CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Reinforced concrete frames with Masonry infill are a popular form of construction of high-rise buildings in urban and semi urban areas around the world.

The masonry infill consists of unreinforced clay bricks or hollow masonry blocks. The locally available masonry infill is commonly used because:

- Cheaper materials with low cost labour availability make this material the preferred choice for under developed or developing countries. The use of these materials is rapidly diminishing in developing or developed countries because of high labour costs, diminishing availability of skilled labour and associated extended construction time.
- The people feel much more secure if the peripheries of their living quarters are built using solid walls. It is very important to have solid walls for the majority of people from different cultures.
- Masonry brick skins with cavities are an effective weather protection as long as cavities, flashings and weep holes are built properly. The face brick outer skin of cavity walls provides a hard wearing maintenance free façade finish provided proper articulation is adopted and cracking of brick walls is avoided. The cavity brick construction is very much unaffordable in many under developed and developing countries. Their infill masonry usually consists of single skin masonry brick with externally applied cement/gypsum-lime render and paint for weatherproofing.

The term infill frame is used to denote a composite structure formed by the combination of a moment resisting plane frame and infill walls. The masonry can be of brick, concrete units, or stones .Usually the RC frame is filled with bricks as non structural wall for interior partition of rooms or external walls in a building. These buildings are generally designed as framed structures without regard to structural action of masonry infill walls. They are considered as non structural elements. Due to this in seismic action, RC frames purely acts as moment resisting frames leading to variation in expected structural response. The effect of infill panels on the response of R/C frames subjected to seismic action is widely recognized and has been subject of numerous experimental and analytical investigations over last five decades. In the current practice of structural design in India masonry infill panels are treated as non-structural element and their strength and stiffness contributions are neglected. In reality the presence of infill wall changes the behavior of frame action into truss action thus changing the lateral load transfer mechanism. In the present study, seismic performance of various configurations of infill panels in RC frames (as shown in Fig – 3, Fig – 6, Fig – 9) are compared with bare frame model (as shown in Fig – 1, Fig – 4, Fig – 7) using nonlinear analysis. Codes of some country develop provisions to take care of brick infill in RC frame. In the present study it is tried to compare the both the above mention method with the brick infill as diagonal strut. The main objectives of this study were to investigate the behavior of multistory infill frames and to evaluate their performance levels when subjected to earthquake loading.

1.2 MOTIVATION OF STUDY

Reinforced concrete (RC) framed buildings with infill walls are usually analyzed and designed as bare frames, without considering the strength and stiffness contributions of the in-fills. However, during earthquakes, these infill walls contribute to the response of the structure and the behavior of in-filled framed buildings is different from that predicted for bare frame structures. Therefore, based on the understanding of the actual response, design provisions need to be developed. Fortunately, a few countries already have codal provisions for seismic design of RC framed buildings with brick masonry in-fills. The present study evaluates the effect of infill walls as a structural member with a view to identify design methodologies that exploit the benefits of in-fills in a rational manner, for improving the contribution of these in-fills and for reducing the detrimental effects during earthquake.

STRUCTURAL RESPONSE OF FRAME STRUCTURES WITH MASONRY INFILLS

The addition of masonry infill panels to an originally bare moment resisting frame increases the lateral stiffness of the structure, thus shifting the natural period of vibration on the earthquake response spectrum in the direction of higher seismic base and storey shears, and attracting earthquake forces to parts of structures not designed to resist them. Furthermore, if the structure is designed to act as a moment resisting frame with a ductile response to the design level earthquakes, neglecting the contribution of infills, the stiffening effect of the infills may increase the column shears resulting in the development of plastic hinges at the top of columns that are in contact with the infill corners.

During an earthquake, these infill walls will increase the lateral earthquake load resistance significantly and often will be damaged prematurely, developing diagonal tension and compression failures or out-of-plane failures. The degree of lateral load resistance depends on the amount of masonry infill walls used. However, for the reasons explained above, masonry infills are commonly used in internal partitioning and external enclosure of buildings, increasing wall-to-floor area ratios. Therefore, in spite of the lower strength and expected brittleness of this type of masonry walls, the frames benefit from the extensive use of masonry walls until the threshold of elastic behaviour has been exceeded.

Beyond the premature failure of brittle masonry, the sudden loss of significant stiffness against lateral drift must be compensated by the slab/beam-column junction of the frame structure. This behaviour causes a high drift demand on the frame members, hence causing increased damage to the structure if there were no masonry infills.

The sudden loss of stiffness in the lateral load resistance mechanism causes a very high concentration of loading. This increased magnitude of loading causes significant damage or even the collapse of slab/beam-column joints. If one or two joints collapse others will follow, causing premature failure of the entire structure.If the frame structure joints are asked to perform satisfactorily under the abovementioned behaviour, it will be extremely hard to satisfy the joint behaviour requirements without using significant sized beams in both directions at the top of the columns in lieu of flat slabs without beams.

The earthquake experience with frame structures and masonry infill shows much greater damage at the vicinity of the first and last column of the frame structures. This is the reason why earthquake prone countries use beams to increase joint resistance.

Figure – 1: Effect of earthquake in brick infill

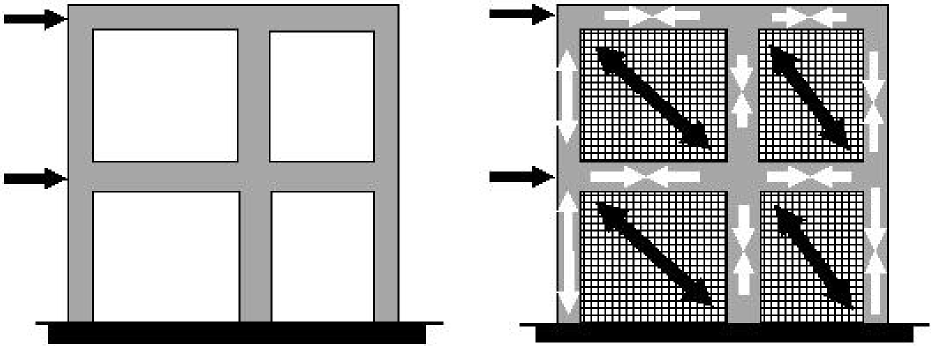
(reference of www.leightongeo.com/taiwan.htm)

Figure – 2: Collapse of building in earthquake

(reference of http://www.eas.slu.edu/Earthquake_Center/TURKEY/)

INFLUENCE OF MASONRY INFILLWALLS

Significant experimental and analytical research effort has been expended till date in understanding the behaviour of masonry infilled frames. Infills interfere with the lateral deformations of the RC frame; separation of frame and infill takes place along one diagonal and a compression strut forms along the other. Thus, infills add lateral stiffness to the building. The structural load transfer mechanism is changed from frame action to predominant truss action (Figure 1); the frame columns now experience increased axial forces but with reduced bending moments and shear forces. When infills are non-uniformly placed in plan or in elevation of the building, a hybrid structural load transfer mechanism with both frame action and truss action may develop. In such structures, there is a large concentration of ductility demand in a few members of the structure. For instance, the *soft-storey effect* (when a storey has no or relatively lesser infills than the adjacent storeys), the *short-column effect* (when infills are raised only up to a partial height of the columns), and *plan-torsion effect* (when infills are unsymmetrically located in plan), cause excessive ductility demands on frame columns and significantly alter the collapse mechanism. Another serious concern with such buildings is the out-of-plane collapse of the infills which can be life threatening. Even when the infills are structurally separated from the RC frame, the separation may not be adequate to prevent the frame from coming in contact with the infills after some lateral displacement; the compression struts may be formed and the stiffness of the building may increase. Infills possess large lateral stiffness and hence draw a significant share of the lateral force. When infills are strong, strength contributed by the infills may be comparable to the strength of the bare frame itself. The mode of failure of an infilled building depends on the relative strengths of frame and infill. And, its ductility depends on the (a) infill properties, (b) relative strengths of frame and infill, (c) ductile detailing of the frame when plastic hinging in the frame controls the failure, (d) reinforcement in the infill when cracking in infills controls the failure, and (e) distribution of infills in plan and elevation of the building.



(a) Frame action in bare frame **(b) Predominant truss action in infilled frame**

Figure – 3: Change in the lateral load transfer mechanism owing to inclusion of masonry infill walls.

In a bare frame, inelastic effects in RC frame members and joints cause energy dissipation, while in an infilled frame, inelastic effects in infills also contribute to it. Thus, energy dissipation in an infilled frame is higher than that in the bare frame. If both frame and infill are detailed to be ductile, then stiffness degradation and strength deterioration under cyclic loading are nominal. However, if inelastic effects are brittle in nature (*e.g.*, cracking of infill, bond slip failure in frame, or shear failure in frame members), the drop in strength and stiffness under repeated loading may be large. When physical gaps exist between the frame and the infills, or when sliding takes place in infills along mortar beds, the hysteresis loops demonstrate increased pinching.

1.3 SPECIFIC POINT OF STUDY

In present study, the effects of brick infill on behavior of RCC building are discussed. Few RCC buildings of different height are considered and earthquake load is applied on each building and effect of brick infill in the structure is compared and studied. Buildings are designed in STAAD PRO software and loading is applied according to IS 875 and IS 1893 (PART 1): 2002. Then all the cases i.e. bare frame, infill effect assuming infill as strut and as surface element are carefully studied.

CHAPTER 2

OBJECTIVE OF STUDY

Following are the objectives of the study:

1) To develop a model of a building of symmetric grid. This building of a regular type is considered to understand the behavior properly.

2) To study the guidelines of IS 1893 (PART 1):2002 and IS 875 with respect to general principles and design criteria.

3) To study the effect of brick infill as per IS 1893 (PART 1):2002 and that of relevant characteristic in real building model.

4) To study the appropriate consideration of brick infill as in real building model and to study the effects of these consideration in the building model and on seismic performance of building.

5) To compare changes in seismic performances affected because of brick infill

6) To draw graphs for changes in building performance and to attempts at developing characteristics equation for relationship amongst various parameters.

CHAPTER 3

3.1 LITERATURE REVIEW:

Proposed Draft Provisions and Commentary on Indian Seismic Code IS1983 By Dr. Sudhir K Jain and Dr. CVR Murty:

Masonry infills possess significant in-plane stiffness and strength, and hence contribute to the overall stiffness and strength of the building. The effect of the infill is lesser if openings are present. However, these infills pose the hazard of out-of-plane collapse. Hence, it is best to avoid situations that lead to infill panels of large width or height. Also, infill can cause irregularities in the building, e.g., short column effect. This should be recognized at the design stage itself.

A number of empirical relationships are available established in the literature for the modulus of elasticity of brick masonry. However, it is very difficult to define the modulus of elasticity of masonry precisely. Large variation has been reported in the relationship between elastic modulus and compressive strength of masonry, fm. For the purpose of this code, therefore, Drysdale's (1993) expression $m\ m\ E = k\ f$ was used with k taken as 550. A limited number of tests conducted recently at IIT Kanpur showed that this value agrees with experimental data reasonably well.

While a number of finite element models have been developed and used to predict the response of masonry infill frames, they are generally too cumbersome and time-consuming to be used in analyzing real-life infill frame structures in design offices. Therefore, a much simplified yet reasonably accurate macro-model is needed that considers various factors that govern the behavior of infill frames. This is usually done by modeling the infill panel as a single diagonal strut connected to the two compressive diagonal corners, as shown in Figure.

The key to the equivalent diagonal strut approach lies in determination of effective width of the equivalent diagonal strut. In the last few decades, several attempts have been made to estimate the effective width of such equivalent diagonal struts. The value of effective width adopted in this code is as per the following: Holmes, M., 1961, "Steel Frames with

Brickwork and Concrete Infilling," *Proceedings of the Institution of Civil Engineers,* Vol. 19, August, pp. 473-478.

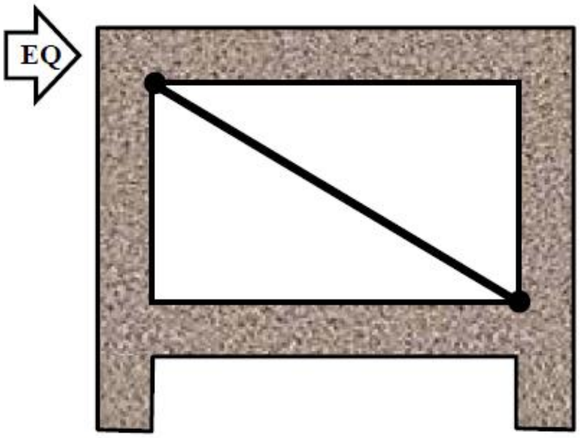


Figure – 4: Equivalent Diagonal Strut Model

The effect of opening in the infill wall is to reduce the lateral stiffness and strength of the frame. This can be represented by a diagonal strut of reduced width. The reduction factor *w* ρ is defined as ratio of reduced strut width to strut-width corresponding to fully infill frame. The equation for *w* ρ is based on the following:

> Mondal, G., 2003, *Lateral Stiffness of Unreinforced Brick Infilled RC Frame with Central Opening*, Master of Technology Thesis, Department of Civil Engineering, Indian Institute of Technology Kanpur, India, July.

Other than self weight, masonry infill is not expected to carry any gravity loads. The contribution of the infill in resisting the lateral loads can be substantial. However, to safeguard against RC frame being designed for a very low seismic force, the frame alone (without infill walls) should be designed to resist at least 50% of the total seismic force.

3.2 CODAL PROVISIONS:

Very few design code have made provisions on RC frames with brick masonry in-fills. Currently As a part of project on Building codes sponsored by Gujrat State Disaster Management Authority, Gandhinagar at Indian institute of Technology Kanpur, Dr. Sudhir K Jain and Dr. C V R Murty suggested some provision which are available as "Draft for comment" but it is still not ready to use. Such an effort to evaluate provision of Eurocode 8 alone in the light of experimental and analytical studies has already begun.

Non linear pushover analyses of plane frames were also performed to study the vulnerability of buildings designed as per BS 8110 and effect of masonry infill. Some of the codal provisions considering the contribution of the infill walls are discussed here.

Euro code 8 (EC 8):

Euro Code 8 considers brick masonry in-filled RC frames as ‘Dual’ System which is classified into three ductility classes, namely High, Medium and Low ductility class. When asymmetrical arrangement of the in-fill causes severe irregularities in the plan, three dimensional analyses are recommended for analysis. When irregularities are not so severe in plan, the accidental eccentricity, e_{li}, is increased by factor of 2, where, $e_{li} = \pm 0.05b_i$ and b_i is the floor dimension perpendicular to the considered direction of seismic action.

The design seismic action effects, except displacement, of RC frames are modified by modification factor of $S_d(T_{ave})/ S_d(T_{bf})$ where, $S_d(T_{ave})$ = design spectrum ordinate corresponding to the average of the natural period of the in-filled and $S_d(T_{bf})$ = that corresponding to the bare frame.

The average value, T_{ave} , of the first mode period of the structure is obtained as :

$$T_{ave} = \frac{T_{bf} + T_{if}}{2}$$

Where,

T_{bf} = First mode period of bare structure without taking into account any stiffness of the in-fills.

T_{if} = First mode period of bare structure taking into account the in-fills as structural elements.

The empirical expressions are provided for the calculations of T_{if}.

The design base shear force, V_b, is calculated as using T_{ave} and distributed over height of the building. The design lateral force, Q_i, at the floor level i is obtained as:

$$Q_i = V_B \frac{W_i h_i}{\sum_{j=1}^{N} W_j h_j}$$

Where,

W_i = the seismic weight of floor i

h_i = the height of floor i measured from the base

N = the total number of floors in the building (number of levels at which the masses are lumped).

When there is a considerable irregularity in the elevation, the code recommends a local increase of seismic effects in the respective storeys. In absence of precise model, a multiplication factor, α , for estimating the increase in the local seismic effect, is provided as a function of total reduction ΔV_{RW} of the resistance of the masonry walls in the storey concerned compared to more in-filled storey and sum $\sum V_{sd}$ of the seismic shear forces acting all structural vertical elements in that floor ,

$$\alpha = 1 + \frac{\Delta V_{RW}}{\sum V_{Sd}}$$

If "α" is less than 1.1, the scaling not required.

<u>Nepal building code 201 (NBC201)</u>:

One particular section of Nepal National Building Code 201 (NBC 201) provides mandatory rules of thumb, which are meant only for ordinary buildings up to three-storeys in the lowest seismic zone in Nepal. In higher seismic regions, adopting these thumb rules is expected to improve their performance. As per these rules, the building is designed to resist seismic forces by composite action. The design base shear force is calculated for the fundamental natural period of the bare structure and distributed over the height of the building as given by equation expressed below.

$$Q_i = V_B \frac{W_i h_i}{\sum_{j=1}^{N} W_j h_j}$$

Where,

W_i = the seismic weight of floor i

h_i = the height of floor i measured from the base

N = the total number of floors in the building (number of levels at which the masses are lumped).

At a particular level i, the shear force, V_{ij}, resisted by an individual load-resisting wall, j, is determined by:

$$V_{ij} = \frac{t_{eij}}{\sum_j t_{eij}} \sum_i^{Roof} Q_i$$

Where,

$\sum_i^{Roof} Q_i$ = the sum of floor loads above the particular level i

t_{eij} = the effective thickness of the particular lateral load resisting wall j at level i

$\sum_j t_{eij}$ = the sum of the effective thicknesses of the j lateral load resisting walls in level i.

The effective wall thickness, t_{eij} , including plaster is given by:

$$t_{eij} = t_i\left(1+\frac{t_{pi}E_p}{t_i E_b}\right)$$

Where,

t_i = the thickness of the lateral load resisting masonry walls at level i

t_{pi} = the total thickness of the plaster acting with the wall at level i

E_p = the modulus of elasticity of plaster and

E_b = the modulus of elasticity of brick masonry.

If a wall does not resist lateral load, compression strut action is not considered to be formed in the particular panel. Bare frame analysis and design, without assistance from infill walls, are done for the combined effects of the following loads:

- Applied gravity loads including the weight of in-fills, and seismic conditions obtained by superposing the effects of two sets of forces, namely:
- Frame member forces arising from the horizontal seismic base shear of $0.25C_dW_t$, where C_d is the design seismic coefficient and W_t is the seismic weight (dead load plus 25 percent of live load)
- Axial forces in frame members arising from the composite action of frame and walls under a horizontal seismic base shear of 0.9CdWt these axial forces are obtained by modeling infill wall panels as diagonal struts and by assuming the frame members and diagonal struts to be pin- jointed.
- The Design base shear force in a column abutting a lateral load resisting wall is $V_{ij}/2$, where as the shear force in the wall is $V_{ij.}$

Indian seismic code :(IS 1893:2000)

The Indian seismic code recommends linear elastic analysis of the bare structure excluding the effect of the brick infills13. The approximate fundamental natural period of vibration, T, (seconds) of an RC moment-resisting frame (MRF) building with brick infill panels is to be estimated by the empirical expression

$$T_{if} = \frac{0.09h}{\sqrt{d}}$$

Where,

h = the total height of the main structure, m

d= the maximum base dimension of the building along the considered direction of seismic force, m.

The code specifies a response reduction factor (2R), depending on the perceived seismic damage of the structure, characterized by ductile or brittle deformations. Hence, values of 6.0 and 10.0 are suggested for ordinary RC MRFs (those designed and detailed as per the Indian concrete code) and for special RC MRFs (those especially detailed to provide ductile behavior as per Indian seismic detailing code), respectively. The base shear is calculated using the first mode period of the building. To obtain the design seismic force, the elastic force corresponding to the fundamental natural period is then reduced to the actual capacity of the structure with the help of this factor. The calculated design base shear force, V_B, is then distributed over the height of the building. The design lateral force, Q_i , at the floor i is obtained by:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{N} W_j h_j^2}$$

Where,

W_i = the seismic weight of floor i

h_i = the height of floor i measured from the base

N = the total number of floors in the building (number of levels at which the masses are lumped).

CHAPTER 4

PROGRAMME OF STUDY

4.1. INTRODUCTION

Significant experimental and analytical research is reported in the literature since five decades, which attempts to understand the behavior of infill frames. Different types of analytical models based on the physical understanding of the overall behavior of an infill panels were developed over the years to mimic the behavior of in-filled frames. For brick infill the single strut model is the most widely used as it is simple and evidently most suitable for large structures (Das and Murthy, 2004). This also well explained in proposed draft provisions and commentary on Indian seismic code IS 1893(Part 1) by Dr. Sudhir K Jain and Dr. C V R Murty. Thus RC frames with un-reinforced masonry walls can be modeled as equivalent braced frames with infill walls replaced by equivalent diagonal strut which can be used in rigorous nonlinear push over analysis.

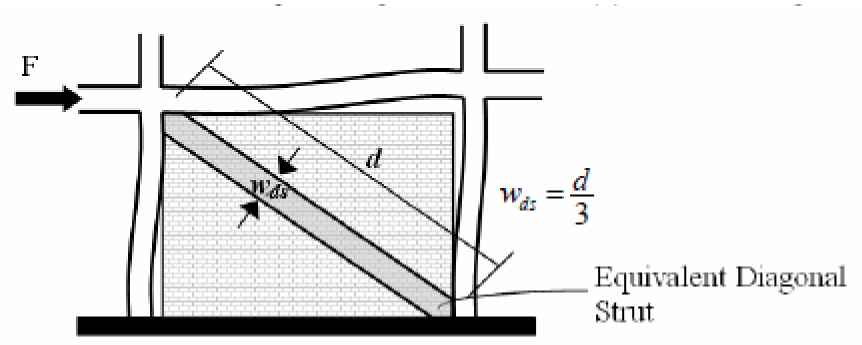


Figure – 5: <u>Details of equivalent strut</u>

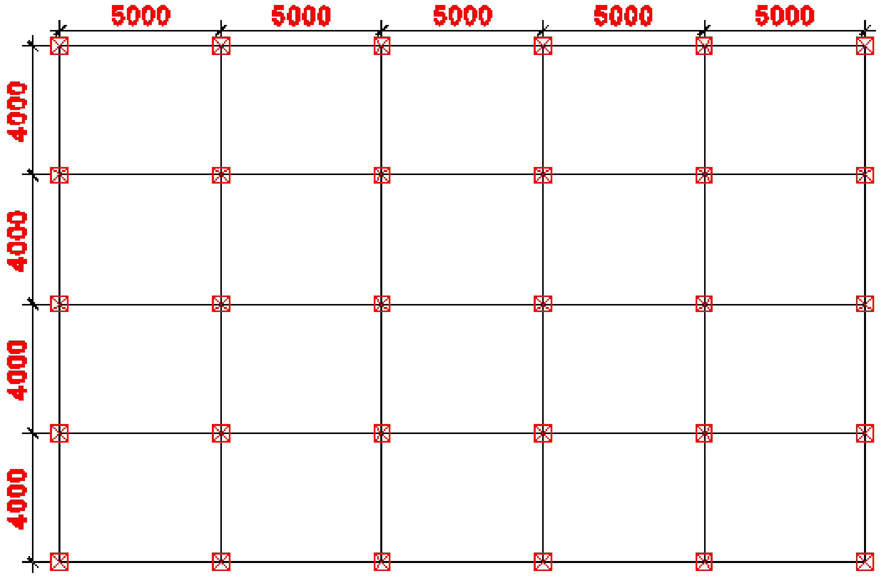
In this study, three different models of eight storey, six storey and three storey building symmetrical in the plan are considered.

Usually in a building 40% to 60% presence of Masonry in-fills (MI) are effective as the remaining portion of the Masonry Infill (MI) are meant for functional purpose such as doors and windows openings (Pauley and Priestley, 1992). In this study the buildings are modeled using 40 % Masonry In fills (MI) but arranging them in only periphery of the building as shown in the Figure 1. The building has five equal bays in X- direction and four equal bays in Y - directions with the plan dimension 25 m 16 m and a storey height of 3.1m each in all the floors. Further inputs include unit weight of the concrete is 25 kN/m^3, unit weight of masonry is 20 kN/m^3, Elastic modulus of steel is 2xl08 kN/m^2, Elastic Modulus of concrete is 25 kN/m^2, Strength of concrete is 25 N/mm^2 (M25), Yield strength of steel is 500 N/mm^2 (Fe-500). The modulus of brick masonry and strut width is obtained from commentary on Indian seismic code IS 1893(Part 1) by Dr. Sudhir K Jain and Dr. C V R Murty recommendations i.e. Em = 550f_m=2035 N/mm^2. Poison's ratio of concrete and masonry are 0.2 and 0.15 respectively. Window openings are assumed tiny relative to the overall wall area thus not included in the as they have no appreciable bearing on the general behavior of the structure (Jain, et al., 1997).

