A COMPARATIVE STUDY ON BEHAVIOUR AND INFLUENCE OF MASONRY INFILL RC FRAME MULTI-STOREYED BUILDING WITH ISOLATED BASE AND FIXED BASE CONDITION

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Abstract - Base isolation consists of the installation of mechanism which decouples the structure from base level by providing seismic isolators. The system which is installed under the superstructure is known as Base Isolation. Infill walls play an important role in addition of stiffness to the structures. Nowadays masonry infill wall panels are used in buildings for aesthetic use by architects. In design process usually contribution of infill walls towards structural stiffness are neglected. Infill walls provide additional stiffness to the structure to resist lateral forces. An attempt has been made by providing isolators and infill for both regular frame and irregular frame structures to know the contribution of isolators and infill walls in high rise buildings.

In the present work, high rise building with isolators and infill walls is analysed for both static and dynamic analysis. Dynamic analysis carried out by response spectrum method. Analysis has been carried out with infill frame and without infill frame for both fixed base and isolated base buildings. Seismic zone V, medium soil considered for analysis. The building considered for the analysis is 20 storied RC frame building. Total 8 models are considered for the analysis. Out of 8 models, 4 models are with masonry infill and 4 models are bare frames. Equivalent Static analysis and Response Spectrum analysis is carried out for all models for determining parameters like storey shear, storey drift, storey displacement and storey acceleration. Analysis has been performed using ETABS software. The results obtained from the analysis are tabulated and compared.

Key Words: Base isolation, Lead Rubber Bearing, Infill frame, Bare frame, ETABS

1. INTRODUCTION

Ground motions which occur naturally and results in the disasters like damage of structure are known as earthquake. Earthquake creates inertia forces proportional to the product of building mass and the ground accelerations. As increases the ground accelerations, to avoid the structural damage the strength of the building must be increased. In some high seismic zones the forces causing acceleration in the building may exceed the acceleration due to gravity. To overcome from this problem, to protect the structures and to reduce the risk of life from strong earthquake the most widely using technique is base isolation.

Multi-storey structures are the most commonly adopted system of shelter in metropolitan cities. Buildings are subjected to two types of loads namely, vertical load due to gravity and Lateral load due to earthquake and wind. As height of the structure increases, the effects of lateral loads dominate as compared to dead and imposed loads. It is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. Masonry infills are normal system used for construction of walls in high rise buildings.

2. INFILL FRAME

The frames are Infilled with stiff construction such as brick or concrete block masonry primarily to create an enclosure and too provide safety to the users. Such masonry walls are known as infill walls. The term Infilled frame is use to denote a composite structure formed by the combination of moment resisting plane frame and infill walls. Masonry infill is often used to fill the voids between the vertical and horizontal elements of the building frames. The masonry infill panels are often cost-effective and suitable for temperature and sound insulation purposes. Masonry infills are normally considered as non-structural elements and their stiffness contributions are generally ignored in practice. such an approach can lead to an unsafe design. Properly designed infills can increase the overall strength, lateral resistance and energy dissipation of the structure.

Masonry infill is having a very high initial in-plane lateral stiffness and low deformability. Therefore, under seismic loads, the whole lateral force transfer mechanism of the structure changes from a predominant frame action to predominant truss action. The change of frame mechanism to truss mechanism leads to a two-fold action. One, which in general is beneficial, it leads to reduction in bending moments and increase in axial forces in the frame members; and two, which changes the natural frequency of the system significantly due to large stiffness addition which is

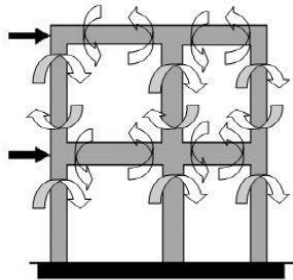generally not traded off completely by increase in mass due to walls.

