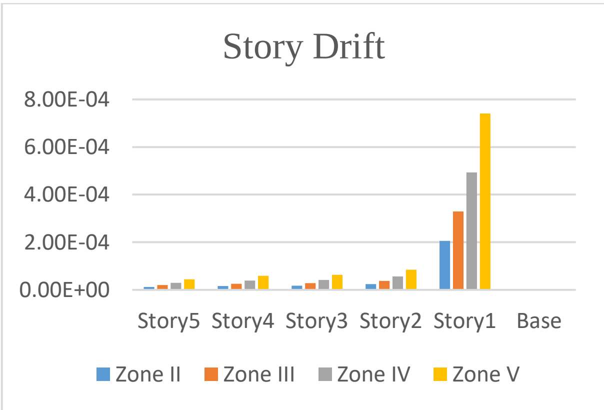


Fig 6: Light weight Block of G+5 Story Building with 20% Opening. Story Displacement, Story Drift, Story Shear





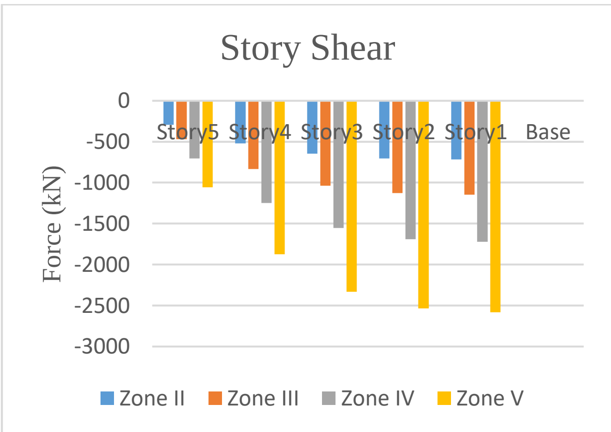
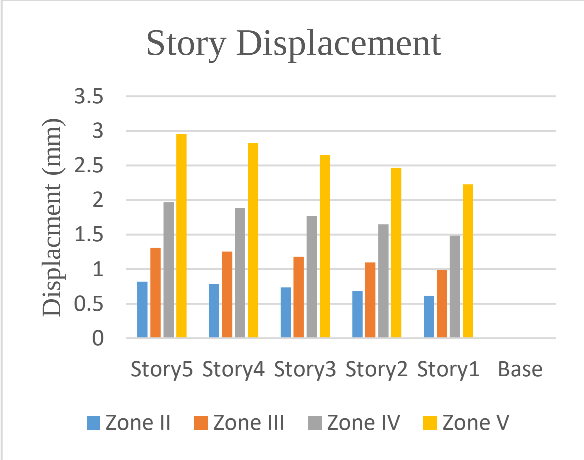
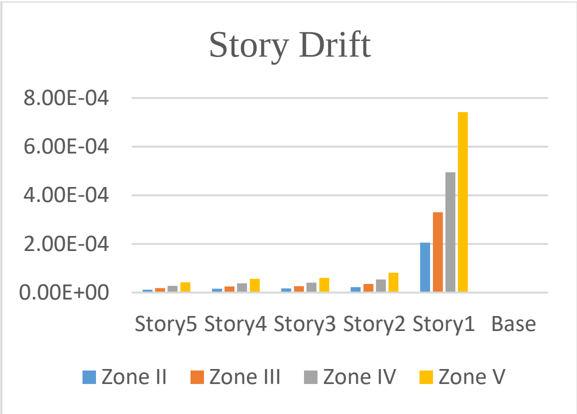


Fig 7: Light weight Block of G+5 Story Building with 10% Opening. Story Displacement, Story Drift, Story Shear