The mass of brick walls are lumped to act at the floor levels. The floor and roof slab are taken as 150 mm thick. The external and internal brick walls are taken to be 230mm and 115mm thick, respectively. The floor finish on floors and weathering course on roof is to be considered as 1.2kN/m^2 and 4.2kN/m^2 respectively. The live load on the floors and roof level are assumed to be 3.5kN/m^2 and 1.5kN/m^2 respectively.

Following different models are investigated in the study.

1. Eight Storey Building –
    a) Model 8.1 : Bare frame (Fig-6)
    b) Model 8.2 : Masonry infill as diagonal strut (Fig-7)
    c) Model 8.3 : Masonry infill as surface element (Fig-8)
2. Six Storey Building –
    a) Model 6.1 : Bare frame (Fig-9)
    b) Model 6.2 : Masonry infill as diagonal strut (Fig-10)
    c) Model 6.3 : Masonry infill as surface element (Fig-11)
3. Three Storey Building –
    a) Model 3.1 : Bare frame (Fig-12)
    b) Model 3.2 : Masonry infill as diagonal strut (Fig-13)
    c) Model 3.3 : Masonry infill as surface element (Fig-14)



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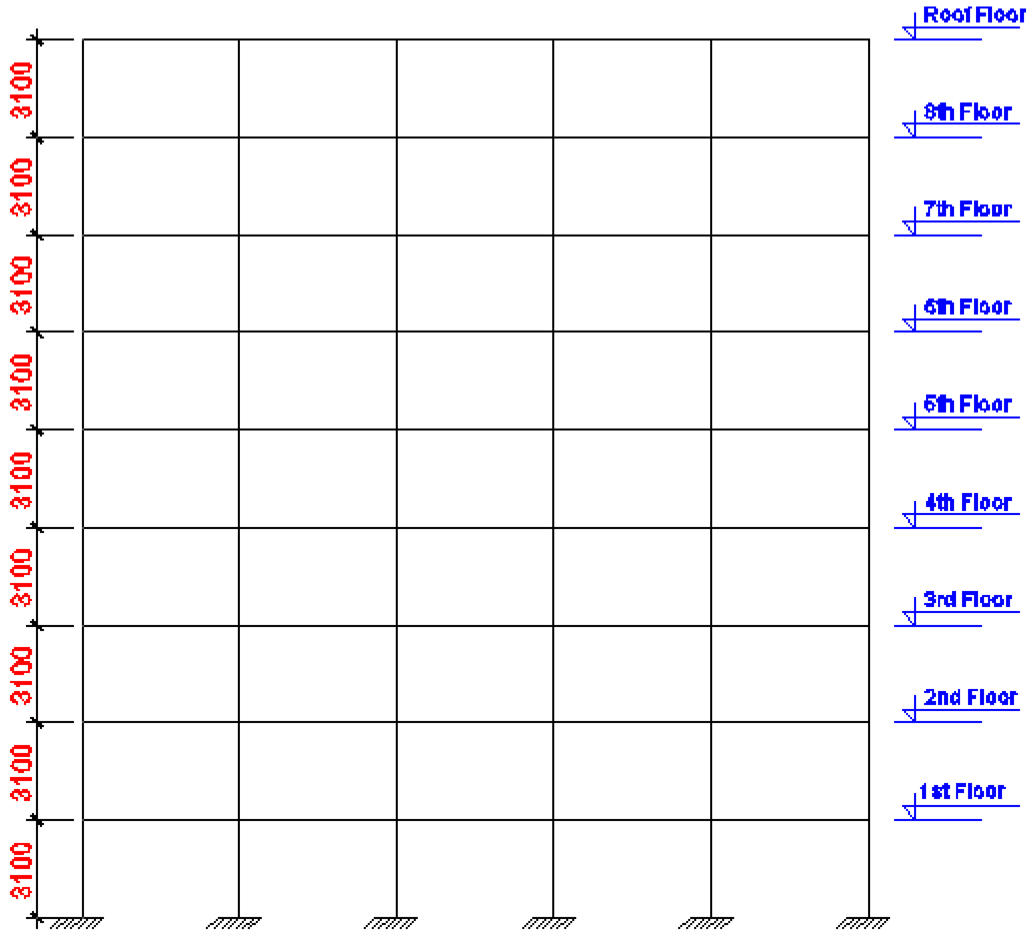

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Figure – 6: Model 8.1: Bare frame

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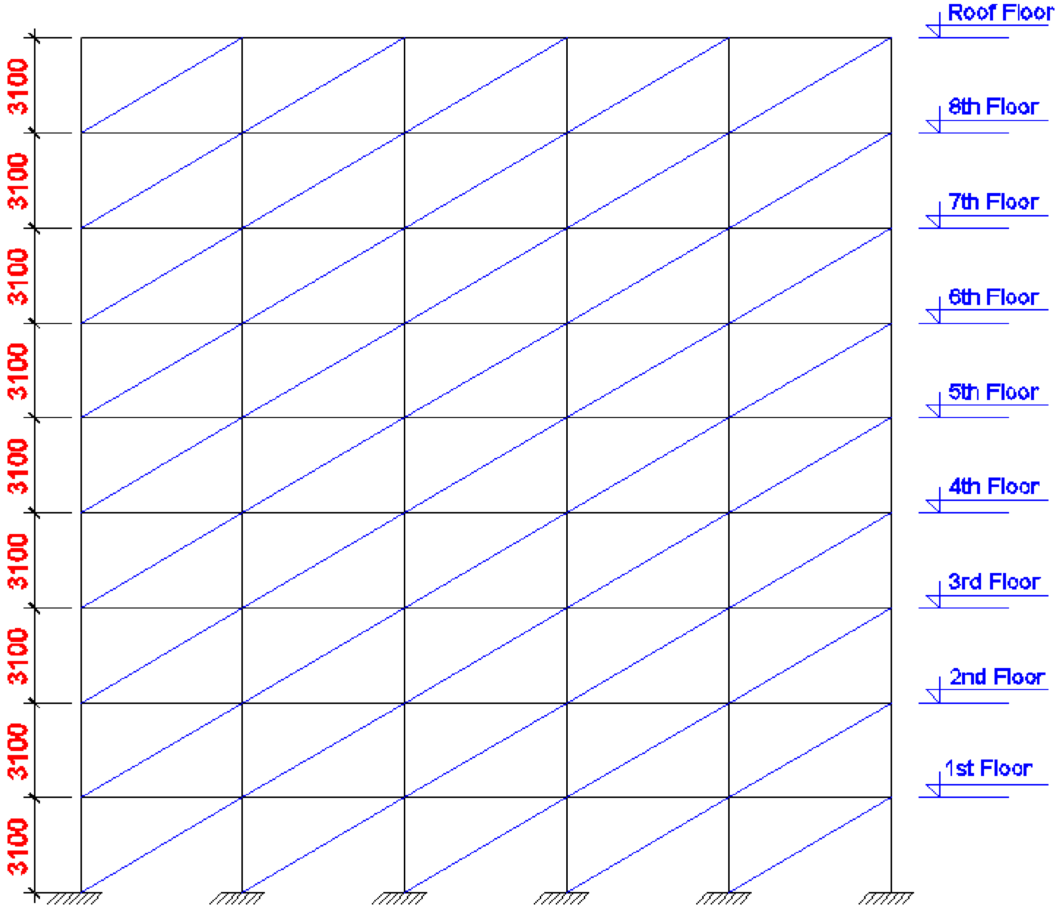

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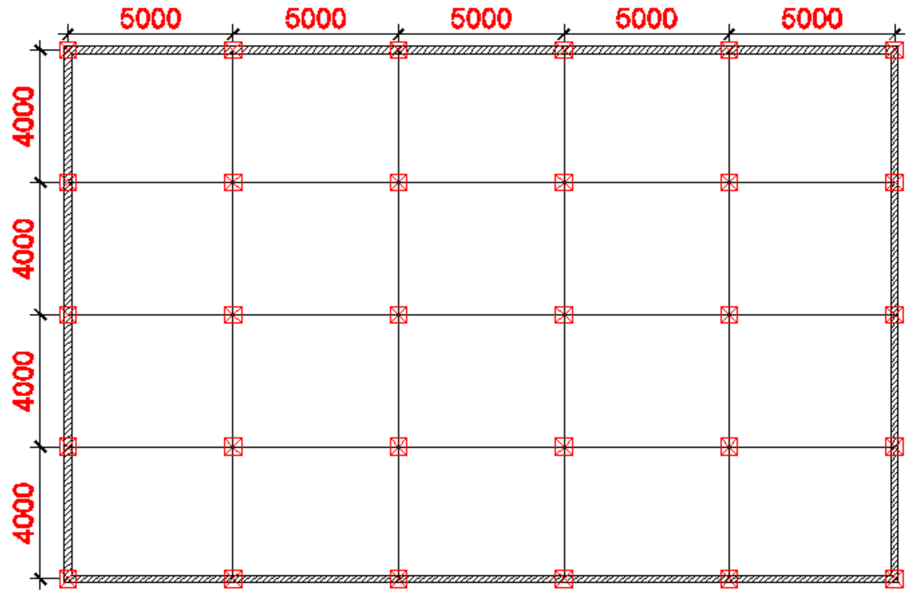
Figure – 7: Model 8.2: Masonry infill as diagonal strut



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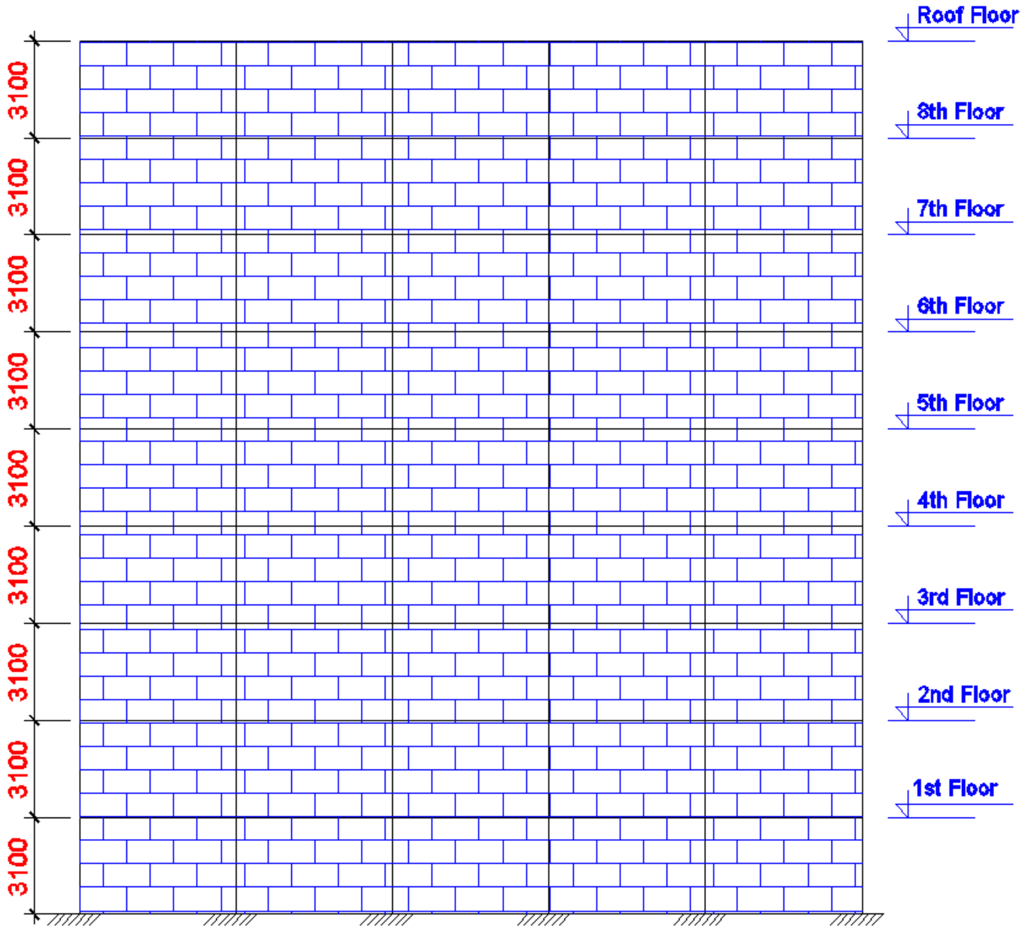

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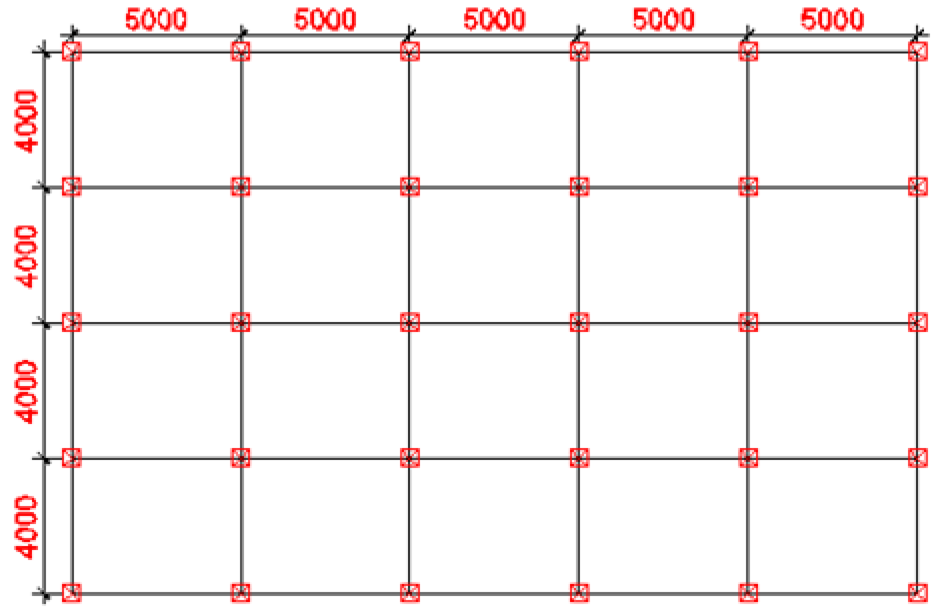
Figure – 8: Model 8.3: Masonry infill as surface element



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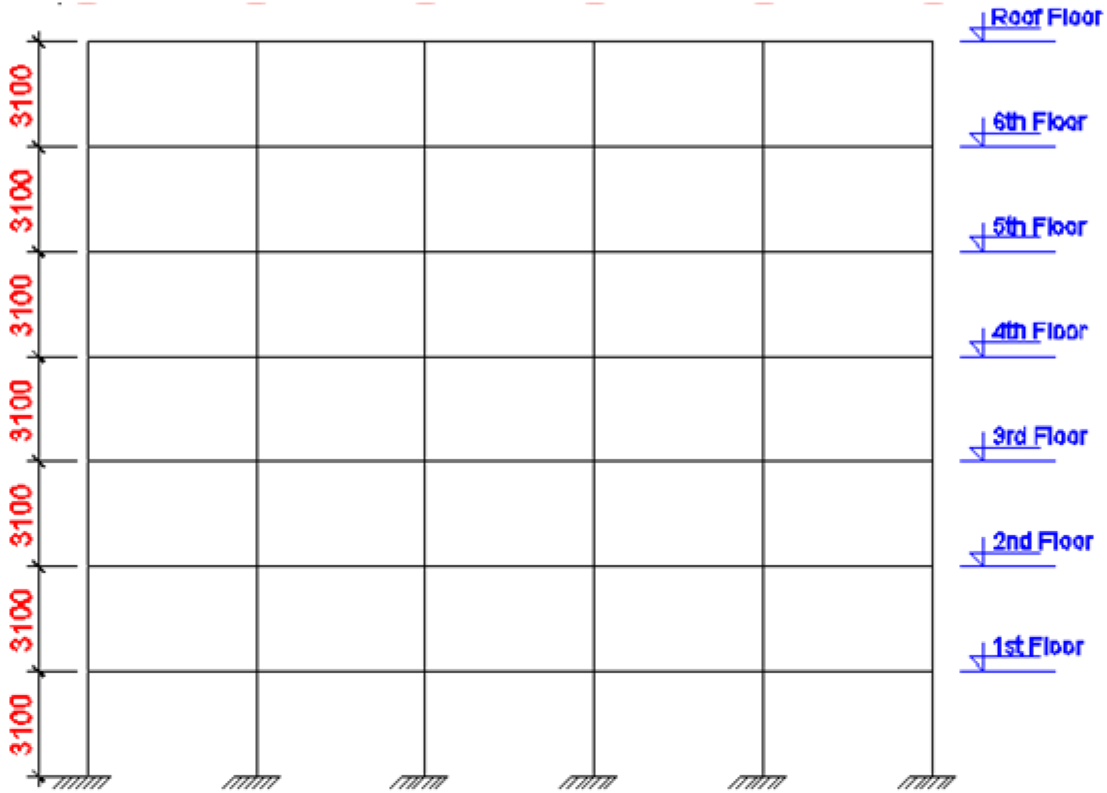
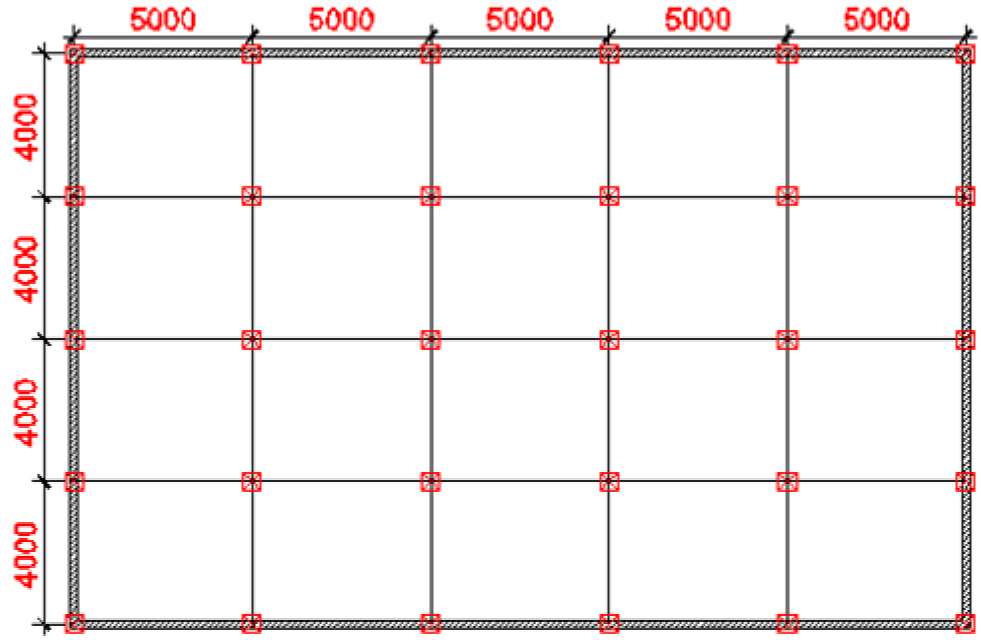


ELEVATION

Figure – 9: Model 6.1: Bare frame



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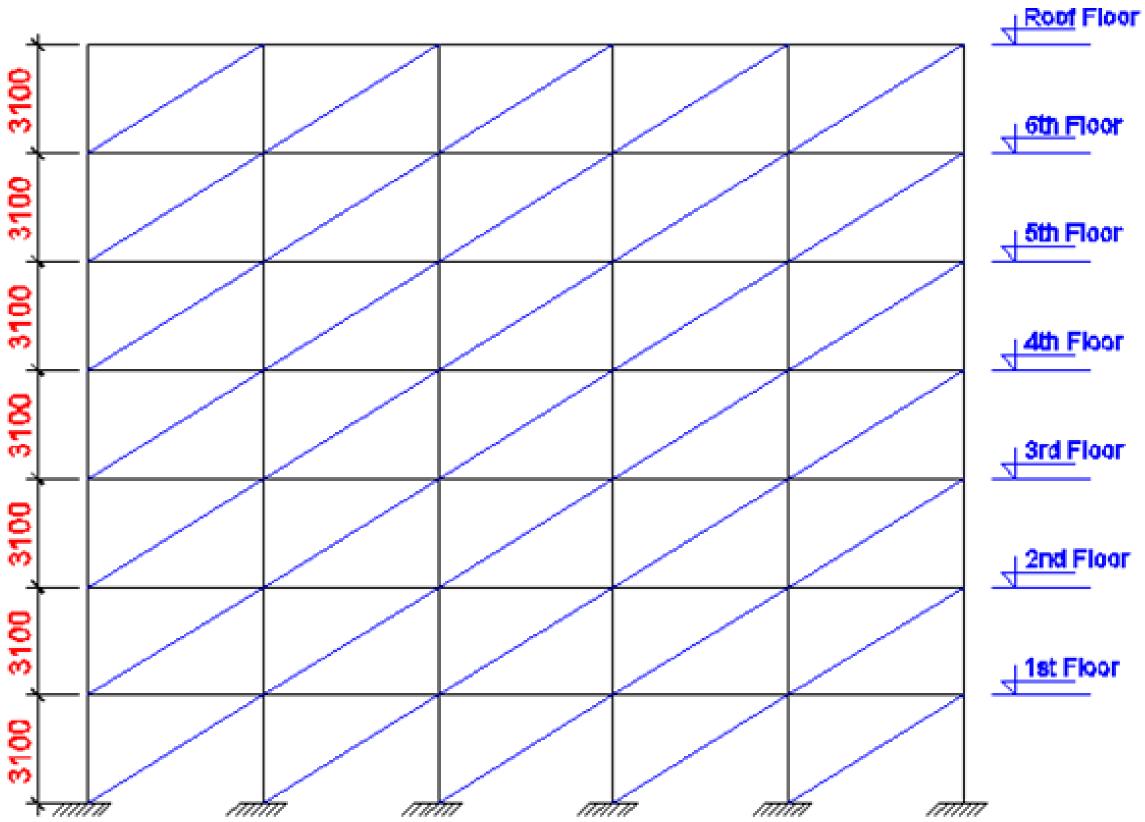

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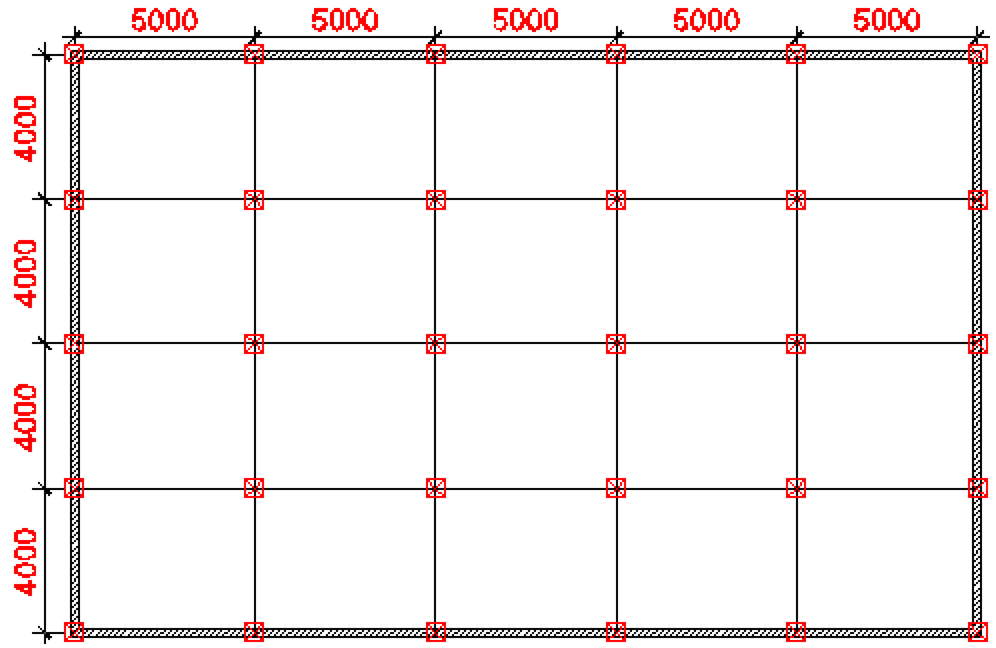
Figure – 10: Model 6.2: Masonry infill as diagonal strut