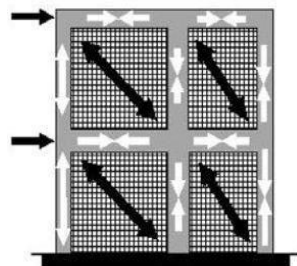**Fig 1: Frame action In bare frame**
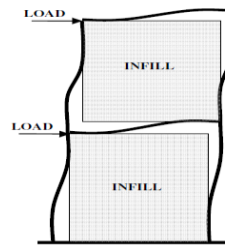

Fig 2: Predominant truss action in infilled frame

2.1. Lead rubber bearing

Fig 3: Lead Rubber Bearing
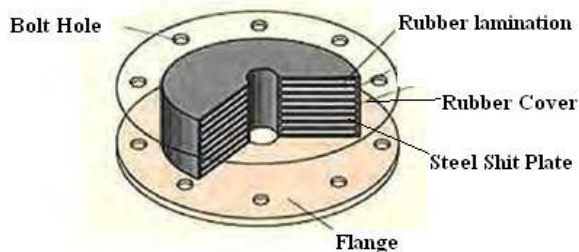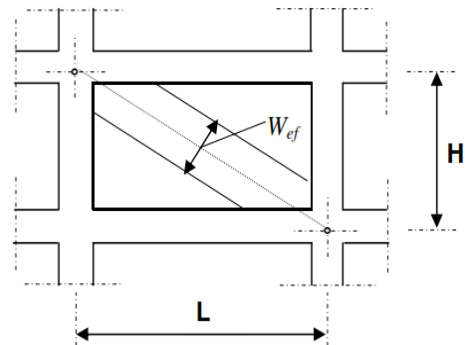
Lead Rubber bearing is the type of elastomeric bearing, which consists of alternative layers of rubber and steel plates. It is also called as high density rubber bearing; the rubber used is natural or synthetic rubber which provides sufficient amount of damping. The damping in the bearing is increased by adding extra fine carbon block, oils, resins and many other types of fillers. On unloading, these bearings formed a hysteresis loop that had a significant amount of damping.

2.2. Equivalent diagonal strut

The simplest (and most developed) method for the analysis of non-integral masonry infill frames is based on the concept of the equivalent diagonal strut. This concept was initially proposed by Polyakov (1956) and later developed by other investigators. In this method, the masonry infill frame structure is modeled as an equivalent braced frame system with a compression diagonal replacing the masonry infill.

Fig 4: laterally loaded infill frame   **Fig 5: Equivalent frame**
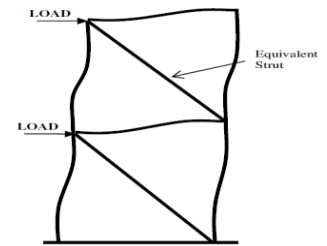
Width of equivalent diagonal strut is calculated using the following formula,

$$a = 0.175(\lambda_1 h_{col})^{-0.4} r_{inf}$$

Here, λ= Coefficient depending on properties of infill and frame, which is obtained using the following formula,

$$\lambda = \sqrt[4]{\frac{E_m t \sin 2\theta}{4 E_c I_c h}}$$

H = Column height between centerlines of beam, m

h = Height of infill panel, m

L = Length of RC frame, m

Ec = Expected modulus of elasticity of   column material, N/mm²

Em = Expected modulus of elasticity of infill materials, N/mm²

Ic = Moment of inertia of column, mm⁴,

t = Thickness of infill panel and equivalent strut, m

θ= Angle whose tangent is the height-to-length aspect ratio, degree.

3. DATA USED FOR ANALYSIS

Total 8 models of R.C.C High Rise Building of 20 stories are taken for analysis using ETABS Software, to know the realistic behavior of building for both static and dynamic loads for zone V with medium soil condition.

