CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Regular building may be defined as building having uniform distributions of storey strength, stiffness, weight, and geometry over their height. Building plan of regular building is symmetric (or almost symmetric) with regard to the main axis of the building. All lateral load resisting systems, such as cores, structural walls, or frames, shall run without interruption from their foundations to the top of the building or, if setbacks at different heights are present, to the top of the relevant zone of the building. In framed buildings the ratio of the actual storey resistance to the resistance required by the analysis should not vary disproportionately between adjacent storeys.

A regular building attracts very less forces in compare to their irregular counterpart. To perform well in an earthquake, a building should possess four main attributes, namely simple and regular configuration, and adequate lateral strength, stiffness and ductility. Buildings having simple regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation, suffer much less damage than buildings with irregular configurations [(IS 1893(Part1): 2002)][1].

No real life structure falls in above category. Major portion of urban building are irregular. Irregularity arises in building when there is non uniform distribution of mass, stiffness, and/or strength along height of building exists. When one or more of these properties is non-uniformly distributed, either individually or in combination with other properties in any direction, the structure is referred to as being irregular.

Irregularity in structure can be broadly classified in to two types as per IS 1893 (PART 1) 2002:

1. **PLAN IRREGULARITY**
    - A. Torsion Irregularity
    - B. Re-entrant Corners
    - C. Diaphragm Discontinuity
    - D. Out-of-Plane Offsets
    - E. Non-parallel Systems

2. **VERTICAL IRREGULARITY**
    - A. Stiffness Irregularity —Soft Storey
    - B. Mass Irregularity
    - C. Vertical Geometric Irregularity
    - D. In-Plane Discontinuity in Vertical Elements Resisting Lateral Force
    - E. Discontinuity in Capacity — Weak Storey

In present study, the effects of mass irregularity on behavior of building are discussed.

MASS IRREGULARITY

When irregularities in building exist due to non uniform distribution of mass along height then it is termed as mass irregular building. Mass irregularity may occur for many reasons. Real building structures fulfill different functions at various levels over their height, e.g., buildings with floors used for commercial purposes, car parking floors, or heavy mechanical equipment. The different use of a specific floor compared to the adjacent ones results in mass irregularity. Some have been initially designed so, e.g., in the case of a educational library etc. Others have become so by accident, for example due to inconsistencies or even errors during the construction process, while many have been rendered irregular during their lifetime because of damage, rehabilitation or change of use.

Some examples are:

1. When building is used for different purpose than it was designed which attract large mass

2. When some floor are reserved for machine tools or swimming room

3. When some floor is used for purpose like library or offices

1.2 MOTIVATION OF STUDY

Every building is constructed to cater some specific purpose. In order to fulfill the desired function, a number of restrictions is imposed during design and construction of building by concerned organization which gives rise irregularity in building. Irregularity may be in sense of irregular distribution of mass, stiffness, strength, setback in plan or elevation or torsion irregularity. In these condition the role of structural engineer become more critical if the building located in seismically active zone. In order to provide the solution which meets the structural performance of building as specified by governing code and simultaneously providing satisfactory output to clients, structural engineer should have sound understanding of response of different types, parts and configuration of building during seismic event. So structure engineer needs a design procedure that can calculate seismic demands of irregular building.

1.3 SPECIFIC POINT OF STUDY

In present study, the effects of mass irregularity on behaviour of building are discussed. A real building is taken which is actually constructed and effect of mass irregularity is studied for that building. Building is designed in STAAD PRO software and loading is applied according to IS 875 and IS 1893 (PART 1): 2002. Then seismic weight of a storey is increased in ratio of 100%, 150%, 200%, 250%, 300%, 350% and 400% with respect to above or below storey and effect of each case is carefully studied . Same process is repeated for each storey and studied carefully.

1.4 ORGANIZATION OF DISSERTATION

For presentation purposes, the dissertation is structured in six chapters. Summaries of the contents of these chapters are given hereafter.

Chapter 1 introduces the background, specific point of study, motivation of study.

Chapter 2 present detailed objective of study.

Chapter3 present literature review, past earthquake event and different codal provision.

Chapter4 discusses programme of study that include building details, input parameters and output parameters.

Chapter 5 present results and discussion.

Chapter6 conclude the dissertation by drawing conclusion from different chapter and suggesting future research requirement.

Appendix present the sraad editor file of building designed which shows the steps followed in design of building.

CHAPTER 2

OBJECTIVE OF STUDY

Following are the objectives of the study:

1.) To develop a model of a real building actually constructed/to be constructed. This building may or may not be perfectly regular as per guidelines of IS 1893 (PART 1):2002.

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 mass irregularity criteria as per IS 1893 (PART 1):2002 and that of relevant characteristic in real building model.

4.) To consider appropriate changes in physical parameter in real building model and to study the effects of these changes on mass irregular storey characteristic of building model and on seismic performance of building.

5.) To study the effects of application of changes(as described in objective no.4 above) in other storey of the real building model and to study changes in seismic performance of building.

6.) To compare changes in seismic performances affected because of changes in mass of ground floor storey (as per objective no.4) and in other stories (as per objective no.5)

7.) To draw graphs for changes in building performance indices vs changes in storey mass and to attempts at developing characteristics equation for relationship amongst various parameters.

CHAPTER 3

LITERATURE REVIEW

The goal of this chapter is to provide background knowledge related to this study. Hereafter, this chapter explores evidence of actual damage to structures due to mass irregular effects during past earthquakes, reviews analytical and experimental studies conducted to investigate the seismic response of mass irregular building.

3.1 Evidence of Damage to Irregular Structures

Experience from past earthquakes shows that irregular buildings are prone to severe damage.

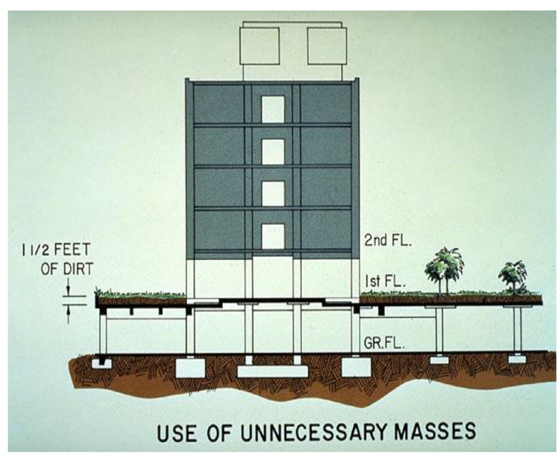

Figure1: Olive View Hospital, San Fernando, California partial View of the 5-story Medical Treatment and Care Unit [2]

The olive view medical centre [2] was a 5 story reinforced concrete structure. Figure 1.1illustrates the damage that olive view hospital suffered during the 1971 San Fernando Earthquake. As shown in Figure 1 a large permanent lateral second floor level displacement of the main Treatment and Care Unit was found. This large inter-story drift, which induced significant non-structural and structural damage and which led to the demolishing of the building, was a consequence of the formation of a soft story at the first story level because of the existence of a reinforced concrete wall above the second floor level caused due to presence of heavy mass on floor .

3.2 PAST STUDY

3.2.1. Valmundsson and Nau (1997) [3] investigated the appropriateness of provisions for considering different irregularities as laid out in the 1994 Uniform Building Code. They considered 2-D building frames with heights of 5, 10 and 20 storeys, assuming the beams to be stiffer than the columns. For each structure height, uniform structures were defined to have a constant mass of 35 Mg at all the floor levels, and the storey stiffness were calculated to give a set of 6 desired fundamental periods. The maximum calculated drifts from the lateral design forces for the regular structures with the target period were found to lie within the UBC limit. Mass irregularities at three floor levels in the elevation of structures were then applied by means of mass ratios (ratio of modified mass of the irregular structure to the mass of uniform structure at a floor level) ranging between 0.1 and 5, and the responses were calculated for design ductility's of 1, 2, 6 and 10 considering four earthquake records. The increase in ductility demand was found to be not greater than 20% for a mass ratio of 1.5 and mass discontinuity was most critical when located on lower floors. Mass irregularity was found to be the least important of the irregularity effects Considered.

3.2.2. Al-Ali and Krawinkler (1998) [4] assessed the effects of vertical irregularities by evaluating the roof drift demands and the distribution of storey demands over the height of the structure. This was obtained by conducting elastic and inelastic dynamic analyses on 2-D single-bay 10-storey generic structures, assuming a column hinge model. A base structure was defined to have a uniform distribution of mass over the height. The stiffness distribution that resulted in a straight-line first mode shape was tuned to produce a first mode period of 3s when designed according to the Modal Superposition technique. Structures with mass irregularities were created by changing the mass distribution of the base model and keeping the same stiffness distribution as the base model. Mass ratios between 0.25 and 4 were chosen and applied either at one floor or in a series of floors, and the stiffnes distribution was tuned until the structures had a fundamental period of 3.0s. Dynamic analyses were then conducted on each structure by subjecting them to a suite of 15 ground motion records. *P*-Delta effects were not considered and Rayleigh damping was used to obtain a damping ratio of 5% for the first and fourth modes. It was found that mass irregularities had a relatively small effect on elastic and inelastic storey shear and storey drift demands. It was also shown that mass increase at the top had a larger effect on roof and storey drifts than when increased mass was applied at the mid-height or at the lower floors. Again it was concluded that mass irregularity effects were less than other types of vertical irregularities..

3.2.3 Michalis *et al.* (2006)[5] carried out incremental dynamic analyses on a realistic nine storey steel frame to evaluate the effect of irregularities for each performance level, from serviceability to global collapse. A mass ratio of 2 was applied at a series of floors over the selected frame and the effects of mass irregularity were evaluated. It was found that the influence of mass irregularity on inter storey drifts was comparable to the influence of stiffness irregularity.

3.2.4. Das and Nau (2003) [6] investigated the definition of irregular structure for different vertical irregularities: stiffness, strength, mass, and that due to the presence of non-structural masonry infill as prescribed in building codes. Linear and nonlinear dynamic time-history (TH) analyses were performed on an ensemble of 78 buildings of 5, 10, and 20 stories and with different story stiffness, strength, and mass ratios. All buildings had three bays in the direction of the ground motion. The lateral force-resisting systems considered were special moment resisting frames (SMRF) designed based on the forces obtained from the ELF procedure according to the strong-column-weak-beam (SCWB) criteria of ACI 318-99 (ACI, 1999) and UBC (1997). They observed that most structures considered in their study performed well when subjected to the design earthquake ground motion. Hence they concluded that the restrictions on the applicability of the ELF procedure given in building codes are unnecessarily conservative for certain types of vertical irregularities considered. the presence of irregularity alters the inelastic response of the building, and there are marked increases in the inelastic story drift in the vicinity of the irregularity. However, in no case did the drift exceed the code-specified limit of 2%. The structure damage indices (a measure of the overall structural damage suffered by the building subjected to scaled ground motion) for all buildings were found to be less than 0.40, i.e., the threshold of repairable damage. The damage indices are insensitive to both the mass ratios and the location of the heavier mass. For all categories of the buildings studied, despite large increases on curvature ductility demands in the plastic regions in the vicinity of the irregularities, the demands did not exceed the computed curvature ductility capacities for which the members were designed. In general, it may be seen that the presence of irregularities has relatively little influence on the responses computed via ELF. This may not be true for a shorter structure, however.

3.2.5. Saleh Malekpour et al. [7] carried out Assessment of Equivalent Static Earthquake Analysis Procedure for Structures with Mass Irregularity in Height by taking four two-dimensional residential type steel structures with 4, 8, 12 and 16 stories and with different forms of mass irregularities in height which are designed using the standard equivalent static procedure per the Iranian Seismic Code of practice. The designed structures, then, were subjected to different nonlinear static (pushover) and dynamic analyses. Two levels of irregularities, i.e. 150 and 300 percents, located at the heights equal to 50% and 75% of the overall height of the structures, have been considered. The results show that the static procedure adapted in the code results in much higher internal forces, story shears and overturning moments in various parts of the structures compared to the dynamic results. Also, study shows that lateral inter-story drifts obtained using the equivalent static procedure and dynamic analyses are quite comparable for short buildings. For taller buildings, in contrast, dynamic analyses showed less inter-story drifts. It is also observed that mass irregularities in height could be responsible for more contribution of higher modes in seismic response of such structures.

3.2.6.**Mohammad Hossein et al. [8]** Carried out Seismic Response of Mass Irregular Steel Moment Resisting Frames (SMRF) According to Performance Levels from IDA Approach by taking Mass irregular structures have stories with effective mass more than 150% of effective mass of adjacent storey. Seismic response of mass irregular structures are assessed by consideration of SMRF structures with 4, 6 and 8 stories, which mass irregularity is applied separately by 1.4 and 2 times mass changes in top and two intermediate stories. Seismic response is achieved by applying Incremental Dynamic Analysis. Mean annual frequency and probability of exceedance in 50 years of performance levels are evaluated by applying PBEE framework and found out Location and number of stories with mass changes are important. Probability of exceedance of limit states in 50 years for structures with mass changes in two intermediate stories are more than mass changes in top storey. For example structures with 140% mass changes in two intermediate stories have more effect in response than 200% mass changes in top storey. Also in some cases, especially for mass changes in two intermediate stories of eight and six stories structure probability of exceedance of collapse is more than 2%. It causes not to overcome our expectation for life safety of occupants according to codes.

3.2.7. Mohammad Ali Hadianfard and Mahdieh Gadami [9] carried out study SEISMIC DEMAND OF STEEL STRUCTURES WITH MASS IRREGULARITY by linear analyses (static analysis and response spectra analysis) and obtained the seismic responses which are compared with exact solution from nonlinear time history analyses. Also the nonlinear time history analysis are carried out to study the nonlinear response of 5, 10 and 15 stories buildings with vertical mass irregularity. The mass irregularity is created by increasing the effective mass (weight) of some floors relative to other floors (2 or 3 time). These floors with additional masses can be located in the first floor, middle floors or upper floors of the building. The drift of stories, plastic hinge rotation and internal forces of columns in the middle frame are investigated. The results show that the linear seismic demand estimated by response spectra analysis is less than seismic demand determined by equivalent static analysis. Also the nonlinear seismic response of building with mass irregularity is varying relative to location and amount of irregularity and it is dependent on the earthquake record selection.. The location of heavier floor has not significant effect on the storey shear, except when the heavier mass is on the middle height of building. Also amount of irregularity has not considerable effect on the storey shear. More plastic hinges are formed on the base floor, and in vicinity of the heavier floors. Plastic hinges are more critical when mass irregularity is on the middle height of the building. Also in the high-rise buildings plastic hinges are formed on the top stories. Buildings with vertical mass irregularity designed with linear static and dynamic response spectra procedure have not well performance under the ground motion. Performance level of buildings varies with height of building, location of mass irregularity and ground motion selection. Furthermore, buildings with vertical mass irregularity usually demonstrate lower performance than the regular buildings.

3.2.8. Vinod K. Sadashiva et al. [10] describes a simple and efficient method for quantifying irregularity limits of 3, 5, 9 and 15 storey shear type structures, assumed to be located in Wellington, Christchurch and Auckland. They were designed in accordance with the Equivalent Static Method of NZS 1170.5. Regular structures were defined to have constant mass at every floor level and were either designed to produce constant inter-storey drift ratio at all the floors simultaneously or to cause uniform stiffness distribution throughout the elevation of structure. Design structural ductility factors of 1, 2, 4 and 6, and target (design) inter-storey drift ratios ranging between 0.5% and 3% were used in this study. Inelastic dynamic time-history analysis was carried out by subjecting these structures to code design level earthquake records. Irregular structures were created by adding additional floor mass of 1.5, 2.5, 3.5 and 5 times the regular floor mass at the first level, mid-height and the roof, and they were designed similar to regular structures. It was found that additional mass, when applied at the first floor or roof generally, produced higher drift demands than regular structures for all mass ratios. When the mass ratio was present at the mid-height, the structures generally tended to produce lesser drift demands than the corresponding regular structures. A simple equation was defined to give a conservative measure of increase in interstorey drift response due to mass irregularity which can be used to set irregularity limits. Current code requirement of 1.5 mass ratios corresponds to an increase in median response of approximately 7.5%. The effect of the magnitude of mass irregularity on drift demand was found to be less influential than the position of mass ratios.

3.2.9. Poncet, L. et al. [11] studied INFLUENCE OF MASS IRREGULARITY ON THE SEISMIC DESIGN AND PERFORMANCE OF MULTI-STOREY BRACED STEEL FRAMES by examining for an eight-storey concentrically braced steel frame with different setback configurations. Three height locations of mass discontinuity and two ratios of seismic weight were considered. A regular structure was also studied for comparison. Both the equivalent static load method and the response spectrum analysis method were used in design. The finding are mass irregularity in eight-storey concentrically braced steel frames designed with static analysis does not seem to have significant detrimental effects on the level of protection against structural collapse, which is in line with the findings of past similar studies and tends to support IBC 2003 provisions that allow mass irregularity to be ignored when deflections remain uniform along the building height. Adopting a dynamic analysis method does not seem to provide marked benefit on the response of the buildings with mass discontinuity. For one of the irregular structures studied, the confidence levels against collapse prevention were noticeably lower, even if dynamic analysis was used in design. For immediate occupancy, mass irregularity has limited effects on elastic building response. If needed, these effects can be reduced, and perhaps eliminated, by using a dynamic analysis method.

Because of the complex behavior of such structures under earthquake excitations, it is not surprising that, in spite of the large research efforts in plan irregular building structures dating back to the 1970s, even in recent years, many papers have been devoted to a better understanding of seismic response. Above research conclude that discontinuities of mass along the height, considered by current seismic codes as irregularities in elevation, do not necessarily result in actual increases in plastic demands and, more generally, in poor seismic behavior. It is observed in all above paper that mass irregularity effect is larger when it is present on top storey. Drift generally increases with mass.

3.3 CODAL PROVISIONS:

Most building codes propose a simplified method called the equivalent lateral force (ELF) procedure or the multi-mode response spectrum method to compute design forces. These methods assume that the dynamic forces developed in a structure during an earthquake are proportional to the maximum ground acceleration and the modal characteristics of the structure. These forces are approximated as a set of equivalent lateral forces which are distributed over the height of the structure. However, the ELF method is based on a number of assumptions which are true for regular structures "structures with uniform distribution of stiffness, strength, and mass over the height". So the current building codes define criteria in order to categorize building structures as either regular or irregular as explained below.

3.3.1 IS CODE 1893 (PART 1): 2002 (TABLE 5 CLAUSES 7.1) [1]

Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storey. The irregularity need not be considered in case of roofs.

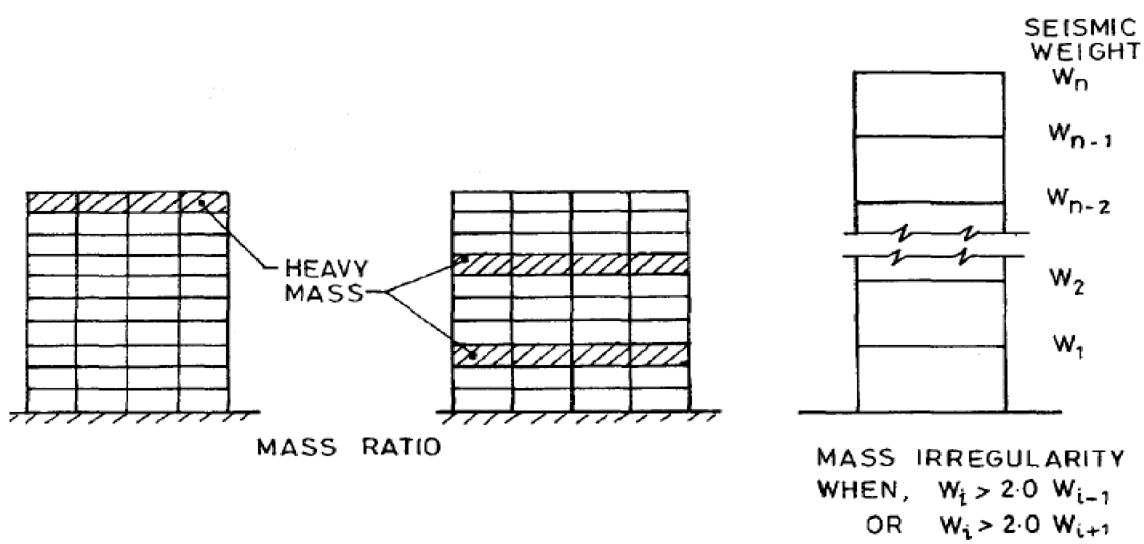

FIG 2.MASS IRREGULARITY[1]

3.3.2. UNIVERSAL BUILDING CODE (SECTION 1629) [12]

Mass irregularity is considered to exist where the effective mass of any story is more than 150% of the effective mass of an adjacent story. A roof that is lighter than the floor below need not be considered.

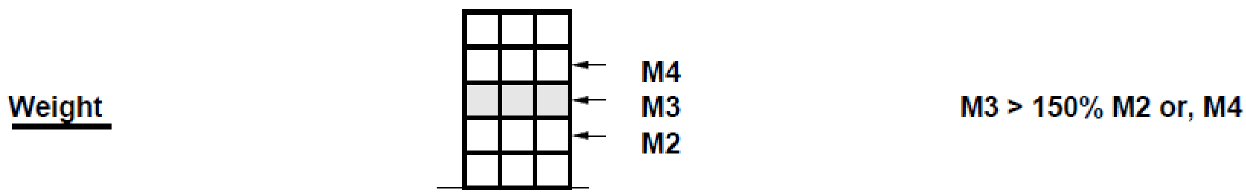

FIG 3 UBC CRITERIA [12]

3.3.3 NEHRP code (BSSC, 2003) [13]:

A structure is defined to be mass irregular if the ratio of Mass between adjacent stories exceeds 150% and the criteria that define the irregularities have been assigned by judgment.

3.3.4 Iranian seismic code (Standard 2800)[14]:

The mass regularity condition is that the effective mass of any story shall not be more than 150 percent of the effective mass of an adjacent story.

3.3.5 International Building Code (IBC) [15]:

Weight (Mass) Irregularity is defined to exist where the effective mass of any story is more than 150% of the effective mass of an adjacent story. A roof that is lighter than the floor below need not be considered.

So **IBC code, IRANIAN code, EURO code, UBC code, NEHRP code** all have same provision for mass irregularity.

CHAPTER 4

PROGRAMME OF STUDY

4.1. INTRODUCTION

Major portion of urban building is irregular. To design irregular building in seismically active area is a challenging job for structural engineer. Structural engineer should be well versed with effect of different irregularities on performance of different types and configuration of building.

Sometime the building is designed irregular and many time it become irregular due to different circumstances like change of use of building, damage or reconstruction. These building should be investigated and designed properly. Different irregularity has different effects on response of given building during seismic event. In present chapter, details of building, different input, and output parameter and analysis process are discussed.