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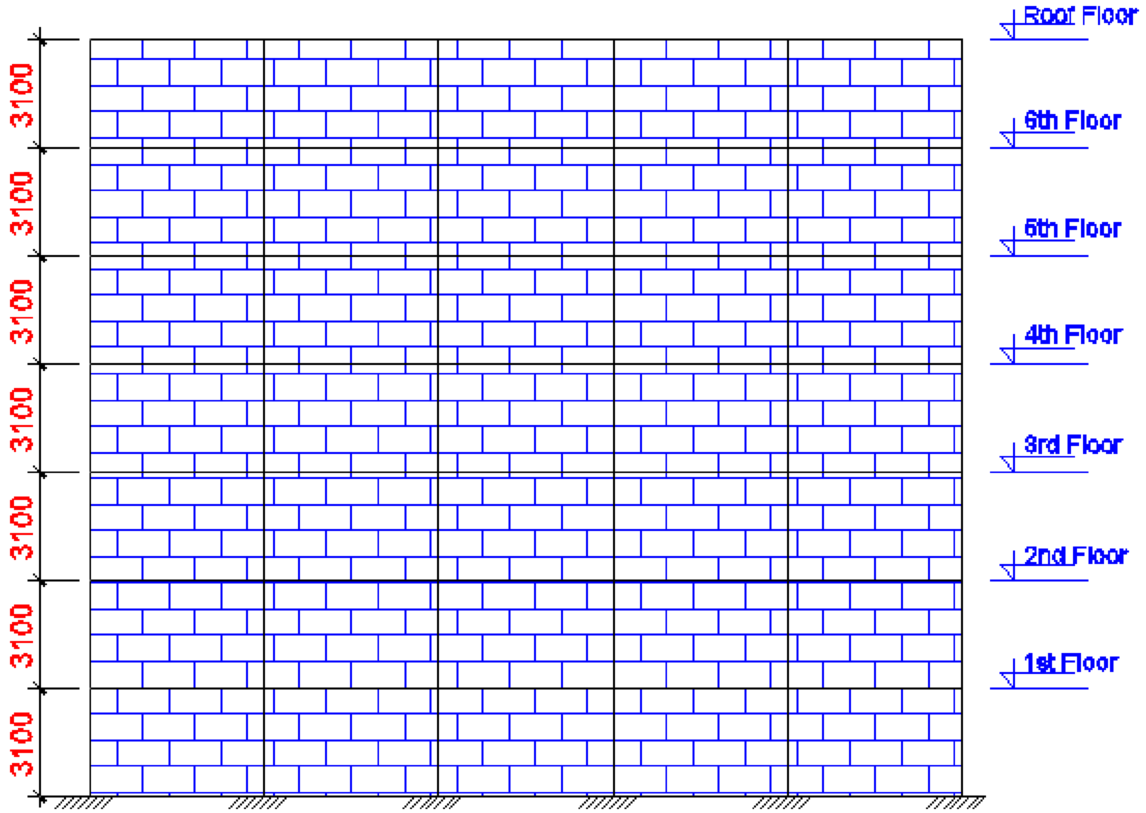

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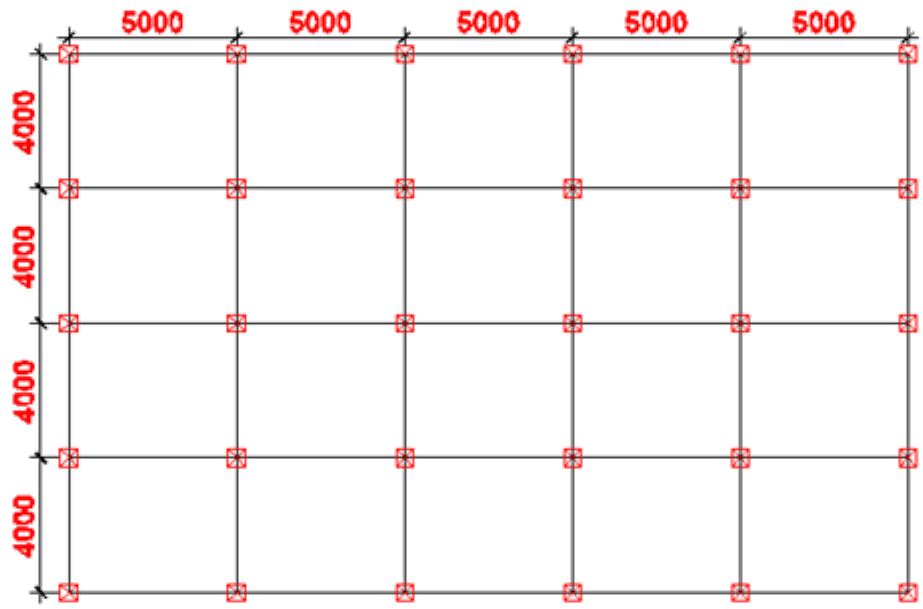
Figure – 11: Model 6.3: Masonry infill as surface element



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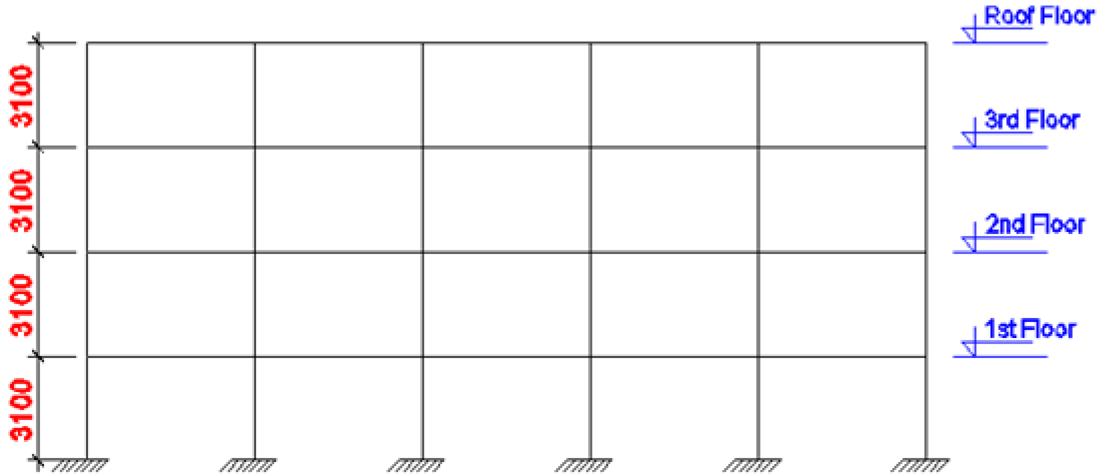

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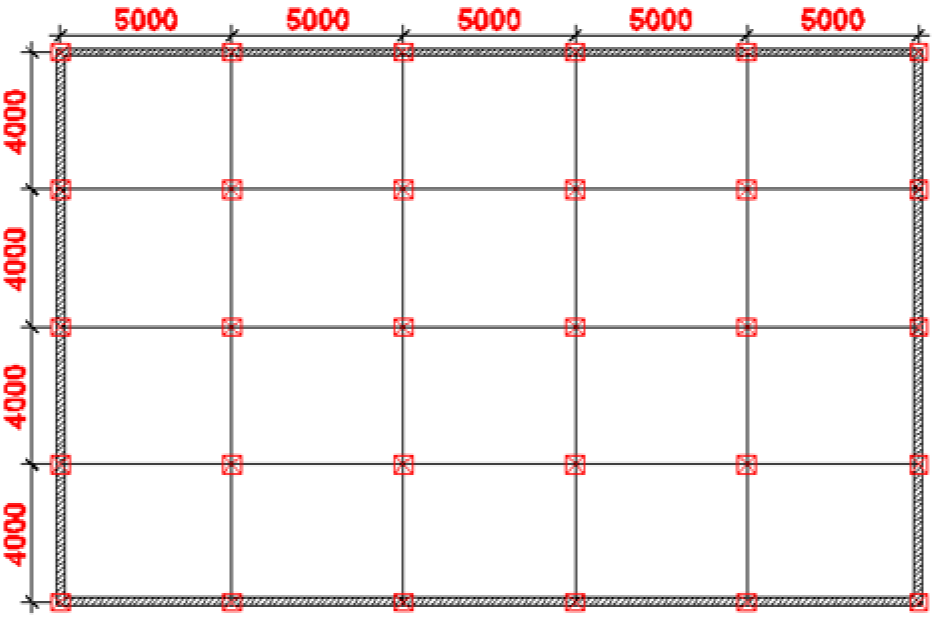
Figure – 12: Model 3.1: Bare frame



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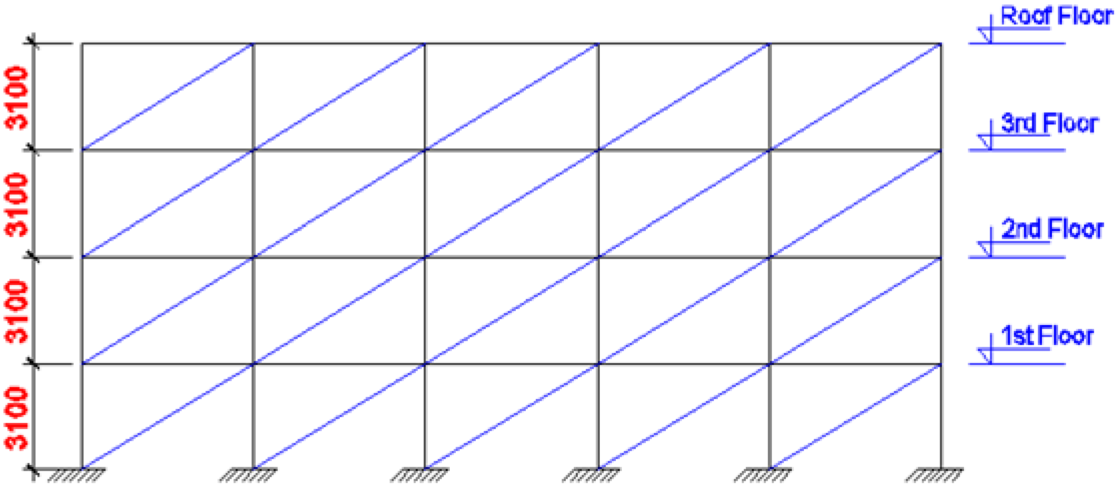

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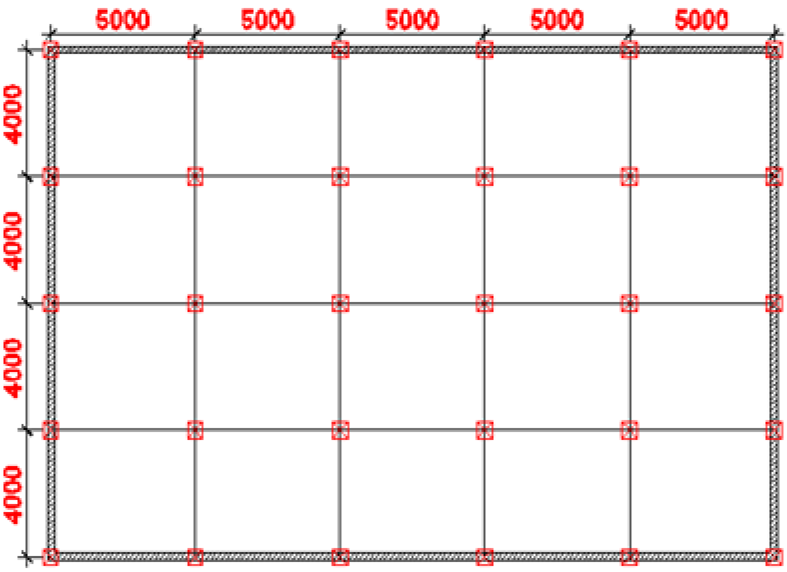
Figure – 13: Model 3.2: Masonry infill as diagonal strut



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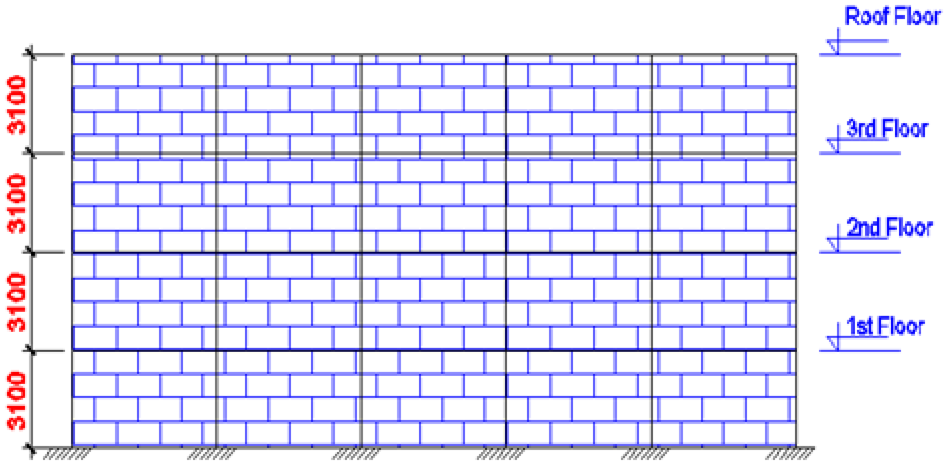

ELEVATION

Figure – 14: Model 3.3: Masonry infill as surface element

The Indian Seismic code recommends the linear elastic analysis of the bare frame structure excluding the effect of the brick infill. The approximate fundamental natural period of vibration, T (seconds) of an RC moment resisting frame (MRF) building with brick infill panels is to be estimated by empirical expression

$$T_a = \frac{0.09h}{\sqrt{d}}$$

Where,

h = Height of building, in m

d = Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.

The Indian code specifies a response reduction factor (R), depending on the perceived seismic damage of the structure, characterized by ductile or brittle deformations. The base shear is calculated using the first mode period of the building. To obtain the design seismic force, the elastic force corresponding to the fundamental natural period is then reduced to the actual capacity of the structure with the help of this factor. The calculated design base shear force, Vb, is then distributed over the height of the building. The design lateral force, Qi, at the floor, i, is obtain by:

$$Q_i = V_B \frac{W_i\, h_i^2}{\sum_{j=1}^{n} W_j\, h_j^2}$$

Where

Q_i = Design lateral force at floor i,

W_i = Seismic weight of floor i,

h_i = Height of floor i measured from base, and

n = Number of storeys in the building is the number of levels ate which the masses are located.

The total design base shear V_b, on the building is calculated as per IS 1893, and given by:

$$V_b = A_h W$$

Where,

W = Seismic weight of the building

A_h = Design horizontal acceleration spectrum value, using the approximate fundamental natural period Ta in the considered direction of vibration; and given by:

$$A_h = \frac{ZI}{2R}\frac{S_a}{g}$$

Where,

Z = Seismic zone factor taken as 0.24 for zone IV

I = Importance factor taken as 1for the ordinary residential buildings

R = response reduction factor taken as 5 for special moment resisting frame

S_a/g = the average response acceleration co-efficient.

The fundamental natural period, T (second), of the bare & in-filled frames are calculated using empirical expressions given in IS 1893. The structure is discretised into three dimensional frame elements. The nodes at each floor are constrained by rigid diaphragms.

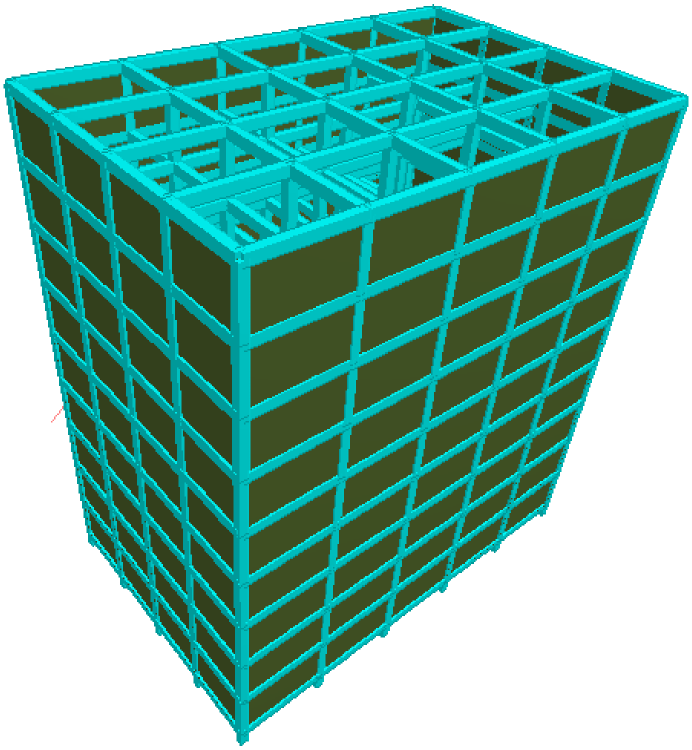

Figure – 15: Model 8.3: Masonry infill as surface element – Rendered View

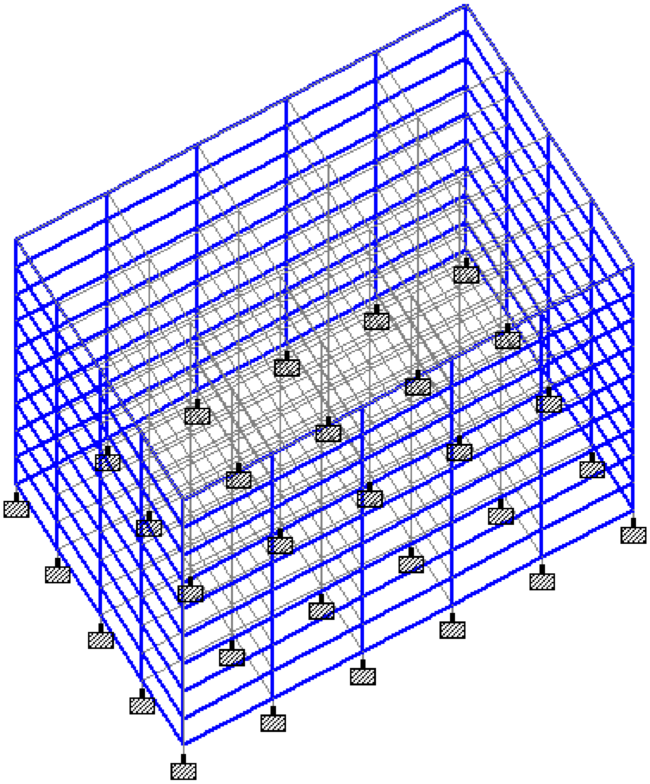

Figure – 16: Model 8.3: Masonry infill as surface element – 3D View

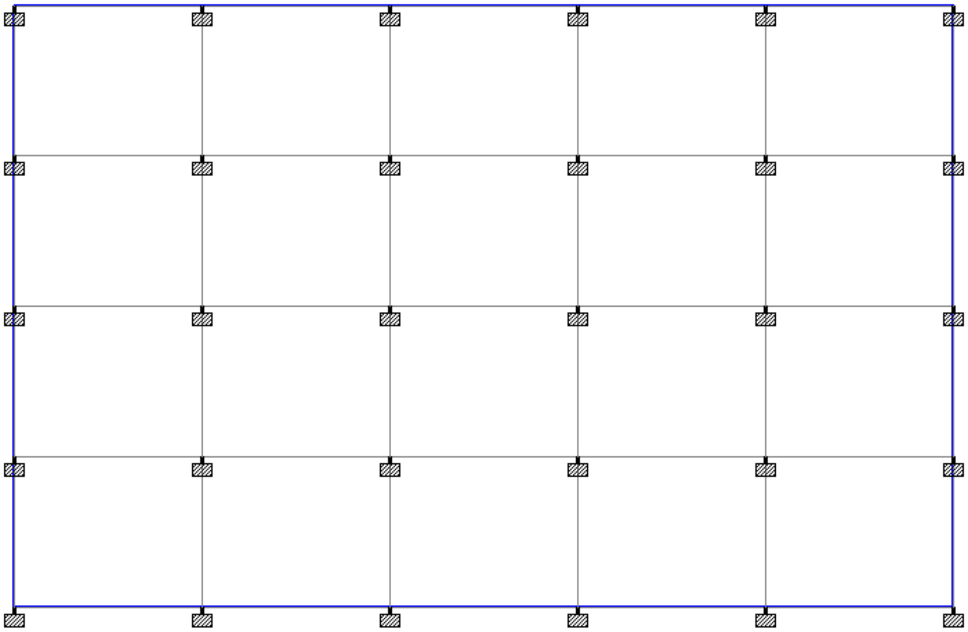

Figure – 17: Model 8.3: Masonry infill as surface element – Plan View

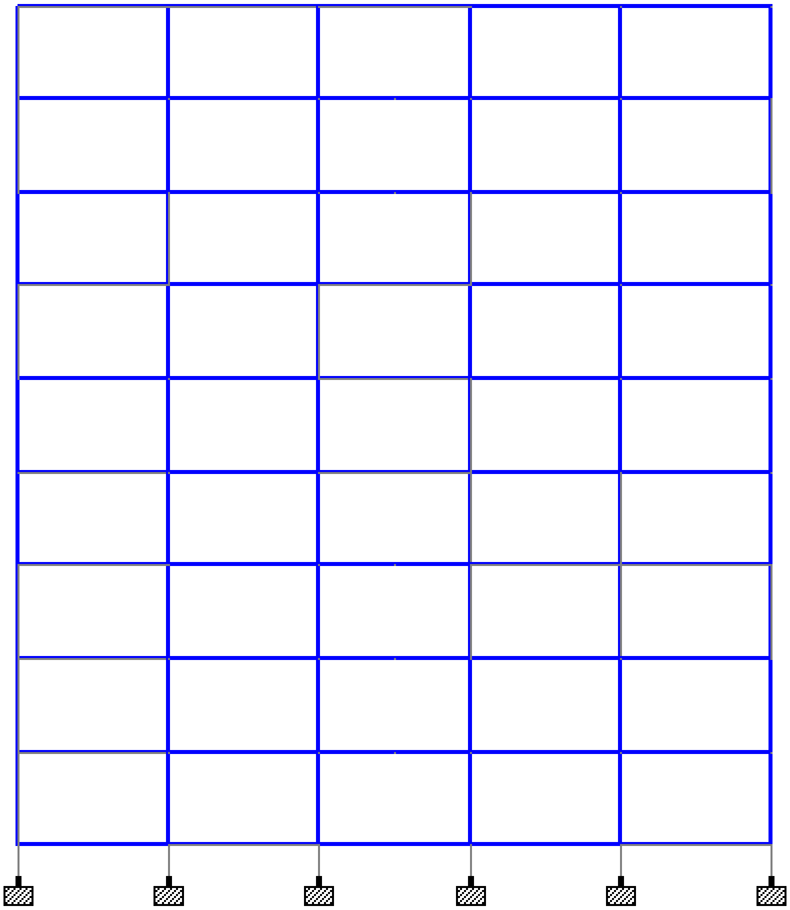

Figure – 18: Model 8.3: Masonry infill as surface element – Front View

TABLE 1

STRUCTURAL DATA	
HEIGHT	28.9m/22.7m/13.4m
WIDTH	16.0m
LENGTH	25.0m
NO. OF STOREY	8/6/4
STOREY HEIGHT	3.1m
TOTAL NO. OF COLUMN	30
TOTAL NO. OF BEAM	11 Nos/floor
CONCRETE GRADE	M25
STEEL GRADE	Fe500
DENSITY OF CONCRETE	25 kN/m^3
POISION RATIO	0.17
YOUNG'S MODULUS OF ELASTICITY	25000N/mm^2
BEAM DIMENSION	400x500mm
COLUMN DIMENSION	400x400mm

TABLE 2

EARTHQUAKE DATA	
ZONE VALUE	0.24
IMPORTANCE FACTOR	1.0
RESPONSE REDUCTION FACTOR	5
TYPE OF SOIL	2
DAMPING	5%
CUT OFF MODE	10

TABLE 3

DEAD LOAD	
ROOF	4.95kN/Sqm
TYPICAL FLOOR	4.95kN/Sqm
230 mm Thick Brick Wall	12kN/m
115 mm Thick Brick Wall	6kN/m
Parapet Wall Load	3.9kN/m

TABLE 4

LIVE LOAD	
ROOF	1.5kN/Sqm
TYPICAL FLOOR	3.5kN/Sqm

4.2 INPUT PARAMETERS

Input parameter are weight on each floor, seismic weight on each floor, dimension of building, beam and column, site condition of building, purpose of building, type of materials used.