Height of each storey = 3 m
Total height of the building = 60 m
Depth of slabs =175mm
Thickness of Masonry infill =20mm
Density of concrete =25 kN/m³
Density of solid blocks masonry =20 kN/m³
Modulus of elasticity of masonry infill =328.394 N/mm²
Poisson's ratio of masonry, µ = 0.2
Other Properties varies with respect to masonry infill panels.
Response reduction value = 5
Zone factor = 0.36
Soil type = Type II (Medium)
Spectrum case name = SPECX/SPECY
Damping = 5%

Fig 6: 3D and plan view of regular building

Load combinations are considered as per limit state of serviceability and limit state of collapse.

Load combinations	Load factors
Gravity analysis	1.5(DL + LL)
Equivalent static analysis	1.2(DL + LL ± EL$_X$)
	1.2(DL + LL ± EL$_Y$)
	1.5(DL ± EL$_X$)
	1.5(DL ± EL$_Y$)
	0.9DL ± 1.5EL$_X$
	0.9DL ± 1.5EL$_Y$
Response spectrum analysis	1.2(DL + LL ± RS$_X$)
	1.2(DL + LL ± RS$_Y$)
	1.5(DL ± RS$_X$)
	1.5(DL ± RS$_Y$)
	0.9DL ± 1.5RS$_X$
	0.9DL ± 1.5RS$_Y$

4. MODEL DETAILS

Following 16 models are considered for this study.

1. Model 1: Plan regular RC MRF Without Infill – Fixed Base
2. Model 2: Plan irregular regular RC MRF Without Infill – Fixed Base
3. Model 3: Plan regular RC MRF Without Infill – Base isolated
4. Model 4: Plan irregular regular RC MRF Without Infill – Base isolated
5. Model 5: Plan regular RC MRF With Infill – Fixed Base
6. Model 6: Plan irregular regular RC MRF With Infill – Fixed Base
7. Model 7: Plan regular RC MRF With Infill – Base isolated
8. Model 8: Plan irregular regular RC MRF With Infill – Base isolated

The entire analysis is carried out using equivalent static method and dynamic analysis is carried out using response spectrum method. The parameters adopted are Base shear, storey displacements, storey drifts and storey shear forces across the height of the structure for all the type of models.
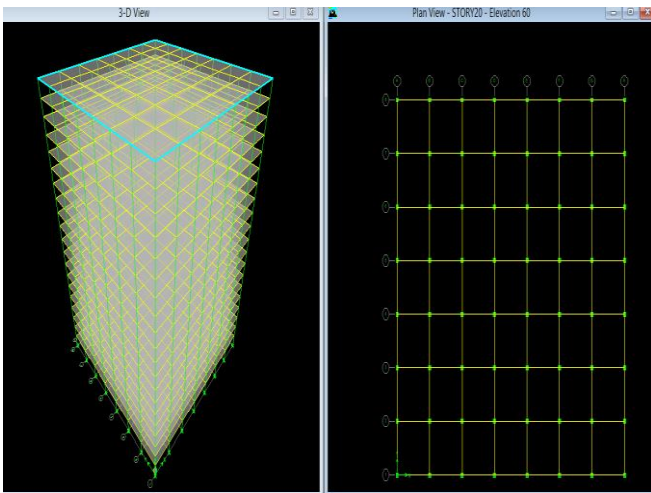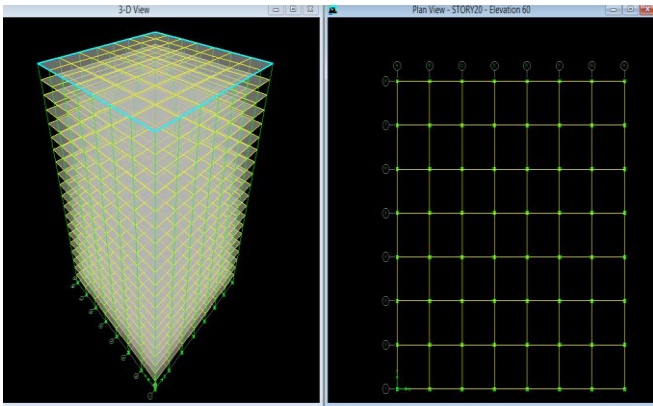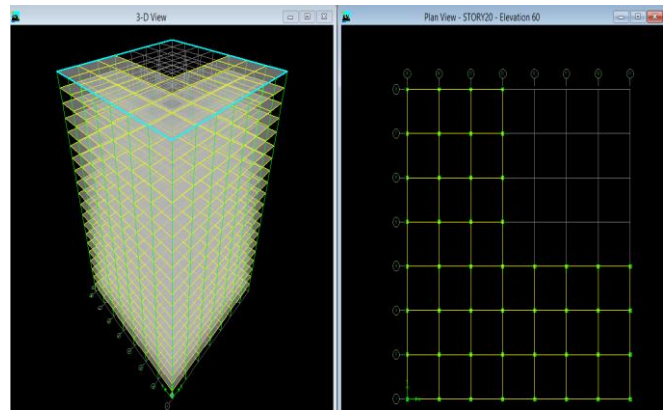
Figure 7: 3D and plan view of regular building with Fixed Base (without infill)