A four storey building is selected as shown in figure below:

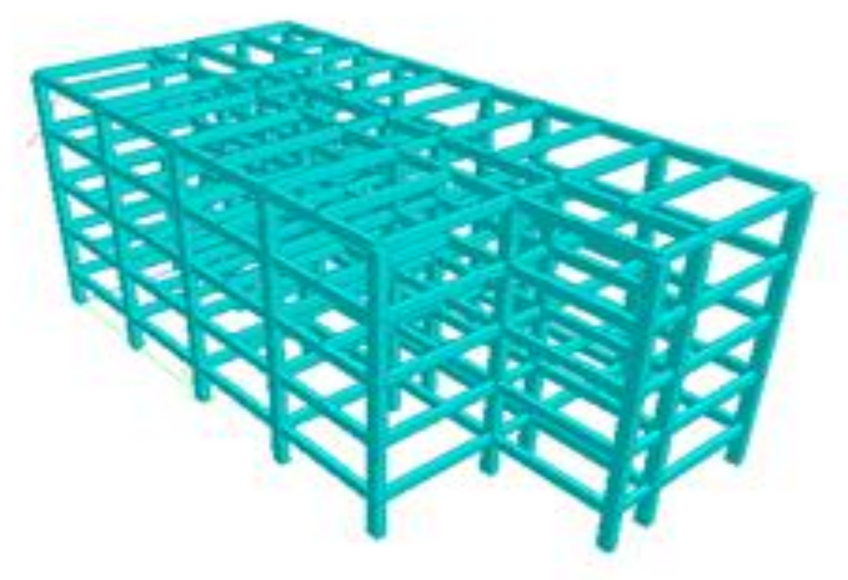

FIG 4 3-D VIEW OF BUILDING (COLUMN-BEAM VIEW)

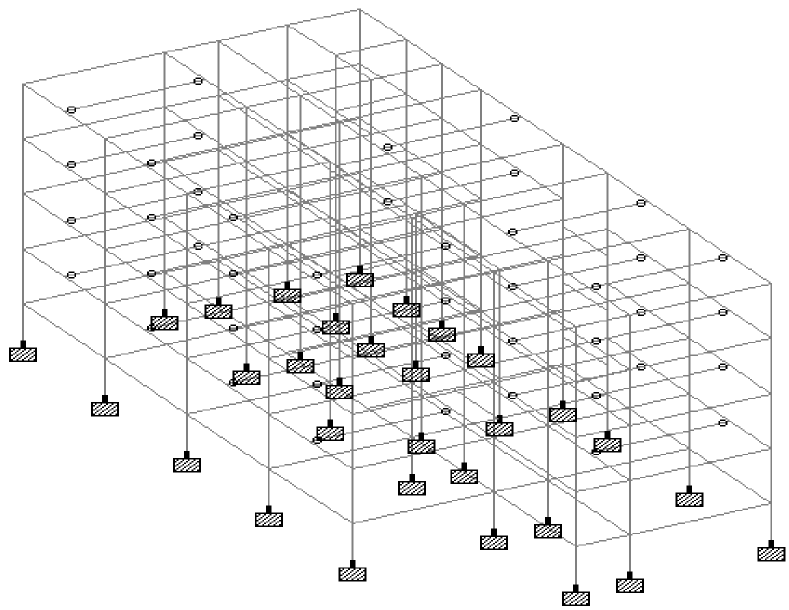

FIG 5 3-D VIEW OF BUILDING

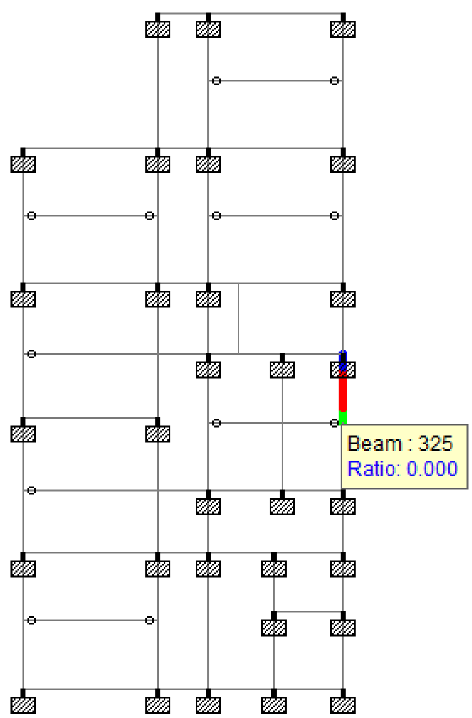

FIG 6: PLAN VIEW OF BUILDING

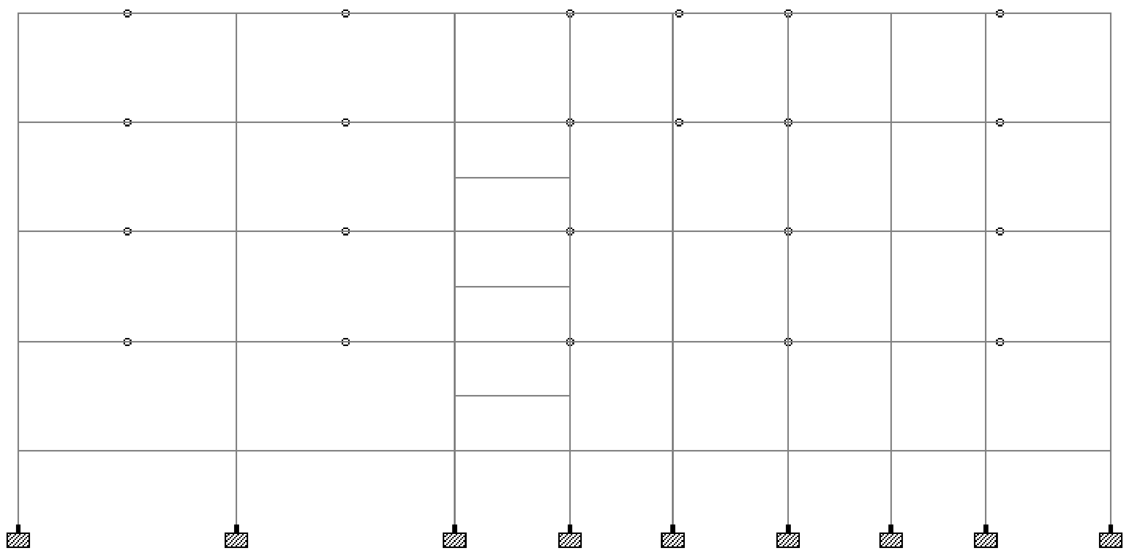

FIG 7 ELEVATION VIEW OF BUILDING

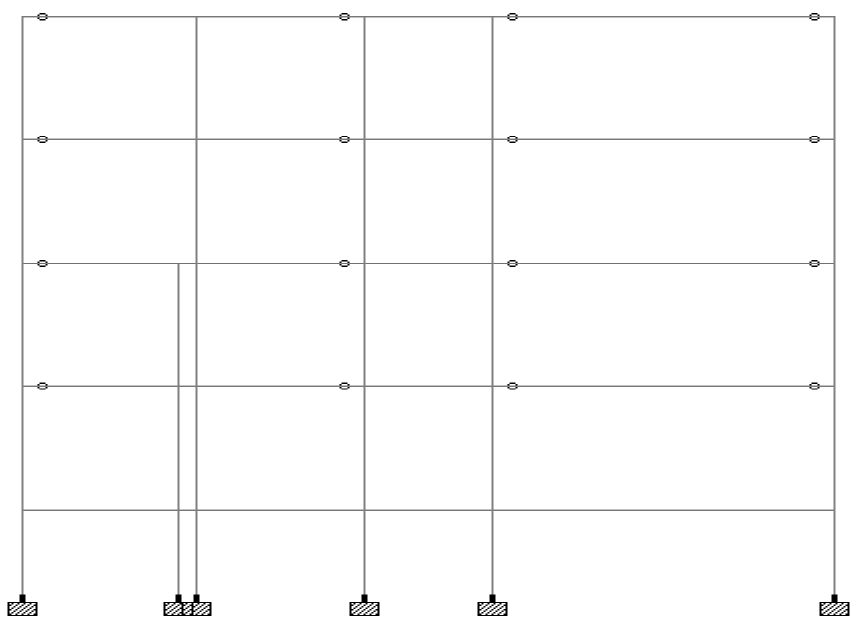

FIG 8 SIDE VIEW OF BUILDING

TABLE 1

STRUCTURAL DATA	
HEIGHT	15.45m
WIDTH	15.65m
LENGTH	33.0m
NO. OF STOREY	4
STOREY HEIGHT	3.3m
TOTAL NO. OF COLUMN	159
TOTAL NO. OF BEAM	346
CONCRETE GRADE	M25
STEEL GRADE	Fe415
DENSITY OF CONCRETE	2402.616 kg/m^3
POISION RATIO	0.17
YOUNG'S MODULUS OF ELASTICITY	25000N/MM^2
BEAM DIMENSION	0.45*0.30m
COLUMN DIMENSION	0.60*0.45m

TABLE 2

EARTHQUAKE DATA	
ZONE VALUE	0.24
IMPORTANCE FACTOR	1.5
RESPONSE REDUCTION FACTOR	5
TYPE OF SOIL	2
DAMPING	5%
CUT OFF MODE	21

TABLE 3

DEAD LOAD	
ROOF	4657.86kN
4TH FLOOR	4887.00kN
3RD FLOOR	4887.00kN
2ND FLOOR	4887.00kN
1ST FLOOR	4887.00kN

TABLE 4

LIVE LOAD	
ROOF	1559kN
4TH FLOOR	1823kN
3RD FLOOR	1823kN
2ND FLOOR	1964kN
1ST FLOOR	1823kN

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 apart 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 [15]

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.

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

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. Keeping dead load constant, the live load of concerned storey is increased in such a way that ratio of total seismic weight on that particular storey to that above or below it become equal to X.
4. Each storey is subjected to live load such that value of X becomes 1.
5. Then resulting building model is analyzed and value of output parameter is noted down.
6. Steps 2 to 6 is repeated for X=1, 1.5, 2, 2.5, 3, 3.5 and 4 for each floor.

CHAPTER 5

RESULT AND DISCUSSION

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

5.1 Variation of frequency vs. mass ratio

TABLE 5

VARIATION OF FREQUENCY VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	1.086	1.086	1.086	1.086	1.086
1.5	1.086	1.074	1.054	1.025	0.993
2	1.085	1.061	1.023	0.966	0.927
2.5	1.084	1.048	1.006	0.926	0.873
3	1.084	1.035	0.967	0.887	0.826
3.5	1.083	1.022	0.941	0.852	0.786
4	1.082	1.009	0.917	0.82	0.751

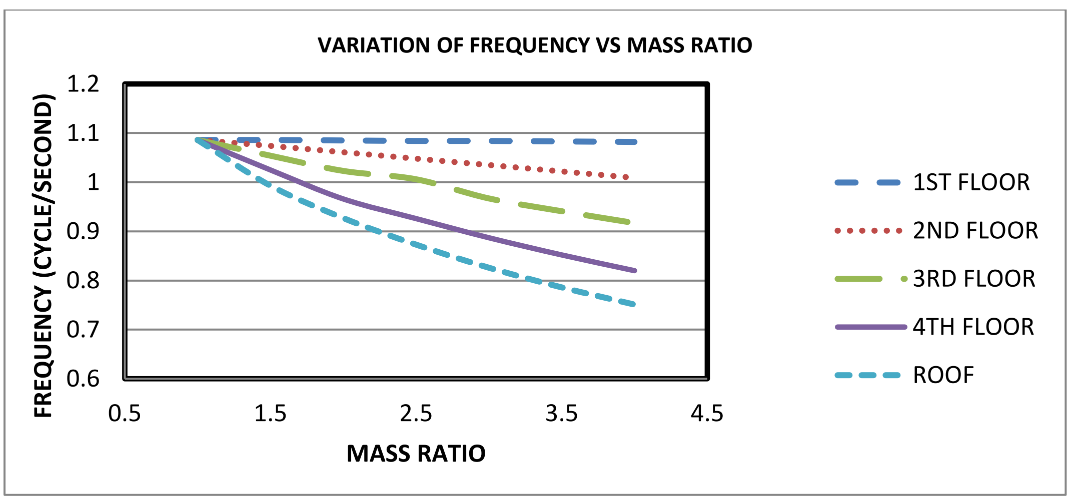

FIG 9 Variation of frequency vs. mass ratio

Frequency of building decreases with increase in loading of structure irrespective of position of increased weight. Maximum effect is observed when maximum weight is present on roof. In this case variation with respect to base case is 30.87%. Least variation is observed when weight is increased on first floor. In this case frequency increased from 1.086 to 1.082 corresponding to mass ratio 1 and 4 respectively. Variation in frequency increases when increased weight is placed on higher floor.

It is observed that the variation of frequency vs. mass ratio follows following equation

TABLE 6

FLOOR	EQUATION
1	Y = -0.001X + 1.087
2	Y = -0.025X + 1.112
3	Y = 0.001X^2 - 0.061X + 1.145
4	Y = 0.012X^2 - 0.150X + 1.222
ROOF	Y = 0.020X^2 - 0.211X + 1.271

5.2 Variation of Time Period vs. Mass Ratio

TABLE 7

VARIATION OF TIME PERIOD VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	0.92063	0.92063	0.92063	0.92063	0.92063
1.5	0.92115	0.93128	0.94852	0.97594	1.00728
2	0.92172	0.94268	0.97735	1.03531	1.07832
2.5	0.9228	0.95461	0.99063	1.0795	1.14598
3	0.92287	0.96654	1.03452	1.12771	1.21026
3.5	0.92342	0.97881	1.06243	1.17416	1.27224
4	0.924	0.99133	1.08998	1.21904	1.33073

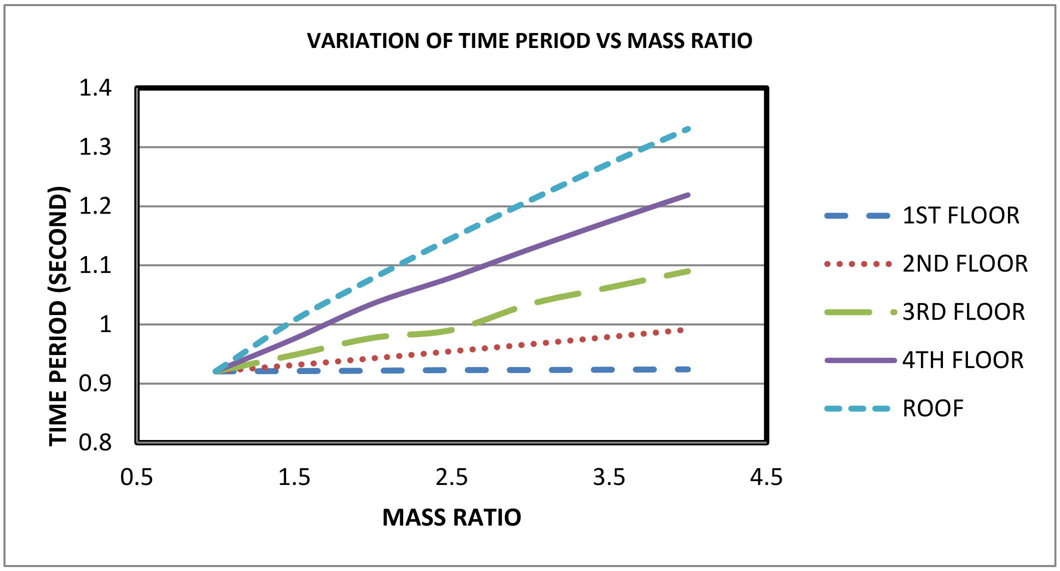

FIG 10 Variation of Time Period vs. Mass Ratio

Time period of building increases with increases in loading of structure irrespective of position of increased weight. It is expected as frequency is inversely proportion to time period. Maximum variation is observed when maximum weight (mass ratio=4) is present on roof (mass ratio=4). In this case, variation with respect to base case is 44.54%.

It is observed that the variation of Time period vs. mass ratio follows following equation:

TABLE 8

FLOOR	EQUATION
1	Y = -0.009X^2 + 0.181 X + 0.751
2	Y = -0.005X^2 + 0.124 X + 0.801
3	Y = 0.002X^2 + 0.043 X + 0.875
4	Y = 0.023 X + 0.896
ROOF	Y = 0.001 X + 0.919

5.3 Variation of Spectral Acceleration vs. Mass Ratio

TABLE 9

VARIATION OF SPECTRAL ACCELERATION VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	1.47726	1.47726	1.47726	1.47726	1.47726
1.5	1.47641	1.46035	1.43381	1.39352	1.35017
2	1.4755	1.44269	1.39151	1.31362	1.26122
2.5	1.47461	1.42466	1.35726	1.25984	1.18676
3	1.47366	1.40708	1.31462	1.20599	1.12373
3.5	1.47279	1.38944	1.28009	1.15827	1.06898
4	1.47186	1.37189	1.24773	1.11563	1.02199

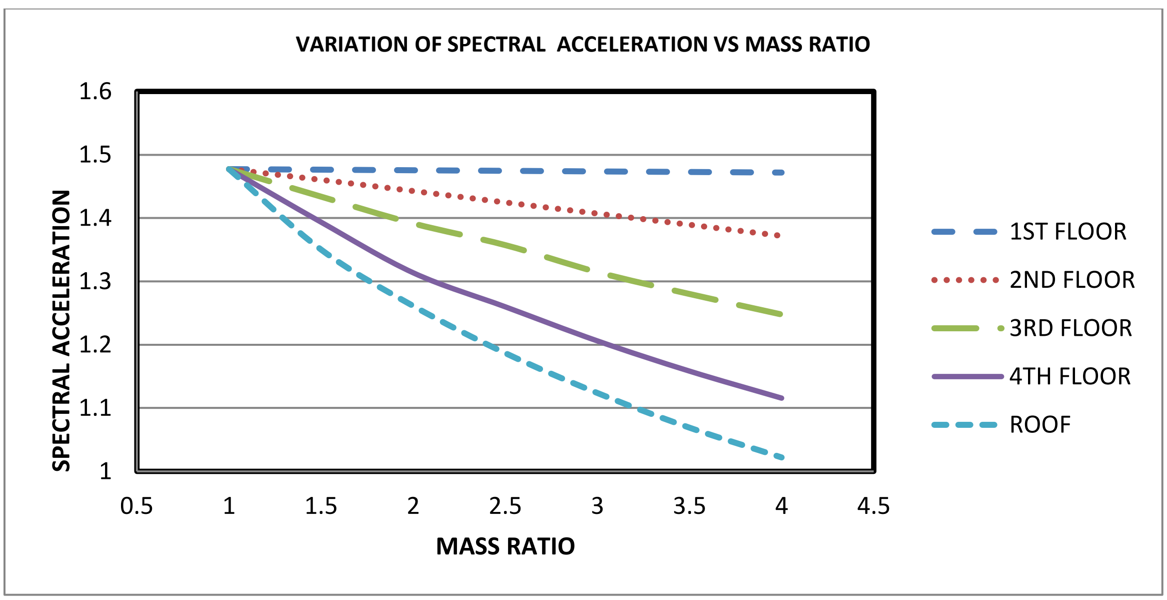

FIG 11 Variation of Spectral Acceleration vs. Mass Ratio

Spectral acceleration of building decreases with increase in loading of structure irrespective of position of increased weight. Maximum effect is observed when maximum weight (mass ratio=4) is present on roof. In this case variation with respect to base case is 30.81%. Least variation is observed when weight is increased on first floor. In this case frequency decreases from 1.47726 to 1.47186 corresponding to mass ratio 1 and 4 respectively.

It is observed that the variation of Spectral acceleration vs. mass ratio follows following equation:

TABLE 10

FLOOR	EQUATION
1	Y = -0.001X + 1.479
2	Y = -0.035X + 1.512
3	Y = 0.003X^2 - 0.095X + 1.568
4	Y = 0.003X^2 - 0.095X + 1.568
ROOF	Y = 0.017X^2 - 0.206X + 1.663

5.4 Variation of BASE SHEAR (KN) vs. Mass Ratio

TABLE 11

VARIATION OF BASE SHEAR (KN) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	1269.11	1269.11	1269.11	1269.11	1269.11
1.5	1292.67	1340.01	1332.79	1298.12	1281.12
2	1319.74	1414.36	1395.65	1333.16	1297.92
2.5	1343.6	1490.45	1469.11	1361.35	1318.89
3	1373.81	1564.75	1513.08	1393.78	1342.61
3.5	1395.97	1639.34	1567.58	1426.44	1368.46
4	1423.05	1713.52	1619.91	1459.12	1395.12

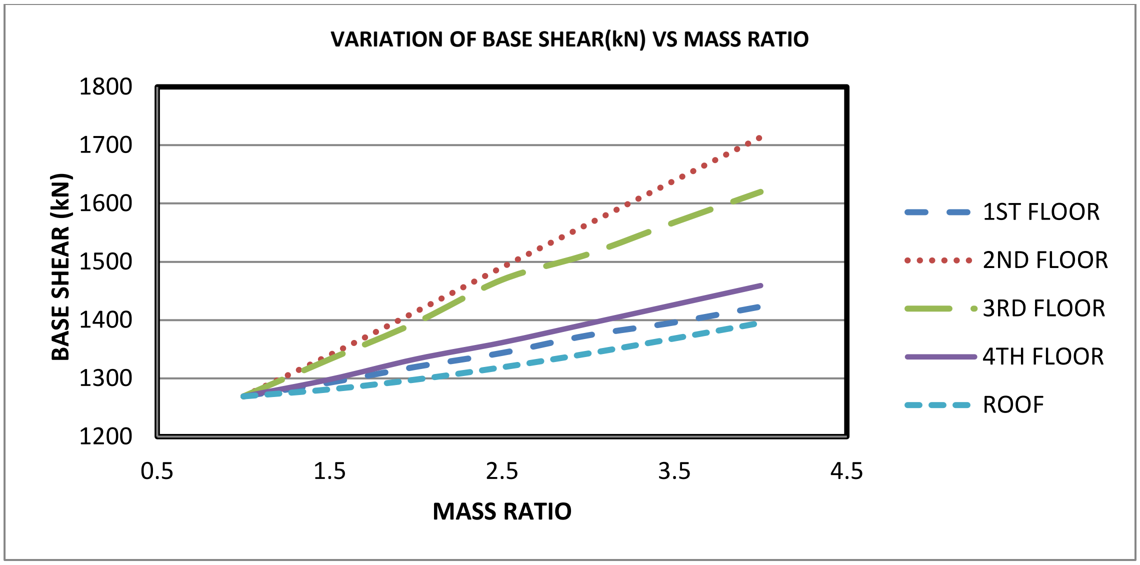

FIG 12 Variation of BASE SHEAR (KN) vs. Mass Ratio

Base shear increases with increase in loading of structure irrespective of position of increased weight. Maximum effect is observed in 2nd floor and it is 35.01% when the mass ratio 4 is on 2nd floor than that of base floor. Least variation is observed when weight is increased on top floor. In this case base shear increased from 1269.11 to 1395.12 KN corresponding to mass ratio 1 and 4 respectively.