Following paragraphs describe each input parameter briefly:

Design Acceleration Spectrum: Design acceleration spectrum refers to an average smoothened plot of maximum acceleration as a function of frequency or time period of vibration for a specified damping ratio for earthquake excitations at the base of a single degree of freedom system.

Importance Factor: It is a factor used to obtain the design seismic force depending on the functional use of the structure, characterized by hazardous consequences of its failure, its post-earthquake functional need, historic value, or economic importance.

Response Reduction Factor: It is the factor by which the actual base shear force, that would be generated if the structure were to remain elastic during its response to the Design Basis Earthquake (DBE) shaking, shall be reduced to obtain the design lateral force.

Zone Factor (Z): It is a factor to obtain the design spectrum depending on the perceived maximum seismic risk characterized by Maximum Considered Earthquake (MCE) in the zone in which the structure is located.

Structural Response Factor ($\frac{S_a}{g}$): It is a factor denoting the acceleration response spectrum of the structure subjected to earthquake ground vibrations, and depends on natural period of vibration and damping of the structure.

Damping: The effect of internal friction, imperfect elasticity of material, slipping, sliding, etc in reducing the amplitude of vibration and is expressed as a percentage of critical damping.

Modal Mass: Modal mass of a structure subjected to horizontal or vertical, as the case maybe, ground motion is a part of the total seismic mass of the structure that is effective in mode ***k*** of vibration. The modal mass for a given mode has a unique value irrespective of scaling of the mode shape.

Normal Mode: A system is said to be vibrating in a normal mode when all its masses attain maximum values of displacements and rotations simultaneously, and pass through equilibrium positions simultaneously.

Seismic Weight: It is the total dead load plus appropriate amounts of specified imposed load.

Partial safety factors for limit state design of reinforced concrete structure

In the limit state design of reinforced concrete structures, the following load combinations shall be accounted for:

1) 1.5 (DL+LL)
2) 1.2 (DL+ZL+EL)
3) 1.5 (DL+EL)
4) 0.9DL+1.5EL

4.3 Earthquake Lateral Force Analysis

The design lateral force shall first be computed for the building as a whole. Then design lateral force calculated shall be distributed to the various floor levels. The overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragm action. There are two commonly used procedures for specifying seismic design lateral forces:

1. Equivalent static force analysis
2. Dynamic analysis

Equivalent static force analysis

The equivalent lateral force analysis for an earthquake converts a dynamic analysis into partly dynamic and partly static analyses for finding the maximum displacement (or stresses) induced in the structure due to earthquake excitation. The equivalent lateral force for an earthquake is defined as a set of lateral static forces which will produce the same peak response of the structure as that obtained by the dynamic analysis of the structure under the same earthquake. This equivalence is restricted only to a single mode of vibration of the structure. Inherently, equivalent static lateral force analysis is based on the following assumptions:

1. Structure is rigid.
2. Perfect fixity between structure and foundation.
3. Same acceleration is induced in each point of structure during ground motion.
4. Dominant effect of earthquake is equivalent to horizontal force of varying magnitude over the height.
5. Base shear on the structure is determined approximately.

However, during an earthquake structure does not remain rigid, it deflects, and thus base shear is disturbed along the height.

The limitation of equivalent static lateral force analysis is that empirical relationships are used to specify dynamic inertial forces as static forces which do not explicitly account for the dynamic characteristics of the particular structure being designed or analyzed. These formulas were developed to approximately represent the dynamic behavior of regular structures. For such structures, the equivalent static force procedure is most often adequate. Structures that are classified as irregular violate the assumptions on which the empirical formulas, used in the equivalent static force procedure, are developed.

Step by step procedure for Equivalent static force analysis according to code

Step-1: Depending on the location of the building site, identify the seismic zone and assign Zone factor (Z)
Step-2: Compute the seismic weight of the building (W)
Step-3: Compute the natural period of the building (T_a)
Step-4: Obtain the data pertaining to type of soil conditions of foundation of the building
Step-5: Using T_a and soil type, compute the average spectral acceleration as per code
Step-6: Assign the value of importance factor (I) depending on occupancy and/or functionality of structure
Step-7: Assign the values of response reduction factor (R) depending on type of structure
Step-8: Knowing Z,$\frac{s_a}{g}$, R and I compute design horizontal acceleration coefficient (A_h)
Step-9: Using A_H and W compute design seismic base shear (V_B), from V_B=A_H W as per code

Dynamic Analysis

1.) Dynamic analysis is classified into two types,
a.) Response spectrum method
b.) Time history method
2.) Dynamic analysis shall be performed to obtain the design seismic force and its distribution along the height of the building and to the various lateral load resisting elements, for the following buildings:
a.) Regular buildings Those greater than 40 m in height in Zones IV and V and those greater than 90 m in height in Zones II and III.

b.) Irregular buildings — All framed buildings higher than 12 m in Zones IV and V, and those greater than 40 m in height in Zones II and III.

3.) Time History Method: Time history method of analysis, when used, shall be based on an appropriate ground motion and shall be performed using accepted principles of dynamics.

4.) Response Spectrum Method: Response spectrum method of analysis shall be performed using the design spectrum

5.) Modes to be considered: The number of modes to be used in the analysis should be such that the sum total of modal masses of all modes considered is at least 90%.

Step by step procedure for Response spectrum method

Step-1: Depending on the location of the building site, identify the seismic zone and assign Zone factor (Z)

Step-2: Compute the seismic weight of the building (W**)**

Step-3: Establish mass [M] and stiffness [K] matrices of the building using system of masses lumped at the floor levels with each mass having one degree of freedom, that of lateral displacement in the direction under consideration. Accordingly, to develop stiffness matrix effective stiffness of each floor is computed using the lateral stiffness coefficients of columns and infill walls. Usually floor slab is assumed to be infinitely stiff.

Step-4: Using [M] and [K] of previous step and employing the principles of dynamics compute the modal frequencies, {w} and corresponding mode shapes, [j] .

Step-5: Compute modal mass M_k of mode k as per code

Step-6: Compute modal participation factors P_k of mode k as per code

Step-7: Compute design lateral force (Q_{ik}) at each floor in each mode as per code

Step-8: Compute storey shear forces in each mode (V_{ik}) acting in storey i in mode k as per code

Step-9: Compute storey shear forces due to all modes considered, V_I in storey i, by combining shear forces due to each mode as per code.

4.4 OUTPUT PARAMETERS:

Parameter in which changes is noted after modifying the structure are frequency, time period, spectral acceleration, base shear, SRSS shear, CQC shear, SHEAR 10 pt shear, ABS shear, storey shear, storey drift and mass participation factor.

Modal Participation Factor: Modal participation factor of mode k of vibration is the amount by which mode k contributes to the overall vibration of the structure under horizontal and vertical earthquake ground motions. Since the amplitudes of 95 percent mode shapes can be scaled arbitrarily, the value of this factor depends on the scaling used for mode shapes.

Natural Period: Natural period of a structure is its time period of undamped free vibration.

Storey Drift: It is the displacement of one level relative to the other level above or below.

Storey Shear: It is the sum of design lateral forces at all levels above the storey under consideration.

Storey drift Limitation: The storey drift in any due to minimum specified design lateral load with partial factor of safety 1.0 shall not be increased by 0.004 times the storey height.

SRSS METHOD: It is approximate for combining modal response. In this method, the squares of a specific response are summed. The square root of this sum is taken to be combines effect. It is important to note that the quantities combined are those for each individual mode.

$$r_o = (\sum_{n=1}^{nN} {r_{no}}^2)^{0.5}$$

This method gives excellence response estimates for structure with well separated natural frequencies.

CQC METHOD: It is modal combination method based on the use of cross modal coefficient. The cross modal coefficient reflects the duration and frequency content of seismic event as well as the modal frequencies and damping ratio of the structure.

$$r_o = (\sum_{i=1}^{N} \sum_{n=1}^{N} \rho_{in} r_{io} r_{no})^{0.5}$$

This method gives acceptable response estimates for types of structure having well separated natural frequencies as well as to those having closely spaced natural frequencies like in multistory building with unsymmetrical plan.

ABS METHOD: It is modal combination method based on assumption that all modal peaks occurs at the same time and algebraic sign is ignored to get an upper bound to the peak value of the total response. This upper bound value (ABS VALUE) is too conservative.

$$r_o \le \sum_{n=0}^{N} r_{no}$$

4.5 DETAILS OF STEPS PERFORMED

1. The building is designed in STAAD PRO V8i with dimension and specification discussed above.
2. For calculating seismic force, every joint in structure is pinned and static analysis is performed to calculate resulting reaction on each joint. Reaction in global y direction is taken as seismic force in all direction and then it is applied on each joint.
3. Then response spectrum analysis is done.
4. Then resulting building model is analyzed and value of output parameter is noted down.
5. These steps are repeated for different height & different type of structures

CHAPTER 5

RESULT AND DISCUSSION

Following result is obtained in the present study which is tabulated and graph is drawn for each output parameter.

Table 5: Fundamental Natural Time period (sec.) of Various Structural systems

System	Model 8.1		Model 8.2		Model 8.3	
Direction	X	Z	X	Z	X	Z
As per IS 1893:2002	0.520	0.650	0.520	0.650	0.520	0.650
As per STAAD analysis	1.436	1.40	1.08246	1.08246	0.70126	0.70126

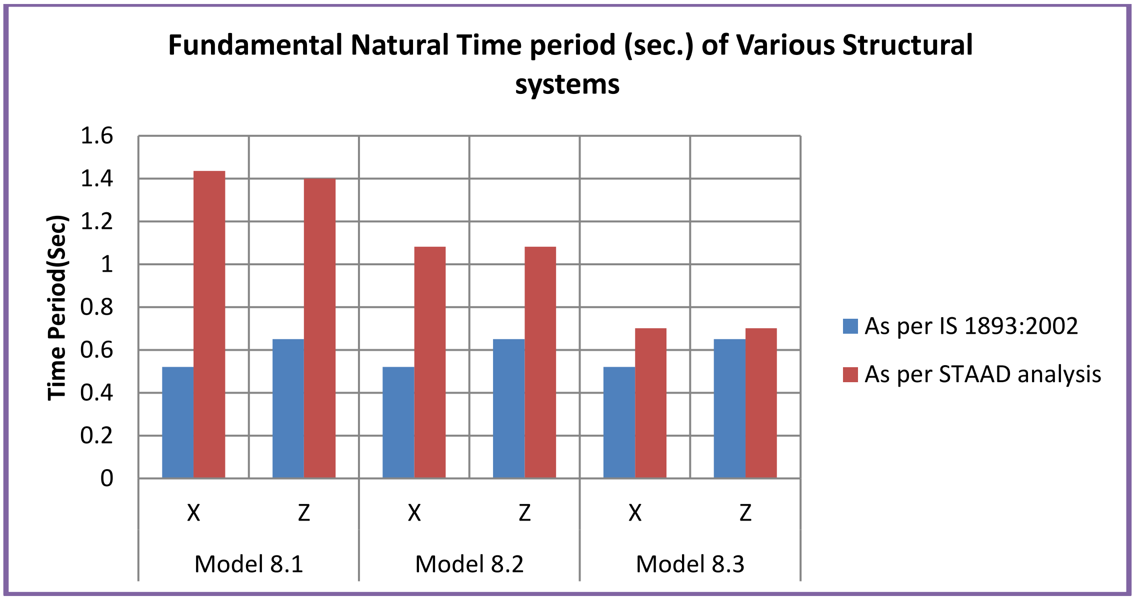

Figure – 19: Comparison of Fundamental Natural Time Period of various structural System

Table 6: Fundamental Natural Time period (sec.) of Various Structural systems

System	Model 6.1		Model 6.2		Model 6.3	
Direction	X	Z	X	Z	X	Z
As per IS 1893:2002	0.4086	0.5108	0.4086	0.5108	0.4086	0.5108
As per STAAD analysis	1.2803	1.2803	0.7349	0.7349	0.551	0.551

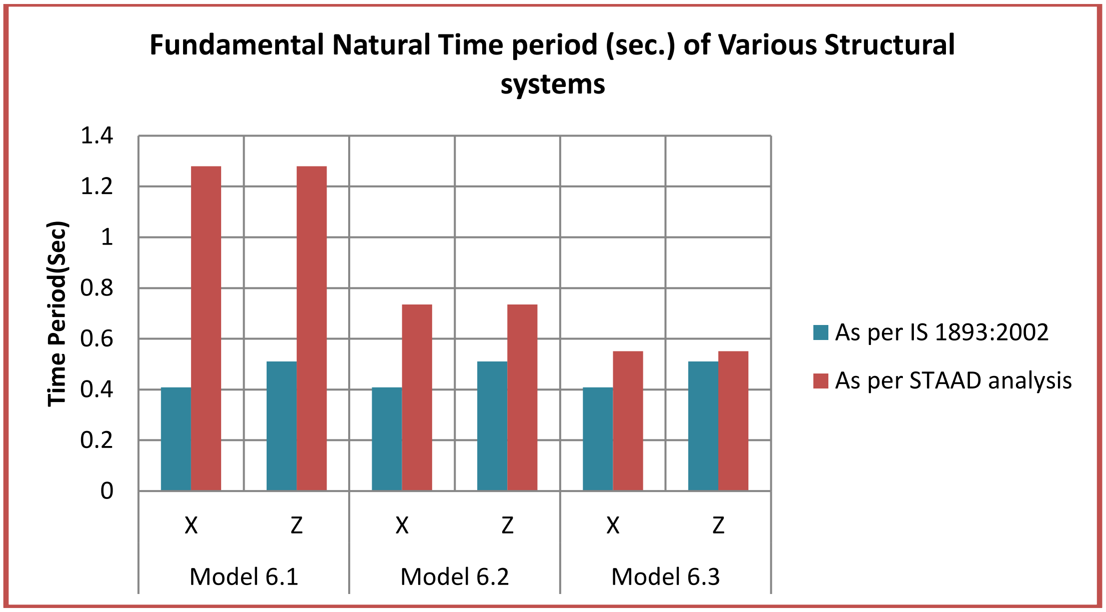

Figure – 20: Comparison of Fundamental Natural Time Period of various structural System

Table 7: Fundamental Natural Time period (sec.) of Various Structural systems

System	Model 3.1		Model 3.2		Model 3.3	
Direction	X	Z	X	Z	X	Z
As per IS 1893:2002	0.2412	0.3015	0.2412	0.3015	0.2412	0.3015
As per STAAD analysis	0.73285	0.73285	0.41986	0.41986	0.33546	0.33546

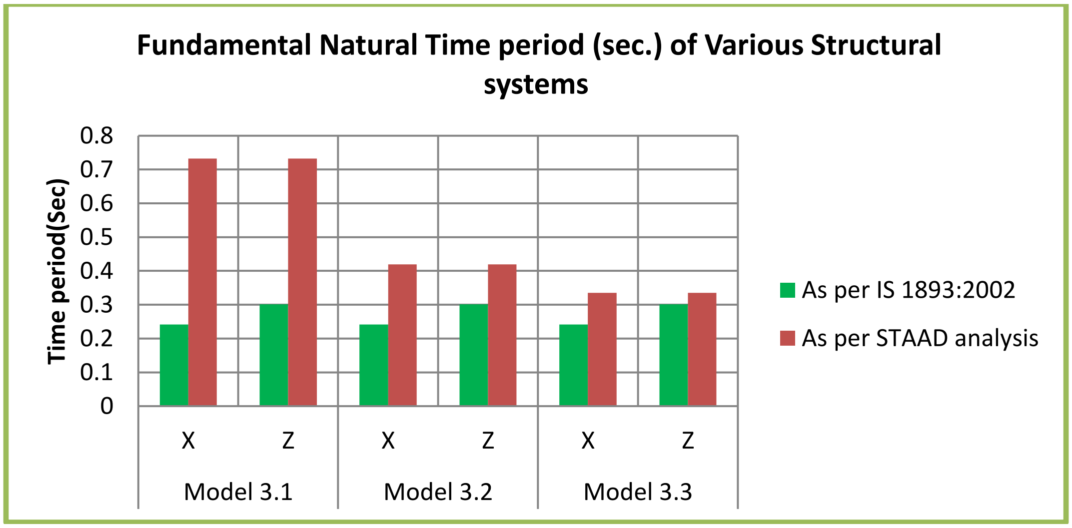

Figure – 21: Comparison of Fundamental Natural Time Period of various structural System

The results obtained for fundamental natural period are shown in Table 5, Table 6 & Table 7 for 8th, 6th & 3rd storey building. It is observed that the analytical natural period do not tally with the natural periods obtained from the empirical expression of the code. Introduction of infill panels in the RC frame reduces the time period of bare frames and also enhances the stiffness of the structure. Bare frame idealization leads to overestimation of natural periods and under estimation of the design lateral forces. It has been found that in Outer infill configuration there was drastic reduction in time period compared to the bare frame. Again it is observed that time period of model with diagonal strut & model with surface element for infill walls is quite comparative.

Table 8: Spectral acceleration & Design Seismic Co-efficient 8th storey buildings for Mode 1

System	Model 8.1		Model 8.2		Model 8.3	
Direction	X	Z	X	Z	X	Z
Spectral acceleration	0.83004	0.83004	1.25639	1.25639	1.9394	1.9394
Design Seismic Co-efficient	0.0199	0.0199	0.0302	0.0302	0.0465	0.0465

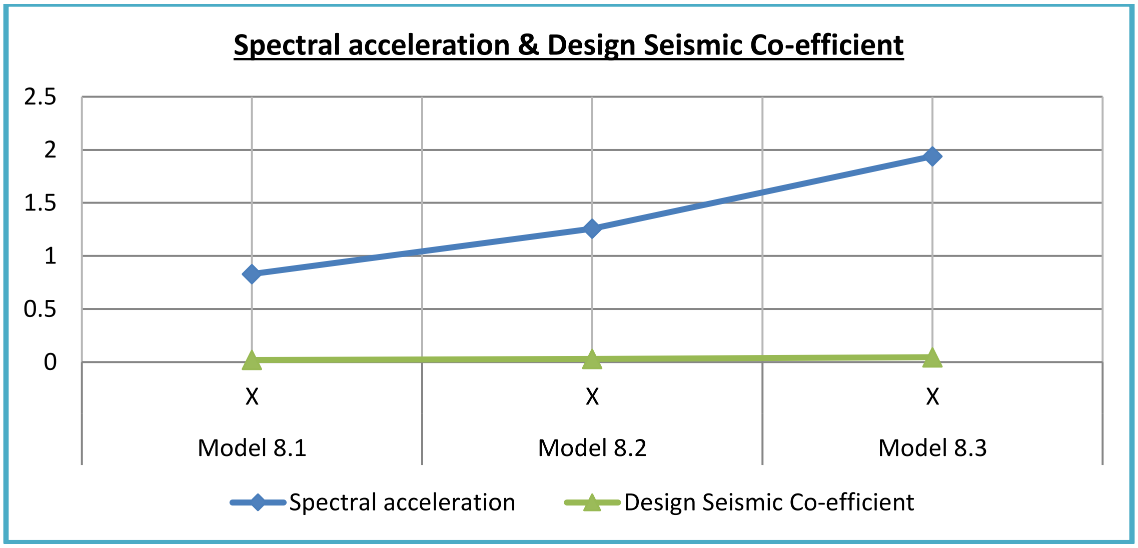

Figure – 22: Comparison of Spectral acceleration & Design Seismic Co0efficient of various structural System

Table 9: Spectral acceleration & Design Seismic Co-efficient 6th storey buildings for Mode 1

System	Model 6.1		Model 6.2		Model 6.3	
Direction	X	Z	X	Z	X	Z
Spectral acceleration	1.06230	1.06230	1.85062	1.85062	2.4685	2.4685
Design Seismic Co-efficient	0.0255	0.0255	0.0444	0.0444	0.0592	0.0592

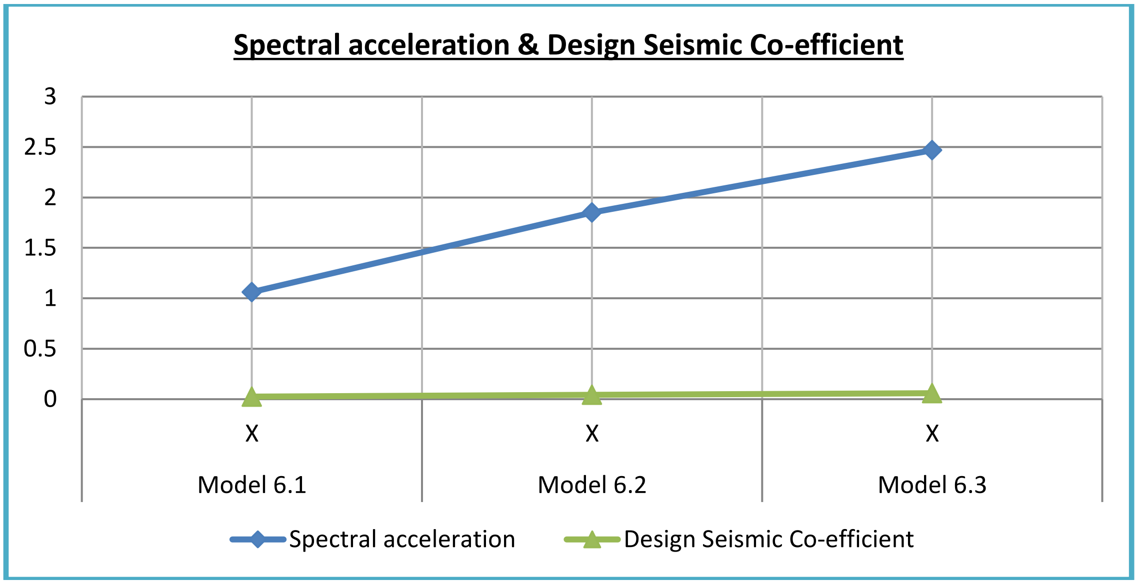

Figure – 23: Comparison of Spectral acceleration & Design Seismic Co0efficient of various structural System

Table 10: Spectral acceleration & Design Seismic Co-efficient 3rd storey buildings for Mode 1

System	Model 3.1		Model 3.2		Model 3.3	
Direction	X	Z	X	Z	X	Z
Spectral acceleration	1.85577	1.85577	2.50000	2.50000	2.50000	2.50000
Design Seismic Co-efficient	0.0445	0.0445	0.0600	0.0600	0.0600	0.0600

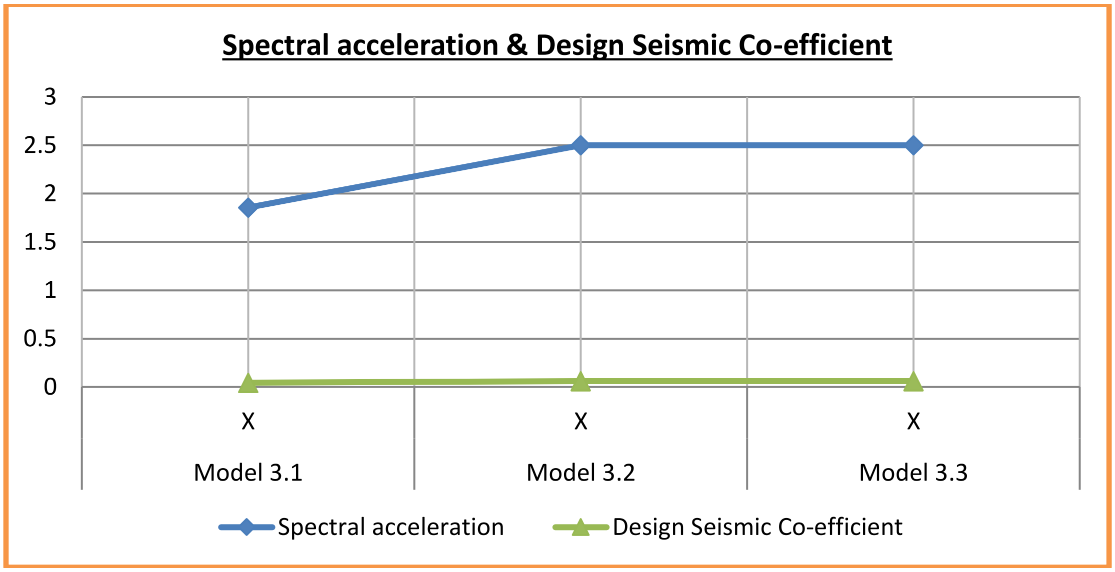

Figure – 24: Comparison of Spectral acceleration & Design Seismic Co0efficient of various structural System