Figure 8: 3D and plan view of irregular building with Fixed Base (without infill)
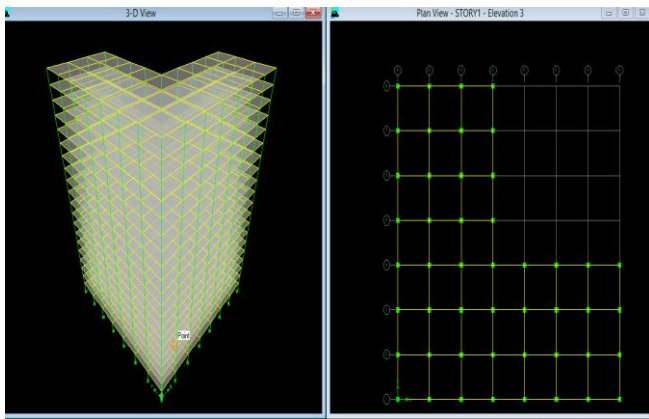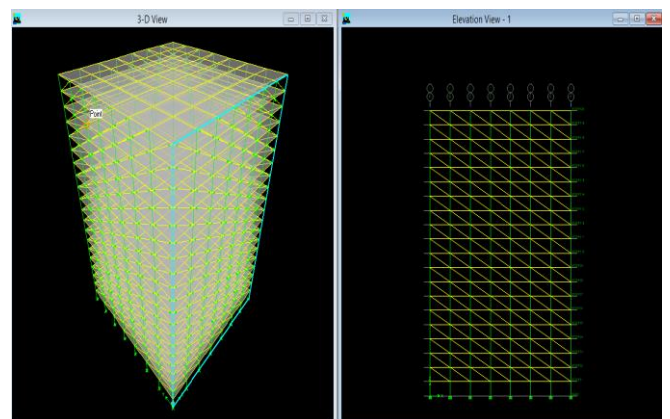

Figure 9: 3D and plan view of regular building with Isolated Base (without infill)
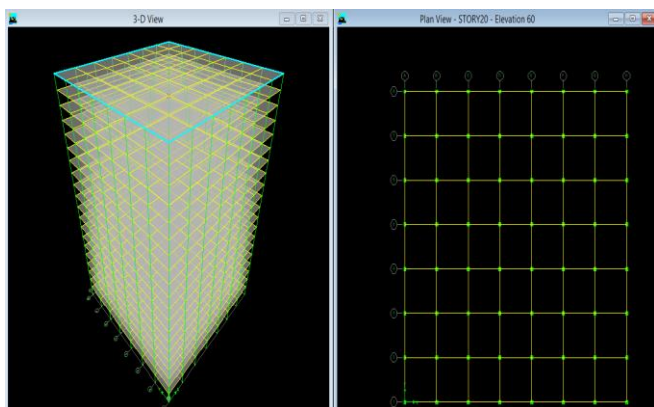

Figure 10: 3D and plan view of irregular building with Isolated Base (without infill)