It is observed that the variation of Base shear vs. mass ratio follows following equation:

TABLE 12

FLOOR	EQUATION
1	$Y = 0.273X^2 + 50.23X + 1217$
2	$Y = 148.7X + 1118$
3	$Y = -7.501X^2 + 154.6X + 1120$
4	$Y = 63.37X + 1204$
ROOF	$Y=5.904X^2 + 13.14X + 1249$

5.5 Variation of SQUARE ROOT OF SUM0 OF SQUARE SHEAR X vs. Mass Ratio

TABLE 13

VARIATION OF SQUARE ROOT OF SUM OF SQUARE SHEAR X (kN) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	1377.05	1377.05	1377.05	1377.05	1377.05
1.5	1421.5	1458.9	1435.98	1407.14	1395.38
2	1490.2	1543.51	1496.36	1443.33	1415.52
2.5	1554.64	1628.57	1557.05	1472.13	1438.52
3	1648.77	1709.63	1608.95	1504.3	1471.19
3.5	1713.47	1790.47	1662.84	1537.55	1501.55
4	1795.69	1869.96	1717.89	1572.84	1530.79

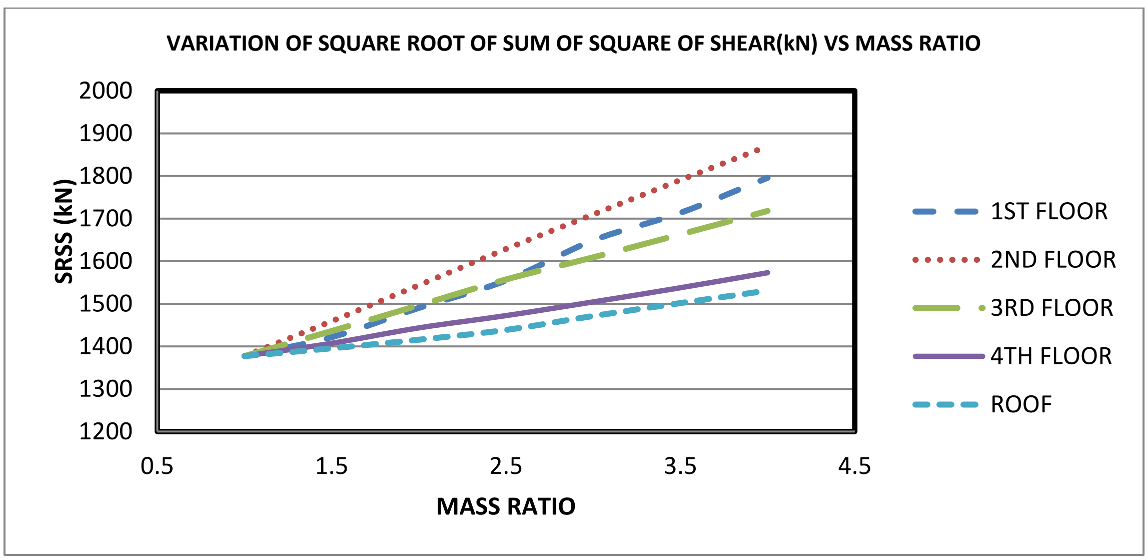

FIG 13 Variation of SQUARE ROOT OF SUM0 OF SQUARE SHEAR X vs. Mass Ratio

It is observed that the variation of SRSS Shear vs. mass ratio follows following equation:

TABLE 14

FLOOR	EQUATION
1	Y = 10.86X^2 + 88.40X + 1271.
2	Y = -1.840X^2 + 174.0X + 1203
3	Y = -3.306X^2 + 130.0X + 1249
4	Y = 0.859X^2 + 60.64X + 1315
ROOF	Y = 5.951X^2 + 22.32X + 1348

5.6 VARIATION OF SHEAR 10 PCT SHEAR X (KN) VS MASS RATIO

TABLE 15

VARIATION OF SHEAR 10 PCT SHEAR X (KN) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	1412.21	1412.21	1412.21	1412.21	1412.21
1.5	1458.58	1497	1474.7	1446.38	1430.13
2	1526.7	1584.97	1538.62	1444.05	1451.74
2.5	1594.15	1673.67	1582.21	1473.1	1476.98
3	1689.25	1759.01	1612.35	1506.61	1473.55
3.5	1760.99	1840.45	1666.7	1540.02	1502.39
4	1843.09	1923.34	1719.22	1573.89	1531.59

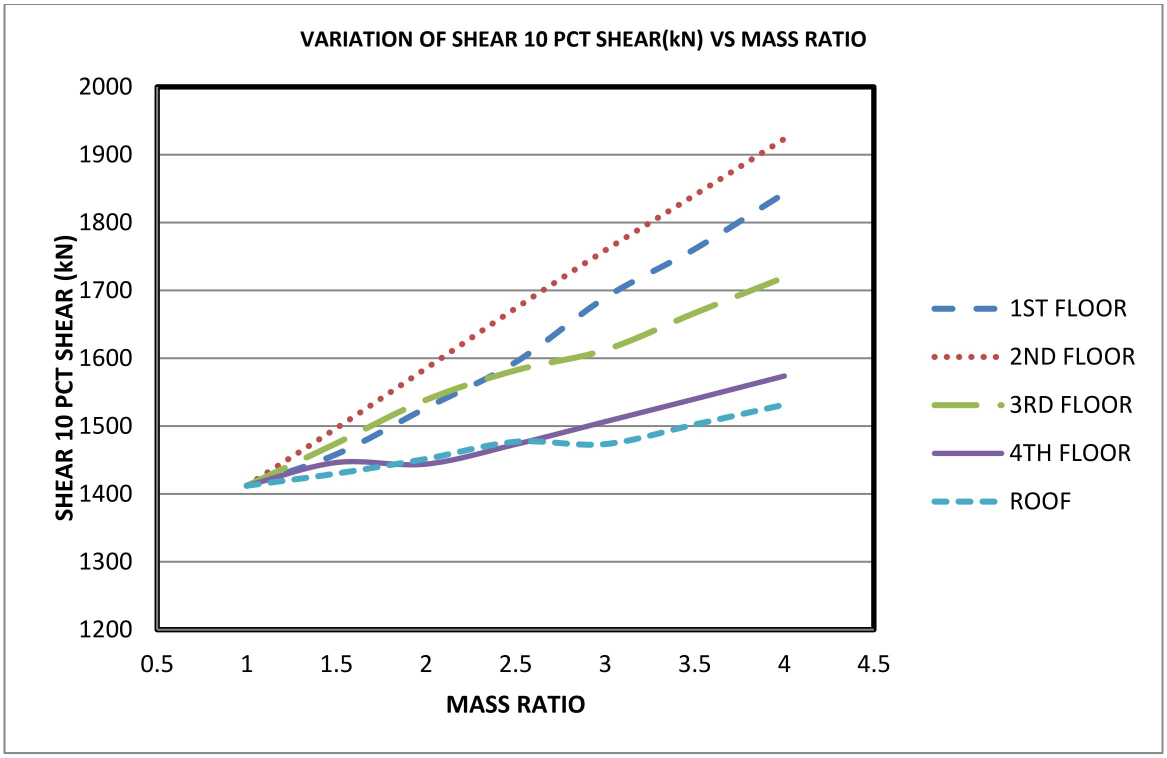

FIG 14 VARIATION OF SHEAR 10 PCT SHEAR X (KN) VS MASS RATIO

The variation of SHEAR 10 PCT Shear vs. mass ratio follows following equation:

TABLE 16

FLOOR	EQUATION
1	Y = 12.00x2 + 87.13X + 1307
2	Y = -2.327x2 + 182.6X + 1230
3	Y = -5.933x2 + 128.1X + 1294
4	Y = 8.862x2 + 8.177X + 1400
ROOF	Y = 1.676x2 + 29.07X + 1383

5.7 VARIATION OF ABS SHEAR X (KN) VS MASS RATIO

TABLE 17

VARIATION OF ABSOLUTE SUM SHEAR X (kN) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	2490.95	2490.95	2490.95	2490.95	2490.95
1.5	2727.13	2634.17	2575.64	2536.42	2542.38
2	2986.66	2780.87	2655.53	2591.82	2591.05
2.5	3200.04	2925.95	2490.95	2635.91	2640.57
3	3489.42	3062.92	2810.16	2684.58	2681.28
3.5	3635.32	3196.2	2881.54	2734.17	2730.21
4	3859.7	3325.04	2949.25	2779.8	2777.2

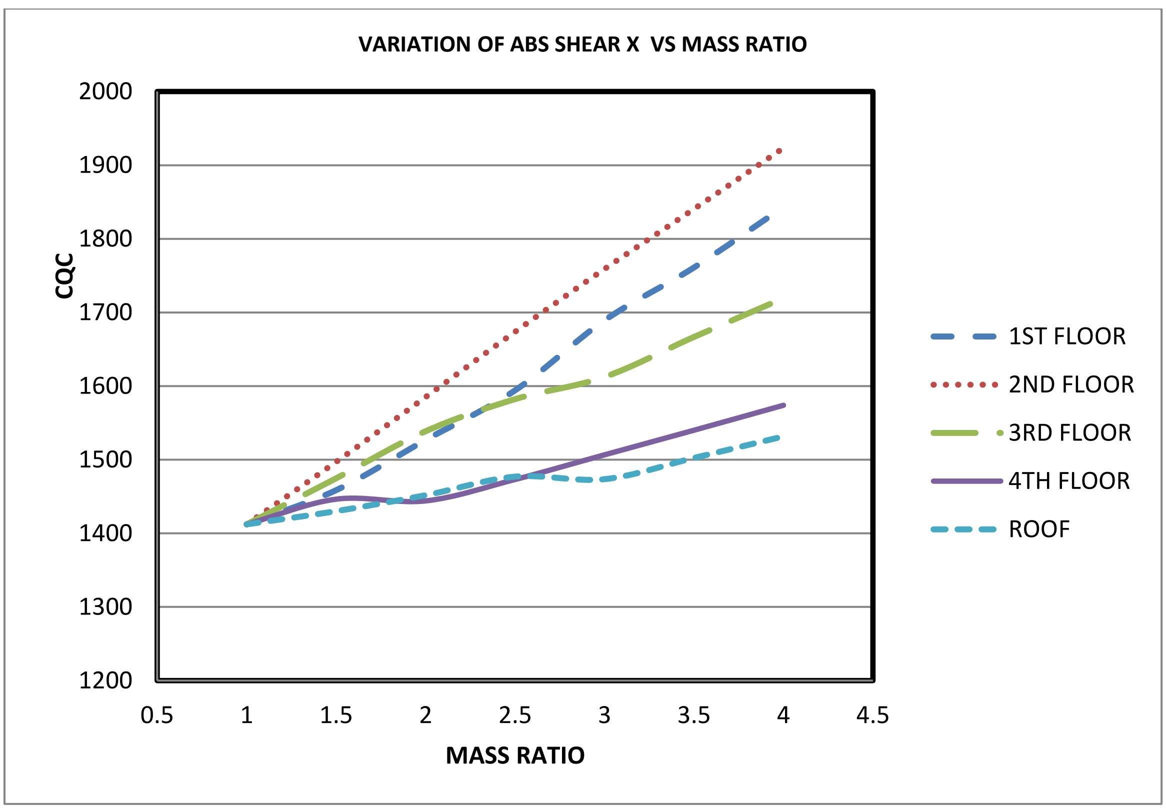

FIG 15 VARIATION OF ABS SHEAR X (KN) VS MASS RATIO

The variation of ABS Shear vs. mass ratio follows following equation:

TABLE 18

FLOOR	EQUATION
1	Y = 12.00X^2 + 87.13X + 1307
2	Y = -2.327X^2 + 182.6X + 1230.
3	Y = -5.933X^2 + 128.1X + 1294
4	Y = 8.862X^2 + 8.177X + 1400
ROOF	Y = 1.676X^2 + 29.07X + 1383

5.8 VARIATION OF CQC SHEAR X (KN) VS MASS RATIO

TABLE 19

VARIATION OF CQC SHEAR X (KN) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	1520.05	1520.05	1520.05	1520.05	1520.05
1.5	1571.5	1608.7	1582.98	1546.03	1525.55
2	1646.9	1700.86	1646.75	1578.83	1540.64
2.5	1718.19	1792.84	1700.05	1605.93	1561.58
3	1827.21	1881.22	1767.75	1637.82	1586.73
3.5	1895.61	1968.53	1824.8	1670.16	1613.84
4	1993.21	2058.52	1879.84	1703.25	1641.79

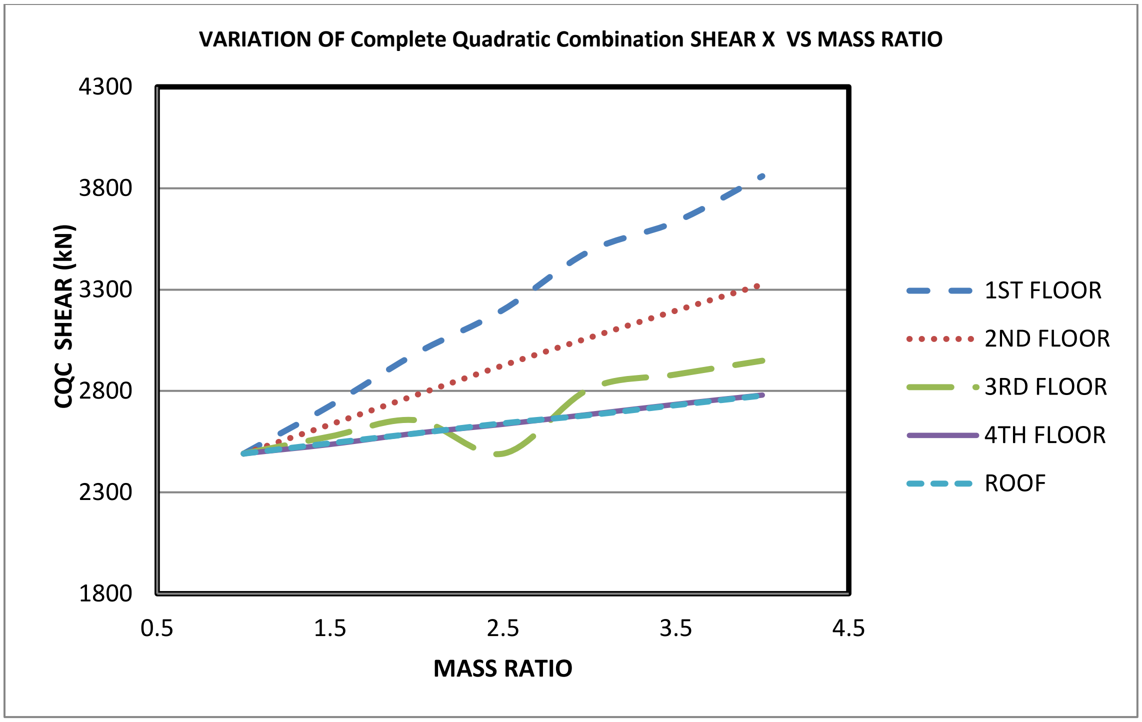

FIG 16 VARIATION OF CQC SHEAR X (KN) VS MASS RATIO

The variation of CQC Shear vs. mass ratio follows following equation:

TABLE 20

FLOOR	EQUATION
1	Y = -22.62X^2 + 572.0X + 1932
2	Y = -7.391X^2 + 316.1X + 2179
3	Y = 40.00X^2 - 47.07X + 2521
4	Y = -0.909X^2 + 101.3X + 2389
ROOF	Y = -0.909X^2 + 101.3X + 2312

SRSS Shear, CQC Shear, ABS Shear and SHEAR 10 PCT Shear shows the same trends as base shear. Maximum effect is observed in 2nd floor in all case while minimum effect is observed when weight is increased on roof

5.9 VARIATION OF ROOF DRIFTS (mm) VS MASS RATIO

TABLE 21

VARIATION OF ROOF DRIFT (mm) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	2.896	2.896	2.896	2.896	2.896
1.5	2.922	2.926	2.855	2.862	3.451
2	2.956	2.951	2.81	2.838	3.847
2.5	2.982	2.974	2.896	2.829	4.193
3	3.023	2.991	2.719	2.825	4.502
3.5	3.046	3.005	2.675	2.827	4.786
4	3.079	3.004	2.633	2.834	4.934

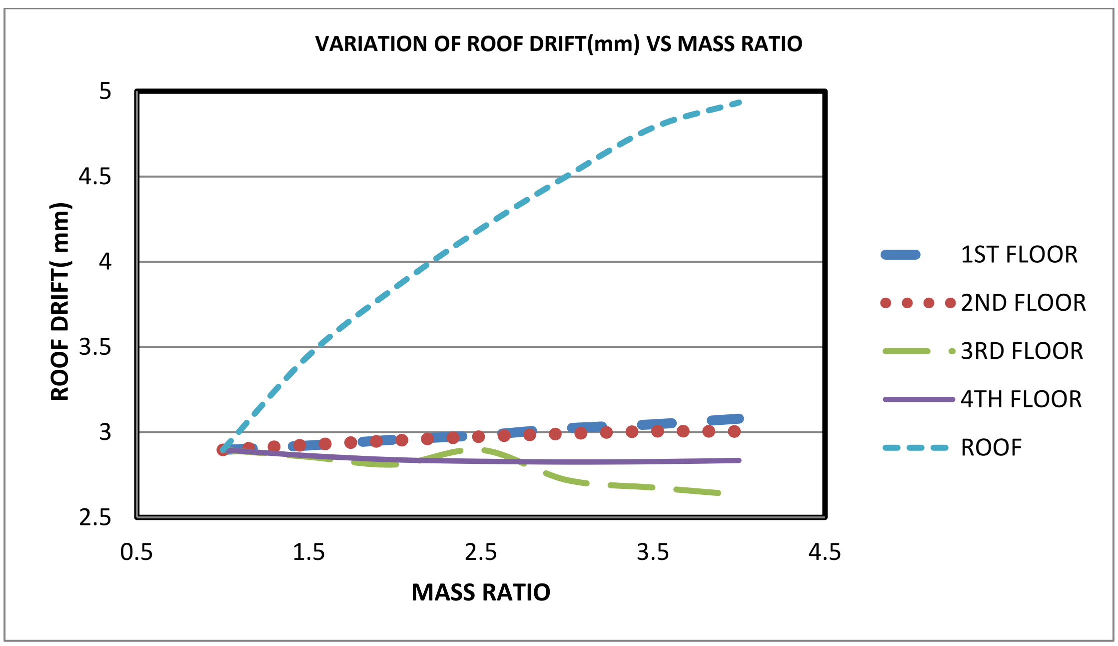

FIG 17 VARIATION OF ROOF DRIFTS (mm) VS MASS RATIO

Roof drift show increasing trend when weight is changed on 1st, 2nd and top floor while show decreasing trend when weight is changed on 3rd and 4th floor. Maximum variation is observed in roof drift when irregularity is induced in top storey by keeping mass ratio equal to 4 and it is 70% more than that of base case while it is 6.31% more than that of base case when irregularity is induced in top storey by keeping mass ratio equal to 4 Least variation is observed when irregularity is induced in middle floor.

The variation of roof drift vs. mass ratio follows following equation:

TABLE 22

FLOOR	EQUATION
1	Y = 0.061X + 2.832
2	Y = 0.037X + 2.870
3	$Y = -0.025X^2 + 0.036X + 2.873$
4	$Y = 0.016X^2 - 0.101X + 2.978$
ROOF	$Y = -0.127X^2 + 1.309X + 1.734$

5.10 VARIATION OF MAX FX (N) VS MASS RATIO

TABLE 23

VARIATION OF MAX FX (N) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	2.35E+05	2.35E+05	2.35E+05	2.35E+05	2.35E+05
1.5	2.44E+05	2.54E+05	2.48E+05	2.42E+05	2.40E+05
2	2.48E+05	2.71E+05	2.61E+05	2.50E+05	2.44E+05
2.5	2.60E+05	2.88E+05	2.75E+05	2.56E+05	2.49E+05
3	2.61E+05	3.04E+05	2.85E+05	2.63E+05	2.54E+05
3.5	2.78E+05	3.20E+05	2.95E+05	2.69E+05	2.60E+05
4	3.18E+05	3.36E+05	3.05E+05	2.75E+05	2.65E+05

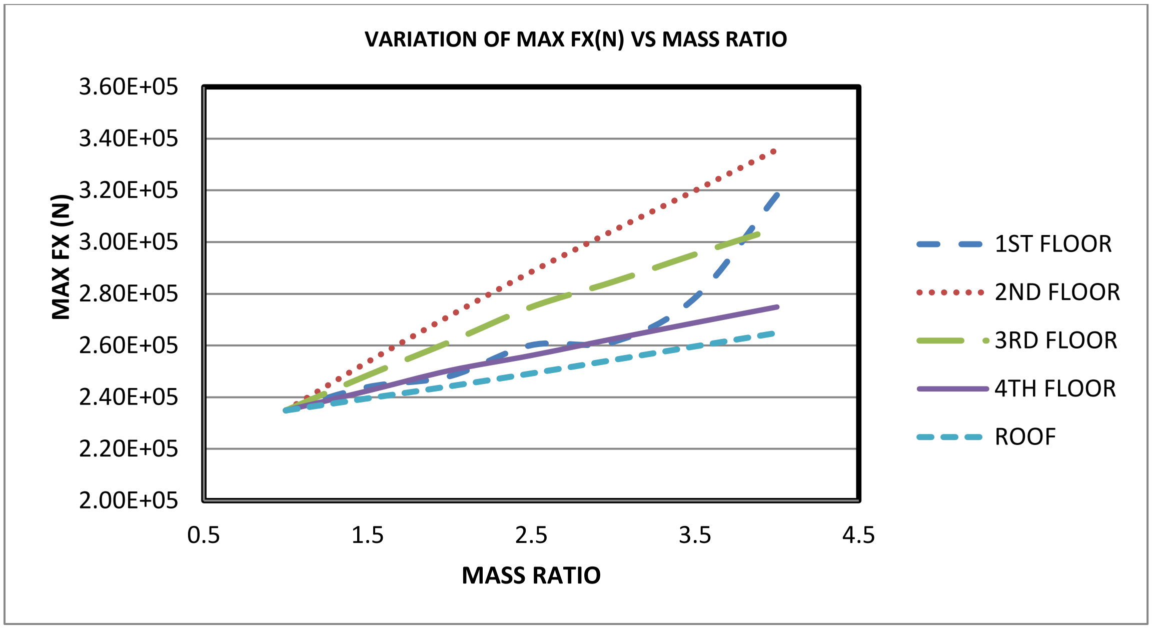

FIG 18 VARIATION OF MAX FX (N) VS MASS RATIO

5.11 VARIATION OF MAX FY (N) VS MASS RATIO

TABLE 24

VARIATION OF MAX FY (N) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	3.04E+06	3.04E+06	3.04E+06	3.04E+06	3.04E+06
1.5	3.31E+06	3.29E+06	3.30E+06	3.33E+06	3.36E+06
2	3.61E+06	3.63E+06	3.58E+06	3.66E+06	3.64E+06
2.5	3.91E+06	3.94E+06	3.96E+06	3.93E+06	3.92E+06
3	4.20E+06	4.25E+06	4.14E+06	4.22E+06	4.20E+06
3.5	4.50E+06	4.56E+06	4.42E+06	4.52E+06	4.49E+06
4	4.80E+06	4.86E+06	4.70E+06	4.82E+06	4.77E+06

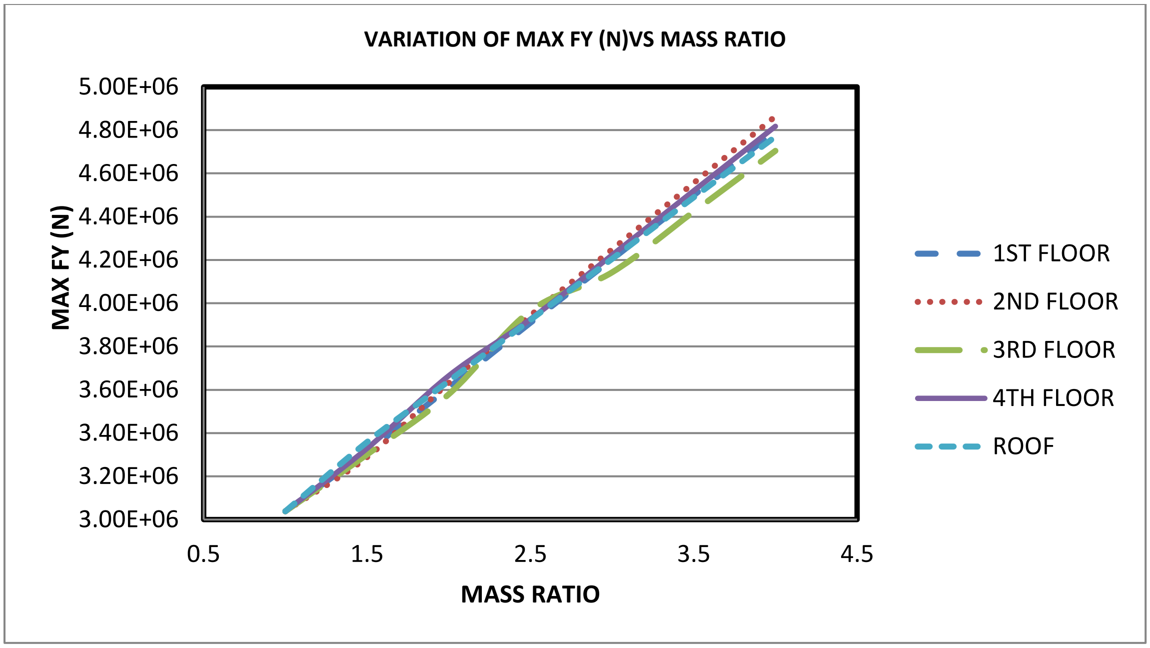

FIG 19 VARIATION OF MAX FY (N) VS MASS RATIO

5.12 VARIATION OF MAX FZ (N) VS MASS RATIO

TABLE 25

VARIATION OF MAX FZ (N) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	1.41E+05	1.41E+05	1.41E+05	1.41E+05	1.41E+05
1.5	1.44E+05	1.46E+05	1.44E+05	1.43E+05	1.41E+05
2	1.48E+05	1.50E+05	1.47E+05	1.44E+05	1.41E+05
2.5	1.56E+05	1.55E+05	1.50E+05	1.45E+05	1.42E+05
3	1.60E+05	1.61E+05	1.53E+05	1.47E+05	1.43E+05
3.5	1.69E+05	1.67E+05	1.55E+05	1.48E+05	1.44E+05
4	1.74E+05	1.73E+05	1.57E+05	1.50E+05	1.46E+05