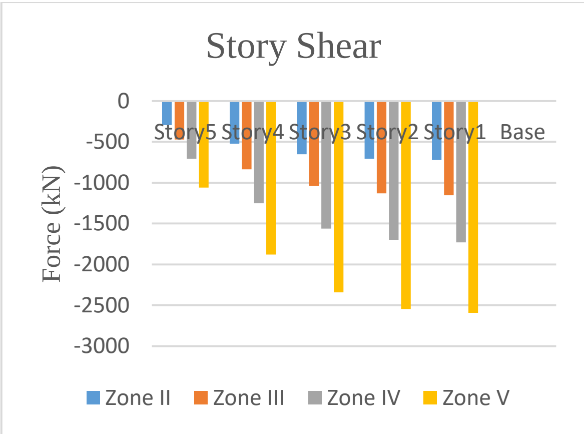
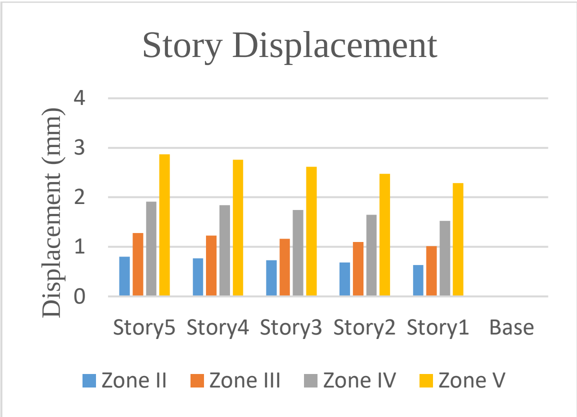
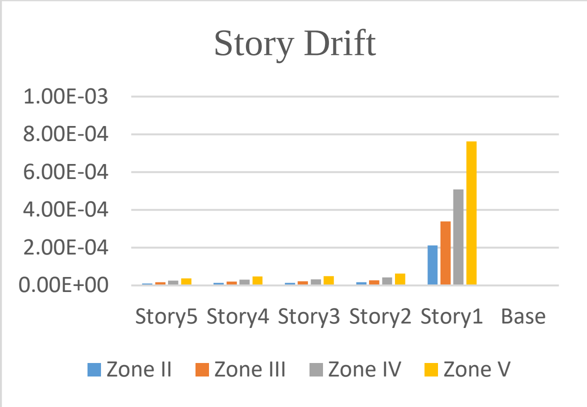


Fig 8: Brick-1 Type of G+5 Story Building with 20% Opening. Story Displacement, Story Drift, Story Shear





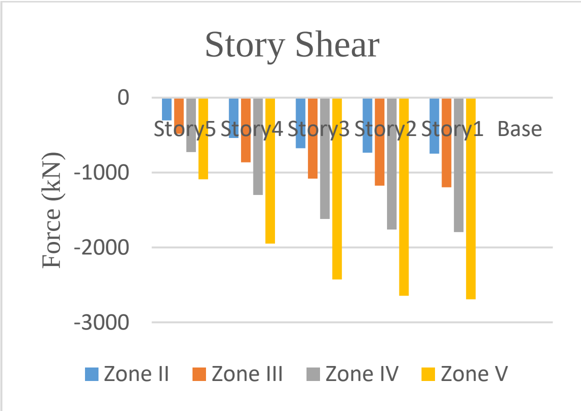
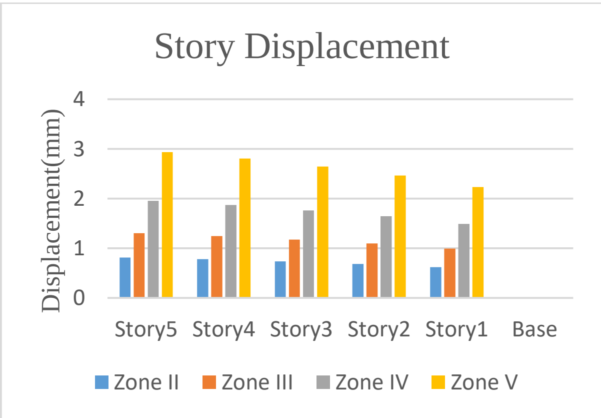
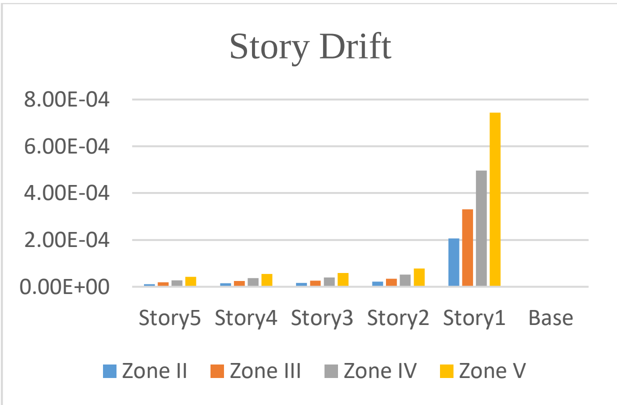


Fig 9: Brick-1 Type of G+5 Story Building with 10% Opening. Story Displacement, Story Drift, Story Shear