Figure 11: 3D and elevation view of regular building with Fixed Base (with infill)
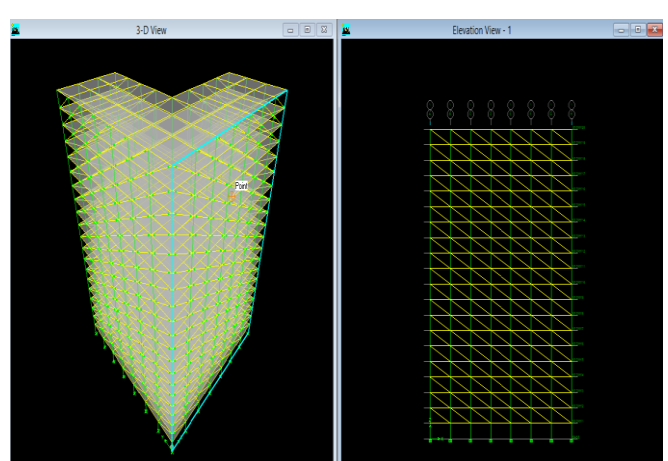

Figure 12: 3D and elevation view of irregular building with Fixed Base (with infill)
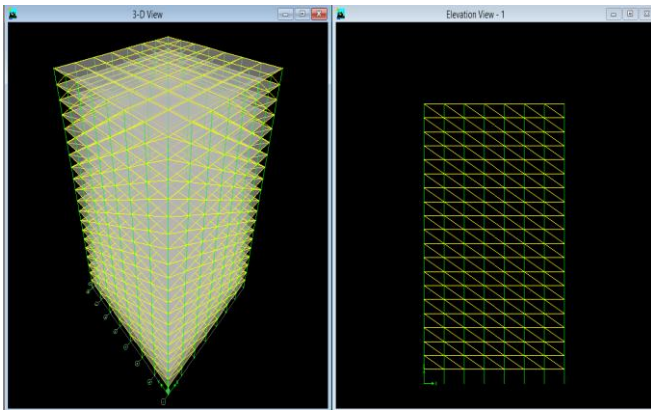
Figure 13: 3D and elevation view of regular building with Isolated Base (with infill)
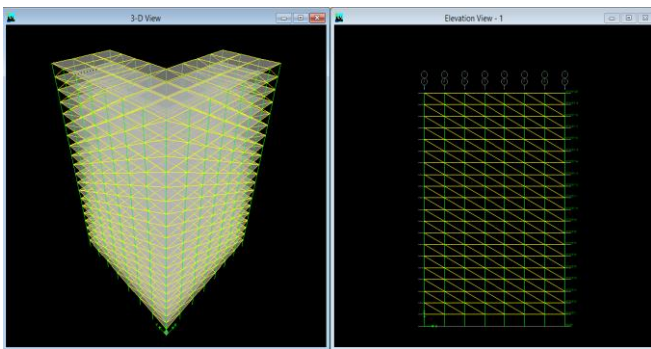

Figure 14: 3D and elevation view of irregular building with Isolated Base (with infill)
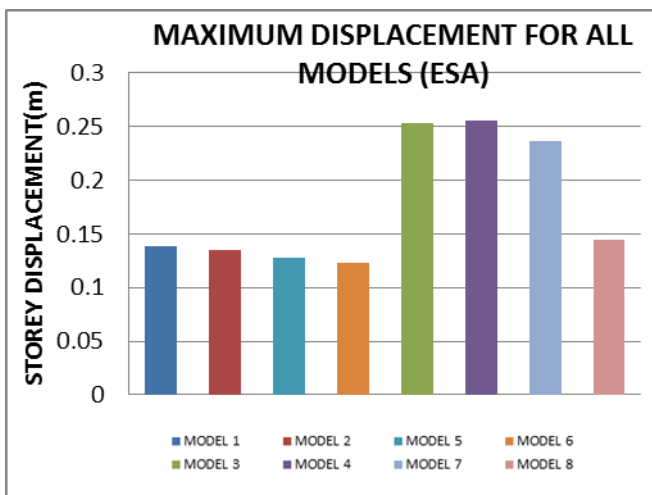
5. RESULTS