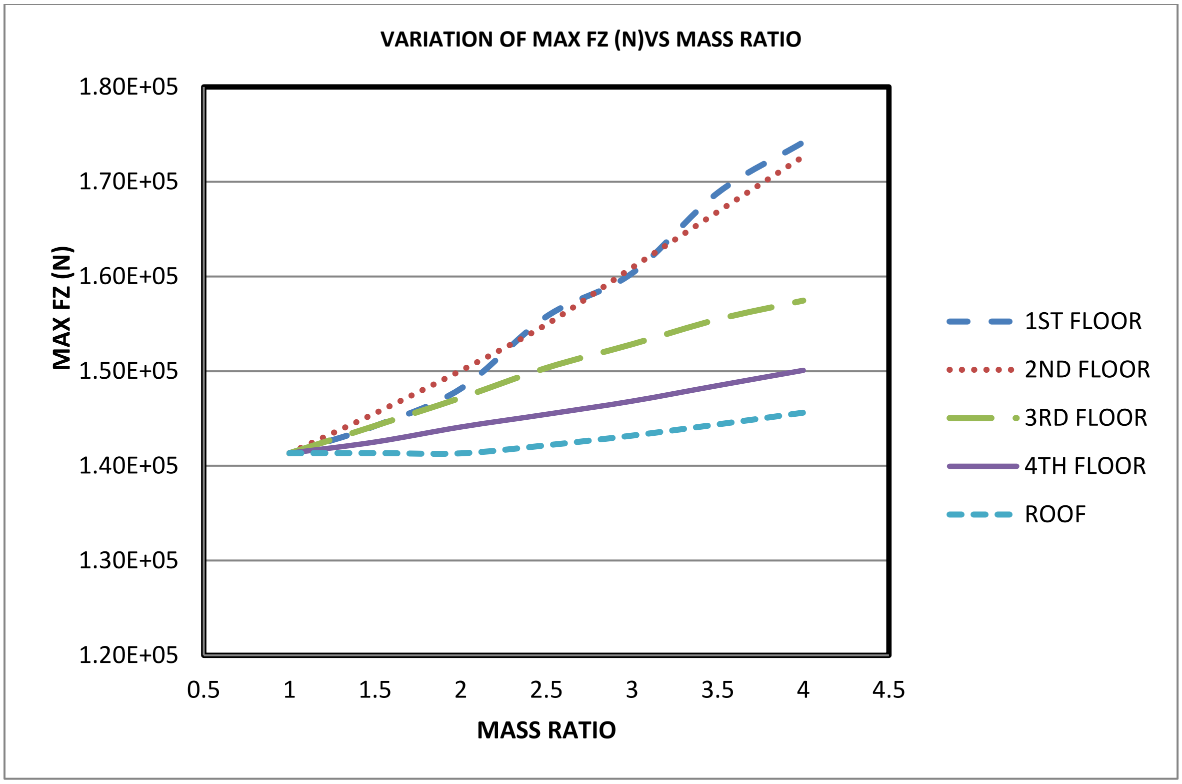

FIG 20 VARIATION OF MAX FZ (N) VS MASS RATIO

5.13 VARIATION OF MAX MX (KN-M) VS MASS RATIO

TABLE 26

VARIATION OF MAX MX (KN-M) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	215.627	215.627	215.627	215.627	215.627
1.5	218.893	2.26E+02	222.126	216.932	213.403
2	223.51	236.349	229.557	224.388	216.826
2.5	226.682	247.182	235.627	230.353	221.07
3	232.773	257.878	249.064	236.695	225.267
3.5	239.658	269.988	258.102	242.932	229.697
4	255.35	282.103	266.407	248.807	234.07

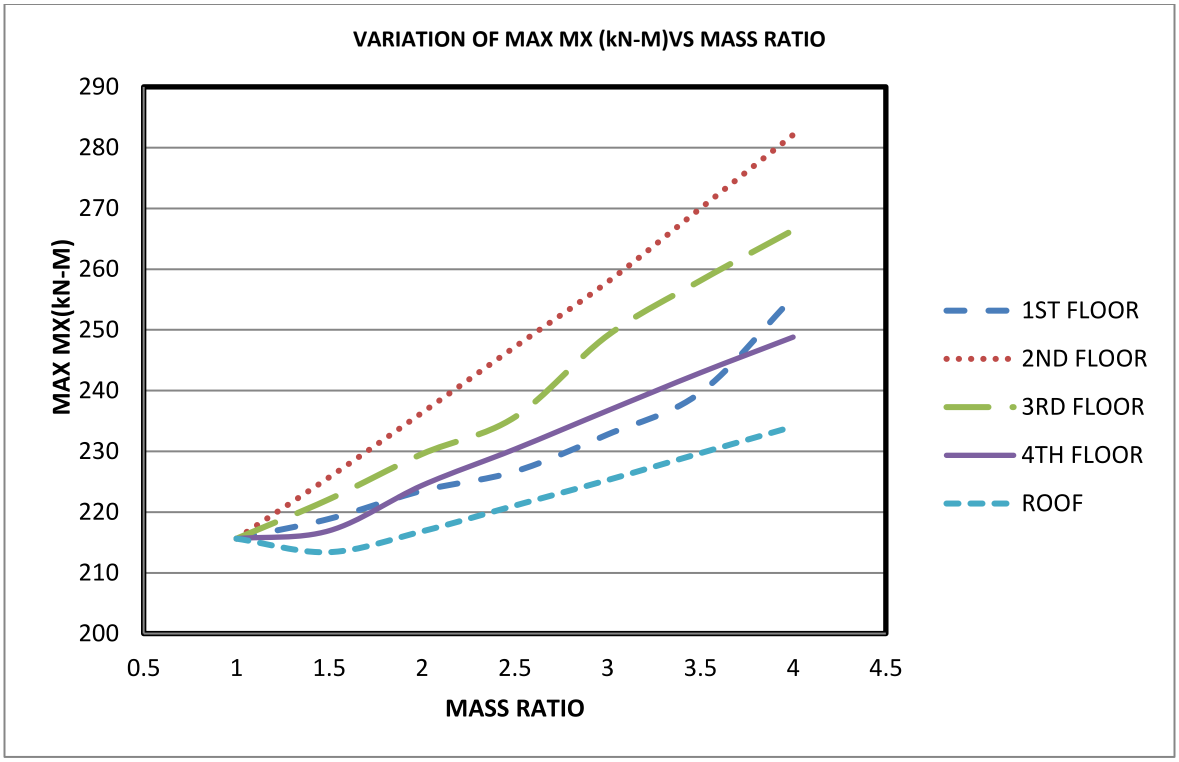

FIG 21 VARIATION OF MAX MX (KN-M) VS MASS RATIO

5.14 VARIATION OF MAX MY (KN-M) VS MASS RATIO

TABLE 27

VARIATION OF MAX MY (KN-M) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	8.564	8.564	8.564	8.564	8.564
1.5	9.224	9.403	9.192	8.945	8.815
2	10.562	10.205	9.784	9.324	9.043
2.5	11.159	10.975	10.5	9.599	9.277
3	12.394	11.693	10.857	9.896	9.517
3.5	13.19	12.39	11.342	10.185	9.759
4	14.652	13.097	11.801	10.465	9.996

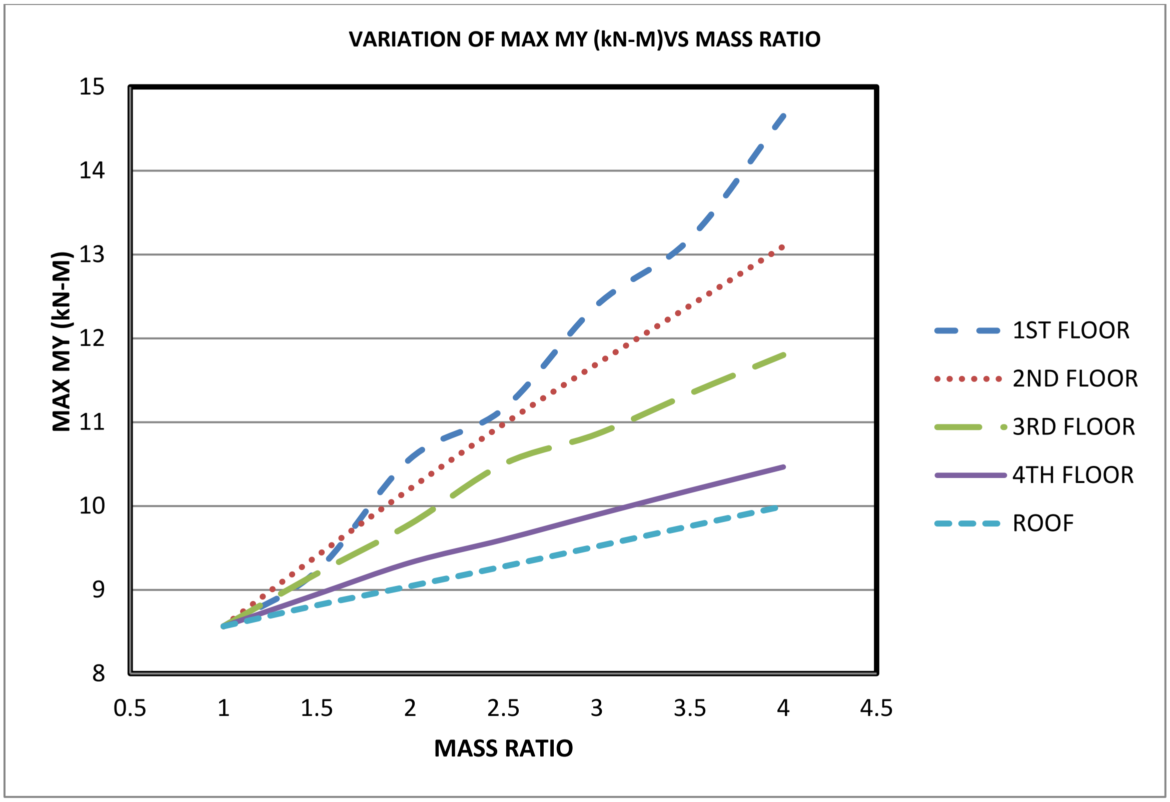

FIG 22 VARIATION OF MAX MY (KN-M) VS MASS RATIO

5.15 VARIATION OF MAX MZ (KN-M) VS MASS RATIO

TABLE 28

VARIATION OF MAX MZ (KN-M) VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	297.519	297.519	297.519	297.519	297.519
1.5	309.488	325.959	318.919	309.757	305.324
2	315.297	352.904	339.168	322.389	312.946
2.5	330.951	378.757	357.519	331.725	320.989
3	333.025	402.922	375.712	341.946	329.31
3.5	350.767	426.42	392.346	351.868	337.739
4	360.96	450.311	408.172	361.549	346.043

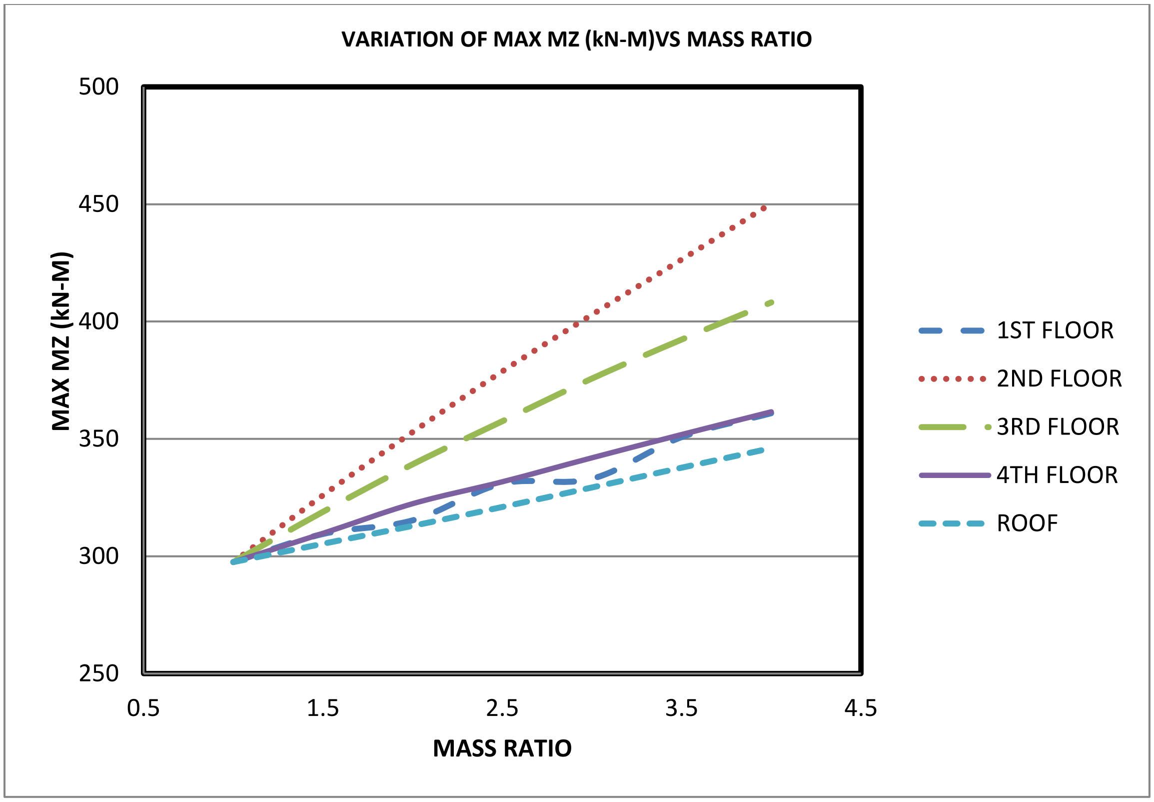

FIG 23 VARIATION OF MAX MZ (KN-M) VS MASS RATIO

The variation of maximum reaction vs. mass ratio follows following equation:

TABLE 29

MAX FX	Y= -1726 X^2+ 32085X + 20441
MAX FY	Y = 55768X + 2E+06
MAX FZ	Y = -355.5X^2 + 7237X + 13431
MAX MX	Y = 1.514X^2 + 9.843X + 203.9
MAX MY	Y = -0.099X^2 + 1.577X + 7.073
MAX MZ	y = -2.202x2 + 47.82x + 252.0

Max FX, FY, FZ, MX, MY, and MZ shows similar and expected trend of increasing with increase in weight applied. Maximum variation is observed in 2nd floor when irregularity is induced in top storey by keeping mass ratio equal to 4 while minimum variation is observed in top floor.

5.16 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR 1ST STOREY

TABLE 30

VARIATION OF SHEAR X(KN) ALONG HEIGHT FOR LOAD CASE FOR 1ST STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	530.05	548.13	570.57	586.64	610.03	619.38	634.96
12.15	932.55	946.51	963.09	976.85	998.16	1010.38	1029.1
8.85	1227.44	1241.34	1257.83	1269.36	1286.16	1293.8	1305.25
5.55	1440.65	1454.69	1471.76	1484.12	1504.42	1514.95	1530.91
2.25	1520.05	1571.5	1646.9	1718.19	1827.21	1895.61	1993.21

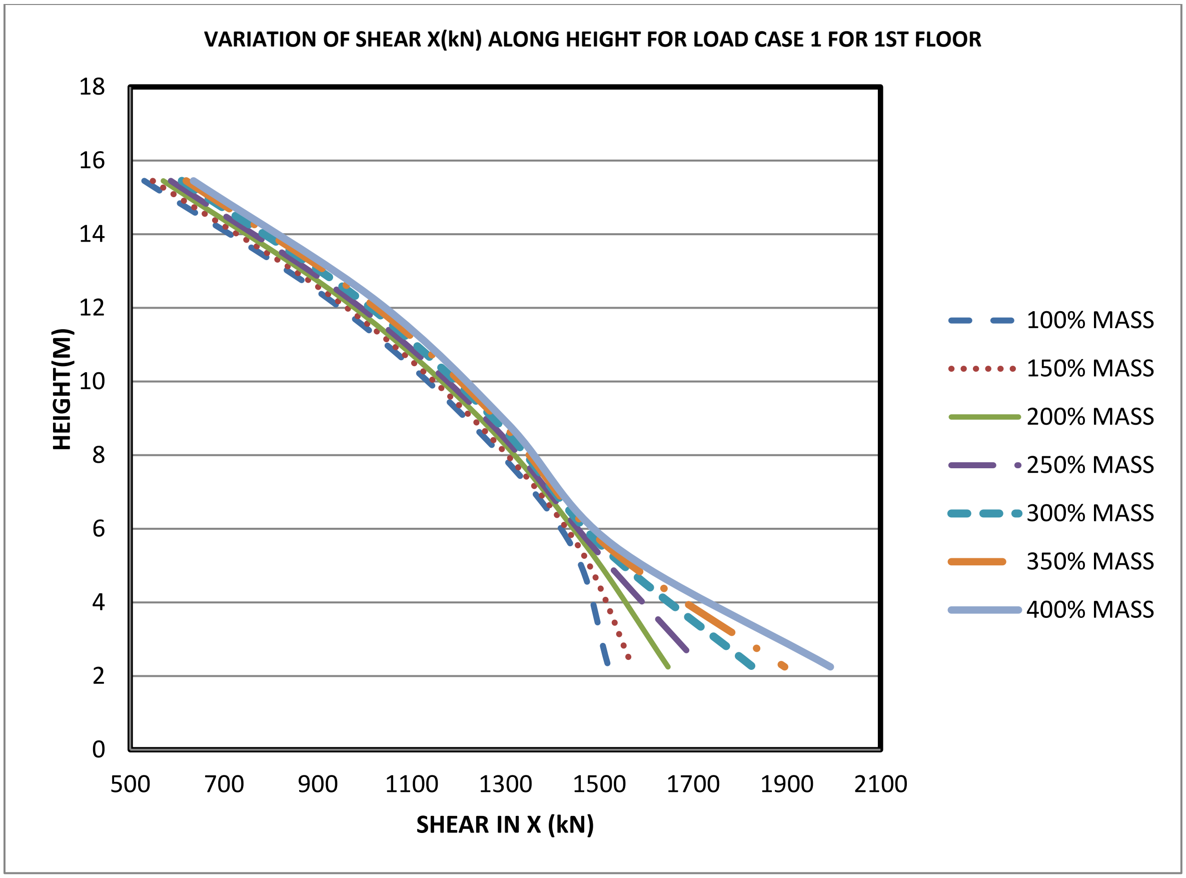

FIG 24 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR 1ST STOREY

5.17 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR 2ND STOREY

TABLE 31

VARIATION OF SHEAR X(KN) ALONG HEIGHT FOR LOAD CASE FOR 2ND STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	530.05	533.16	534.92	536.64	538	539.03	537.79
12.15	932.55	946.56	958.86	970.03	979.13	986.72	989.66
8.85	1227.44	1239.22	1250.67	1261.77	1271.54	1280.17	1284.96
5.55	1440.65	1528.18	1619.39	1710.92	1799.21	1886.69	1976.52
2.25	1520.05	1608.7	1700.86	1792.84	1881.22	1968.53	2058.52

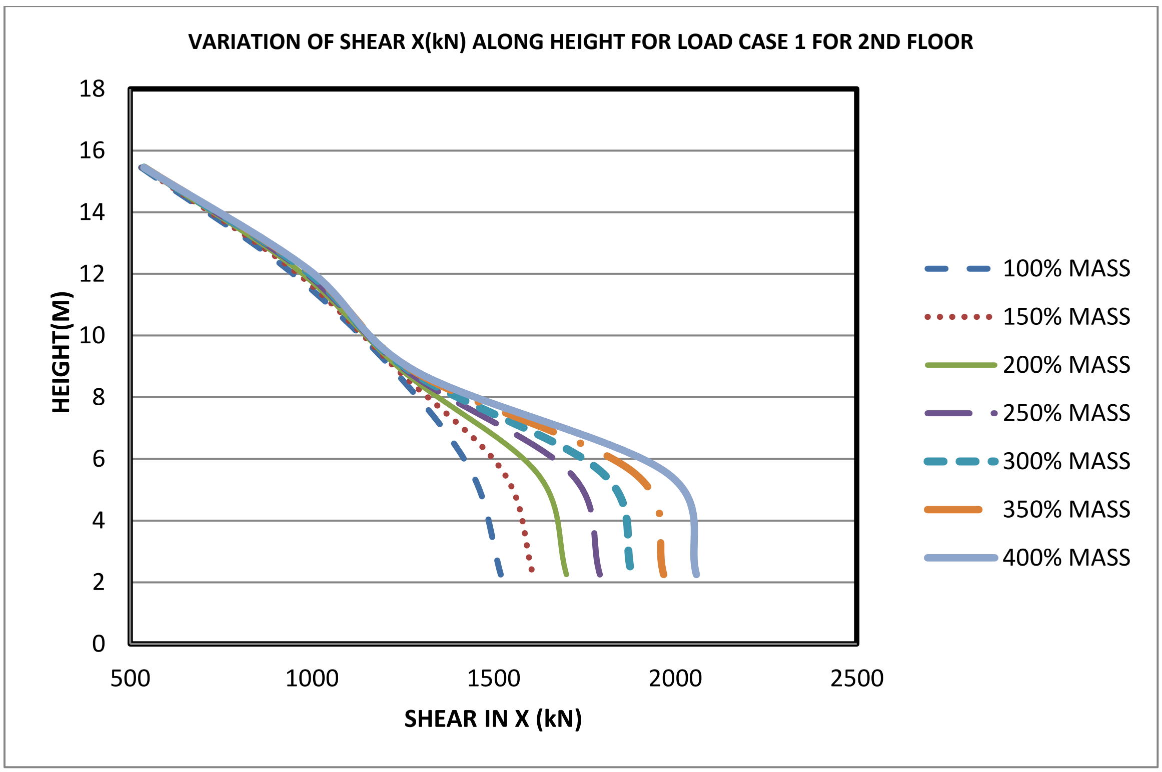

FIG 25 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR 2ND STOREY

5.18 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR 3RD STOREY

TABLE 32

VARIATION OF SHEAR X(KN) ALONG HEIGHT FOR LOAD CASE FOR 3RD STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	530.05	518.4	505.83	530.05	479.26	466.7	454.55
12.15	932.55	914.71	895.47	932.55	855.32	835.67	816.51
8.85	1227.44	1301.11	1374.33	1227.44	1511.72	1575.6	1636.76
5.55	1440.65	1507.04	1573.06	1440.65	1697.81	1756.2	1812.43
2.25	1520.05	1582.98	1646.75	1520.05	1767.75	1824.8	1879.84