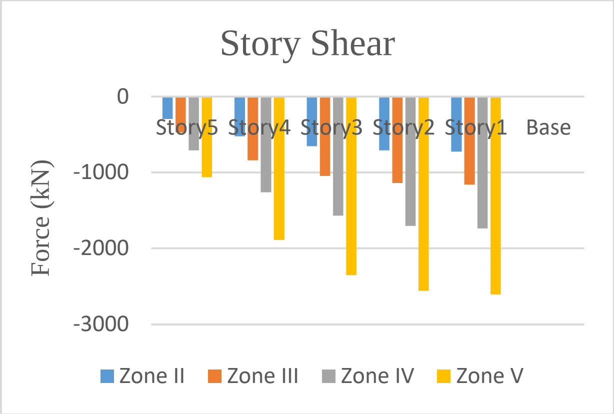
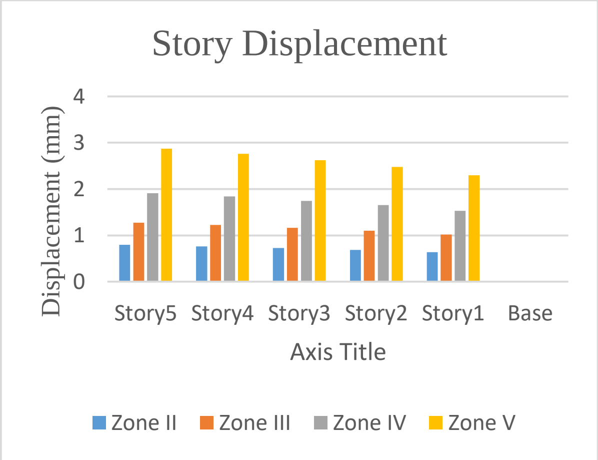
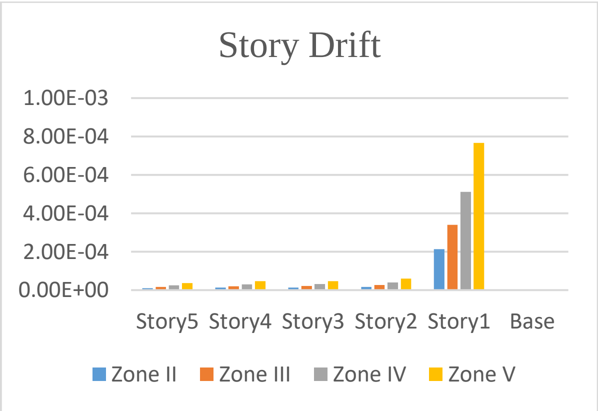


Fig 10: Brick-2 Type of G+5 Story Building with 20% Opening. Story Displacement, Story Drift, Story Shear





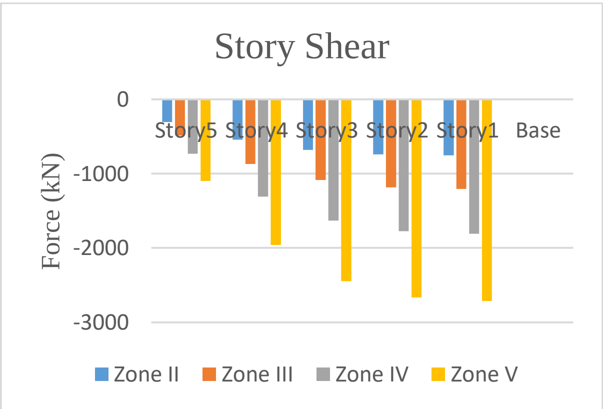


Fig 11: Brick-2 Type of G+5 Story Building with 10% Opening. Story Displacement, Story Drift, Story Shear

6. CONCLUSION

In G+5 light weight block story displacement with 20% opening 3.20, story drift 5.4 and story shear 1040.974 that compare with Brick-1 type and Brick-2 type we get story displacement 2.95, story Drift 4.3 and story shear 1060.975 respectively we get story displacement 2.87, story drift 3.7, story shear 1090.81 in Zone V.

Light weight block have higher story displacement, compare to Brick-1 & Brick-2 type Masonry.

Also story Drift is higher in Light weight block compare to Brick-1 and Brick-2 type Masonry

But in Story Shear Brick-2 type Masonry is higher compare to Brick-1 and Light weight block.

In light weight block we provide manually opening in software and get the story displacement in 20% opening is 2.92mm and in 10% opening get displacement 2.03mm and provide strut based on mainstone equation and get the result in 20% opening 3.20mm and in 10% opening 2.97mm.And also in Brick-1 type masonry result of 20% and 10% respectively 2.76mm and 3.005 and provide strut we get the displacement 2.95mm and 2.87mm. In Brick-2 with manually 3.11mm in 20% opening and 2.96mm in 10% opening. And provide strut as per mainstone we get the displacement 2.93mm in 20% and 2.86mm in 10% opening.

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