Table 11: Peak Storey Shear of 8th storey buildings

System	Model 8.1		Model 8.2		Model 8.3	
Direction	X (kN)	Z (kN)	X (kN)	Z (kN)	X (kN)	Z (kN)
Terrace Floor	142.86	142.45	394.32	357.72	294.91	260.9
8th Floor	334.64	337.85	794.36	701.92	724.78	628.36
7th Floor	488.64	497.16	1019.84	883.79	1124.9	956.03
6th Floor	592.79	601.61	1210.60	1030.74	1488.2	1243.8
5th Floor	669.06	679.42	1375.41	1156.98	1810.1	1493.9
4th Floor	736.54	749.26	1517.90	1269.15	2090.8	1708.7
3rd Floor	806.94	819.68	1640.02	1371.00	2330.2	1889.3
2nd Floor	877.23	893.28	1740.00	1459.99	2525.7	2035.3
1st Floor	930.04	945.84	1805.79	1519.90	2666.5	2137.4
Ground Floor	932.41	948.04	1811.32	1523.99	2680.5	2145.7
Foundation	932.41	948.04	1811.32	1523.99	2680.5	2145.7

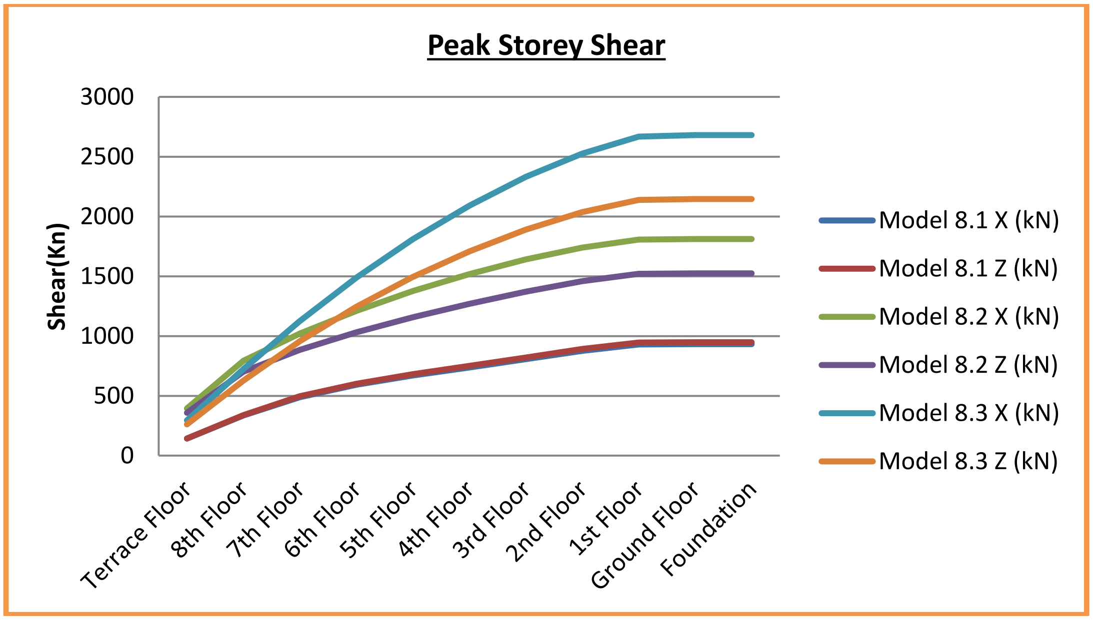

Figure – 25: Comparison of Peak Storey Shear of various structural System

Table 12: Peak Storey Shear of 6th storey buildings

System	Model 6.1		Model 6.2		Model 6.3	
Direction	X (kN)	Z (kN)	X (kN)	Z (kN)	X (kN)	Z (kN)
Terrace Floor	162.68	166.50	280.07	251.15	306.53	313.12
6th Floor	377.70	385.83	676.30	596.12	749.5	757.83
5th Floor	536.60	548.13	1017.84	882.56	1151	1151.3
4th Floor	650.90	665.45	1301.43	1113.79	1503.3	1487.9
3rd Floor	749.90	766.93	1532.21	1302.01	1803.7	1767.9
2nd Floor	840.81	859.57	1708.62	1448.75	2049.7	1990
1st Floor	898.23	918.07	1816.86	1538.88	2228.2	2141.1
Ground Floor	900.60	920.41	1825.44	1544.76	2246.1	2153.2
Foundation	900.60	920.41	1825.44	1544.76	2246.1	2153.2

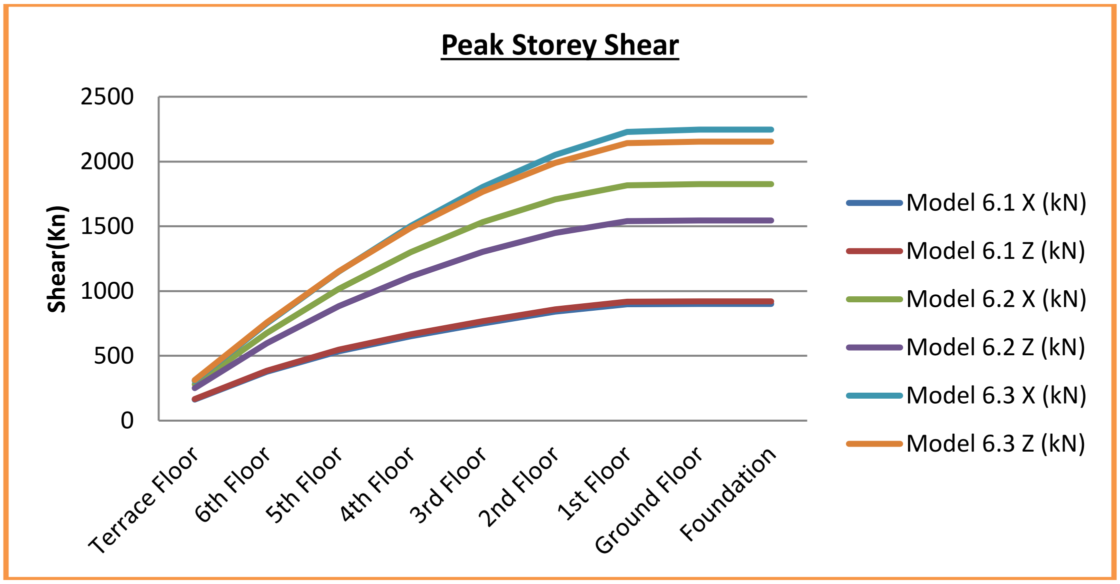

Figure – 26: Comparison of Peak Storey Shear of various structural System

Table 13: Peak Storey Shear of 3rd storey buildings

System	Model 3.1		Model 3.2		Model 3.3	
Direction	X (kN)	Z (kN)	X (kN)	Z (kN)	X (kN)	Z (kN)
Terrace Floor	244.66	250.11	308.80	312.66	291.61	301.31
3rd Floor	539.20	553.46	715.02	716.56	692.51	703.15
2nd Floor	752.69	773.48	1023.97	1019.12	1029.5	1027.9
1st Floor	878.43	902.87	1218.33	1204.50	1280.4	1254.6
Ground Floor	883.88	908.27	1234.19	1216.87	1305.5	1273
Foundation	883.88	908.27	1234.19	1216.87	1305.5	1273

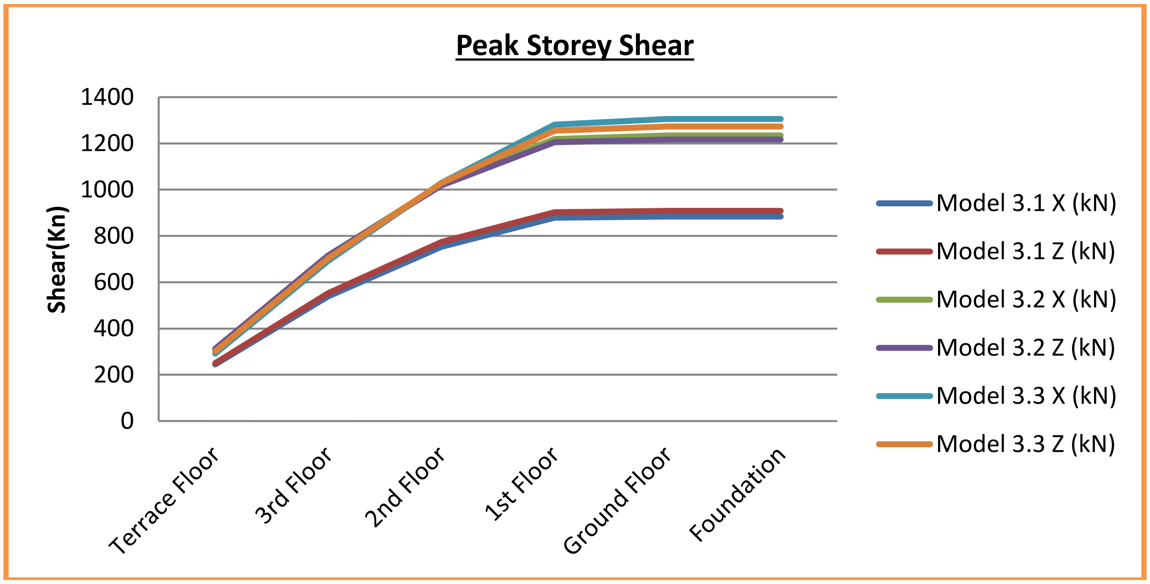

Figure – 27: Comparison of Peak Storey Shear of various structural System

Table 14: Base Shear of 8th storey buildings

System	Model 8.1		Model 8.2		Model 8.3	
Direction	X (kN)	Z (kN)	X (kN)	Z (kN)	X (kN)	Z (kN)
SRSS Shear	931.11	947.07	1809.46	1522.96	2680.5	2145.4
10pct Shear	931.11	947.07	1809.92	1522.96	2680.5	2145.4
ABS Shear	1325.8	1304.94	2266.36	1997.54	2924.6	2493.5
CQC Shear	932.41	948.04	1811.32	1523.99	2680.5	2145.7

Table 15: Base Shear of 6th storey buildings

System	Model 6.1		Model 6.2		Model 6.3	
Direction	X (kN)	Z (kN)	X (kN)	Z (kN)	X (kN)	Z (kN)
SRSS Shear	900.60	920.41	1825.01	1544.60	2246.1	2153.2
10pct Shear	900.60	920.41	1825.01	1544.60	2246.1	2153.2
ABS Shear	1101.70	1126.51	2054.43	1787.40	2405.5	2352.9
CQC Shear	900.60	920.41	1825.44	1544.76	2246.1	2153.2

Table 16: Base Shear of 3rd storey buildings

System	Model 3.1		Model 3.2		Model 3.3	
Direction	X (kN)	Z (kN)	X (kN)	Z (kN)	X (kN)	Z (kN)
SRSS Shear	883.68	908.12	1233.95	1216.70	1305.5	1272.9
10pct Shear	883.68	908.12	1233.95	1216.70	1305.5	1272.9
ABS Shear	1036.59	1053.53	1358.59	1349.77	1360.9	1358.4
CQC Shear	883.88	908.27	1234.19	1216.87	1305.5	1273

Performance evaluation using First Mode lateral load pattern resulted in higher base shear than Codal load pattern. From Table 17, Table 18 & Table 19 it was observed that for First mode load pattern the base shear increases compared to bare frame model. Again it is observed that base shear of model with diagonal strut & model with surface element for infill walls is quite comparative.

Table 17: Storey Displacement of 8th storey buildings

	Model 8.1		Model 8.2		Model 8.3	
	X (mm)	Z (mm)	X (mm)	Z (mm)	X (mm)	Z (mm)
Terrace Floor	59.34	50.274	19.12	22.94	7.361	9.597
8th Floor	58.25	49.154	18.19	21.56	7.117	9.184
7th Floor	56.11	47.192	16.76	19.64	6.755	8.609
6th Floor	51.33	43.001	15.02	17.40	6.265	7.87
5th Floor	45.19	37.724	13.03	14.91	5.655	6.983
4th Floor	37.92	31.553	10.82	12.23	4.939	5.969
3rd Floor	29.60	24.562	8.43	9.39	4.134	4.852
2nd Floor	20.27	16.796	5.93	6.47	3.261	3.657
1st Floor	10.15	8.414	3.34	3.51	2.264	2.341

Figure – 28: Comparison of Storey Displacement of various structural System

Table 18: Storey Displacement of 6th storey buildings

	Model 6.1		Model 6.2		Model 6.3	
	X (mm)	Z (mm)	X (mm)	Z (mm)	X (mm)	Z (mm)
Terrace Floor	38.252	36.729	9.325	13.096	4.602	6.923
6th Floor	36.675	35.076	8.88	12.322	4.41	6.557
5th Floor	33.47	31.899	8.085	11.084	4.104	6.004
4th Floor	28.788	27.355	6.973	9.44	3.677	5.268
3rd Floor	22.847	21.657	5.596	7.468	3.142	4.373
2nd Floor	15.807	14.967	4.015	5.257	2.52	3.354
1st Floor	7.946	7.538	2.292	2.895	1.771	2.176

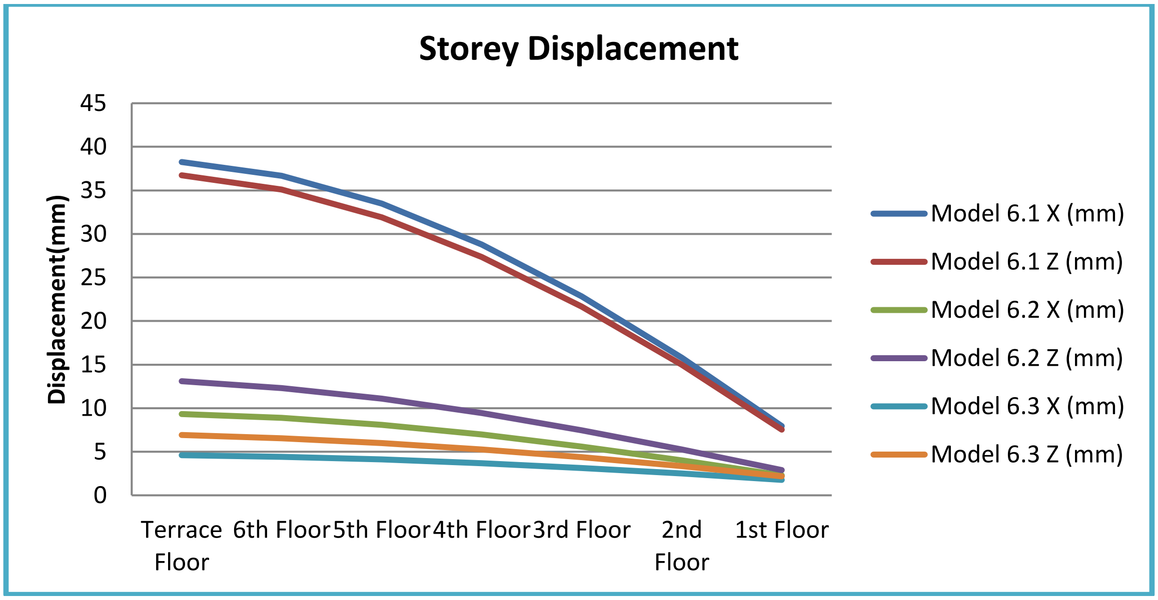

Figure – 29: Comparison of Storey Displacement of various structural System

Table 19: Storey Displacement of 3th storey buildings

	Model 3.1		Model 3.2		Model 3.3	
	X (mm)	Z (mm)	X (mm)	Z (mm)	X (mm)	Z (mm)
Terrace Floor	12.909	12.224	3.098	4.139	1.785	2.463
3rd Floor	11.518	10.894	2.8	3.693	1.647	2.232
2nd Floor	8.618	8.149	2.183	2.831	1.408	1.837
1st Floor	4.538	4.303	1.313	1.648	1.03	1.25

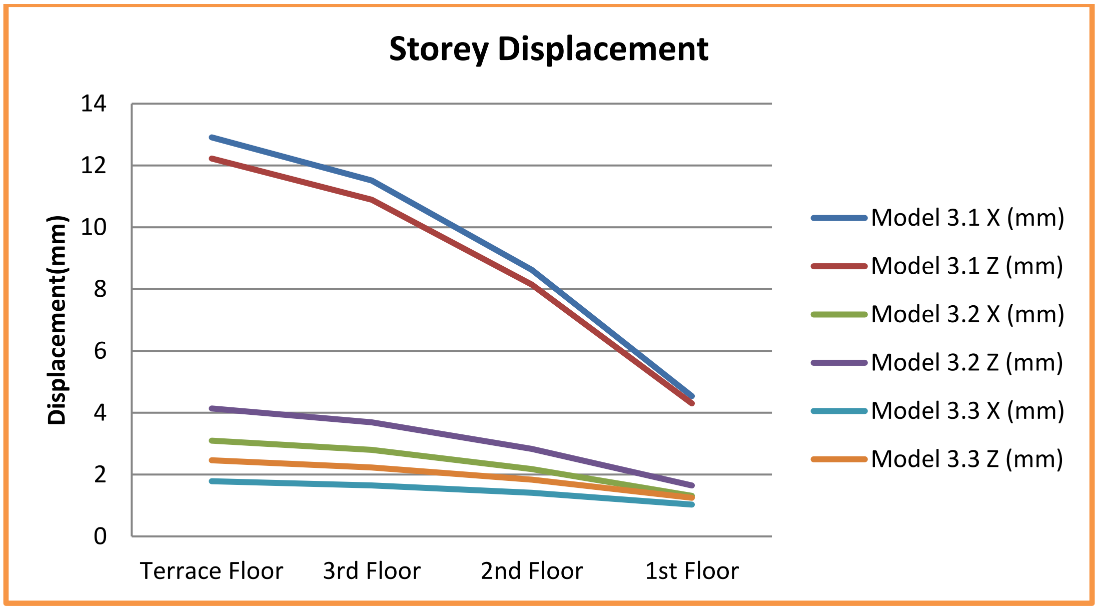

Figure – 30: Comparison of Storey Displacement of various structural System

Comparison of Column Design

Comparison of design of corner column, peripheral column & internal column is done for all nine structural systems & tabulated below. Parameters considered for design are tabulated in table 20. For comparison all parameters are considered same for all structures.

Table 20: Parameters considered for design

Concrete grade	M25
Steel Grade	Fe500
Size of Column	400x400
Size of Beam	400x500
Floor to floor height	3100mm
Column Cover	40mm
Beam Cover	25mm

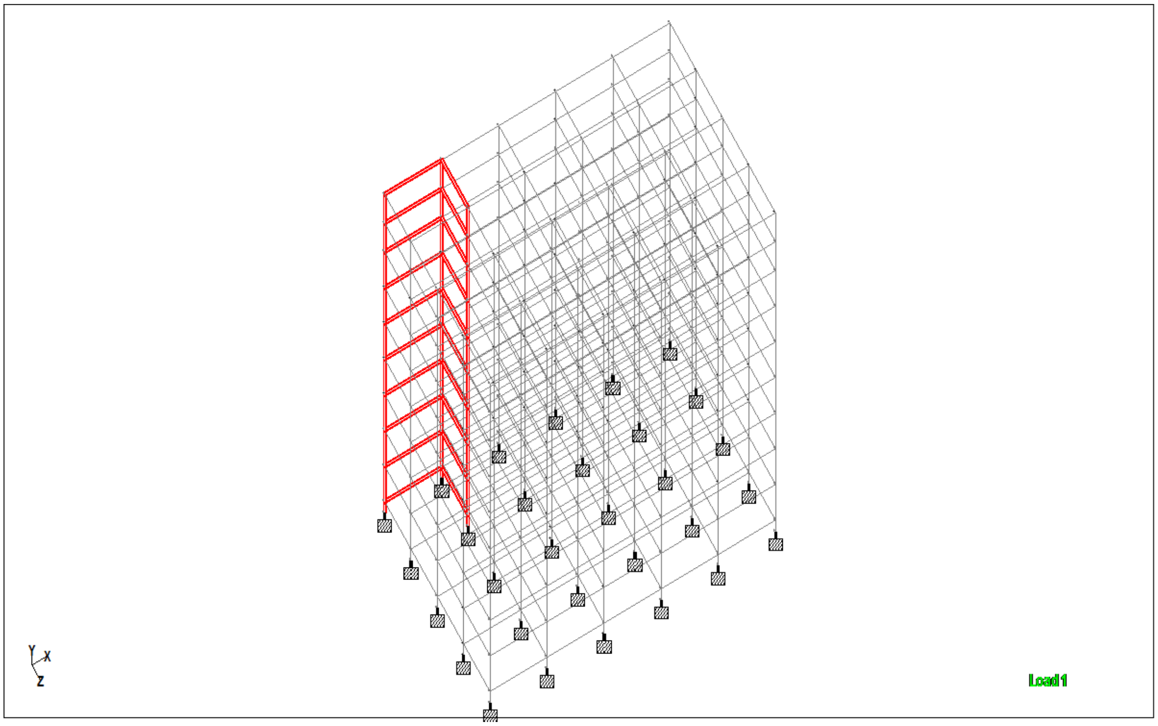

Figure – 31: Corner, Peripheral & Centre Column & its Connecting Beam

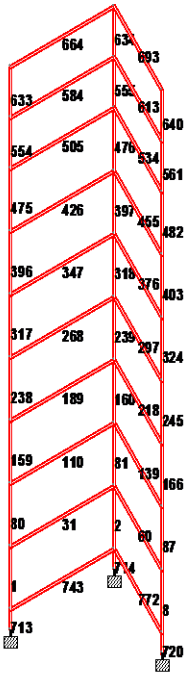

Figure – 32: Designed Columns & Beam

Table 21: Reinforcement required in corner column 3 Storey building

Corner Column						
Model	Model 3.1 - Bare Frame Model		Model 3.2 - Masonry infill as Diagonal Strut		Model 3.3 - Masonry infill as surface element	
	Reqd. R/F (mm^2)	%	Reqd. R/F (mm^2)	%	Reqd. R/F (mm^2)	%
GF	1515	0.95%	752	0.47%	408	0.26%
1st F	1200	0.75%	527	0.33%	471	0.29%
2nd F	1079	0.67%	350	0.22%	523	0.33%
3rd F	1050	0.66%	474	0.30%	702	0.44%

Table 22: Reinforcement required in Peripheral column 3 Storey building

Peripheral Column						
Model	Model 3.1 - Bare Frame Model		Model 3.2 - Masonry infill as Diagonal Strut		Model 3.3 - Masonry infill as surface element	
	Reqd. R/F (mm^2)	%	Reqd. R/F (mm^2)	%	Reqd. R/F (mm^2)	%
GF	1516	0.95%	777	0.49%	455	0.28%
1st F	1319	0.82%	559	0.35%	211	0.13%
2nd F	963	0.60%	341	0.21%	212	0.13%
3rd F	629	0.39%	159	0.10%	500	0.31%

Table 23: Reinforcement required in Internal Column 3 Storey building

Internal Column						
Model	Model 3.1 - Bare Frame Model		Model 3.2 - Masonry infill as Diagonal Strut		Model 3.3 - Masonry infill as surface element	
	Reqd. R/F (mm^2)	%	Reqd. R/F (mm^2)	%	Reqd. R/F (mm^2)	%
GF	1836	1.15%	1108	0.69%	1067	0.67%
1st F	1154	0.72%	800	0.50%	765	0.48%
2nd F	751	0.47%	499	0.31%	473	0.30%
3rd F	347	0.22%	200	0.13%	188	0.12%