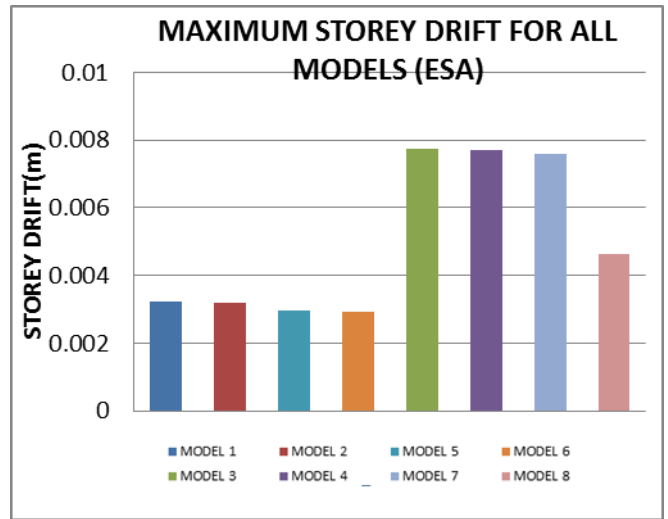Fig.15: Maximum Story Displacements for all models (ESA)

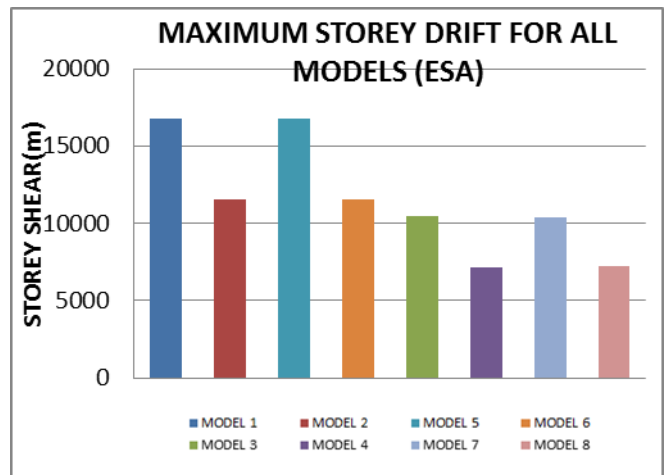Fig.16: Maximum Story Drift for all models (ESA)

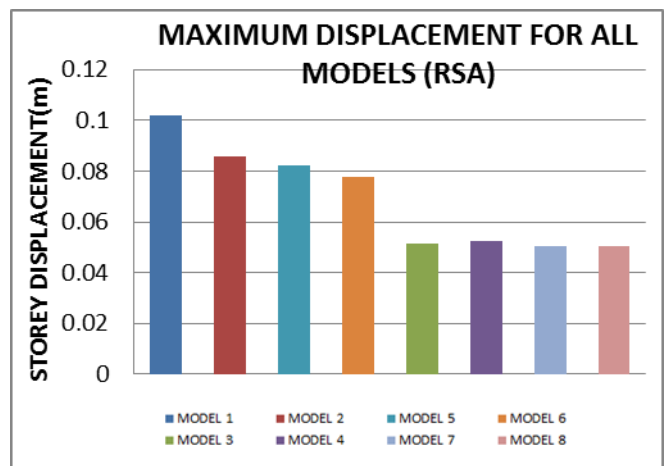Fig.17: Max. Story Shear for all models (ESA)