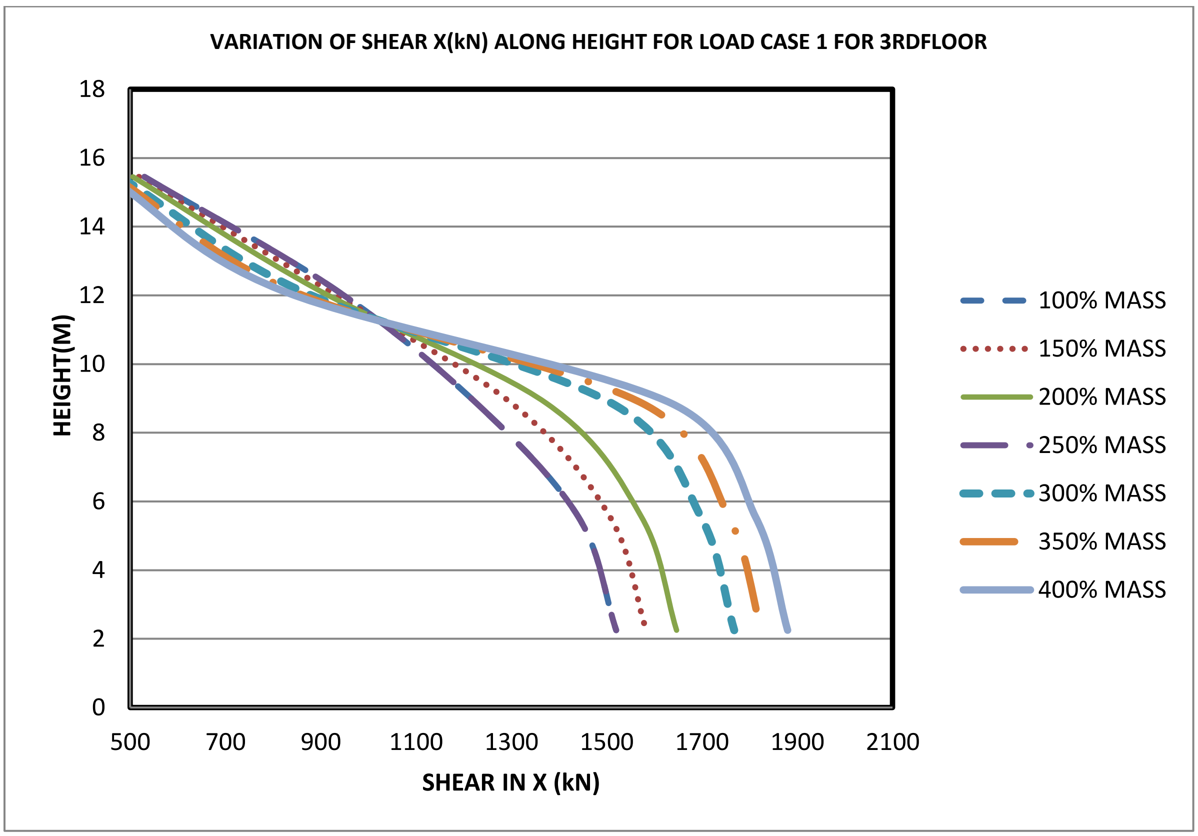

FIG 26 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR 3RD STOREY

5.19 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR 4TH STOREY

TABLE 33

VARIATION OF SHEAR X(KN) ALONG HEIGHT FOR LOAD CASE FOR 4TH STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	530.05	502.49	477.14	460.77	444.39	430.76	417.41
12.15	932.55	1004.08	1077.86	1131.25	1188.28	1242.4	1293.73
8.85	1227.44	1271.08	1320.57	1358.73	1401.33	1443.2	1484.28
5.55	1440.65	1470.25	1506.28	1535.5	1569.28	1603.52	1637.76
2.25	1520.05	1546.03	1578.83	1605.93	1637.82	1670.16	1703.25

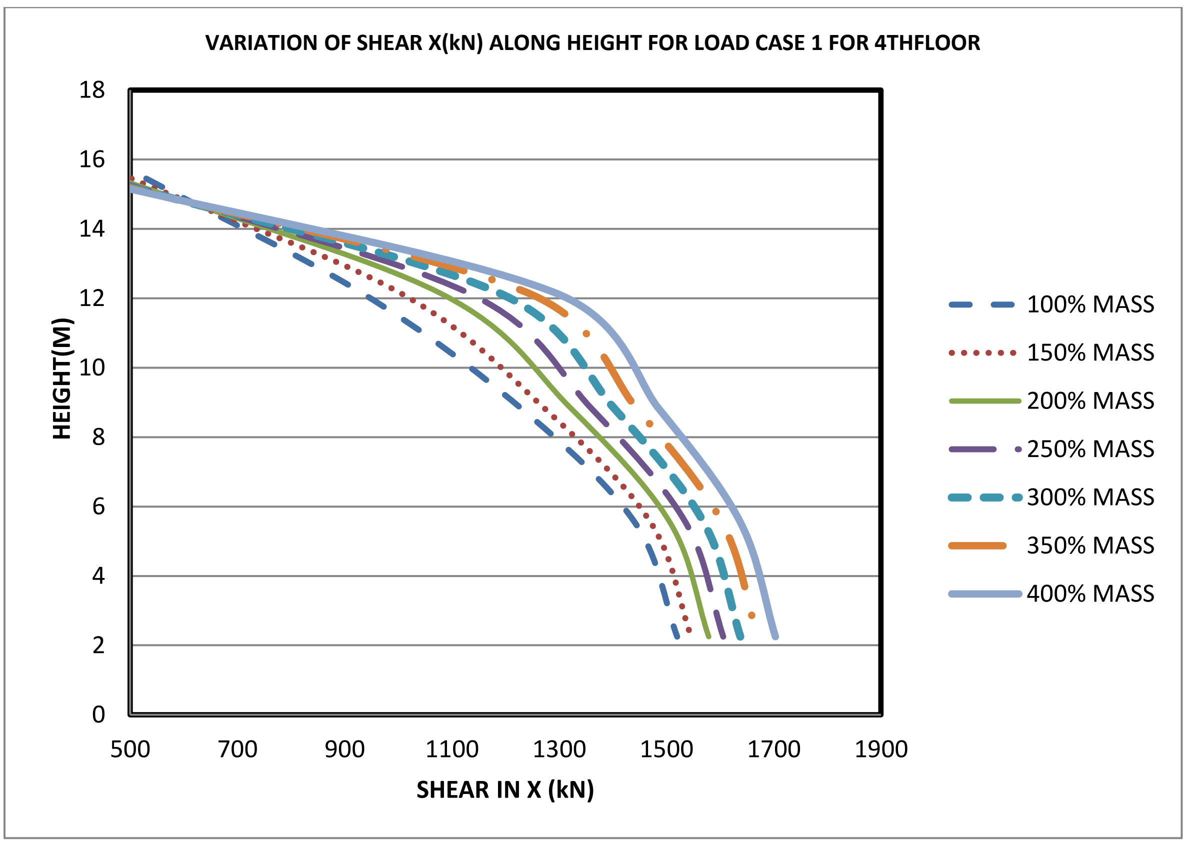

FIG 27 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR 4TH STOREY

5.20 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR TOP STOREY

TABLE 34

VARIATION OF SHEAR X(kN) ALONG HEIGHT FOR LOAD CASE FOR TOP STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	530.05	681.57	786.4	875.44	952.1	1022.31	1085.05
12.15	932.55	1012.51	1072.73	1127.59	1177.92	1226.28	1271.58
8.85	1227.44	1259.3	1289.86	1322.33	1355.38	1389.98	1424.2
5.55	1440.65	1449.73	1467.04	1489.83	1515.52	1543.95	1573.14
2.25	1520.05	1525.55	1540.64	1561.58	1586.73	1613.83	1641.79

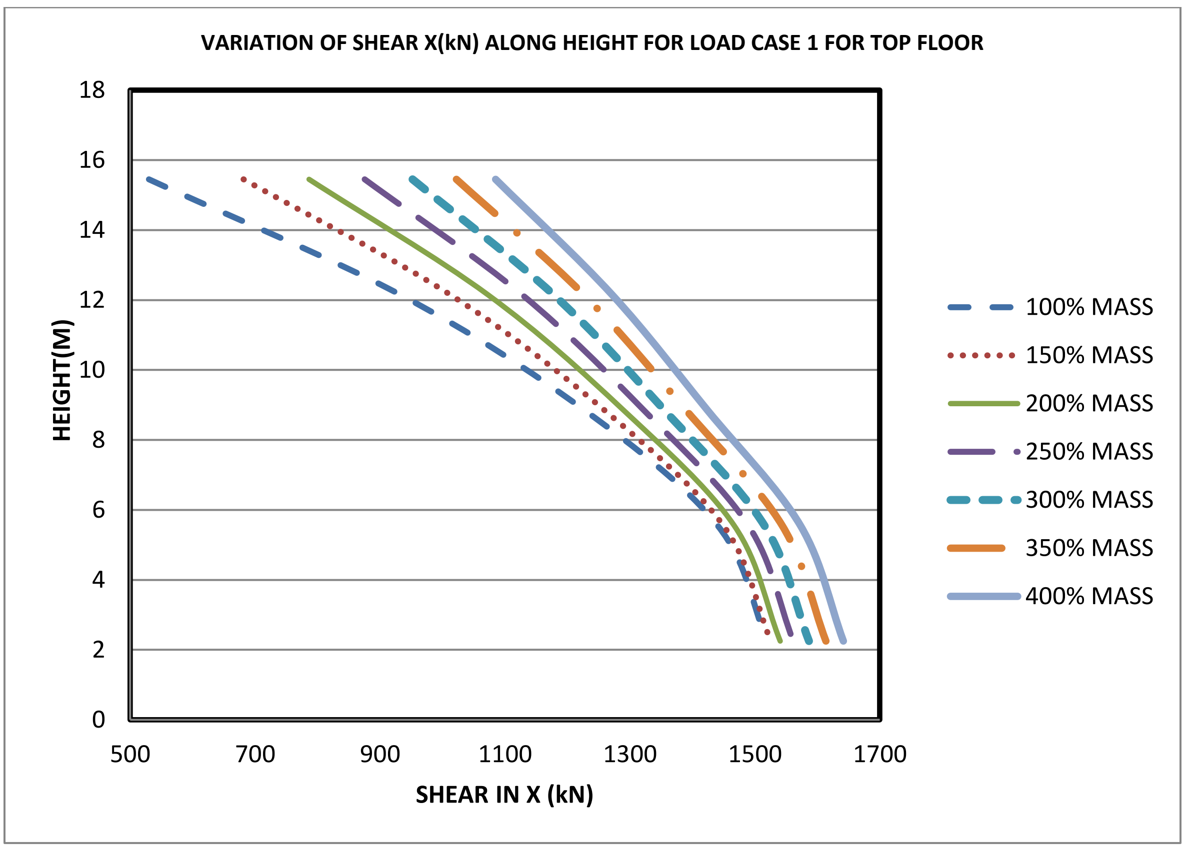

FIG 28 VARIATION OF SHEAR X (KN) ALONG HEIGHT FOR LOAD CASE FOR TOP STOREY

5.21 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR 1ST STOREY

TABLE 35

VARIATION OF SHEAR Z(KN) ALONG HEIGHT FOR LOAD CASE FOR 1ST STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	600.78	616.55	635.49	649.9	670.3	680.39	696.39
12.15	1096.3	1110.63	1129.43	1144.34	1168.27	1182.09	1202.45
8.85	1467.78	1481.84	1498.35	1510.44	1528.82	1537.4	1551.61
5.55	1717.4	1733.4	1753.79	1768.28	1791.24	1802.51	1819.59
2.25	1803.88	1860.2	1932.63	1993.02	2095.46	2161.85	2261.41

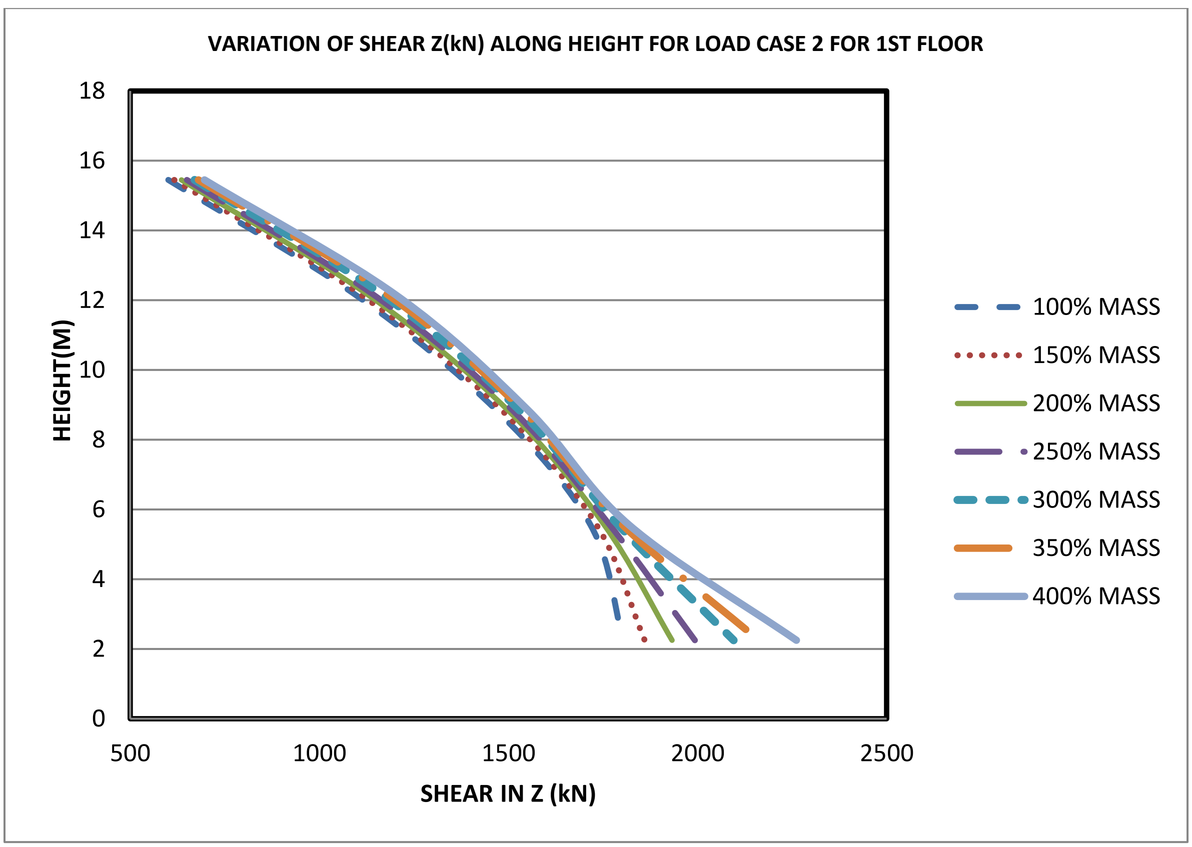

FIG 29 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR 1ST STOREY

5.22 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR 2ND STOREY

TABLE 36

VARIATION OF SHEAR Z(KN) ALONG HEIGHT FOR LOAD CASE FOR 2ND STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	600.78	606.35	610.77	614.62	617.03	619.57	620.35
12.15	1096.3	1113.89	1130.55	1145.75	1157.54	1168.74	1178.23
8.85	1467.78	1484.72	1501.49	1517.75	1531.74	1545.06	1556.38
5.55	1717.4	1820.94	1929.44	2040.19	2149.48	2257.8	2365.38
2.25	1803.88	1908.38	2018.38	2130.49	2241.04	2350.08	2458.33

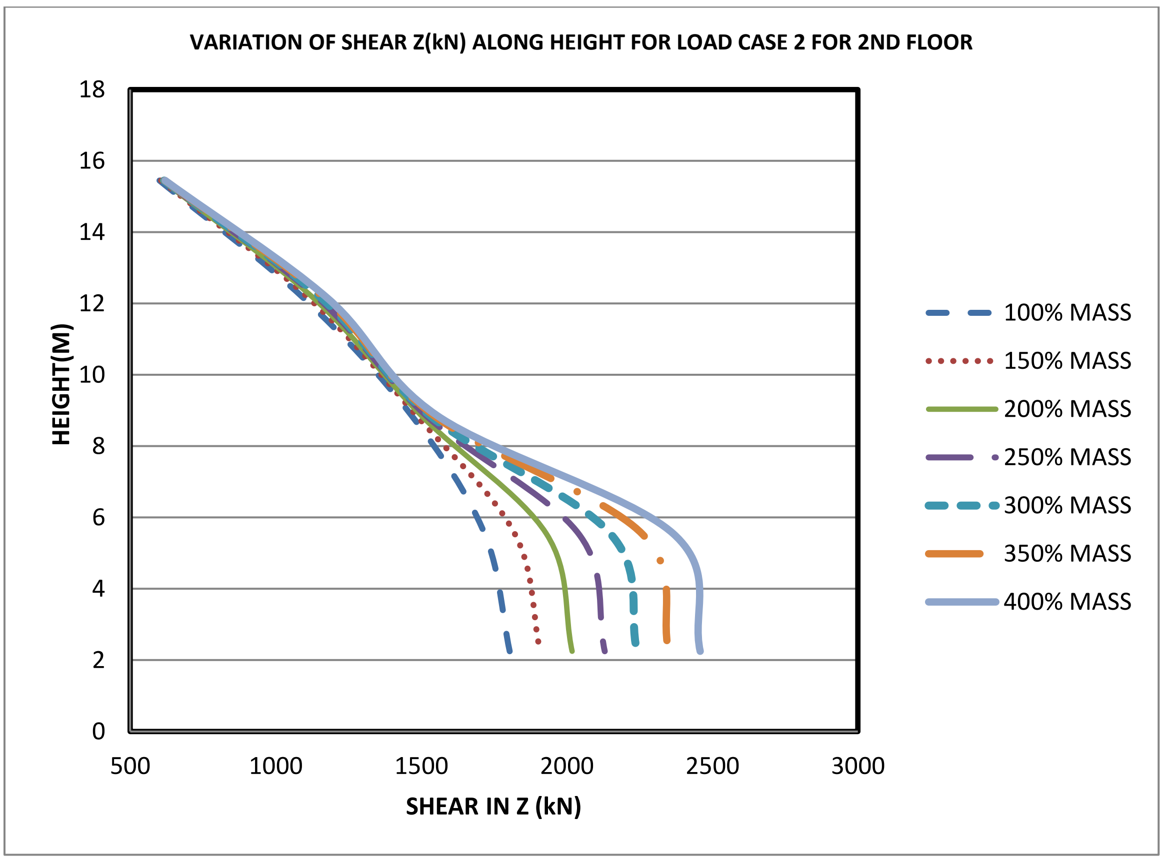

FIG 30 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR 2ND STOREY

5.23 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR 3RD STOREY

TABLE 37

VARIATION OF SHEAR Z(KN) ALONG HEIGHT FOR LOAD CASE FOR 3RD STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	600.78	586.39	570.96	600.78	540.35	524.84	502.71
12.15	1096.3	1072.69	1047.91	1096.3	999.17	976.03	953.8
8.85	1467.78	1552.46	1637.3	1467.78	1798.16	1872.88	1938.12
5.55	1717.4	1794.8	1872.43	1717.4	2020.5	2090.27	2156.08
2.25	1803.88	1878.21	1953.64	1803.88	2098.63	2166.64	2227.76

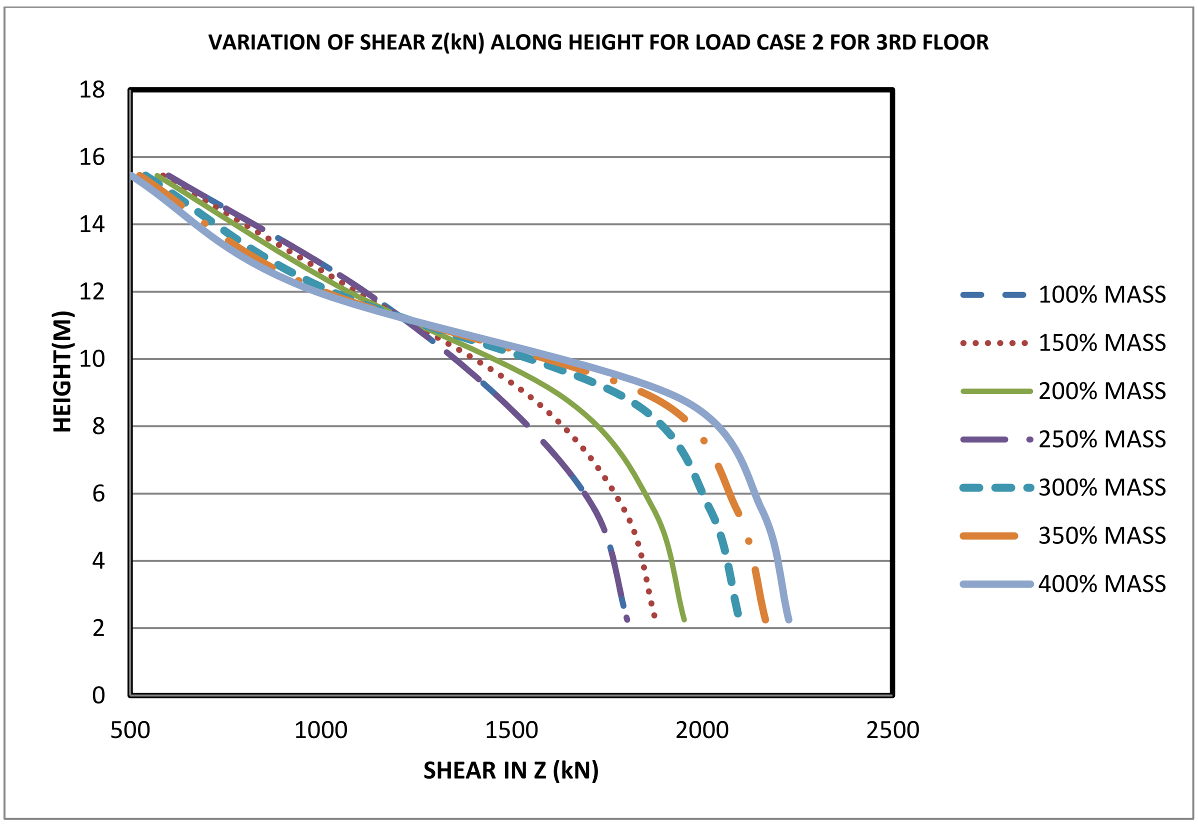

FIG 31 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR 3RD STOREY

5.24 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR 4TH STOREY

TABLE 38

VARIATION OF SHEAR Z(KN) ALONG HEIGHT FOR LOAD CASE FOR 4TH STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	600.78	568.42	537.88	519.44	480.56	463.85	450.73
12.15	1096.3	1183	1272.91	1340.19	1409.05	1477.02	1541.32
8.85	1467.78	1523.11	1585.99	1634.81	1688.26	1742.27	1795.45
5.55	1717.4	1756.04	1801.98	1841.855	1884.99	1929.88	1974.36
2.25	1803.88	1837.14	1869.96	1915.69	1959.29	2001.84	2046.43