Table 24: Reinforcement required in Corner Column 6 Storey building

Corner Column						
Model	Model 6.1 - Bare Frame Model		Model 6.2 - Masonry infill as Diagonal Strut		Model 6.3 - Masonry infill as surface element	
	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%
GF	3514	2.20%	Reinforcement exceed Maximum Limit		885	0.55%
1st F	2905	1.82%	4490	2.81%	572	0.36%
2nd F	2258	1.41%	1059	0.66%	503	0.31%
3rd F	1880	1.18%	790	0.49%	551	0.34%
4th F	1605	1.00%	542	0.34%	612	0.38%
5th F	1447	0.90%	415	0.26%	641	0.40%
6th F	1338	0.84%	651	0.41%	824	0.52%

Table 25: Reinforcement required in Peripheral Column 6 Storey building

Peripheral Column						
Model	Model 6.1 - Bare Frame Model		Model 6.2 - Masonry infill as Diagonal Strut		Model 6.3 - Masonry infill as surface element	
	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%
GF	5375	3.36%	2304	1.44%	825	0.52%
1st F	4484	2.80%	1344	0.84%	408	0.26%
2nd F	3497	2.19%	1013	0.63%	244	0.15%
3rd F	2670	1.67%	791	0.49%	378	0.24%
4th F	1964	1.23%	570	0.36%	590	0.37%
5th F	1418	0.89%	356	0.22%	698	0.44%
6th F	994	0.62%	525	0.33%	1151	0.72%

Table 26: Reinforcement required in Internal Column 6 Storey building

Internal Column						
Model	Model 6.1 - Bare Frame Model		Model 6.2 - Masonry infill as Diagonal Strut		Model 6.3 - Masonry infill as surface element	
	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%
GF	6144	3.84%	3657	2.29%	2756	1.72%
1st F	5269	3.29%	2176	1.36%	1536	0.96%
2nd F	4037	2.52%	1280	0.80%	1172	0.73%
3rd F	2946	1.84%	1037	0.65%	904	0.57%
4th F	1800	1.13%	750	0.47%	647	0.40%
5th F	1125	0.70%	466	0.29%	397	0.25%
6th F	540	0.34%	221	0.14%	872	0.55%

Table 27: Reinforcement required in Corner Column 8 Storey building

Corner Column						
Model	Model 8.1 - Bare Frame Model		Model 8.2 - Masonry infill as Diagonal Strut		Model 8.3 - Masonry infill as surface element	
	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%
GF	5632	3.52%	Reinforcement exceed Maximum Limit		1184	0.74%
1st F	4992	3.12%	Reinforcement exceed Maximum Limit		585	0.37%
2nd F	4233	2.65%	5624	3.52%	474	0.30%
3rd F	3328	2.08%	1792	1.12%	514	0.32%
4th F	2745	1.72%	1116	0.70%	544	0.34%
5th F	2194	1.37%	877	0.55%	584	0.37%
6th F	2081	1.30%	815	0.51%	638	0.40%
7th F	1526	0.95%	832	0.52%	690	0.43%
8th F	1682	1.05%	1280	0.80%	1280	0.80%

Table 28: Reinforcement required in Peripheral Column 8 Storey building

Peripheral Column						
Model	Model 8.1 - Bare Frame Model		Model 8.2 - Masonry infill as Diagonal Strut		Model 8.3 - Masonry infill as surface element	
	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%
GF	Reinforcement exceed Maximum Limit		4857	3.04%	1099	0.69%
1st F	Reinforcement exceed Maximum Limit		3667	2.29%	551	0.34%
2nd F	6190	3.87%	2688	1.68%	342	0.21%
3rd F	5083	3.18%	1792	1.12%	374	0.23%
4th F	4206	2.63%	1082	0.68%	616	0.39%
5th F	3385	2.12%	847	0.53%	823	0.51%
6th F	2565	1.60%	615	0.38%	999	0.62%
7th F	1510	0.94%	616	0.39%	1084	0.68%
8th F	1269	0.79%	1280	0.80%	1705	1.07%

Table 29: Reinforcement required in Internal Column 8 Storey building

Internal Column						
Model	Model 8.1 - Bare Frame Model		Model 8.2 - Masonry infill as Diagonal Strut		Model 8.3 - Masonry infill as surface element	
	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%	Reqd. R/F (mm2)	%
GF	Reinforcement exceed Maximum Limit		5706	3.57%	5442	3.40%
1st F	Reinforcement exceed Maximum Limit		5182	3.24%	3077	1.92%
2nd F	Reinforcement exceed Maximum Limit		3203	2.00%	1920	1.20%
3rd F	5606	3.50%	2048	1.28%	1280	0.80%
4th F	4524	2.83%	1277	0.80%	1034	0.65%
5th F	3404	2.13%	999	0.62%	798	0.50%
6th F	2252	1.41%	723	0.45%	570	0.36%
7th F	1070	0.67%	504	0.32%	906	0.57%
8th F	758	0.47%	704	0.44%	1896	1.19%

From above tables of comparison we can see that required reinforcement is much higher in bare frame model in comparison to the infill conditions. Further we can optimize the sizes of columns to achieve the minimum reinforcement requirement as per code i.e. 0.8%.

Comparison of Beam Design

For comparing beam design 2nd floor beam is considered for all structure.

Beam 110 – connecting corner column & peripheral column

Beam 139 – Connecting peripheral column & internal column

Table 30: Peripheral Beam: Model 3.1 - Bare Frame Model

BEAM NO. 110 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP	995.21	532.46	418.55	508.51	973.46
BOTTOM	406.78	699	842.66	615.66	319.6

Table 31: Peripheral Beam: Model 3.2 - Masonry infill as Diagonal Strut

BEAM NO. 110 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP	399.27	319.6	0	319.6	524.51
BOTTOM	0	318.92	318.92	318.92	0

Table 32: Peripheral Beam: Model 3.3 - Masonry infill as surface element

BEAM NO. 110 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP	378.78	0	0	319.6	519.82
TOP	378.78	0	0	319.6	519.82

Table 33: Internal Beam: Model 3.1 - Bare Frame Model

BEAM NO. 139 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	881.49	578.53	484.05	526.29	775.53
BOTTOM	506.41	674.76	760.98	609.96	388.29

Table 34: Internal Beam: Model 3.2 - Masonry infill as Diagonal Strut

BEAM NO. 139 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	428.64	318.92	318.92	318.92	343.14
BOTTOM	318.92	318.92	322.58	318.92	318.92

Table 35: Internal Beam: Model 3.3 - Masonry infill as surface element

BEAM NO. 139 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	404.05	318.92	0	318.92	318.92
BOTTOM	0	318.92	318.92	318.92	0

Table 36: Peripheral Beam: Model 6.1 - Bare Frame Model

BEAM NO. 110 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP	1909.81	1299.45	1104.87	1179.88	1723.89
BOTTOM	1137.52	1496.92	1672.27	1354.27	909.65

Table 37: Peripheral Beam: Model 6.2 - Masonry infill as Diagonal Strut

BEAM NO. 110 DESIGN RESULTS					
SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP	458.44	317.56	317.56	317.56	624.3
BOTTOM	317.56	317.56	396.73	317.56	0

Table 38: Peripheral Beam: Model 6.3 - Masonry infill as surface element

BEAM NO. 110 DESIGN RESULTS					
SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP	412.52	319.6	0	319.6	520.6
BOTTOM	0	318.92	328.78	318.92	0

Table 39: Internal Beam: Model 6.1 - Bare Frame Model

BEAM NO. 139 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	1814.45	1382.29	1216.6	1221.05	1463.61
BOTTOM	1301.75	1478.16	1564.66	1351.47	1047.33

Table 40: Internal Beam: Model 6.2 - Masonry infill as Diagonal Strut

BEAM NO. 139 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	731.58	376.28	319.6	319.6	460.21
BOTTOM	319.6	381.41	520.87	436.35	319.6

Table 41: Internal Beam: Model 6.3 - Masonry infill as surface element

BEAM NO. 139 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	572	318.92	318.92	318.92	318.92
BOTTOM	0	318.92	324.81	318.92	318.92

Table 42: Peripheral Beam: Model 8.1 - Bare Frame Model

BEAM NO. 110 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP	2323.98	1798.34	1581.29	1633.2	2047.67
BOTTOM	1676.76	1955.25	2070.78	1841.68	1341.04

Table 43: Peripheral Beam: Model 8.2 - Masonry infill as Diagonal Strut

BEAM NO. 110 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP	590.73	319.6	319.6	319.6	761.56
BOTTOM	317.56	466.71	562.66	319.53	0

Table 44: Peripheral Beam: Model 8.3 - Masonry infill as surface element

BEAM NO. 110 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1250.0 mm	2500.0 mm	3750.0 mm	5000.0 mm
TOP	450.05	319.6	0	319.6	530.23
BOTTOM	0	319.6	359.01	319.6	0

Table 45: Internal Beam: Model 8.1 - Bare Frame Model

BEAM NO. 139 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	2014.03	1615.69	1424.25	1414.3	1649.54
BOTTOM	1556.47	1746.51	1806.79	1592.13	1234.25

Table 46: Internal Beam: Model 8.2 - Masonry infill as Diagonal Strut

BEAM NO. 139 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	891.17	497.06	359.03	362.52	517.33
BOTTOM	316.2	470.73	623.86	550.3	345.14

Table 47: Internal Beam: Model 8.3 - Masonry infill as surface element

BEAM NO. 139 DESIGN RESULTS, SIZE : 400x500					
SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	623.55	319.6	319.6	319.6	319.6
BOTTOM	0	319.6	340.72	319.6	319.6

CHAPTER 6

CONCLUSIONS

Following conclusion can be drawn on the basis of this study:

It has been found that calculation of earthquake forces by treating RC frames as bare frames without regards to infill leads to underestimation of base shear. The performance of fully masonry infill panels was significantly superior to that of bare frame. Brick infill walls present in RC frame building reduce the structural drift but increases strength and stiffness. Therefore it is essential for the structural systems selected, to be thoroughly investigated and well understood. It has been found that the IS code provisions do not provide any guidelines for the analysis and design of RC frames with infill panels. Reinforced concrete buildings with infill walls are usually analysed and designed as bare frames, without considering the strength and stiffness contribution of the in-fills. From this exercise we can observe that, during earthquake, these infill walls contribute to the response of the structure and the behavior of the infill framed building is different from that predicted for bare frame structure. It is understood that in case of stilt floor, which is the case of many urban areas, this should be well investigated before selecting the structural system. However this can be established through different investigation.

SCOPE OF FURTHER STUDY

In the present study only nine type of uniform building is selected. In order to develop the generalized effect on different output parameter considered in this study with mass irregularity, different types of building has to be considered i.e. building with different storey in different site and different specification.

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16. **IS 456**
17. **STAAD PRO V8i**

APPENDIX: 1

Following is STAAD editor file of original building which is designed in STAAD PRO V8i:

```
STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 10-Aug-13
JOB NAME Model 8.1 - Bare Frame Model
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 0 3.1 0; 3 5 0 0; 4 5 3.1 0; 5 10 0 0; 6 10 3.1 0; 7 15 0 0;
8 15 3.1 0; 9 20 0 0; 10 20 3.1 0; 11 25 0 0; 12 25 3.1 0; 13 0 0 4;
14 0 3.1 4; 15 5 0 4; 16 5 3.1 4; 17 10 0 4; 18 10 3.1 4; 19 15 0 4;
20 15 3.1 4; 21 20 0 4; 22 20 3.1 4; 23 25 0 4; 24 25 3.1 4; 25 0 0 8;
26 0 3.1 8; 27 5 0 8; 28 5 3.1 8; 29 10 0 8; 30 10 3.1 8; 31 15 0 8;
32 15 3.1 8; 33 20 0 8; 34 20 3.1 8; 35 25 0 8; 36 25 3.1 8; 37 0 0 12;
38 0 3.1 12; 39 5 0 12; 40 5 3.1 12; 41 10 0 12; 42 10 3.1 12; 43 15 0 12;
44 15 3.1 12; 45 20 0 12; 46 20 3.1 12; 47 25 0 12; 48 25 3.1 12; 49 0 0 16;
50 0 3.1 16; 51 5 0 16; 52 5 3.1 16; 53 10 0 16; 54 10 3.1 16; 55 15 0 16;
56 15 3.1 16; 57 20 0 16; 58 20 3.1 16; 59 25 0 16; 60 25 3.1 16; 61 0 6.2 0;
62 5 6.2 0; 63 10 6.2 0; 64 15 6.2 0; 65 20 6.2 0; 66 25 6.2 0; 67 0 6.2 4;
68 5 6.2 4; 69 10 6.2 4; 70 15 6.2 4; 71 20 6.2 4; 72 25 6.2 4; 73 0 6.2 8;
74 5 6.2 8; 75 10 6.2 8; 76 15 6.2 8; 77 20 6.2 8; 78 25 6.2 8; 79 0 6.2 12;
80 5 6.2 12; 81 10 6.2 12; 82 15 6.2 12; 83 20 6.2 12; 84 25 6.2 12;
85 0 6.2 16; 86 5 6.2 16; 87 10 6.2 16; 88 15 6.2 16; 89 20 6.2 16;
90 25 6.2 16; 91 0 9.3 0; 92 5 9.3 0; 93 10 9.3 0; 94 15 9.3 0; 95 20 9.3 0;
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96 25 9.3 0; 97 0 9.3 4; 98 5 9.3 4; 99 10 9.3 4; 100 15 9.3 4; 101 20 9.3 4;
102 25 9.3 4; 103 0 9.3 8; 104 5 9.3 8; 105 10 9.3 8; 106 15 9.3 8;
107 20 9.3 8; 108 25 9.3 8; 109 0 9.3 12; 110 5 9.3 12; 111 10 9.3 12;
112 15 9.3 12; 113 20 9.3 12; 114 25 9.3 12; 115 0 9.3 16; 116 5 9.3 16;
117 10 9.3 16; 118 15 9.3 16; 119 20 9.3 16; 120 25 9.3 16; 121 0 12.4 0;
122 5 12.4 0; 123 10 12.4 0; 124 15 12.4 0; 125 20 12.4 0; 126 25 12.4 0;
127 0 12.4 4; 128 5 12.4 4; 129 10 12.4 4; 130 15 12.4 4; 131 20 12.4 4;
132 25 12.4 4; 133 0 12.4 8; 134 5 12.4 8; 135 10 12.4 8; 136 15 12.4 8;
137 20 12.4 8; 138 25 12.4 8; 139 0 12.4 12; 140 5 12.4 12; 141 10 12.4 12;
142 15 12.4 12; 143 20 12.4 12; 144 25 12.4 12; 145 0 12.4 16; 146 5 12.4 16;
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DEFINE MATERIAL START
ISOTROPIC M25
E 2.5e+007
POISSON 0.17
DENSITY 25
ALPHA 1e-005
DAMP 0.05
ISOTROPIC CONCRETE
E 2.17185e+007
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POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
ISOTROPIC BRICK
E 2.2e+006
POISSON 0.17
DENSITY 0
ALPHA 1e-005
DAMP 0.05
END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
1 TO 30 80 TO 109 159 TO 188 238 TO 267 317 TO 346 396 TO 425 475 TO 504 554 -
555 TO 583 633 TO 662 713 TO 742 PRIS YD 0.4 ZD 0.4
MEMBER PROPERTY INDIAN
31 TO 79 110 TO 158 189 TO 237 268 TO 316 347 TO 395 426 TO 474 505 TO 553 -
584 TO 632 664 TO 712 743 TO 791 PRIS YD 0.5 ZD 0.4
CONSTANTS
MATERIAL M25 ALL
SUPPORTS
8033 TO 8062 FIXED
***************************************
SLAVE ZX MASTER 1001 JOINT 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 -
36 38 40 42 44 46 48 50 52 54 56 58 60
SLAVE ZX MASTER 2001 JOINT 61 TO 90
SLAVE ZX MASTER 3001 JOINT 91 TO 120
SLAVE ZX MASTER 4001 JOINT 121 TO 150
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SLAVE ZX MASTER 5001 JOINT 151 TO 180
SLAVE ZX MASTER 6001 JOINT 181 TO 210
SLAVE ZX MASTER 7001 JOINT 211 TO 240
SLAVE ZX MASTER 8001 JOINT 241 TO 270
SLAVE ZX MASTER 8032 JOINT 8002 TO 8031
DEFINE 1893 LOAD
*******SEISMIC ZONE-IV (IS 1893 :2002, PART 1)
ZONE 0.24 RF 5 I 1 SS 2 ST 3 DM 0.05
*PX 0.693 PZ 0.742 DT 1
***************************MODAL WEIGHT**************************
JOINT WEIGHT
1 WEIGHT 80.784
2 WEIGHT 113.517
3 WEIGHT 116.252
4 WEIGHT 187.251
5 WEIGHT 113.969
6 WEIGHT 181.25
7 WEIGHT 113.969
8 WEIGHT 181.25
9 WEIGHT 116.252
10 WEIGHT 187.251
11 WEIGHT 80.784
12 WEIGHT 113.517
13 WEIGHT 104.678
14 WEIGHT 174.008
15 WEIGHT 109.572
16 WEIGHT 256.915
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17 WEIGHT 108.296
18 WEIGHT 249.988
19 WEIGHT 108.296
20 WEIGHT 249.988
21 WEIGHT 109.572
22 WEIGHT 256.915
23 WEIGHT 104.678
24 WEIGHT 174.008
25 WEIGHT 102.241
26 WEIGHT 168.031
27 WEIGHT 108.167
28 WEIGHT 250.322
29 WEIGHT 106.99
30 WEIGHT 243.29
31 WEIGHT 106.99
32 WEIGHT 243.29
33 WEIGHT 108.167
34 WEIGHT 250.322
35 WEIGHT 102.241
36 WEIGHT 168.031
37 WEIGHT 104.678
38 WEIGHT 174.008
39 WEIGHT 109.572
40 WEIGHT 256.915
41 WEIGHT 108.296
42 WEIGHT 249.988
43 WEIGHT 108.296
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44 WEIGHT 249.988

45 WEIGHT 109.572

46 WEIGHT 256.915

47 WEIGHT 104.678

48 WEIGHT 174.008

49 WEIGHT 80.784

50 WEIGHT 113.517

51 WEIGHT 116.252

52 WEIGHT 187.251

53 WEIGHT 113.969

54 WEIGHT 181.25

55 WEIGHT 113.969

56 WEIGHT 181.25

57 WEIGHT 116.252

58 WEIGHT 187.251

59 WEIGHT 80.784

60 WEIGHT 113.517

61 WEIGHT 114.224

62 WEIGHT 187.174

63 WEIGHT 181.814

64 WEIGHT 181.814

65 WEIGHT 187.174

66 WEIGHT 114.224

67 WEIGHT 174.233

68 WEIGHT 255.551

69 WEIGHT 249.532

70 WEIGHT 249.532

71 WEIGHT 255.551

72 WEIGHT 174.233

73 WEIGHT 168.878

74 WEIGHT 249.814

75 WEIGHT 243.752

76 WEIGHT 243.752

77 WEIGHT 249.814

78 WEIGHT 168.878

79 WEIGHT 174.233

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91 WEIGHT 114.119

92 WEIGHT 187.197

93 WEIGHT 181.73

94 WEIGHT 181.73

95 WEIGHT 187.197

96 WEIGHT 114.119

97 WEIGHT 174.204

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100 WEIGHT 249.594

101 WEIGHT 255.757

102 WEIGHT 174.204

103 WEIGHT 168.745

104 WEIGHT 249.885

105 WEIGHT 243.665

106 WEIGHT 243.665

107 WEIGHT 249.885

108 WEIGHT 168.745

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112 WEIGHT 249.594

113 WEIGHT 255.757

114 WEIGHT 174.204

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155 WEIGHT 187.19

156 WEIGHT 114.143

157 WEIGHT 174.207

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163 WEIGHT 168.774

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165 WEIGHT 243.684

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175 WEIGHT 114.143

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179 WEIGHT 187.19

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210 WEIGHT 114.061

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229 WEIGHT 173.025

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233 WEIGHT 253.863

234 WEIGHT 173.025

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240 WEIGHT 113.447

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242 WEIGHT 184.584

243 WEIGHT 180.036

244 WEIGHT 180.036

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251 WEIGHT 251.703

252 WEIGHT 171.944

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8005 WEIGHT 112.01

8006 WEIGHT 117.206

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8025 WEIGHT 108.975

8026 WEIGHT 66.382

8027 WEIGHT 117.206

8028 WEIGHT 112.01

8029 WEIGHT 112.01

8030 WEIGHT 117.206

8031 WEIGHT 66.382

8033 WEIGHT 2

8034 WEIGHT 2

8035 WEIGHT 2

8036 WEIGHT 2

8037 WEIGHT 2

8038 WEIGHT 2

8039 WEIGHT 2

8040 WEIGHT 2

8041 WEIGHT 2

8042 WEIGHT 2

8043 WEIGHT 2

8044 WEIGHT 2

8045 WEIGHT 2

8046 WEIGHT 2

8047 WEIGHT 2

8048 WEIGHT 2

8049 WEIGHT 2

8050 WEIGHT 2

8051 WEIGHT 2

8052 WEIGHT 2

8053 WEIGHT 2

8054 WEIGHT 2

8055 WEIGHT 2

8056 WEIGHT 2

8057 WEIGHT 2

8058 WEIGHT 2

8059 WEIGHT 2

8060 WEIGHT 2

8061 WEIGHT 2

8062 WEIGHT 2

CUT OFF MODE SHAPE 10

****

**********MULTIPLYING FACTOR (Vb/VB)= AS PER OUT FILE*****************

APPENDIX: 2

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 10-Aug-13

JOB NAME Model 8.2 - Masonry infill as Diagonal Strut