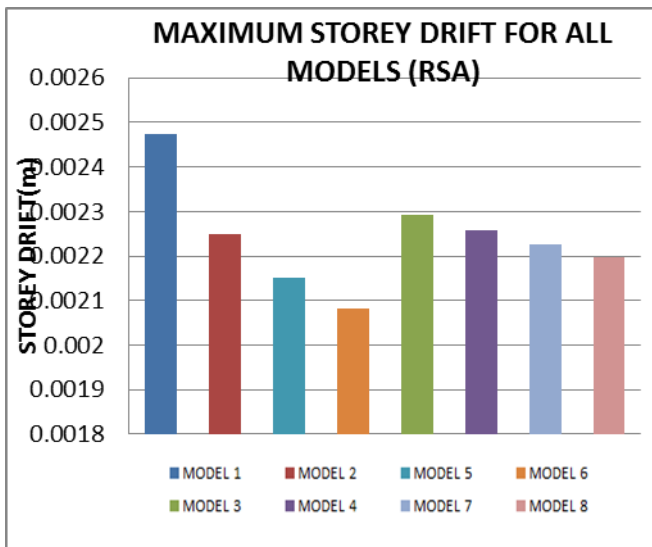Fig.18: Maximum Story Displacements for all models (RSA)
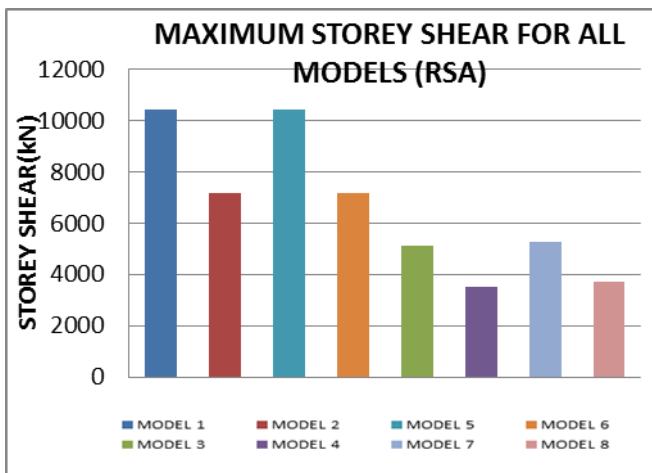
Fig.19: Maximum Story Drift for all models (RSA)

Fig.20: Maximum Story Shear for all models (RSA)

6. CONCLUSIONS

6.1 Storey displacement:

The maximum lateral storey displacement occurs at terrace floor for all types of structures (fixed base and isolator base). From the results it is observed that, there is increment of displacement for isolated models compared to fixed base models.

There is a decrement in the displacement for infill wall structures when compared to bare frame.

An average increment of displacement in the isolated base structure is 15% to 20% for Equivalent Static Analysis.

An average increment of displacement in the isolated base structure is 10% to 15% for Response Spectrum Analysis.

There is an increment in displacement values for ESA compared to RSA analysis results.

6.2 Storey drifts:

It is observed that the maximum storey drift occurs at mid height level and goes on decreasing from mid height towards roof level.

It is clearly observed from the result that all isolated based structures have decrement in drift values compared to fixed base structures.

All bare frame models have more drift values compared to infill frame models; hence wall infill's adds additional stiffness to the structure.

For all infill models average reduction of drift value is 8 to 15% compared to Bare frame models for Equivalent Static Analysis.

For all infill models average reduction of drift value is 5 to 10% compared to Bare frame models for Response Spectrum Analysis.

The results of Equivalent static analysis shows increment in drift values compared to results of Response spectrum analysis.

6.3 Base shear:

From the results the maximum shear is obtained at ground level as base shear is always directly proportional to self-weight of the structure and it occurs at ground contact area of the structure.

All bare frame models have less base shear values compared to infill frame models, indicates structure with increment in base shear will be much stiffer due to resistance against lateral forces.

The results indicate that all isolated based structures have lesser base shear values compared to fixed base structures.

It is clear that there is decrement in storey shear for isolated base models compared to fixed base models.

It is shown that, the average decrement in storey shear of 35% for base isolated structure in Equivalent Static Analysis and is of 50% in Response Spectrum Analysis.

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