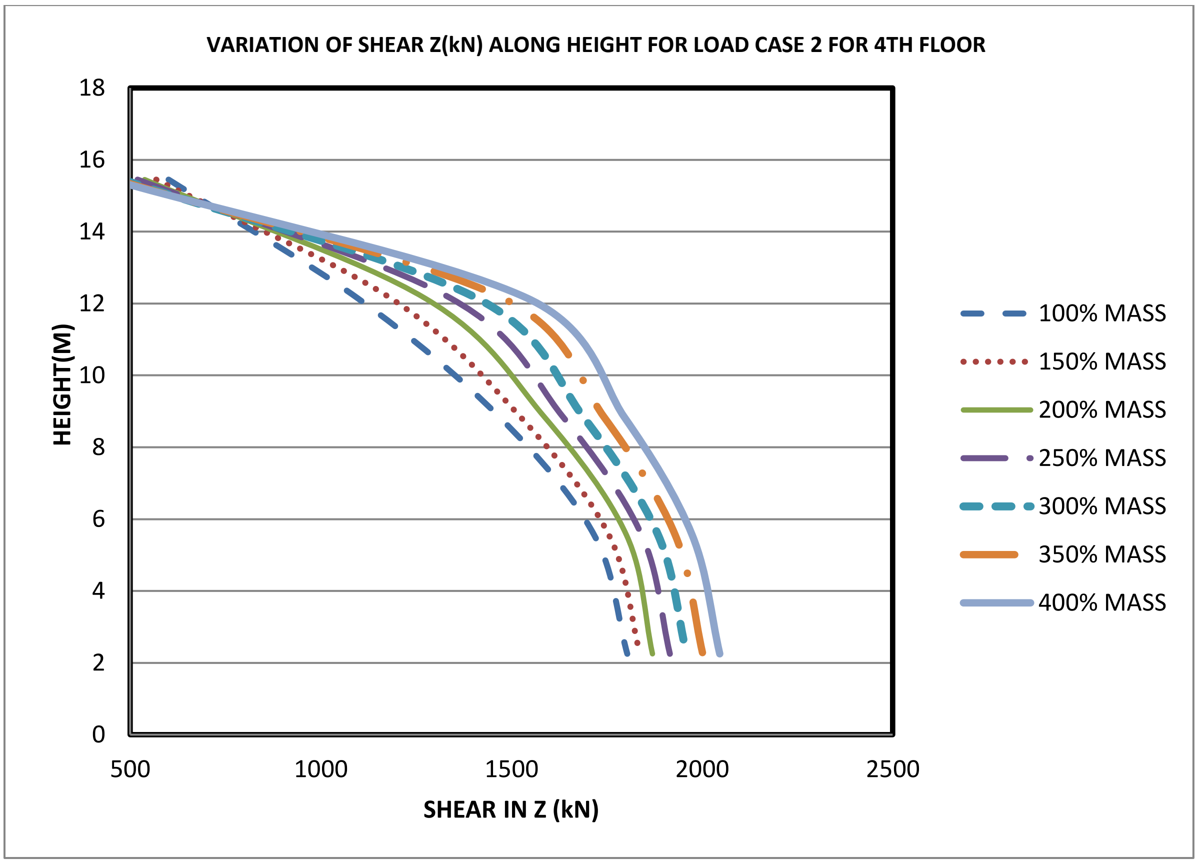

FIG 32 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR 4TH STOREY

5.25 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR TOP STOREY

TABLE 39

VARIATION OF SHEAR Z(KN) ALONG HEIGHT FOR LOAD CASE FOR TOP STOREY							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	600.78	775.52	887.8	994.35	1088.49	1173.01	1248.95
12.15	1096.3	1191.88	1262.58	1329.05	1390.75	1449.65	1504.84
8.85	1467.78	1506.47	1538.07	1577.62	1619	1660.77	1702.1
5.55	1717.4	1725.62	1742.27	1767.83	1797.45	1830.38	1864.47
2.25	1803.88	1805.64	1821.92	1844.96	1875.08	1906.01	1938.33

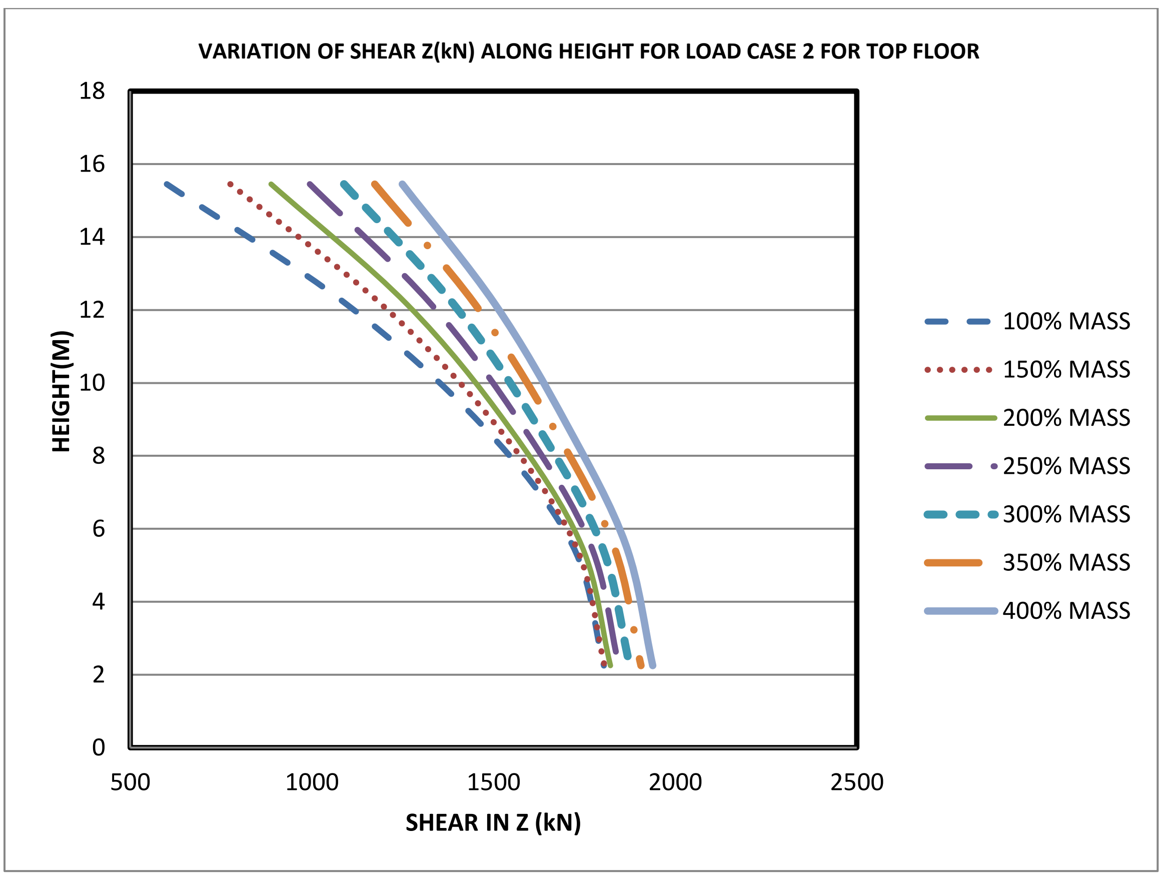

FIG 33 VARIATION OF SHEAR Z (KN) ALONG HEIGHT FOR LOAD CASE FOR TOP STOREY

Storey shear increases with increases in weight applied in a storey. A large variation in storey shear is observed in a storey or below it when mass irregularity is induced in that particular storey. Maximum variation is observed when weight is increased on 1st floor. Shear in x and z shows same variation. When mass ratio is 4 on 1st floor, the variation of shear on 1st floor is 31.13% more than that of base case while change in top storey shear is 19.8% to that of base shear. When mass ratio is 4 on 2nd floor, the variation of shear on 1st floor is 35.85% more than that of base case while change in top storey shear is 1.88% to that of base shear

5.26 VARIATION OF STOREY DRIFT (MM) ALONG HEIGHT FOR 1ST FLOOR

TABLE 40

VARIATION OF STOREY DRIFT(MM) ALONG HEIGHT FOR 1ST FLOOR							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	2.896	2.922	2.956	2.982	3.023	3.046	3.079
12.15	3.939	3.971	4.012	4.041	4.089	4.111	4.147
8.85	3.165	3.193	3.228	3.253	3.294	3.313	3.343
5.55	2.773	2.804	2.831	2.825	2.86	2.841	2.849
2.25	1.797	1.854	1.905	1.957	2.032	2.093	2.163

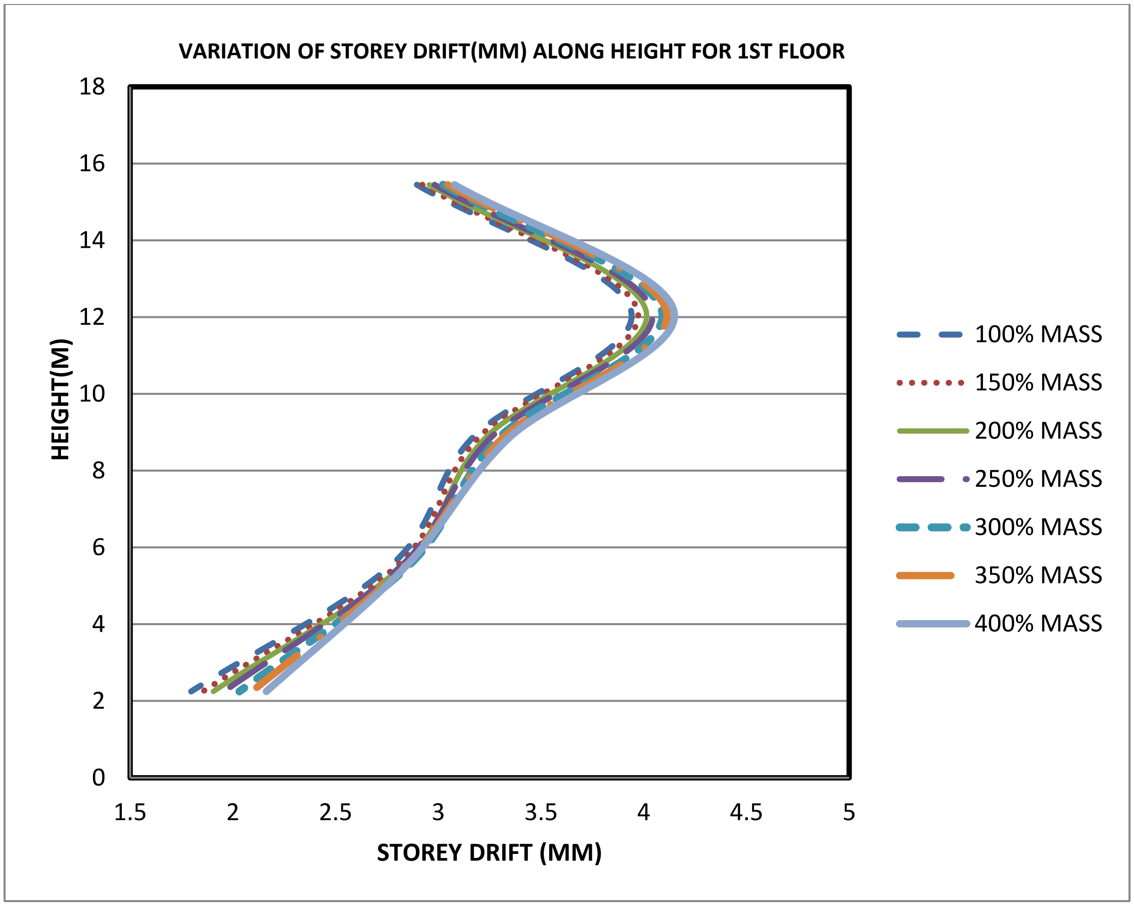

FIG 34 VARIATION OF STOREY DRIFT (MM) ALONG HEIGHT FOR 1ST FLOOR

5.27 VARIATION OF STOREY DRIFT (MM) ALONG HEIGHT FOR 2ND FLOOR

TABLE 41

VARIATION OF STOREY DRIFT(MM) ALONG HEIGHT FOR 2ND FLOOR							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	2.896	2.926	2.951	2.974	2.991	3.005	3.004
12.15	3.939	4.04	4.141	4.239	4.332	4.419	4.5
8.85	3.165	3.265	3.367	3.466	3.559	3.65	3.737
5.55	2.773	2.911	3.036	3.165	3.287	3.421	3.551
2.25	1.797	1.914	2.041	2.159	2.272	2.383	2.497

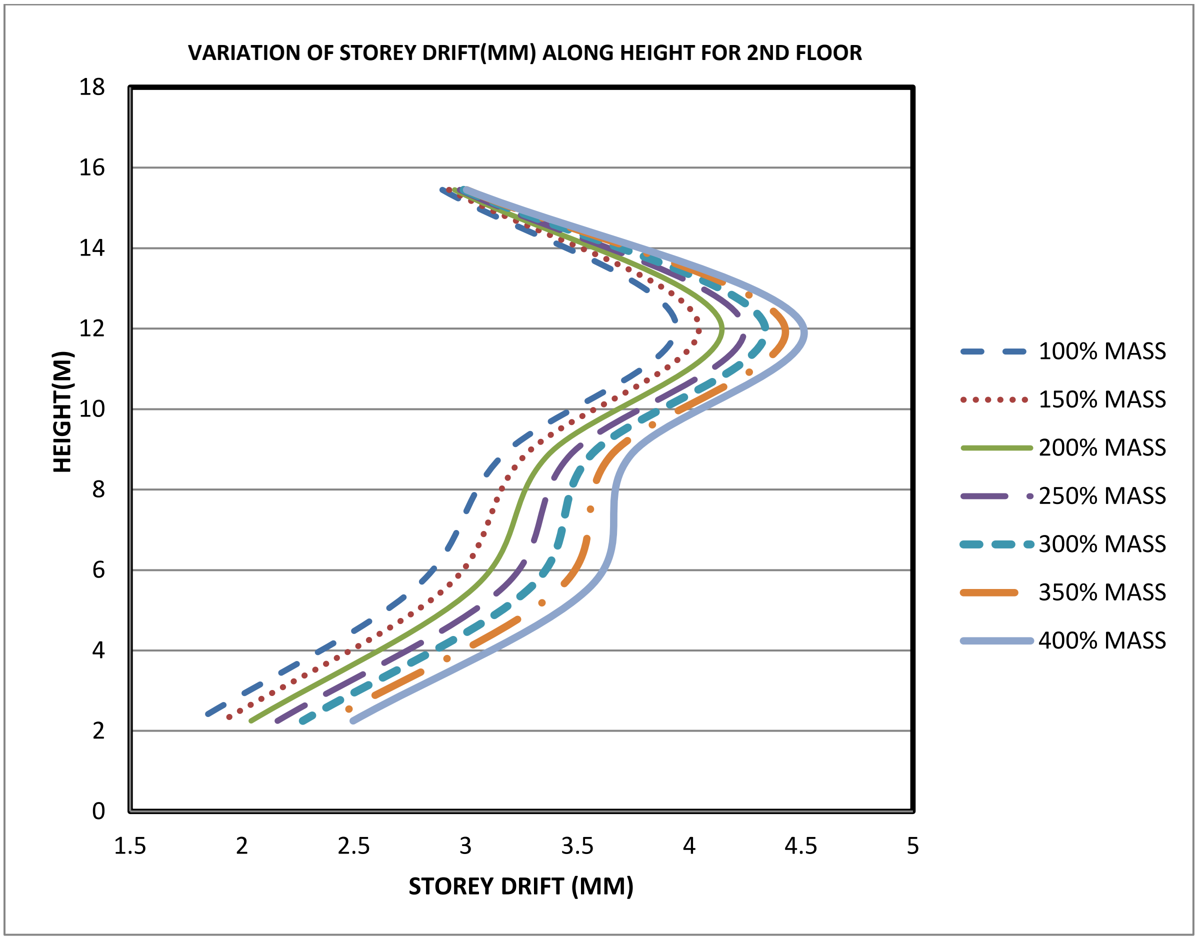

FIG 35 VARIATION OF STOREY DRIFT (MM) ALONG HEIGHT FOR 2ND FLOOR

5.28 VARIATION OF STOREY DRIFT (MM) ALONG HEIGHT FOR 3RD FLOOR

TABLE 42

VARIATION OF STOREY DRIFT(MM) ALONG HEIGHT FOR 3RD FLOOR							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	2.896	2.855	2.81	2.896	2.719	2.675	2.633
12.15	3.939	4.099	4.246	3.939	4.494	4.6	4.697
8.85	3.165	3.35	3.528	3.165	3.846	3.989	4.122
5.55	2.773	2.933	3.068	2.797	3.323	3.442	3.558
2.25	1.797	1.898	1.987	1.807	2.155	2.224	2.307

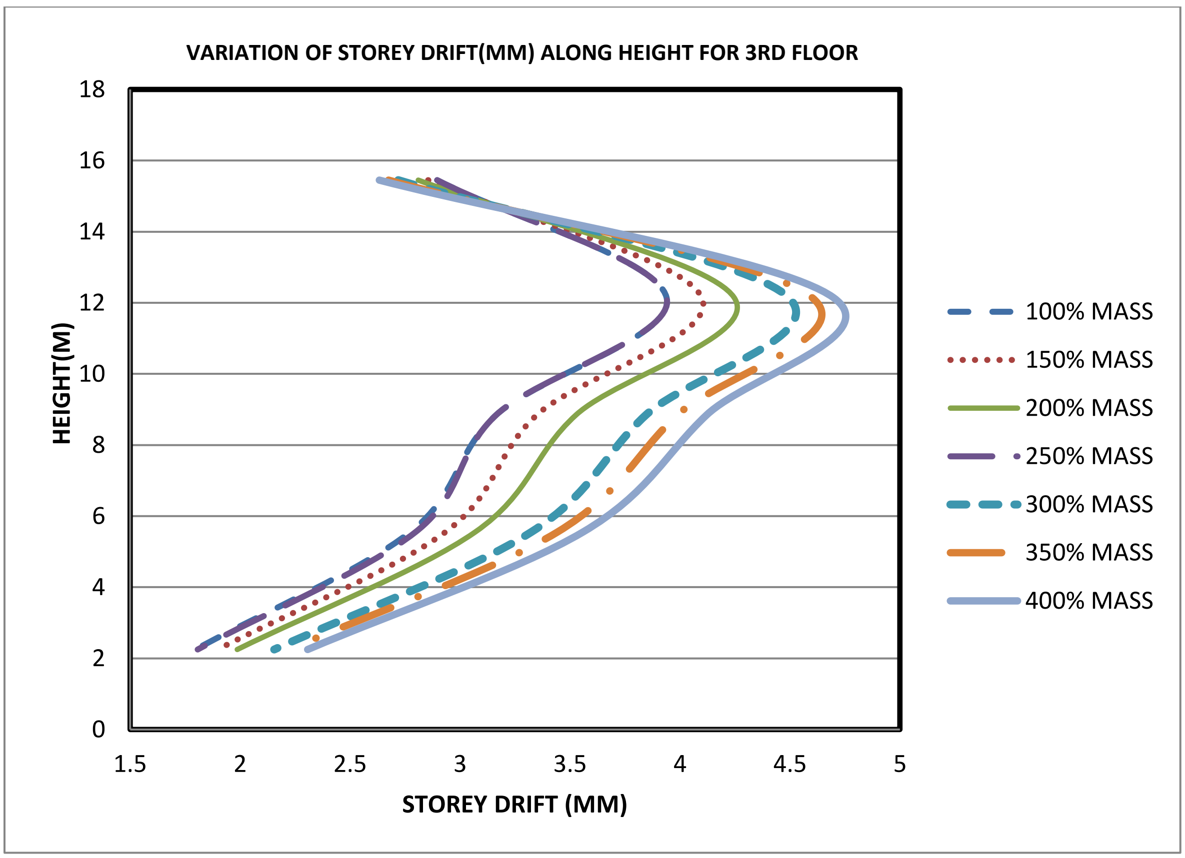

FIG 36 VARIATION OF STOREY DRIFT(MM) ALONG HEIGHT FOR 3RD FLOOR

5.29 VARIATION OF STOREY DRIFT (MM) ALONG HEIGHT FOR 4TH FLOOR

TABLE 43

VARIATION OF STOREY DRIFT(MM) ALONG HEIGHT FOR 4TH FLOOR							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	2.896	2.862	2.838	2.829	2.825	2.827	2.834
12.15	3.939	4.157	4.359	4.496	4.639	4.77	4.894
8.85	3.165	3.345	3.513	3.628	3.746	3.856	3.96
5.55	2.773	2.882	2.977	3.05	3.132	3.212	3.291
2.25	1.797	1.844	1.907	1.939	1.995	2.042	2.088

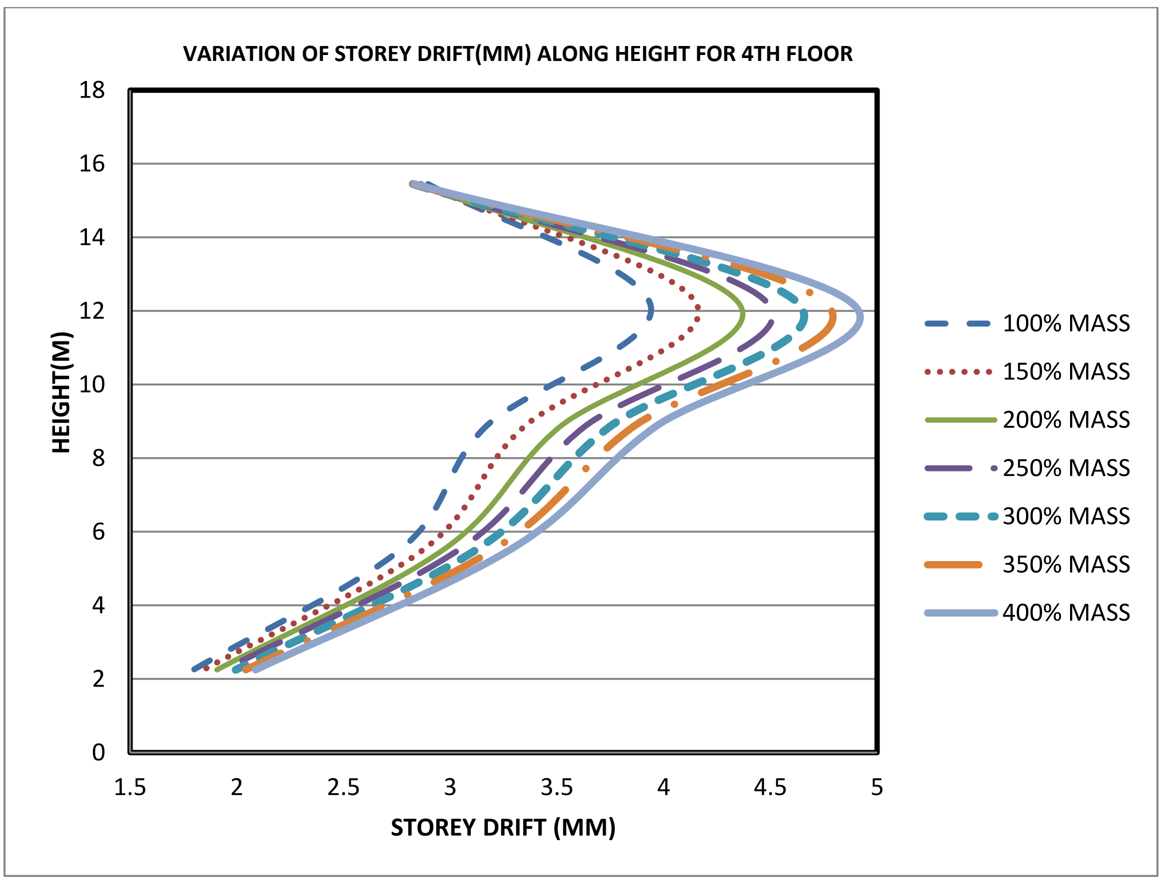

FIG 37 VARIATION OF STOREY DRIFT (MM) ALONG HEIGHT FOR 4TH FLOOR

5.30 VARIATION OF STOREY DRIFT (MM) ALONG HEIGHT FOR TOP FLOOR

TABLE 44

VARIATION OF STOREY DRIFT(MM) ALONG HEIGHT FOR TOP FLOOR							
FLOOR HEIGHT	1	1.5	2	2.5	3	3.5	4
15.45	2.896	3.451	3.847	4.193	4.502	4.786	4.934
12.15	3.939	4.159	4.321	4.47	4.609	4.743	4.871
8.85	3.165	3.289	3.382	3.469	3.554	3.637	3.719
5.55	2.773	2.822	2.858	2.904	2.951	3.013	3.072
2.25	1.797	1.824	1.85	1.881	1.915	1.944	1.991