```
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 0 3.1 0; 3 5 0 0; 4 5 3.1 0; 5 10 0 0; 6 10 3.1 0; 7 15 0 0;
8 15 3.1 0; 9 20 0 0; 10 20 3.1 0; 11 25 0 0; 12 25 3.1 0; 13 0 0 4;
14 0 3.1 4; 15 5 0 4; 16 5 3.1 4; 17 10 0 4; 18 10 3.1 4; 19 15 0 4;
20 15 3.1 4; 21 20 0 4; 22 20 3.1 4; 23 25 0 4; 24 25 3.1 4; 25 0 0 8;
26 0 3.1 8; 27 5 0 8; 28 5 3.1 8; 29 10 0 8; 30 10 3.1 8; 31 15 0 8;
32 15 3.1 8; 33 20 0 8; 34 20 3.1 8; 35 25 0 8; 36 25 3.1 8; 37 0 0 12;
38 0 3.1 12; 39 5 0 12; 40 5 3.1 12; 41 10 0 12; 42 10 3.1 12; 43 15 0 12;
44 15 3.1 12; 45 20 0 12; 46 20 3.1 12; 47 25 0 12; 48 25 3.1 12; 49 0 0 16;
50 0 3.1 16; 51 5 0 16; 52 5 3.1 16; 53 10 0 16; 54 10 3.1 16; 55 15 0 16;
56 15 3.1 16; 57 20 0 16; 58 20 3.1 16; 59 25 0 16; 60 25 3.1 16; 61 0 6.2 0;
62 5 6.2 0; 63 10 6.2 0; 64 15 6.2 0; 65 20 6.2 0; 66 25 6.2 0; 67 0 6.2 4;
68 5 6.2 4; 69 10 6.2 4; 70 15 6.2 4; 71 20 6.2 4; 72 25 6.2 4; 73 0 6.2 8;
74 5 6.2 8; 75 10 6.2 8; 76 15 6.2 8; 77 20 6.2 8; 78 25 6.2 8; 79 0 6.2 12;
80 5 6.2 12; 81 10 6.2 12; 82 15 6.2 12; 83 20 6.2 12; 84 25 6.2 12;
85 0 6.2 16; 86 5 6.2 16; 87 10 6.2 16; 88 15 6.2 16; 89 20 6.2 16;
90 25 6.2 16; 91 0 9.3 0; 92 5 9.3 0; 93 10 9.3 0; 94 15 9.3 0; 95 20 9.3 0;
96 25 9.3 0; 97 0 9.3 4; 98 5 9.3 4; 99 10 9.3 4; 100 15 9.3 4; 101 20 9.3 4;
102 25 9.3 4; 103 0 9.3 8; 104 5 9.3 8; 105 10 9.3 8; 106 15 9.3 8;
107 20 9.3 8; 108 25 9.3 8; 109 0 9.3 12; 110 5 9.3 12; 111 10 9.3 12;
112 15 9.3 12; 113 20 9.3 12; 114 25 9.3 12; 115 0 9.3 16; 116 5 9.3 16;
117 10 9.3 16; 118 15 9.3 16; 119 20 9.3 16; 120 25 9.3 16; 121 0 12.4 0;
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127 0 12.4 4; 128 5 12.4 4; 129 10 12.4 4; 130 15 12.4 4; 131 20 12.4 4;
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142 15 12.4 12; 143 20 12.4 12; 144 25 12.4 12; 145 0 12.4 16; 146 5 12.4 16;
147 10 12.4 16; 148 15 12.4 16; 149 20 12.4 16; 150 25 12.4 16; 151 0 15.5 0;
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192 25 18.6 4; 193 0 18.6 8; 194 5 18.6 8; 195 10 18.6 8; 196 15 18.6 8;
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945 269 8031; 946 265 8020; 947 259 8014; 948 253 8008; 949 247 8002;
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DEFINE MATERIAL START
ISOTROPIC M25
E 2.5e+007
POISSON 0.17
DENSITY 25
ALPHA 1e-005
DAMP 0.05
ISOTROPIC CONCRETE
E 2.17185e+007
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
ISOTROPIC BRICK
E 2.2e+006
POISSON 0.17
DENSITY 0
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ALPHA 1e-005
DAMP 0.05
END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
1 TO 30 80 TO 109 159 TO 188 238 TO 267 317 TO 346 396 TO 425 475 TO 504 554 -
555 TO 583 633 TO 662 713 TO 742 PRIS YD 0.4 ZD 0.4
MEMBER PROPERTY INDIAN
31 TO 79 110 TO 158 189 TO 237 268 TO 316 347 TO 395 426 TO 474 505 TO 553 -
584 TO 632 664 TO 712 743 TO 791 PRIS YD 0.5 ZD 0.4
MEMBER PROPERTY INDIAN
872 TO 935 946 TO 953 PRIS YD 1.69 ZD 0.23
792 TO 871 936 TO 945 PRIS YD 1.96 ZD 0.23
CONSTANTS
MATERIAL M25 MEMB 1 TO 662 664 TO 791
MATERIAL BRICK MEMB 792 TO 953
SUPPORTS
8033 TO 8062 FIXED
***************************************
MEMBER TRUSS
792 TO 953
SLAVE ZX MASTER 1001 JOINT 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 -
36 38 40 42 44 46 48 50 52 54 56 58 60
SLAVE ZX MASTER 2001 JOINT 61 TO 90
SLAVE ZX MASTER 3001 JOINT 91 TO 120
SLAVE ZX MASTER 4001 JOINT 121 TO 150
SLAVE ZX MASTER 5001 JOINT 151 TO 180
SLAVE ZX MASTER 6001 JOINT 181 TO 210
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SLAVE ZX MASTER 8032 JOINT 8002 TO 8031

SLAVE ZX MASTER 7001 JOINT 211 TO 240

SLAVE ZX MASTER 8001 JOINT 241 TO 270

DEFINE 1893 LOAD

********SEISMIC ZONE-IV (IS 1893 :2002, PART 1)

ZONE 0.24 RF 5 I 1 SS 2 ST 3 DM 0.05

*PX 0.693 PZ 0.742 DT 1

***************************MODAL WEIGHT**************************

JOINT WEIGHT

1 WEIGHT 81.595

2 WEIGHT 113.086

3 WEIGHT 116.409

4 WEIGHT 187.528

5 WEIGHT 113.992

6 WEIGHT 181.892

7 WEIGHT 113.992

8 WEIGHT 181.892

9 WEIGHT 116.409

10 WEIGHT 187.528

11 WEIGHT 81.595

12 WEIGHT 113.086

13 WEIGHT 104.819

14 WEIGHT 174.477

15 WEIGHT 109.544

16 WEIGHT 255.528

17 WEIGHT 108.272

18 WEIGHT 249.399
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19 WEIGHT 108.272

20 WEIGHT 249.399

21 WEIGHT 109.544

22 WEIGHT 255.528

23 WEIGHT 104.819

24 WEIGHT 174.477

25 WEIGHT 102.261

26 WEIGHT 168.83

27 WEIGHT 108.155

28 WEIGHT 249.753

29 WEIGHT 106.975

30 WEIGHT 243.558

31 WEIGHT 106.975

32 WEIGHT 243.558

33 WEIGHT 108.155

34 WEIGHT 249.753

35 WEIGHT 102.261

36 WEIGHT 168.83

37 WEIGHT 104.819

38 WEIGHT 174.477

39 WEIGHT 109.544

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47 WEIGHT 104.819

48 WEIGHT 174.477

49 WEIGHT 81.595

50 WEIGHT 113.086

51 WEIGHT 116.409

52 WEIGHT 187.528

53 WEIGHT 113.992

54 WEIGHT 181.892

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56 WEIGHT 181.892

57 WEIGHT 116.409

58 WEIGHT 187.528

59 WEIGHT 81.595

60 WEIGHT 113.086

61 WEIGHT 114.189

62 WEIGHT 187.509

63 WEIGHT 182.324

64 WEIGHT 182.324

65 WEIGHT 187.509

66 WEIGHT 114.189

67 WEIGHT 174.697

68 WEIGHT 254.458

69 WEIGHT 249.049

70 WEIGHT 249.049

71 WEIGHT 254.458

72 WEIGHT 174.697

73 WEIGHT 169.489

74 WEIGHT 249.361

75 WEIGHT 243.932

76 WEIGHT 243.932

77 WEIGHT 249.361

78 WEIGHT 169.489

79 WEIGHT 174.697

80 WEIGHT 254.458

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84 WEIGHT 174.697

85 WEIGHT 114.189

86 WEIGHT 187.509

87 WEIGHT 182.324

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89 WEIGHT 187.509

90 WEIGHT 114.189

91 WEIGHT 113.99

92 WEIGHT 187.535

93 WEIGHT 182.265

94 WEIGHT 182.265

95 WEIGHT 187.535

96 WEIGHT 113.99

97 WEIGHT 174.69

98 WEIGHT 254.607

99 WEIGHT 249.093

100 WEIGHT 249.093

101 WEIGHT 254.607

102 WEIGHT 174.69

103 WEIGHT 169.398

104 WEIGHT 249.409

105 WEIGHT 243.865

106 WEIGHT 243.865

107 WEIGHT 249.409

108 WEIGHT 169.398

109 WEIGHT 174.69

110 WEIGHT 254.607

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115 WEIGHT 113.99

116 WEIGHT 187.535

117 WEIGHT 182.265

118 WEIGHT 182.265

119 WEIGHT 187.535

120 WEIGHT 113.99

121 WEIGHT 113.995

122 WEIGHT 187.534

123 WEIGHT 182.272

124 WEIGHT 182.272

125 WEIGHT 187.534

126 WEIGHT 113.995

127 WEIGHT 174.695

128 WEIGHT 254.588

129 WEIGHT 249.088

130 WEIGHT 249.088

131 WEIGHT 254.588

132 WEIGHT 174.695

133 WEIGHT 169.411

134 WEIGHT 249.403

135 WEIGHT 243.875

136 WEIGHT 243.875

137 WEIGHT 249.403

138 WEIGHT 169.411

139 WEIGHT 174.695

140 WEIGHT 254.588

141 WEIGHT 249.088

142 WEIGHT 249.088

143 WEIGHT 254.588

144 WEIGHT 174.695

145 WEIGHT 113.995

146 WEIGHT 187.534

147 WEIGHT 182.272

148 WEIGHT 182.272

149 WEIGHT 187.534

150 WEIGHT 113.995

151 WEIGHT 113.982

152 WEIGHT 187.522

153 WEIGHT 182.276

154 WEIGHT 182.276
155 WEIGHT 187.522
156 WEIGHT 113.982
157 WEIGHT 174.686
158 WEIGHT 254.579
159 WEIGHT 249.085
160 WEIGHT 249.085
161 WEIGHT 254.579
162 WEIGHT 174.686
163 WEIGHT 169.416
164 WEIGHT 249.401
165 WEIGHT 243.879
166 WEIGHT 243.879
167 WEIGHT 249.401
168 WEIGHT 169.416
169 WEIGHT 174.686
170 WEIGHT 254.579
171 WEIGHT 249.085
172 WEIGHT 249.085
173 WEIGHT 254.579
174 WEIGHT 174.686
175 WEIGHT 113.982
176 WEIGHT 187.522
177 WEIGHT 182.276
178 WEIGHT 182.276
179 WEIGHT 187.522
180 WEIGHT 113.982

181 WEIGHT 113.765

182 WEIGHT 187.519

183 WEIGHT 182.238

184 WEIGHT 182.238

185 WEIGHT 187.519

186 WEIGHT 113.765

187 WEIGHT 174.666

188 WEIGHT 254.664

189 WEIGHT 249.112

190 WEIGHT 249.112

191 WEIGHT 254.664

192 WEIGHT 174.666

193 WEIGHT 169.354

194 WEIGHT 249.426

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196 WEIGHT 243.845

197 WEIGHT 249.426

198 WEIGHT 169.354

199 WEIGHT 174.666

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201 WEIGHT 249.112

202 WEIGHT 249.112

203 WEIGHT 254.664

204 WEIGHT 174.666

205 WEIGHT 113.765

206 WEIGHT 187.519

207 WEIGHT 182.238

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208 WEIGHT 182.238

209 WEIGHT 187.519

210 WEIGHT 113.765

211 241 8002 8007 WEIGHT 113.674

212 242 WEIGHT 186.171

213 243 WEIGHT 181.304

214 244 WEIGHT 181.304

215 245 WEIGHT 186.171

216 WEIGHT 113.674

217 247 252 8013 WEIGHT 173.423

218 WEIGHT 252.853

219 WEIGHT 247.693

220 WEIGHT 247.693

221 WEIGHT 252.853

222 WEIGHT 173.423

223 253 258 8019 WEIGHT 168.542

224 WEIGHT 248.006

225 WEIGHT 242.817

226 WEIGHT 242.817

227 WEIGHT 248.006

228 WEIGHT 168.542

229 259 264 8025 WEIGHT 173.423

230 WEIGHT 252.853

231 WEIGHT 247.693

232 WEIGHT 247.693

233 WEIGHT 252.853

234 WEIGHT 173.423
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235 265 270 WEIGHT 113.674

236 266 WEIGHT 186.171

237 267 WEIGHT 181.304

238 268 WEIGHT 181.304

239 269 WEIGHT 186.171

240 WEIGHT 113.674

241 8002 8007 WEIGHT 114.116

242 8003 WEIGHT 184.846

243 8004 WEIGHT 180.459

244 8005 WEIGHT 180.459

245 8006 WEIGHT 184.846

246 8007 WEIGHT 114.116

247 8008 8013 WEIGHT 172.28

248 WEIGHT 250.789

249 WEIGHT 246.224

250 WEIGHT 246.224

251 WEIGHT 250.789

252 WEIGHT 172.28

253 8014 8019 WEIGHT 167.896

254 WEIGHT 246.509

255 WEIGHT 241.949

256 WEIGHT 241.949

257 WEIGHT 246.509

258 WEIGHT 167.896

259 8020 8025 WEIGHT 172.28

260 WEIGHT 250.789

261 WEIGHT 246.224

262 WEIGHT 246.224

263 WEIGHT 250.789

264 WEIGHT 172.28

265 WEIGHT 114.116

266 8027 WEIGHT 184.846

267 8028 WEIGHT 180.459

268 8029 WEIGHT 180.459

269 8030 WEIGHT 184.846

270 8031 WEIGHT 114.116

8002 WEIGHT 66.303

8003 WEIGHT 117.361

8004 WEIGHT 112.328

8005 WEIGHT 112.328

8006 WEIGHT 117.361

8007 WEIGHT 66.303

8008 WEIGHT 109.246

8009 WEIGHT 173.595

8010 WEIGHT 167.615

8011 WEIGHT 167.615

8012 WEIGHT 173.595

8013 WEIGHT 109.246

8014 WEIGHT 104.287

8015 WEIGHT 168.014

8016 WEIGHT 161.899

8017 WEIGHT 161.899

8018 WEIGHT 168.014

8019 WEIGHT 104.287

8020 WEIGHT 109.246

8021 WEIGHT 173.595

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8023 WEIGHT 167.615

8024 WEIGHT 173.595

8025 WEIGHT 109.246

8026 WEIGHT 66.303

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8030 WEIGHT 117.361

8031 WEIGHT 66.303

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8062 WEIGHT 2
CUT OFF MODE SHAPE 10
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LOAD 1 SEIMIC LOAD X- DIR
JOINT LOAD
1 FX 81.595 FY 81.595 FZ 81.595
2 FX 113.086 FY 113.086 FZ 113.086
3 FX 116.409 FY 116.409 FZ 116.409
4 FX 187.528 FY 187.528 FZ 187.528
5 FX 113.992 FY 113.992 FZ 113.992
6 FX 181.892 FY 181.892 FZ 181.892
7 FX 113.992 FY 113.992 FZ 113.992
8 FX 181.892 FY 181.892 FZ 181.892
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9 FX 116.409 FY 116.409 FZ 116.409

10 FX 187.528 FY 187.528 FZ 187.528

11 FX 81.595 FY 81.595 FZ 81.595

12 FX 113.086 FY 113.086 FZ 113.086

13 FX 104.819 FY 104.819 FZ 104.819

14 FX 174.477 FY 174.477 FZ 174.477

15 FX 109.544 FY 109.544 FZ 109.544

16 FX 255.528 FY 255.528 FZ 255.528

17 FX 108.272 FY 108.272 FZ 108.272

18 FX 249.399 FY 249.399 FZ 249.399

19 FX 108.272 FY 108.272 FZ 108.272

20 FX 249.399 FY 249.399 FZ 249.399

21 FX 109.544 FY 109.544 FZ 109.544

22 FX 255.528 FY 255.528 FZ 255.528

23 FX 104.819 FY 104.819 FZ 104.819

24 FX 174.477 FY 174.477 FZ 174.477

25 FX 102.261 FY 102.261 FZ 102.261

26 FX 168.83 FY 168.83 FZ 168.83

27 FX 108.155 FY 108.155 FZ 108.155

28 FX 249.753 FY 249.753 FZ 249.753

29 FX 106.975 FY 106.975 FZ 106.975

30 FX 243.558 FY 243.558 FZ 243.558

31 FX 106.975 FY 106.975 FZ 106.975

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35 FX 102.261 FY 102.261 FZ 102.261

36 FX 168.83 FY 168.83 FZ 168.83

37 FX 104.819 FY 104.819 FZ 104.819

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47 FX 104.819 FY 104.819 FZ 104.819

48 FX 174.477 FY 174.477 FZ 174.477

49 FX 81.595 FY 81.595 FZ 81.595

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57 FX 116.409 FY 116.409 FZ 116.409

58 FX 187.528 FY 187.528 FZ 187.528

59 FX 81.595 FY 81.595 FZ 81.595

60 FX 113.086 FY 113.086 FZ 113.086

61 FX 114.189 FY 114.189 FZ 114.189

62 FX 187.509 FY 187.509 FZ 187.509

63 FX 182.324 FY 182.324 FZ 182.324

64 FX 182.324 FY 182.324 FZ 182.324

65 FX 187.509 FY 187.509 FZ 187.509

66 FX 114.189 FY 114.189 FZ 114.189

67 FX 174.697 FY 174.697 FZ 174.697

68 FX 254.458 FY 254.458 FZ 254.458

69 FX 249.049 FY 249.049 FZ 249.049

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71 FX 254.458 FY 254.458 FZ 254.458

72 FX 174.697 FY 174.697 FZ 174.697

73 FX 169.489 FY 169.489 FZ 169.489

74 FX 249.361 FY 249.361 FZ 249.361

75 FX 243.932 FY 243.932 FZ 243.932

76 FX 243.932 FY 243.932 FZ 243.932

77 FX 249.361 FY 249.361 FZ 249.361

78 FX 169.489 FY 169.489 FZ 169.489

79 FX 174.697 FY 174.697 FZ 174.697

80 FX 254.458 FY 254.458 FZ 254.458

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84 FX 174.697 FY 174.697 FZ 174.697

85 FX 114.189 FY 114.189 FZ 114.189

86 FX 187.509 FY 187.509 FZ 187.509

87 FX 182.324 FY 182.324 FZ 182.324

88 FX 182.324 FY 182.324 FZ 182.324

89 FX 187.509 FY 187.509 FZ 187.509

90 FX 114.189 FY 114.189 FZ 114.189

91 FX 113.99 FY 113.99 FZ 113.99

92 FX 187.535 FY 187.535 FZ 187.535

93 FX 182.265 FY 182.265 FZ 182.265

94 FX 182.265 FY 182.265 FZ 182.265

95 FX 187.535 FY 187.535 FZ 187.535

96 FX 113.99 FY 113.99 FZ 113.99

97 FX 174.69 FY 174.69 FZ 174.69

98 FX 254.607 FY 254.607 FZ 254.607

99 FX 249.093 FY 249.093 FZ 249.093

100 FX 249.093 FY 249.093 FZ 249.093

101 FX 254.607 FY 254.607 FZ 254.607

102 FX 174.69 FY 174.69 FZ 174.69

103 FX 169.398 FY 169.398 FZ 169.398

104 FX 249.409 FY 249.409 FZ 249.409

105 FX 243.865 FY 243.865 FZ 243.865

106 FX 243.865 FY 243.865 FZ 243.865

107 FX 249.409 FY 249.409 FZ 249.409

108 FX 169.398 FY 169.398 FZ 169.398

109 FX 174.69 FY 174.69 FZ 174.69

110 FX 254.607 FY 254.607 FZ 254.607

111 FX 249.093 FY 249.093 FZ 249.093

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113 FX 254.607 FY 254.607 FZ 254.607

114 FX 174.69 FY 174.69 FZ 174.69

115 FX 113.99 FY 113.99 FZ 113.99

116 FX 187.535 FY 187.535 FZ 187.535

117 FX 182.265 FY 182.265 FZ 182.265

118 FX 182.265 FY 182.265 FZ 182.265

119 FX 187.535 FY 187.535 FZ 187.535

120 FX 113.99 FY 113.99 FZ 113.99

121 FX 113.995 FY 113.995 FZ 113.995

122 FX 187.534 FY 187.534 FZ 187.534

123 FX 182.272 FY 182.272 FZ 182.272

124 FX 182.272 FY 182.272 FZ 182.272

125 FX 187.534 FY 187.534 FZ 187.534

126 FX 113.995 FY 113.995 FZ 113.995

127 FX 174.695 FY 174.695 FZ 174.695

128 FX 254.588 FY 254.588 FZ 254.588

129 FX 249.088 FY 249.088 FZ 249.088

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131 FX 254.588 FY 254.588 FZ 254.588

132 FX 174.695 FY 174.695 FZ 174.695

133 FX 169.411 FY 169.411 FZ 169.411

134 FX 249.403 FY 249.403 FZ 249.403

135 FX 243.875 FY 243.875 FZ 243.875

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137 FX 249.403 FY 249.403 FZ 249.403

138 FX 169.411 FY 169.411 FZ 169.411

139 FX 174.695 FY 174.695 FZ 174.695

140 FX 254.588 FY 254.588 FZ 254.588

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144 FX 174.695 FY 174.695 FZ 174.695

145 FX 113.995 FY 113.995 FZ 113.995

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149 FX 187.534 FY 187.534 FZ 187.534

150 FX 113.995 FY 113.995 FZ 113.995

151 FX 113.982 FY 113.982 FZ 113.982

152 FX 187.522 FY 187.522 FZ 187.522

153 FX 182.276 FY 182.276 FZ 182.276

154 FX 182.276 FY 182.276 FZ 182.276

155 FX 187.522 FY 187.522 FZ 187.522

156 FX 113.982 FY 113.982 FZ 113.982

157 FX 174.686 FY 174.686 FZ 174.686

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159 FX 249.085 FY 249.085 FZ 249.085

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161 FX 254.579 FY 254.579 FZ 254.579

162 FX 174.686 FY 174.686 FZ 174.686

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164 FX 249.401 FY 249.401 FZ 249.401

165 FX 243.879 FY 243.879 FZ 243.879

166 FX 243.879 FY 243.879 FZ 243.879

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169 FX 174.686 FY 174.686 FZ 174.686

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171 FX 249.085 FY 249.085 FZ 249.085

172 FX 249.085 FY 249.085 FZ 249.085

173 FX 254.579 FY 254.579 FZ 254.579

174 FX 174.686 FY 174.686 FZ 174.686

175 FX 113.982 FY 113.982 FZ 113.982

176 FX 187.522 FY 187.522 FZ 187.522

177 FX 182.276 FY 182.276 FZ 182.276

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179 FX 187.522 FY 187.522 FZ 187.522

180 FX 113.982 FY 113.982 FZ 113.982

181 FX 113.765 FY 113.765 FZ 113.765

182 FX 187.519 FY 187.519 FZ 187.519

183 FX 182.238 FY 182.238 FZ 182.238

184 FX 182.238 FY 182.238 FZ 182.238

185 FX 187.519 FY 187.519 FZ 187.519

186 FX 113.765 FY 113.765 FZ 113.765

187 FX 174.666 FY 174.666 FZ 174.666

188 FX 254.664 FY 254.664 FZ 254.664

189 FX 249.112 FY 249.112 FZ 249.112

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191 FX 254.664 FY 254.664 FZ 254.664

192 FX 174.666 FY 174.666 FZ 174.666

193 FX 169.354 FY 169.354 FZ 169.354

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195 FX 243.845 FY 243.845 FZ 243.845

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199 FX 174.666 FY 174.666 FZ 174.666

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205 FX 113.765 FY 113.765 FZ 113.765

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210 FX 113.765 FY 113.765 FZ 113.765

211 241 8002 8007 FX 113.674 FY 113.674 FZ 113.674

212 242 FX 186.171 FY 186.171 FZ 186.171

213 243 FX 181.304 FY 181.304 FZ 181.304

214 244 FX 181.304 FY 181.304 FZ 181.304

215 245 FX 186.171 FY 186.171 FZ 186.171

216 FX 113.674 FY 113.674 FZ 113.674

217 247 252 8013 FX 173.423 FY 173.423 FZ 173.423

218 FX 252.853 FY 252.853 FZ 252.853

219 FX 247.693 FY 247.693 FZ 247.693

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221 FX 252.853 FY 252.853 FZ 252.853

222 FX 173.423 FY 173.423 FZ 173.423

223 253 258 8019 FX 168.542 FY 168.542 FZ 168.542

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225 FX 242.817 FY 242.817 FZ 242.817

226 FX 242.817 FY 242.817 FZ 242.817

227 FX 248.006 FY 248.006 FZ 248.006

228 FX 168.542 FY 168.542 FZ 168.542

229 259 264 8025 FX 173.423 FY 173.423 FZ 173.423

230 FX 252.853 FY 252.853 FZ 252.853

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233 FX 252.853 FY 252.853 FZ 252.853

234 FX 173.423 FY 173.423 FZ 173.423

235 265 270 FX 113.674 FY 113.674 FZ 113.674

236 266 FX 186.171 FY 186.171 FZ 186.171

237 267 FX 181.304 FY 181.304 FZ 181.304

238 268 FX 181.304 FY 181.304 FZ 181.304

239 269 FX 186.171 FY 186.171 FZ 186.171

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241 8002 8007 FX 114.116 FY 114.116 FZ 114.116

242 8003 FX 184.846 FY 184.846 FZ 184.846

243 8004 FX 180.459 FY 180.459 FZ 180.459

244 8005 FX 180.459 FY 180.459 FZ 180.459

245 8006 FX 184.846 FY 184.846 FZ 184.846

246 8007 FX 114.116 FY 114.116 FZ 114.116

247 8008 8013 FX 172.28 FY 172.28 FZ 172.28

248 FX 250.789 FY 250.789 FZ 250.789

249 FX 246.224 FY 246.224 FZ 246.224

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251 FX 250.789 FY 250.789 FZ 250.789

252 FX 172.28 FY 172.28 FZ 172.28

253 8014 8019 FX 167.896 FY 167.896 FZ 167.896

254 FX 246.509 FY 246.509 FZ 246.509

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258 FX 167.896 FY 167.896 FZ 167.896

259 8020 8025 FX 172.28 FY 172.28 FZ 172.28

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265 FX 114.116 FY 114.116 FZ 114.116

266 8027 FX 184.846 FY 184.846 FZ 184.846

267 8028 FX 180.459 FY 180.459 FZ 180.459

268 8029 FX 180.459 FY 180.459 FZ 180.459

269 8030 FX 184.846 FY 184.846 FZ 184.846

270 8031 FX 114.116 FY 114.116 FZ 114.116

8002 FX 66.303 FY 66.303 FZ 66.303

8003 FX 117.361 FY 117.361 FZ 117.361

8004 FX 112.328 FY 112.328 FZ 112.328

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8007 FX 66.303 FY 66.303 FZ 66.303

8008 FX 109.246 FY 109.246 FZ 109.246

8009 FX 173.595 FY 173.595 FZ 173.595

8010 FX 167.615 FY 167.615 FZ 167.615

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8022 FX 167.615 FY 167.615 FZ 167.615

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8025 FX 109.246 FY 109.246 FZ 109.246

8026 FX 66.303 FY 66.303 FZ 66.303

8027 FX 117.361 FY 117.361 FZ 117.361

8028 FX 112.328 FY 112.328 FZ 112.328

8029 FX 112.328 FY 112.328 FZ 112.328

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8031 FX 66.303 FY 66.303 FZ 66.303

8033 FX 2 FY 2 FZ 2

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8059 FX 2 FY 2 FZ 2

8060 FX 2 FY 2 FZ 2

8061 FX 2 FY 2 FZ 2

8062 FX 2 FY 2 FZ 2

*****MULTIPLYING FACTOR ( Vb/VB )= AS PER OUT FILE*****************

SPECTRUM CQC 1893 TOR X 0.024 ACC SCALE 1 DAMP 0.05
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SOIL TYPE 2
*********MULTIPLYING FACTOR ( Vb/VB )= AS PER OUT FILE ****************
LOAD 2 LOADTYPE None  TITLE SEIMIC LOAD Z- DIR
SPECTRUM CQC 1893 TOR Z 0.024 ACC SCALE 1 DAMP 0.05
SOIL TYPE 2
****************DEAD LOAD*****************************************
LOAD 3 LOADTYPE Dead  TITLE LOAD DL
SELFWEIGHT Y -1
FLOOR LOAD
YRANGE 3 28 FLOAD -4.95 GY
MEMBER LOAD
36 TO 50 60 TO 75 115 TO 129 139 TO 154 194 TO 208 218 TO 233 273 TO 287 297 -
298 TO 312 352 TO 366 376 TO 391 431 TO 445 455 TO 470 510 TO 524 534 TO 549 -
589 TO 603 613 TO 628 748 TO 762 772 TO 787 UNI GY -6
31 TO 35 51 TO 59 76 TO 79 110 TO 114 130 TO 138 155 TO 158 189 TO 193 209 -
210 TO 217 234 TO 237 268 TO 272 288 TO 296 313 TO 316 347 TO 351 367 TO 375 -
392 TO 395 426 TO 430 446 TO 454 471 TO 474 505 TO 509 525 TO 533 -
550 TO 553 584 TO 588 604 TO 612 629 TO 632 743 TO 747 763 TO 771 -
788 TO 791 UNI GY -12
664 TO 668 684 TO 692 709 TO 712 UNI GY -3.9
LOAD 4 LOADTYPE Live  TITLE LOAD LL
FLOOR LOAD
YRANGE 3 25 FLOAD -3.5 GY
YRANGE 26 28 FLOAD -1.5 GY
****************Lump Mass***********
*LOAD COMB 100 (SELF+DL+0.50LL)
*3 1.0 4 0.5
```

```
*PERFORM ANALYSIS
*FINISH
************ Load Combination ***********
************EARTH QUAKE LOAD***********************
LOAD COMB 100 (SELF+DL+LL)
3 1.0 4 1.0
LOAD COMB 101 1.5*(DL+LL)
3 1.5 4 1.5
LOAD COMB 102 1.2*(DL+LL+EQX)
3 1.2 4 1.2 1 1.2
LOAD COMB 103 1.2*(DL+LL-EQX)
3 1.2 4 1.2 1 -1.2
LOAD COMB 104 1.2*(DL+LL+EQZ)
3 1.2 4 1.2 2 1.2
LOAD COMB 105 1.2*(DL+LL-EQZ)
3 1.2 4 1.2 2 -1.2
LOAD COMB 106 1.5*(DL+EQX)
3 1.5 1 1.5
LOAD COMB 107 1.5*(DL-EQX)
3 1.5 1 -1.5
LOAD COMB 108 1.5*(DL+EQZ)
3 1.5 2 1.5
LOAD COMB 109 1.5*(DL-EQZ)
3 1.5 2 -1.5
LOAD COMB 110 (0.9*DL+1.5*EQX)
3 0.9 1 1.5
LOAD COMB 111 (0.9*DL-1.5*EQX)
```

```
3 0.9 1 -1.5
LOAD COMB 112 (0.9*DL+1.5*EQZ)
3 0.9 2 1.5
LOAD COMB 113 (0.9*DL-1.5*EQZ)
3 0.9 2 -1.5
PERFORM ANALYSIS
LOAD LIST 101 TO 113
PERFORM ANALYSIS PRINT ALL
START CONCRETE DESIGN
CODE INDIAN
*START CONCRETE DESIGN
*CODE IS13920
*END CONCRETE DESIGN
FYSEC 500000 ALL
FYMAIN 500000 ALL
FC 25000 ALL
MINSEC 6 ALL
MAXSEC 20 ALL
MAXMAIN 32 ALL
METHOD 1 MEMB 1 2 8 80 81 87 159 160 166 238 239 245 317 318 324 396 397 403 -
475 476 482 554 555 561 633 634 640 713 714 720
RATIO 4 MEMB 1 2 8 80 81 87 159 160 166 238 239 245 317 318 324 396 397 403 -
475 476 482 554 555 561 633 634 640 713 714 720
RATIO 2.5 MEMB 31 60 110 139 189 218 268 297 347 376 426 455 505 534 584 613 -
664 693 743 772
CLEAR 0.025 MEMB 31 60 110 139 189 218 268 297 347 376 426 455 505 534 584 -
613 664 693 743 772
```

```
*TRACK 2 ALL
DESIGN COLUMN 1 2 8 80 81 87 159 160 166 238 239 245 317 318 324 396 397 403 -
475 476 482 554 555 561 633 634 640 713 714 720
DESIGN BEAM 31 60 110 139 189 218 268 297 347 376 426 455 505 534 584 613 -
664 693 743 772
END CONCRETE DESIGN
FINISH
```

APPENDIX: 3

```
STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 10-Aug-13
JOB NAME Model 8.3 - Masonry infill as surface element
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
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12 24 23 11 SURFACE 6

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58 56 55 57 SURFACE 11

56 54 53 55 SURFACE 12

54 52 51 53 SURFACE 13

52 50 49 51 SURFACE 14

50 38 37 49 SURFACE 15

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26 14 13 25 SURFACE 17

14 2 1 13 SURFACE 18

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62 63 6 4 SURFACE 20

63 64 8 6 SURFACE 21

64 65 10 8 SURFACE 22

65 66 12 10 SURFACE 23

66 72 24 12 SURFACE 24

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84 90 60 48 SURFACE 27

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87 86 52 54 SURFACE 31

86 85 50 52 SURFACE 32

85 79 38 50 SURFACE 33

79 73 26 38 SURFACE 34

73 67 14 26 SURFACE 35

67 61 2 14 SURFACE 36

91 92 62 61 SURFACE 37

92 93 63 62 SURFACE 38

93 94 64 63 SURFACE 39

94 95 65 64 SURFACE 40

95 96 66 65 SURFACE 41

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180 179 149 150 SURFACE 82

179 178 148 149 SURFACE 83

178 177 147 148 SURFACE 84

177 176 146 147 SURFACE 85

176 175 145 146 SURFACE 86

175 169 139 145 SURFACE 87

169 163 133 139 SURFACE 88

163 157 127 133 SURFACE 89

157 151 121 127 SURFACE 90

181 182 152 151 SURFACE 91

182 183 153 152 SURFACE 92

183 184 154 153 SURFACE 93

184 185 155 154 SURFACE 94

185 186 156 155 SURFACE 95

186 192 162 156 SURFACE 96

192 198 168 162 SURFACE 97

198 204 174 168 SURFACE 98

204 210 180 174 SURFACE 99

210 209 179 180 SURFACE 100

209 208 178 179 SURFACE 101

208 207 177 178 SURFACE 102

207 206 176 177 SURFACE 103

206 205 175 176 SURFACE 104

205 199 169 175 SURFACE 105

199 193 163 169 SURFACE 106

193 187 157 163 SURFACE 107

187 181 151 157 SURFACE 108

211 212 182 181 SURFACE 109

212 213 183 182 SURFACE 110

213 214 184 183 SURFACE 111

214 215 185 184 SURFACE 112

215 216 186 185 SURFACE 113

216 222 192 186 SURFACE 114

222 228 198 192 SURFACE 115

228 234 204 198 SURFACE 116

234 240 210 204 SURFACE 117

240 239 209 210 SURFACE 118

239 238 208 209 SURFACE 119

238 237 207 208 SURFACE 120

237 236 206 207 SURFACE 121

236 235 205 206 SURFACE 122

235 229 199 205 SURFACE 123

229 223 193 199 SURFACE 124

223 217 187 193 SURFACE 125

217 211 181 187 SURFACE 126

241 242 212 211 SURFACE 127

242 243 213 212 SURFACE 128

243 244 214 213 SURFACE 129

244 245 215 214 SURFACE 130

245 246 216 215 SURFACE 131

246 252 222 216 SURFACE 132

252 258 228 222 SURFACE 133

258 264 234 228 SURFACE 134

264 270 240 234 SURFACE 135

270 269 239 240 SURFACE 136

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269 268 238 239 SURFACE 137
268 267 237 238 SURFACE 138
267 266 236 237 SURFACE 139
266 265 235 236 SURFACE 140
265 259 229 235 SURFACE 141
259 253 223 229 SURFACE 142
253 247 217 223 SURFACE 143
247 241 211 217 SURFACE 144
8002 8003 242 241 SURFACE 145
8003 8004 243 242 SURFACE 146
8004 8005 244 243 SURFACE 147
8005 8006 245 244 SURFACE 148
8006 8007 246 245 SURFACE 149
8007 8013 252 246 SURFACE 150
8013 8019 258 252 SURFACE 151
8019 8025 264 258 SURFACE 152
8025 8031 270 264 SURFACE 153
8031 8030 269 270 SURFACE 154
8030 8029 268 269 SURFACE 155
8029 8028 267 268 SURFACE 156
8028 8027 266 267 SURFACE 157
8027 8026 265 266 SURFACE 158
8026 8020 259 265 SURFACE 159
8020 8014 253 259 SURFACE 160
8014 8008 247 253 SURFACE 161
8008 8002 241 247 SURFACE 162
************************************************************************
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DEFINE MATERIAL START
ISOTROPIC M25
E 2.5e+007
POISSON 0.17
DENSITY 25
ALPHA 1e-005
DAMP 0.05
ISOTROPIC CONCRETE
E 2.17185e+007
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
ISOTROPIC BRICK
E 2.2e+006
POISSON 0.17
DENSITY 0
ALPHA 1e-005
DAMP 0.05
END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
1 TO 30 80 TO 109 159 TO 188 238 TO 267 317 TO 346 396 TO 425 475 TO 504 554 -
555 TO 583 633 TO 662 713 TO 742 PRIS YD 0.4 ZD 0.4
MEMBER PROPERTY INDIAN
31 TO 79 110 TO 158 189 TO 237 268 TO 316 347 TO 395 426 TO 474 505 TO 553 -
584 TO 632 664 TO 712 743 TO 791 PRIS YD 0.5 ZD 0.4
SURFACE PROPERTY
```

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1 TO 162 THICKNESS 0.23
CONSTANTS
MATERIAL M25 ALL
SURFACE CONSTANTS
MATERIAL BRICK LIST 1 TO 162
SUPPORTS
8033 TO 8062 FIXED
********************************************
SLAVE ZX MASTER 1001 JOINT 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 -
36 38 40 42 44 46 48 50 52 54 56 58 60
SLAVE ZX MASTER 2001 JOINT 61 TO 90
SLAVE ZX MASTER 3001 JOINT 91 TO 120
SLAVE ZX MASTER 4001 JOINT 121 TO 150
SLAVE ZX MASTER 5001 JOINT 151 TO 180
SLAVE ZX MASTER 6001 JOINT 181 TO 210
SLAVE ZX MASTER 7001 JOINT 211 TO 240
SLAVE ZX MASTER 8001 JOINT 241 TO 270
SLAVE ZX MASTER 8032 JOINT 8002 TO 8031
DEFINE 1893 LOAD
********SEISMIC ZONE-IV (IS 1893 :2002, PART 1)
ZONE 0.24 RF 5 I 1 SS 2 ST 3 DM 0.05
*PX 0.693 PZ 0.742 DT 1
***************************MODAL WEIGHT**************************
JOINT WEIGHT
1 WEIGHT 81.595
2 WEIGHT 113.086
3 WEIGHT 116.409
```

4 WEIGHT 187.528
5 WEIGHT 113.992
6 WEIGHT 181.892
7 WEIGHT 113.992
8 WEIGHT 181.892
9 WEIGHT 116.409
10 WEIGHT 187.528
11 WEIGHT 81.595
12 WEIGHT 113.086
13 WEIGHT 104.819
14 WEIGHT 174.477
15 WEIGHT 109.544
16 WEIGHT 255.528
17 WEIGHT 108.272
18 WEIGHT 249.399
19 WEIGHT 108.272
20 WEIGHT 249.399
21 WEIGHT 109.544
22 WEIGHT 255.528
23 WEIGHT 104.819
24 WEIGHT 174.477
25 WEIGHT 102.261
26 WEIGHT 168.83
27 WEIGHT 108.155
28 WEIGHT 249.753
29 WEIGHT 106.975
30 WEIGHT 243.558

31 WEIGHT 106.975

32 WEIGHT 243.558

33 WEIGHT 108.155

34 WEIGHT 249.753

35 WEIGHT 102.261

36 WEIGHT 168.83

37 WEIGHT 104.819

38 WEIGHT 174.477

39 WEIGHT 109.544

40 WEIGHT 255.528

41 WEIGHT 108.272

42 WEIGHT 249.399

43 WEIGHT 108.272

44 WEIGHT 249.399

45 WEIGHT 109.544

46 WEIGHT 255.528

47 WEIGHT 104.819

48 WEIGHT 174.477

49 WEIGHT 81.595

50 WEIGHT 113.086

51 WEIGHT 116.409

52 WEIGHT 187.528

53 WEIGHT 113.992

54 WEIGHT 181.892

55 WEIGHT 113.992

56 WEIGHT 181.892

57 WEIGHT 116.409

58 WEIGHT 187.528

59 WEIGHT 81.595

60 WEIGHT 113.086

61 WEIGHT 114.189

62 WEIGHT 187.509

63 WEIGHT 182.324

64 WEIGHT 182.324

65 WEIGHT 187.509

66 WEIGHT 114.189

67 WEIGHT 174.697

68 WEIGHT 254.458

69 WEIGHT 249.049

70 WEIGHT 249.049

71 WEIGHT 254.458

72 WEIGHT 174.697

73 WEIGHT 169.489

74 WEIGHT 249.361

75 WEIGHT 243.932

76 WEIGHT 243.932

77 WEIGHT 249.361

78 WEIGHT 169.489

79 WEIGHT 174.697

80 WEIGHT 254.458

81 WEIGHT 249.049

82 WEIGHT 249.049

83 WEIGHT 254.458

84 WEIGHT 174.697

85 WEIGHT 114.189

86 WEIGHT 187.509

87 WEIGHT 182.324

88 WEIGHT 182.324

89 WEIGHT 187.509

90 WEIGHT 114.189

91 WEIGHT 113.99

92 WEIGHT 187.535

93 WEIGHT 182.265

94 WEIGHT 182.265

95 WEIGHT 187.535

96 WEIGHT 113.99

97 WEIGHT 174.69

98 WEIGHT 254.607

99 WEIGHT 249.093

100 WEIGHT 249.093

101 WEIGHT 254.607

102 WEIGHT 174.69

103 WEIGHT 169.398

104 WEIGHT 249.409

105 WEIGHT 243.865

106 WEIGHT 243.865

107 WEIGHT 249.409

108 WEIGHT 169.398

109 WEIGHT 174.69

110 WEIGHT 254.607

111 WEIGHT 249.093

112 WEIGHT 249.093

113 WEIGHT 254.607

114 WEIGHT 174.69

115 WEIGHT 113.99

116 WEIGHT 187.535

117 WEIGHT 182.265

118 WEIGHT 182.265

119 WEIGHT 187.535

120 WEIGHT 113.99

121 WEIGHT 113.995

122 WEIGHT 187.534

123 WEIGHT 182.272

124 WEIGHT 182.272

125 WEIGHT 187.534

126 WEIGHT 113.995

127 WEIGHT 174.695

128 WEIGHT 254.588

129 WEIGHT 249.088

130 WEIGHT 249.088

131 WEIGHT 254.588

132 WEIGHT 174.695

133 WEIGHT 169.411

134 WEIGHT 249.403

135 WEIGHT 243.875

136 WEIGHT 243.875

137 WEIGHT 249.403

138 WEIGHT 169.411

139 WEIGHT 174.695

140 WEIGHT 254.588

141 WEIGHT 249.088

142 WEIGHT 249.088

143 WEIGHT 254.588

144 WEIGHT 174.695

145 WEIGHT 113.995

146 WEIGHT 187.534

147 WEIGHT 182.272

148 WEIGHT 182.272

149 WEIGHT 187.534

150 WEIGHT 113.995

151 WEIGHT 113.982

152 WEIGHT 187.522

153 WEIGHT 182.276

154 WEIGHT 182.276

155 WEIGHT 187.522

156 WEIGHT 113.982

157 WEIGHT 174.686

158 WEIGHT 254.579

159 WEIGHT 249.085

160 WEIGHT 249.085

161 WEIGHT 254.579

162 WEIGHT 174.686

163 WEIGHT 169.416

164 WEIGHT 249.401

165 WEIGHT 243.879

166 WEIGHT 243.879

167 WEIGHT 249.401

168 WEIGHT 169.416

169 WEIGHT 174.686

170 WEIGHT 254.579

171 WEIGHT 249.085

172 WEIGHT 249.085

173 WEIGHT 254.579

174 WEIGHT 174.686

175 WEIGHT 113.982

176 WEIGHT 187.522

177 WEIGHT 182.276

178 WEIGHT 182.276

179 WEIGHT 187.522

180 WEIGHT 113.982

181 WEIGHT 113.765

182 WEIGHT 187.519

183 WEIGHT 182.238

184 WEIGHT 182.238

185 WEIGHT 187.519

186 WEIGHT 113.765

187 WEIGHT 174.666

188 WEIGHT 254.664

189 WEIGHT 249.112

190 WEIGHT 249.112

191 WEIGHT 254.664

192 WEIGHT 174.666

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****************
LOAD 2 LOADTYPE None  TITLE SEIMIC LOAD Z- DIR
SPECTRUM CQC 1893 TOR Z 0.024 ACC SCALE 1 DAMP 0.05
SOIL TYPE 2
**************DEAD LOAD*****************************************
LOAD 3 LOADTYPE Dead  TITLE LOAD DL
SELFWEIGHT Y -1
FLOOR LOAD
YRANGE 3 28 FLOAD -4.95 GY
MEMBER LOAD
36 TO 50 60 TO 75 115 TO 129 139 TO 154 194 TO 208 218 TO 233 273 TO 287 297 -
298 TO 312 352 TO 366 376 TO 391 431 TO 445 455 TO 470 510 TO 524 534 TO 549 -
589 TO 603 613 TO 628 748 TO 762 772 TO 787 UNI GY -6
31 TO 35 51 TO 59 76 TO 79 110 TO 114 130 TO 138 155 TO 158 189 TO 193 209 -
210 TO 217 234 TO 237 268 TO 272 288 TO 296 313 TO 316 347 TO 351 367 TO 375 -
392 TO 395 426 TO 430 446 TO 454 471 TO 474 505 TO 509 525 TO 533 -
550 TO 553 584 TO 588 604 TO 612 629 TO 632 743 TO 747 763 TO 771 -
788 TO 791 UNI GY -12
664 TO 668 684 TO 692 709 TO 712 UNI GY -3.9
LOAD 4 LOADTYPE Live  TITLE LOAD LL
FLOOR LOAD
YRANGE 3 25 FLOAD -3.5 GY
YRANGE 26 28 FLOAD -1.5 GY
****************Lump Mass***********
*LOAD COMB 100 (SELF+DL+0.50LL)
*3 1.0 4 0.5
*PERFORM ANALYSIS
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*FINISH

************ Load Combination ***********

************EARTH QUAKE LOAD***********************

LOAD COMB 100 (SELF+DL+LL)

3 1.0 4 1.0

LOAD COMB 101 1.5*(DL+LL)

3 1.5 4 1.5

LOAD COMB 102 1.2*(DL+LL+EQX)

3 1.2 4 1.2 1 1.2

LOAD COMB 103 1.2*(DL+LL-EQX)

3 1.2 4 1.2 1 -1.2

LOAD COMB 104 1.2*(DL+LL+EQZ)

3 1.2 4 1.2 2 1.2

LOAD COMB 105 1.2*(DL+LL-EQZ)

3 1.2 4 1.2 2 -1.2

LOAD COMB 106 1.5*(DL+EQX)

3 1.5 1 1.5

LOAD COMB 107 1.5*(DL-EQX)

3 1.5 1 -1.5

LOAD COMB 108 1.5*(DL+EQZ)

3 1.5 2 1.5

LOAD COMB 109 1.5*(DL-EQZ)

3 1.5 2 -1.5

LOAD COMB 110 (0.9*DL+1.5*EQX)

3 0.9 1 1.5

LOAD COMB 111 (0.9*DL-1.5*EQX)

3 0.9 1 -1.5
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```
LOAD COMB 112 (0.9*DL+1.5*EQZ)
3 0.9 2 1.5
LOAD COMB 113 (0.9*DL-1.5*EQZ)
3 0.9 2 -1.5
PERFORM ANALYSIS
LOAD LIST 101 TO 113
PERFORM ANALYSIS PRINT ALL
START CONCRETE DESIGN
CODE INDIAN
*START CONCRETE DESIGN
*CODE IS13920
*END CONCRETE DESIGN
FYSEC 500000 ALL
FYMAIN 500000 ALL
FC 25000 ALL
MINSEC 6 ALL
MAXSEC 20 ALL
MAXMAIN 32 ALL
METHOD 1 MEMB 1 2 8 80 81 87 159 160 166 238 239 245 317 318 324 396 397 403 -
475 476 482 554 555 561 633 634 640 713 714 720
RATIO 4 MEMB 1 2 8 80 81 87 159 160 166 238 239 245 317 318 324 396 397 403 -
475 476 482 554 555 561 633 634 640 713 714 720
RATIO 2.5 MEMB 31 60 110 139 189 218 268 297 347 376 426 455 505 534 584 613 -
664 693 743 772
CLEAR 0.025 MEMB 31 60 110 139 189 218 268 297 347 376 426 455 505 534 584 -
613 664 693 743 772
*TRACK 2 ALL
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DESIGN COLUMN 1 2 8 80 81 87 159 160 166 238 239 245 317 318 324 396 397 403 -
475 476 482 554 555 561 633 634 640 713 714 720
DESIGN BEAM 31 60 110 139 189 218 268 297 347 376 426 455 505 534 584 613 -
664 693 743 772
END CONCRETE DESIGN
FINISH
```