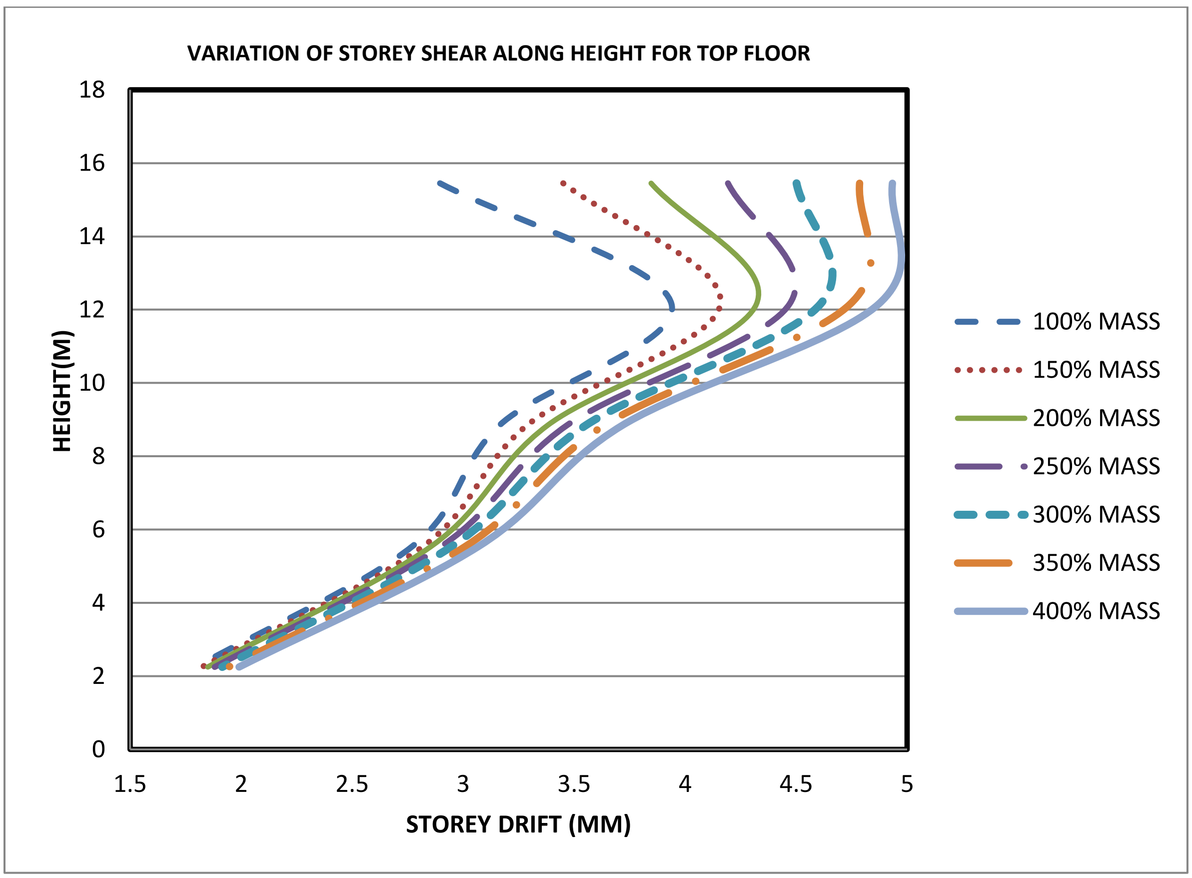

FIG 38 VARIATION OF STOREY DRIFT (MM) ALONG HEIGHT FOR TOP FLOOR

5.31 VARIATION OF STOREY DRIFT ALONG HEIGHT FOR 200% MASS

TABLE 45

VARIATION OF STOREY DRIFT ALONG HEIGHT FOR 200% MASS					
FLOOR HEIGHT	1	2	3	4	5
15.45	2.956	2.951	2.81	2.838	3.847
12.15	4.012	4.141	4.246	4.359	4.321
8.85	3.228	3.367	3.528	3.513	3.382
5.55	2.831	3.036	3.068	2.977	2.858
2.25	1.905	2.041	1.987	1.907	1.85

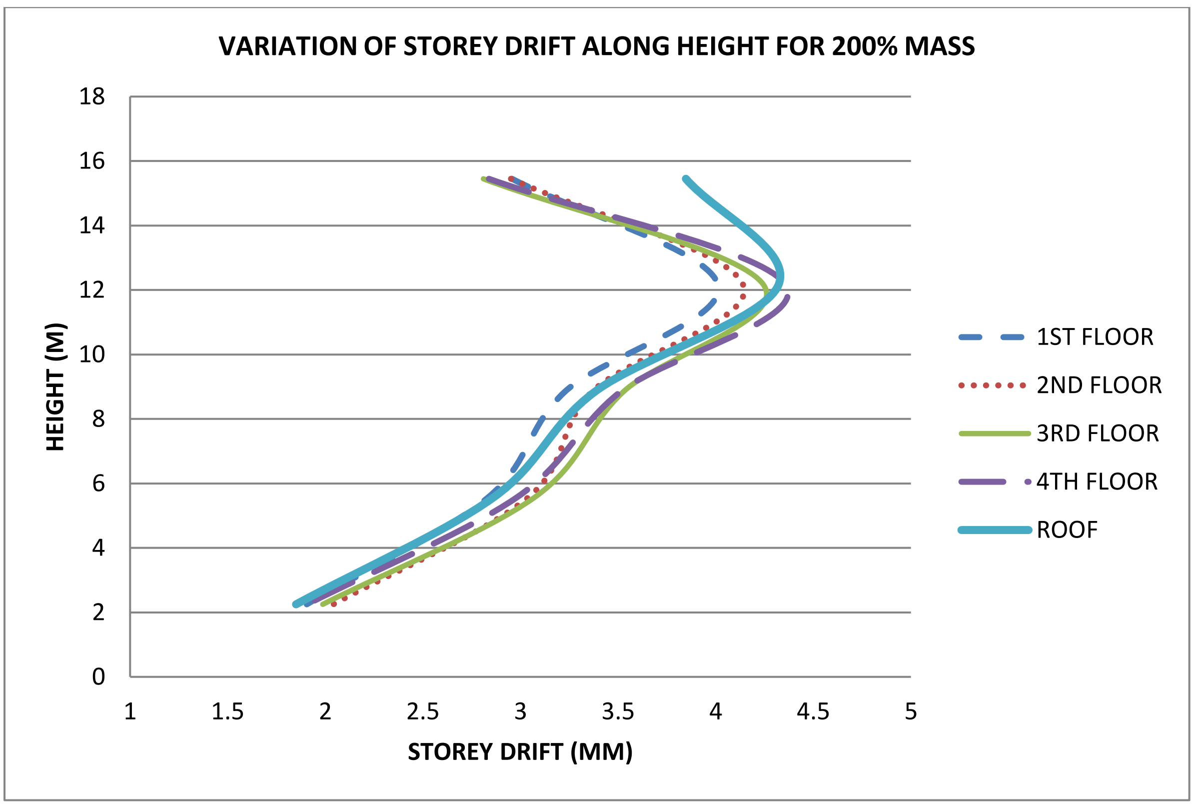

FIG 39 VARIATION OF STOREY DRIFT ALONG HEIGHT FOR 200% MASS

Storey drift increases with increases in weight applied in a storey. Maximum variation is observed in 4th floor in every case while minimum variation is noted down in 1st floor. It can be induced from graph 5.26 to 31 that drift in middle storey is more than that of top story. Least variation is seen in lower floor. Maximum effect is observed when weight is changes on top floor and it is 70.37% while when weight is increased by mass ratio 2, the variation of 52.5% ,44.58%, 41.42%, 48.82% and 107.9% occurs between top and 1st floor for change in mass for 1st , 2nd , 3rd , 4th and top storey respectively

5.32 VARIATION OF MASS PARTICIPATION FACTOR % IN X WITH MODE

TABLE 46

Mode	Participation X %
1	58.003
2	12.298
3	5.713
4	8.867
5	1.449
6	0.445
7	3.962
8	0.549
9	0.055
10	0
11	0.001
12	0.001
13	0.025
14	0
15	0
16	0.002
17	0.003
18	0.019
19	0
20	0.024
21	0.137

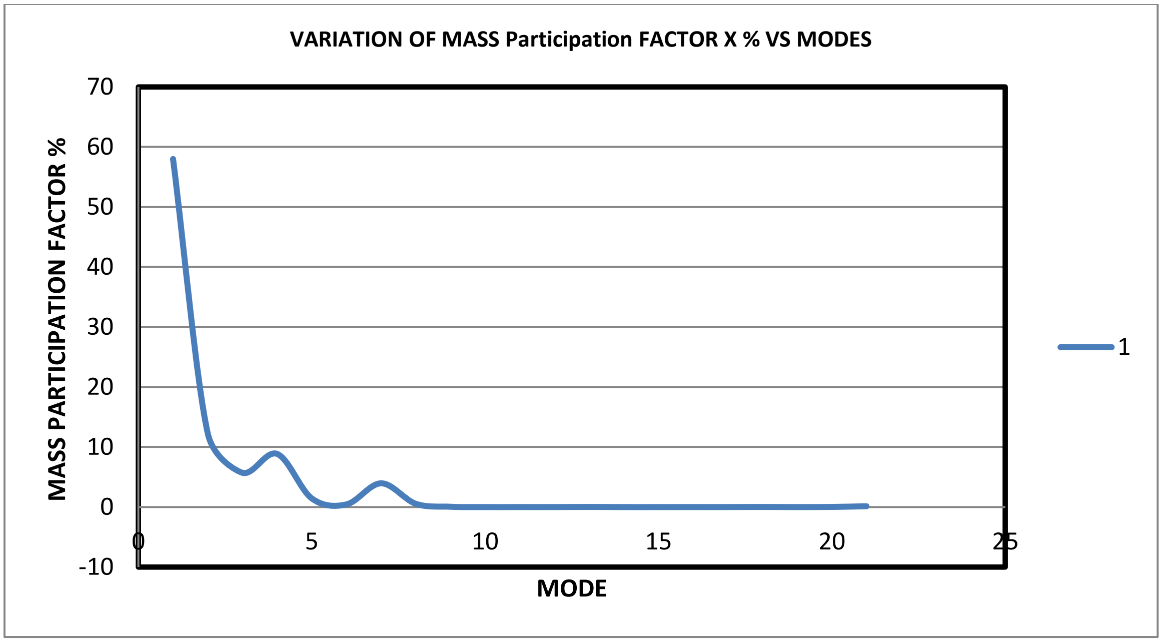

FIG 40 VARIATION OF MASS PARTICIPATION FACTOR % IN X WITH MODE

5.33 VARIATION OF MASS PARTICIPATION FACTOR % IN Y WITH MODE

TABLE 47

Mode	Participation Y %
1	0
2	0.001
3	0
4	0.001
5	0.006
6	0.003
7	0
8	0.029
9	0.015
10	0.011
11	0.104
12	12.898
13	8.37
14	2.775
15	0.137
16	0.238
17	0.047
18	0.21
19	4.697
20	0.443
21	4.964

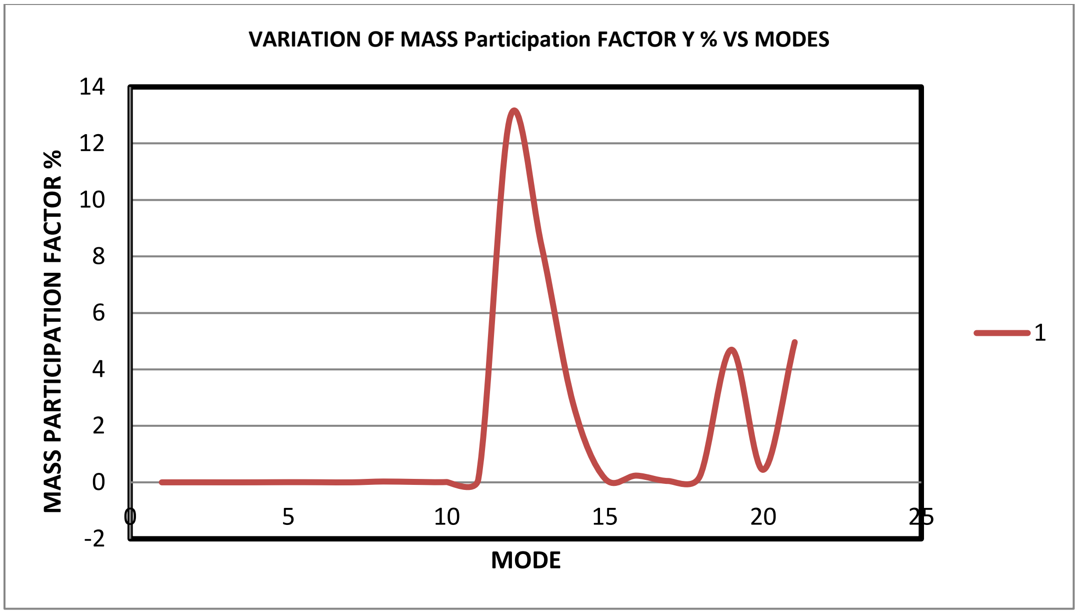

FIG 41 VARIATION OF MASS PARTICIPATION FACTOR % IN Y WITH MODE

5.34 VARIATION OF MASS PARTICIPATION FACTOR % IN Z WITH MODE

TABLE 48

Mode	Participation Z %
1	1.656
2	43.592
3	31.168
4	0.113
5	4.737
6	5.921
7	0.014
8	0.998
9	3.981
10	0.008
11	0.013
12	0
13	0.001
14	0
15	0
16	0
17	0.006
18	0
19	0.002
20	0.001
21	0.001

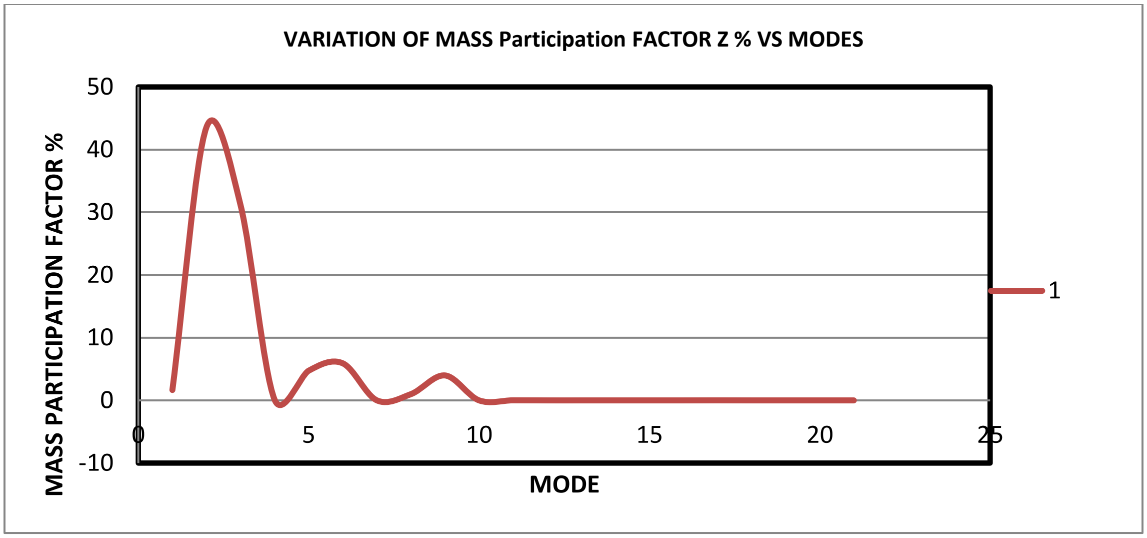

FIG 42 VARIATION OF MASS PARTICIPATION FACTOR % IN Z WITH MODE

5.35 VARIATION OF MASS PARTICIPATION FACTOR % IN X WITH MASS RATIO

TABLE 49

VARIATION OF MASS PARTICIPATION FACTOR % IN X WITH MASS RATIO					
	1st FLOOR	2nd FLOOR	3rd FLOOR	4th FLOOR	5th FLOOR
1	58.003	58.003	58.003	58.003	58.003
1.5	55.575	58.111	59.156	58.884	59.01
2	52.948	58.322	60.229	59.846	59.909
2.5	51.372	58.614	61.003	60.555	60.804
3	48.982	58.952	62.061	61.313	61.67
3.5	48.114	59.329	62.837	62.023	62.507
4	46.736	59.728	63.538	62.684	63.287

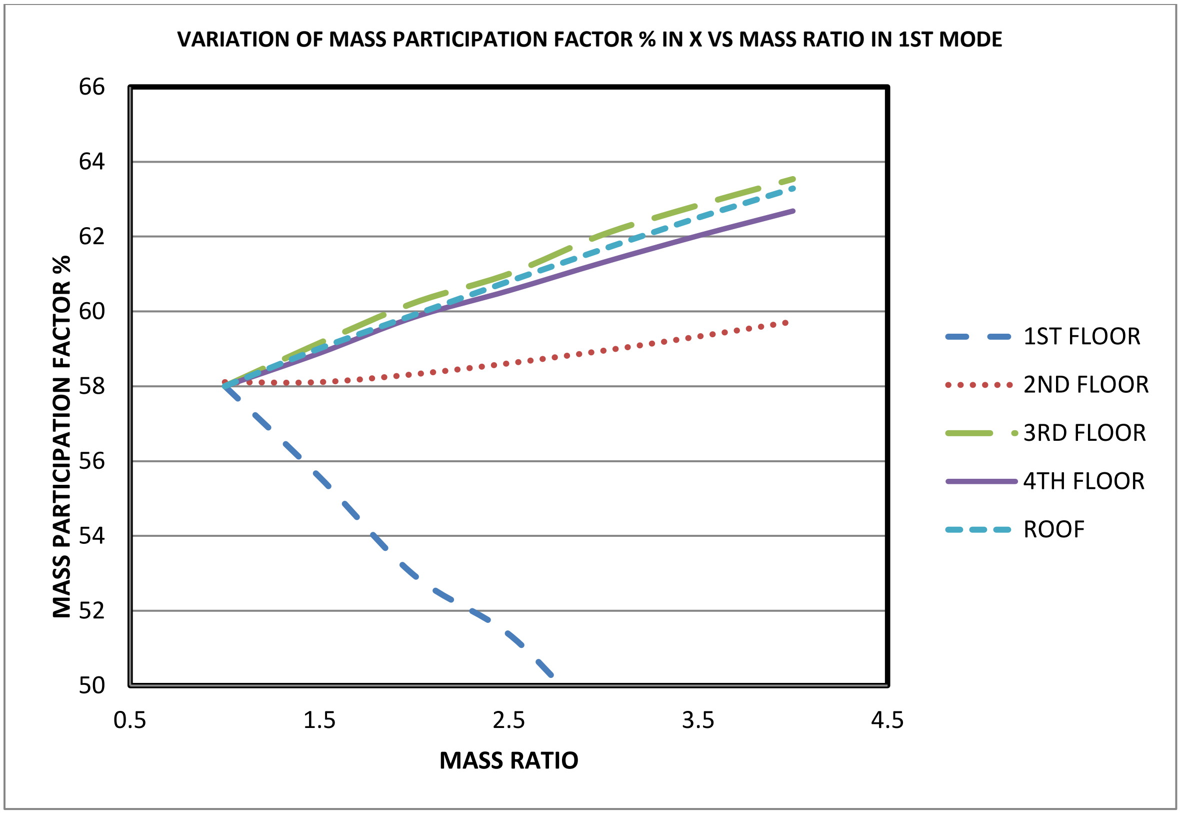

FIG 43 VARIATION OF MASS PARTICIPATION FACTOR % IN X WITH MASS RATIO

5.36 VARIATION OF MASS PARTICIPATION FACTOR % IN Z WITH MASS RATIO

TABLE 50

VARIATION OF MASS PARTICIPATION FACTOR % IN Z WITH MASS RATIO					
	1st FLOOR	2nd FLOOR	3rd FLOOR	4th FLOOR	5th FLOOR
1	43.592	43.592	43.592	43.592	43.592
1.5	41.817	44.459	46.507	48.07	48.013
2	39.878	45.432	49.154	51.821	50.793
2.5	38.752	46.479	51.592	54.105	52.977
3	36.97	47.537	53.502	56.231	54.757
3.5	36.387	48.627	55.271	58	56.271
4	35.39	49.728	56.832	59.502	57.557

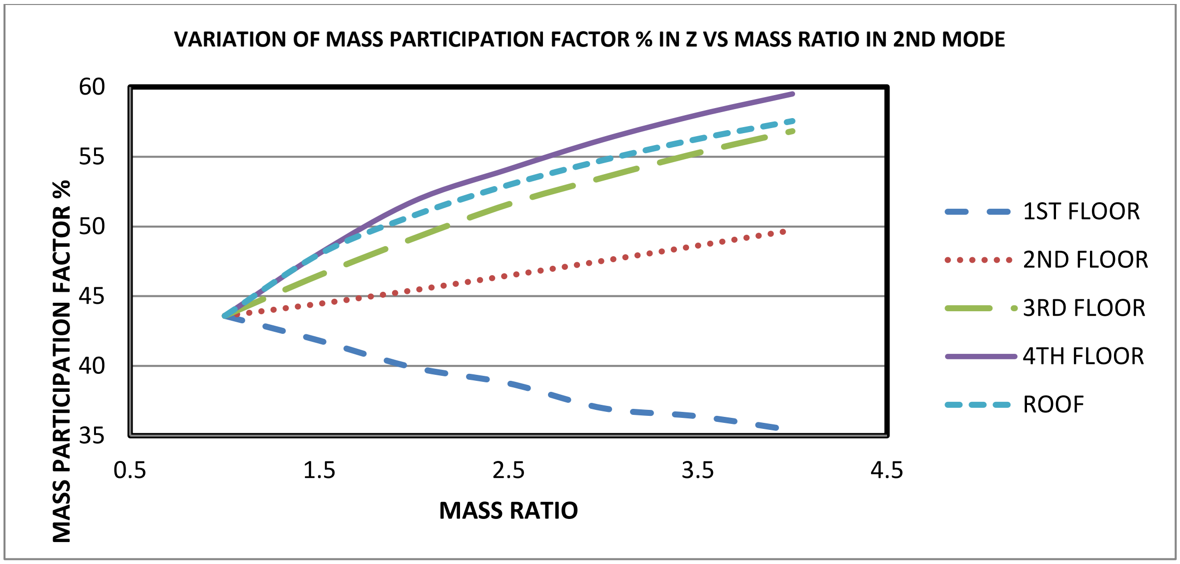

FIG 44 VARIATION OF MASS PARTICIPATION FACTOR % IN Z WITH MASS RATIO

Mass participation factor % in x is decreases from mode 1 onward to mode 21.This conclude that mode 1 is dominant for mass participation factor in x direction. With increase in weight, mass participation factor % in x for mode 1 decreases when changes done in 1st floor while it increases when changes done in other floor. Similar trend is observed for mass participation factor in z except mode 2 is dominant in this case. Variation from 1st mode to 2nd mode in mass participation factor in x is -78.79% while that of z direction is changes from 1.656 to 43.592.Participation of higher mode is dominant in y and z direction than in x direction.

The variation of mass participation factor % vs. mode follows following equation

TABLE 51

X	$Y = -0.008X^5 + 0.233X^4 - 3.311X^3 + 24.33X^2 - 87.16X + 120.4$
Y	$Y = 0.002X^5 - 0.057X^4 + 0.738X^3 - 4.440X^2 + 11.10X - 8.225$
Z	$Y = 0.013X^5 - 0.353X^4 + 4.635X^3 - 29.79X^2 + 80.58X - 46.02$

5.37 MODE SHAPE

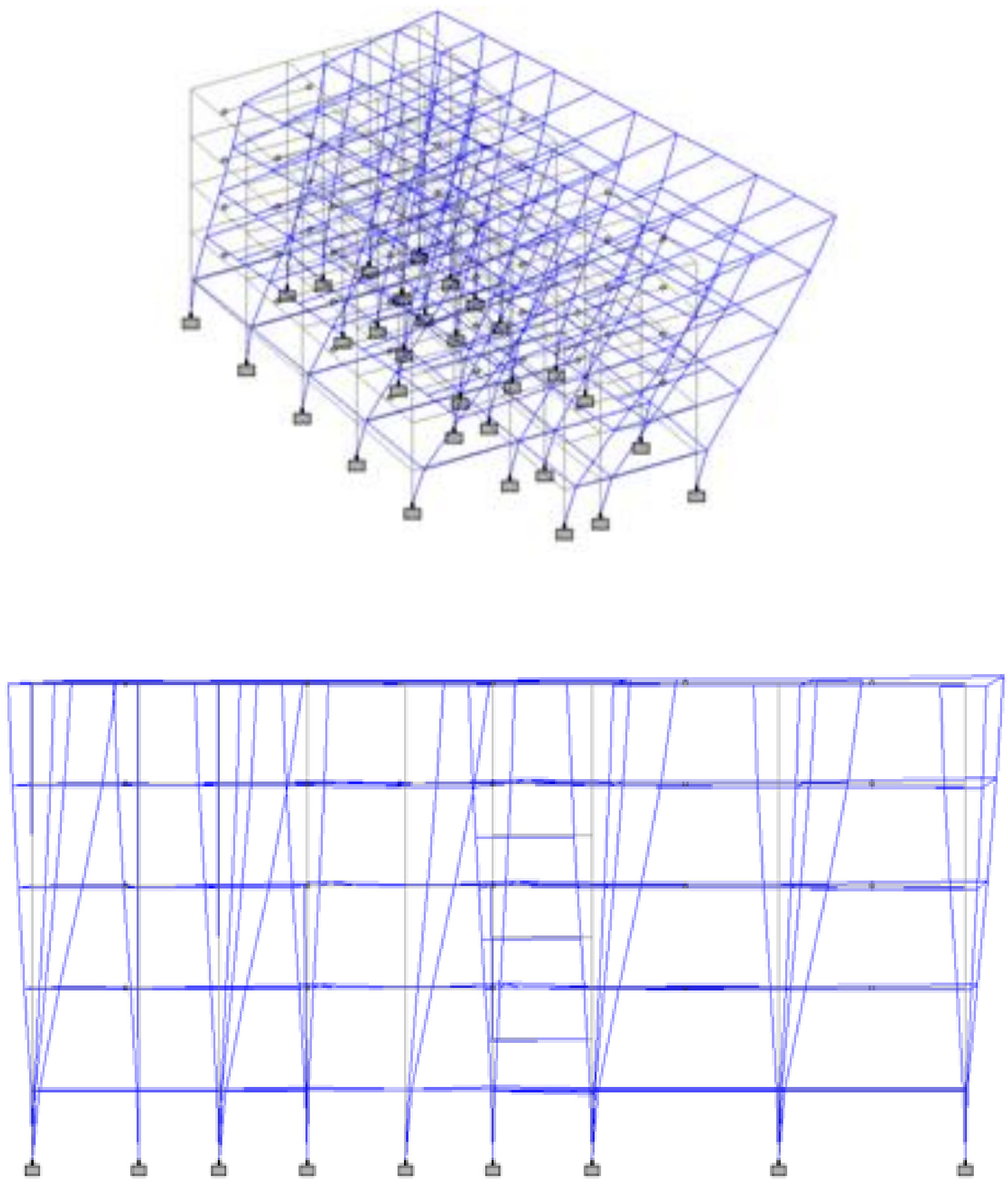

Fig 45, 46 MODE SHAPE

CHAPTER 6

CONCLUSIONS

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

1. Fundamental frequency of building decreases with increase in mass applied on the building. Value of frequency decreases as mass changes floor changes from lower to upper floor. Effect on frequency and time period is maximum when mass is increased on uppermost floor. Time period shows opposite trend to that of frequency. Spectral acceleration approximately shows same trend as frequency.
2. Base shear, SRSS, ABS, CQC and SHEAR 10PCT shear increases with mass. Maximum effect is observed when mass is changed in lower floor.
3. Roof drift show increasing trend when weight is increased on lower and top floor while show decreasing trend when weight is increased on middle floor. Maximum variation is observed in roof drift when irregularity is induced in top storey.
4. Storey shear increases with increases in weight applied in a storey. A large variation in storey shear is observed in a storey or below it when mass irregularity is induced in that particular storey. Maximum variation is observed when weight is increased on lower floor.
5. Storey drift increases with increases in weight applied in a storey. Maximum variation is observed in upper floor in every case while minimum variation is noted down in lower floor. Maximum effect is observed when weight is changes on top floor.
6. Mode 1 is dominant for mass participation factor in x direction and Mode 2 is dominant for mass participation factor in z direction. Participation of higher mode is dominant in y and z direction than in x direction.

SCOPE OF FURTHER STUDY

In the present study only one type of 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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18. **STAAD PRO V8i**

APPENDIX:

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

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 21-Apr-13

END JOB INFORMATION

INPUT WIDTH 79

UNIT METER KN

JOINT COORDINATES

1 0 0 0; 2 6.6 0 0; 3 9.05 0 0; 4 15.65 0 0; 5 0 0 6.6; 6 6.6 0 6.6;

7 9.05 0 6.6; 8 15.65 0 6.6; 9 9.05 0 9.7; 10 15.65 0 9.7; 11 0 0 13.2;

12 6.6 0 13.2; 13 9.05 0 16.3; 14 15.65 0 16.3; 15 9.05 0 19.8;

16 15.65 0 19.8; 17 0 0 19.8; 18 6.6 0 19.8; 19 9.05 0 26.4; 20 15.65 0 26.4;

21 0 0 26.4; 22 6.6 0 26.4; 23 9.05 0 33; 24 15.65 0 33; 25 6.6 0 33;

26 0 2.25 0; 27 6.6 2.25 0; 28 9.05 2.25 0; 29 15.65 2.25 0; 30 0 2.25 6.6;

31 6.6 2.25 6.6; 32 9.05 2.25 6.6; 33 15.65 2.25 6.6; 34 9.05 2.25 9.7;

35 12.65 2.25 9.7; 36 0 2.25 13.2; 37 6.6 2.25 13.2; 38 15.65 2.25 9.7;

39 9.05 2.25 16.3; 40 12.65 2.25 16.3; 41 15.65 2.25 16.3; 42 9.05 2.25 19.8;

43 15.65 2.25 19.8; 44 0 2.25 19.8; 45 6.6 2.25 19.8; 46 0 2.25 26.4;

47 6.6 2.25 26.4; 48 9.05 2.25 26.4; 49 15.65 2.25 26.4; 50 6.6 2.25 33;

51 9.05 2.25 33; 52 15.65 2.25 33; 53 0 5.55 0; 54 6.6 5.55 0; 55 9.05 5.55 0;

56 15.65 5.55 0; 57 0 5.55 6.6; 58 6.6 5.55 6.6; 59 9.05 5.55 6.6;

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80 0 5.55 3.3; 81 6.6 5.55 3.3; 82 0 5.55 9.7; 83 6.6 5.55 9.7; 84 0 5.55 16.3;
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UNIT MMS NEWTON

DEFINE MATERIAL START

ISOTROPIC MATERIAL1

E 25000

POISSON 0.17

DENSITY 2.4e-005

DAMP 7.90066e+033

END DEFINE MATERIAL

UNIT METER KN

CONSTANTS

MATERIAL MATERIAL1 MEMB 1 TO 85 87 TO 142 144 147 149 TO 172 174 TO 228 230 -

233 235 TO 243 245 TO 249 252 255 TO 258 260 TO 314 316 319 321 TO 370 372 -

373 TO 374 376 TO 401 403 406 408 TO 455 458 TO 504

MEMBER PROPERTY INDIAN

***COLUMN**

37 TO 61 98 TO 122 185 TO 209 271 TO 295 358 TO 370 372 TO 374 376 TO 382 -450 TO 455 461 462 485 TO 504 PRIS YD 0.45 ZD 0.6

414 TO 419 PRIS YD 0.6 ZD 0.45

***PLINTH BEAM**

1 3 TO 13 16 TO 23 26 TO 34 36 123 423 424 427 428 463 TO 466 - 468 PRIS YD 0.6 ZD 0.3

2 14 15 24 25 35 420 TO 422 425 426 429 467 PRIS YD 0.45 ZD 0.3

***BEAMS**

62 64 TO 70 72 TO 74 79 80 82 TO 85 87 TO 95 97 124 TO 142 144 147 149 151 -152 TO 157 159 TO 161 166 167 169 TO 172 174 TO 182 184 210 TO 228 230 233 -235 237 TO 243 245 TO 247 252 255 TO 258 260 TO 268 270 296 TO 314 316 319 -321 TO 327 329 TO 338 341 TO 355 357 383 TO 401 403 406 408 TO 413 469 470 -472 TO 474 476 TO 478 480 TO 482 484 PRIS IY 100 YD 0.6 ZD 0.3

63 71 75 TO 78 81 96 150 158 162 TO 165 168 183 236 248 249 269 328 339 340 -356 430 TO 449 458 TO 460 471 475 479 483 PRIS IY 100 YD 0.45 ZD 0.3

SUPPORTS

1 TO 25 227 228 239 TO 242 FIXED

MEMBER RELEASE

127 138 TO 142 213 224 TO 228 299 310 TO 314 326 386 397 TO 401 -

413 START FX FZ MX MY MZ

127 140 TO 142 213 226 TO 228 299 312 TO 314 326 386 399 TO 401 -

413 END FX FZ MX MY MZ

CUT OFF MODE SHAPE 21

DEFINE 1893 LOAD

ZONE 0.24 RF 5 I 1.5 SS 2 ST 1 DM 0.05

SELFWEIGHT

LOAD 1 EQX

JOINT LOAD

1 FX 7.29

2 FX 7.29

3 FX 7.29

4 FX 7.29

5 FX 7.29

6 FX 7.29

7 FX 7.29

8 FX 7.29

9 FX 7.29

10 FX 7.29

11 FX 7.29

12 FX 7.29

13 FX 7.29

14 FX 7.29

15 FX 7.29

16 FX 7.29

17 FX 7.29

18 FX 7.29

19 FX 7.29

20 FX 7.29

21 FX 7.29

22 FX 7.29

23 FX 7.29

24 FX 7.29

25 FX 7.29

26 FX 220.187

27 FX 272.646

28 FX 236.409

29 FX 115.404

30 FX 352.938

31 FX 349.267

32 FX 293.953

33 FX 126.557

34 FX 242.602

35 FX 243.454

36 FX 369.985

37 FX 279.239

38 FX 93.671

39 FX 196.047

40 FX 198.889

41 FX 78.968

42 FX 137.696

43 FX 253.012

44 FX 326.209

45 FX 333.074

46 FX 220.614

47 FX 362.96

48 FX 384.079

49 FX 329.414

50 FX 111.796

51 FX 238.803

52 FX 199.885

53 FX 155.291

54 FX 189.936

55 FX 244.505

56 FX 118.872

57 FX 201.572

58 FX 236.769

59 FX 301.155

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63 FX 229.023

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65 FX 97.112

66 FX 255.836

67 FX 188.688

68 FX 34.91

69 FX 280.8

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71 FX 186.845

72 FX 214.141

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75 FX 206.408

76 FX 179.647

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96 FX 152.751

97 FX 187.876

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207 FX 250.487

208 FX 177.433

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211 FZ 181.356

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213 FZ 218.958

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258 FZ 200.257

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260 FZ 156.177

261 FZ 144.844

262 FZ 113.516

SPECTRUM CQC 1893 TOR X 0.036 ACC SCALE 1 DAMP 0.05 LIN MIS

SOIL TYPE 2

LOAD 2 EQZ

SPECTRUM CQC 1893 TOR Z 0.036 ACC SCALE 1 DAMP 0.05

SOIL TYPE 2

LOAD 3 WALL

SELFWEIGHT Y -1

MEMBER LOAD

1 3 5 6 9 TO 12 15 TO 17 20 22 26 28 31 32 34 62 64 66 67 70 TO 73 76 TO 78 - 81 83 87 89 92 93 95 123 TO 125 128 130 132 135 137 144 147 149 151 153 154 -157 158 160 163 TO 165 168 170 174 176 179 180 182 210 211 214 216 218 221 -223 230 233 235 237 239 240 243 246 249 256 260 262 265 266 268 296 297 300 -302 304 307 309 316 319 321 TO 323 325 427 428 458 TO 460 UNI GY -14.3

2 4 7 8 13 14 19 23 24 29 30 33 36 63 65 68 69 74 75 80 84 85 90 91 94 97 -126 129 131 133 134 136 140 142 150 152 155 156 159 161 162 167 169 171 172 - 175 177 178 181 184 212 215 217 219 220 222 236 238 241 242 245 247 248 252 -255 257 258 261 263 264 267 270 298 301 303 305 306 308 324 423 -424 UNI GY -8.1

25 UNI GY -9.8

327 TO 329 332 335 337 340 343 346 347 349 352 353 355 TO 357 384 387 389 -391 394 396 403 410 412 UNI GY -5.8

LOAD 4 DL

FLOOR LOAD

****

*__TERRACE LVL__

YRANGE 2.0 3.0 FLOAD -4.75 XRANGE 0 15.7 ZRANGE 0 33.1

*__ADD TOILET__

YRANGE 2.0 3.0 FLOAD -14.75 XRANGE 9 15.7 ZRANGE 0 6.7

****

* FIRST FLOOR LVL

****

YRANGE 5.55 5.55 FLOAD -4.75 XRANGE 0 15.7 ZRANGE 0 33.1

*ADD TOILET

YRANGE 5.55 5.55 FLOAD -14.75 XRANGE 9 15.7 ZRANGE 0 6.7

****

* SECOND FLOOR LVL

****

YRANGE 8.85 8.85 FLOAD -4.75 XRANGE 0 15.7 ZRANGE 0 33.1

*ADD TOILET

YRANGE 8.85 8.85 FLOAD -14.75 XRANGE 9 15.7 ZRANGE 0 6.7

****

* THIRD FLOOR LVL

****

YRANGE 12.15 12.15 FLOAD -4.75 XRANGE 0 15.7 ZRANGE 0 33.1

*ADD TOILET

YRANGE 12.15 12.15 FLOAD -14.75 XRANGE 9 15.7 ZRANGE 0 6.7

****

* TERRACE LVL

****

YRANGE 15.45 15.45 FLOAD -8 XRANGE 0 15.7 ZRANGE 0 33.1

MEMBER LOAD

*STAIR

429 UNI GY -18.6

85 172 258 458 TO 460 UNI GY -24

LOAD 5 LL

FLOOR LOAD

****

*TERRACE LVL

YRANGE 2.0 3.0 FLOAD -3 XRANGE 0 15.7 ZRANGE 0 33.1

*ADD CORRIDOR

YRANGE 2.0 3.0 FLOAD -3 XRANGE 6.5 9.1 ZRANGE 0 33.1

YRANGE 2.0 3.0 FLOAD -3 XRANGE 9 12.7 ZRANGE 9.6 16.4

***ADD STORE**

YRANGE 2.0 3.0 FLOAD -3 XRANGE 9 15.7 ZRANGE 6.5 9.75

YRANGE 2.0 3.0 FLOAD -3 XRANGE 0 6.7 ZRANGE 23 26.5

YRANGE 2.0 3.0 FLOAD -3 XRANGE 9 15.7 ZRANGE 29.6 33.1

***DEDUCT TOILET**

YRANGE 2.0 3.0 FLOAD 3 XRANGE 9 15.7 ZRANGE 0 6.7

****

***   FIRST FLOOR LVL**

****

YRANGE 5.55 5.55 FLOAD -3 XRANGE 0 15.7 ZRANGE 0 33.1

***ADD CORRIDOR**

YRANGE 5.55 5.55 FLOAD -3 XRANGE 6.5 9.1 ZRANGE 0 33.1

YRANGE 5.55 5.55 FLOAD -3 XRANGE 9 12.7 ZRANGE 9.6 16.4

***ADD STORE**

YRANGE 5.55 5.55 FLOAD -3 XRANGE 9 15.7 ZRANGE 6.5 9.75

YRANGE 5.55 5.55 FLOAD -3 XRANGE 0 6.7 ZRANGE 23 26.5

YRANGE 5.55 5.55 FLOAD -3 XRANGE 9 15.7 ZRANGE 29.6 33.1

***DEDUCT TOILET**

YRANGE 5.55 5.55 FLOAD 3 XRANGE 9 15.7 ZRANGE 0 6.7

****

*   **SECOND FLOOR LVL**

****

YRANGE 8.85 8.85 FLOAD -3 XRANGE 0 15.7 ZRANGE 0 33.1

***ADD CORRIDOR**

YRANGE 8.85 8.85 FLOAD -3 XRANGE 6.5 9.1 ZRANGE 0 33.1

YRANGE 8.85 8.85 FLOAD -3 XRANGE 9 12.7 ZRANGE 9.6 16.4

***ADD STORE**

YRANGE 8.85 8.85 FLOAD -3 XRANGE 9 15.7 ZRANGE 6.5 9.75

***DEDUCT TOILET**

YRANGE 8.85 8.85 FLOAD 3 XRANGE 9 15.7 ZRANGE 0 6.7

****

* **THIRD FLOOR LVL**

****

YRANGE 12.15 12.15 FLOAD -3 XRANGE 0 15.7 ZRANGE 0 33.1

***ADD CORRIDOR**

YRANGE 12.15 12.15 FLOAD -3 XRANGE 6.5 9.1 ZRANGE 0 33.1

***ADD STORE**

YRANGE 12.15 12.15 FLOAD -3 XRANGE 9 15.7 ZRANGE 6.5 9.75

***DEDUCT TOILET**

YRANGE 12.15 12.15 FLOAD 3 XRANGE 9 15.7 ZRANGE 0 6.7

****

* **TERRACE LVL**

****

YRANGE 15.45 15.45 FLOAD -3 XRANGE 0 15.7 ZRANGE 0 33.1

MEMBER LOAD

***STAIR**

429 UNI GY -10

85 172 258 458 TO 460 UNI GY -13.2

LOAD COMB 6 (DL +EQ.LL)

3 1.0 4 1.0 5 0.5

LOAD COMB 7 1.5(DL + LL)100%

3 1.5 4 1.5 5 1.5

LOAD COMB 12 1.2(EQX + DL + 0.5LL)

1 1.2 3 1.2 4 1.2 5 0.6

LOAD COMB 13 1.2(-EQX + DL + 0.5LL)

1 -1.2 3 1.2 4 1.2 5 0.6

LOAD COMB 14 1.2(EQZ + DL + 0.5LL)

2 1.2 3 1.2 4 1.2 5 0.6

LOAD COMB 15 1.2(-EQZ + DL + 0.5LL)

2 -1.2 3 1.2 4 1.2 5 0.6

LOAD COMB 16 1.5(EQX + DL)

1 1.5 3 1.5 4 1.5

LOAD COMB 17 1.5(-EQX + DL)

1 -1.5 3 1.5 4 1.5

LOAD COMB 18 1.5(EQZ + DL)

2 1.5 3 1.5 4 1.5

LOAD COMB 19 1.5(-EQZ + DL)

2 -1.5 3 1.5 4 1.5

LOAD COMB 20 (1.5*EQX +0.9* DL)

1 1.5 3 0.9 4 0.9

LOAD COMB 21 (1.5*-EQX + 0.9*DL)

1 -1.5 3 0.9 4 0.9

LOAD COMB 22 (1.5*EQZ + 0.9*DL)

2 1.5 3 0.9 4 0.9

LOAD COMB 23 (1.5*-EQZ + 0.9*DL)

2 -1.5 3 0.9 4 0.9

LOAD COMB 24 (DL + LL)

3 1.0 4 1.0 5 0.7

LOAD COMB 31 (DL + LL)

3 1.0 4 1.0 5 1.0

LOAD COMB 32 (EQX + DL + 0.5LL)

1 1.0 3 1.0 4 1.0 5 0.5

LOAD COMB 33 (-EQX + DL + 0.5LL)

1 -1.0 3 1.0 4 1.0 5 0.5

LOAD COMB 34 (EQZ + DL + 0.5LL)

2 1.0 3 1.0 4 1.0 5 0.5

LOAD COMB 35 (-EQZ + DL + 0.5LL)

2 -1.0 3 1.0 4 1.0 5 0.5

LOAD COMB 36 (EQX + DL)

1 1.0 3 1.0 4 1.0

LOAD COMB 37 (-EQX + DL)

1 -1.0 3 1.0 4 1.0

LOAD COMB 38 (EQZ + DL)

2 1.0 3 1.0 4 1.0

LOAD COMB 39 (-EQZ + DL)

2 -1.0 3 1.0 4 1.0

LOAD COMB 40 (EQX +0.9* DL)

1 1.0 3 0.9 4 0.9

LOAD COMB 41 (-EQX + 0.9*DL)

1 -1.0 3 0.9 4 0.9

LOAD COMB 42 (EQZ + 0.9*DL)

2 1.0 3 0.9 4 0.9

LOAD COMB 43 (-EQZ + 0.9*DL)

2 -1.0 3 0.9 4 0.9

PERFORM ANALYSIS

LOAD LIST 24

PRINT SUPPORT REACTION ALL

LOAD LIST 32 TO 43

PRINT SUPPORT REACTION ALL

LOAD LIST 31 TO 43

PRINT JOINT DISPLACEMENTS LIST 184 TO 190 192 193 196 TO 224 226

LOAD LIST 7 12 TO 23

START CONCRETE DESIGN

CODE INDIAN

UNIT MMS NEWTON

FC 25 MEMB 1 TO 85 87 TO 142 144 147 149 TO 172 174 TO 228 230 233 -
235 TO 243 245 TO 249 252 255 TO 258 260 TO 314 316 319 321 TO 370 -
372 TO 374 376 TO 401 403 406 408 TO 455 458 TO 463

FYMAIN 415 MEMB 1 TO 85 87 TO 142 144 147 149 TO 172 174 TO 228 230 233 235 -236 TO 243 245 TO 249 252 255 TO 258 260 TO 314 316 319 321 TO 370 -372 TO 374 376 TO 401 403 406 408 TO 455 458 TO 463

FYSEC 415 MEMB 1 TO 85 87 TO 142 144 147 149 TO 172 174 TO 228 230 233 235 -236 TO 243 245 TO 249 252 255 TO 258 260 TO 314 316 319 321 TO 370 -372 TO 374 376 TO 401 403 406 408 TO 455 458 TO 463

MINMAIN 16 MEMB 1 TO 85 87 TO 142 144 147 149 TO 172 174 TO 228 230 233 235 -236 TO 243 245 TO 249 252 255 TO 258 260 TO 314 316 319 321 TO 370 -372 TO 374 376 TO 401 403 406 408 TO 455 458 TO 463

MAXMAIN 32 MEMB 1 TO 85 87 TO 142 144 147 149 TO 172 174 TO 228 230 233 235 -236 TO 243 245 TO 249 252 255 TO 258 260 TO 314 316 319 321 TO 370 -372 TO 374 376 TO 401 403 406 408 TO 455 458 TO 463

RATIO 6 MEMB 11 TO 85 87 TO 142 144 147 149 TO 172 174 TO 228 230 233 235 -236 TO 243 245 TO 249 252 255 TO 258 260 TO 314 316 319 321 TO 370 -372 TO 374 376 TO 401 403 406 408 TO 455 458 TO 463

TRACK 1 MEMB 1 TO 85 87 TO 142 144 147 149 TO 172 174 TO 228 230 233 -235 TO 243 245 TO 249 252 255 TO 258 260 TO 314 316 319 321 TO 370 -372 TO 374 376 TO 401 403 406 408 TO 455 458 TO 463

RFACE 2 MEMB 414 TO 419

RFACE 3 MEMB 37 TO 61 98 TO 122 185 TO 209 271 TO 295 358 TO 370 372 TO 374 -376 TO 382 450 TO 455 461 462 485 TO 504

DESIGN COLUMN 37 TO 61 98 TO 122 185 TO 209 271 TO 295 358 TO 370 372 TO 374 -376 TO 382 414 TO 419 450 TO 455 461 462 485 TO 504

DESIGN BEAM 1 TO 36 62 TO 85 87 TO 97 123 TO 142 144 147 149 TO 172 -174 TO 184 210 TO 228 230 233 235 TO 243 245 TO 249 252 255 TO 258 -260 TO 270 296 TO 314 316 319 321 TO 357 383 TO 401 403 406 408 TO 413 420 -421 TO 449 458 TO 460 463

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