**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**
2. Torsion Irregularity
3. Re-entrant Corners
4. Diaphragm Discontinuity
5. Out-of-Plane Offsets
6. Non-parallel Systems
7. **VERTICAL IRREGULARITY**
8. Stiffness Irregularity —Soft Storey
9. Mass Irregularity
10. Vertical Geometric Irregularity
11. In-Plane Discontinuity in Vertical Elements Resisting Lateral Force
12. 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.

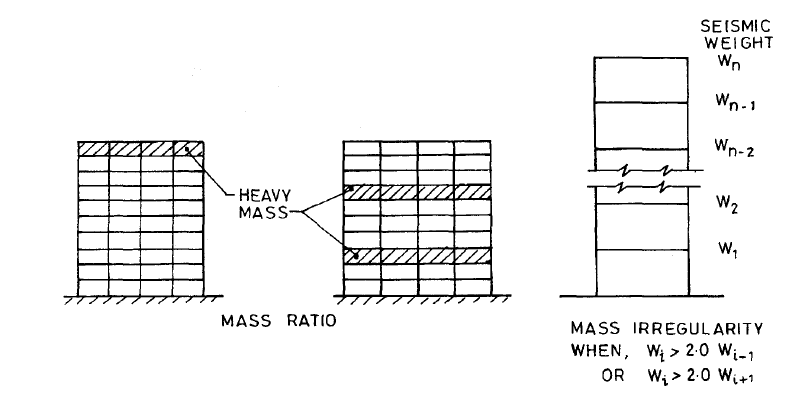
Because of the complex behavior of such structures under earthquake excitations, it is not surprising that, in spite of the large research efforts in plan irregular building structures dating back to the 1970s, even in recent years, many papers have been devoted to a better understanding of seismic response. 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]**

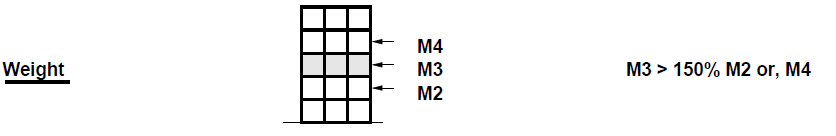
Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storey. The irregularity need not be considered in case of roofs.



**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**

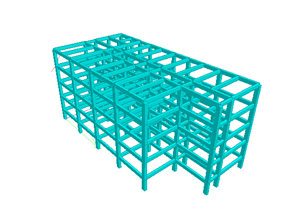
**PROGRAMME OF STUDY**

**4.1. INTRODUCTION**

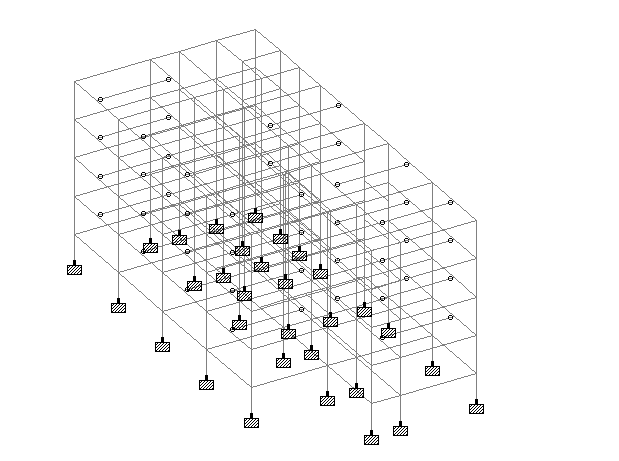
Major portion of urban building is irregular. To design irregular building in seismically active area is a challenging job for structural engineer. Structural engineer should be well versed with effect of different irregularities on performance of different types and configuration of building.

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.

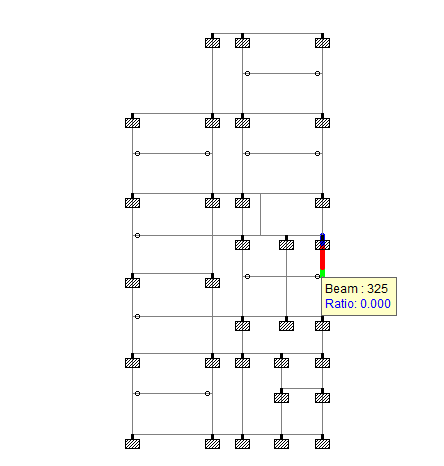
A four storey building is selected as shown in figure below:



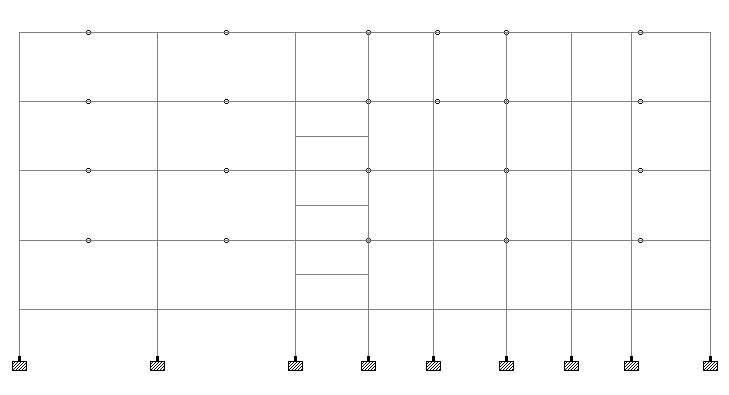
**FIG 4 3-D VIEW OF BUILDING (COLUMN-BEAM VIEW)**



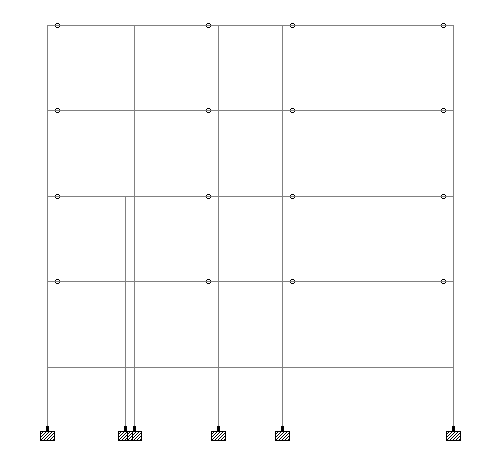
**FIG 5 3-D VIEW OF BUILDING**



**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 ( )**: 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 ()

Step-4: Obtain the data pertaining to type of soil conditions of foundation of the building

Step-5: Using Ta 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,, R and I compute design horizontal acceleration coefficient ()

Step-9: Using and W compute design seismic base shear (), from =W as per code

**Dynamic Analysis**

1. Dynamic analysis is classified into two types,
2. Response spectrum method
3. Time history method
4. 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:
5. 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.
6. 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.
7. 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.
8. Response Spectrum Method: Response spectrum method of analysis shall be performed using the design spectrum
9. 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 of mode k as per code

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

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

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

Step-9: Compute storey shear forces due to all modes considered, 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 otherlevel 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:** Itis 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.

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.

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.

**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.

1. Each storey is subjected to live load such that value of X becomes 1.
2. Then resulting building model is analyzed and value of output parameter is noted down.
3. 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 = 0.001 - 0.061X + 1.145 |
| 4 | Y = 0.012 - 0.150X + 1.222 |
| ROOF | Y = 0.020 - 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 = -0.009 + 0.181 X + 0.751 |
| 2 | Y = -0.005 + 0.124 X + 0.801 |
| 3 | Y = 0.002 + 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 = 0.003 - 0.095X + 1.568 |
| 4 | Y = 0.003 - 0.095X + 1.568 |
| ROOF | Y = 0.017 - 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 = 0.273 + 50.23X + 1217 |
| 2 | Y = 148.7X + 1118 |
| 3 | Y = -7.501 + 154.6X + 1120 |
| 4 | Y = 63.37X + 1204 |
| ROOF | Y=5.904 + 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 = 10.86 + 88.40X + 1271. |
| 2 | Y = -1.840 + 174.0X + 1203 |
| 3 | Y = -3.306 + 130.0X + 1249 |
| 4 | Y = 0.859 + 60.64X + 1315 |
| ROOF | Y = 5.951 + 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 = 12.00 + 87.13X + 1307 |
| 2 | Y = -2.327 + 182.6X + 1230. |
| 3 | Y = -5.933 + 128.1X + 1294 |
| 4 | Y = 8.862 + 8.177X + 1400 |
| ROOF | Y = 1.676 + 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 = -22.62 + 572.0X + 1932 |
| 2 | Y = -7.391 + 316.1X + 2179 |
| 3 | Y = 40.00 - 47.07X + 2521 |
| 4 | Y = -0.909 + 101.3X + 2389 |
| ROOF | Y = -0.909 + 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 = -0.025 + 0.036X + 2.873 |
| 4 | Y = 0.016 - 0.101X + 2.978 |
| ROOF | Y = -0.127 + 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+ 32085X + 20441 |
| MAX FY | Y = 55768X + 2E+06 |
| MAX FZ | Y = -355.5 + 7237X + 13431 |
| MAX MX | Y = 1.514 + 9.843X + 203.9 |
| MAX MY | Y = -0.099 + 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**

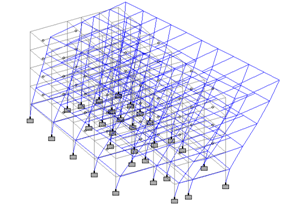
Mass participation factor %in xis decreases from mode 1 onward to mode 21.This conclude that mode 1 is dominant for mass participation factor in x direction. With increase in weight, mass participation factor % in x for mode 1 decreases when changes done in 1st floor while it increases when changes done 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 = - 0.008X5 + 0.233X4 - 3.311X3 + 24.33X2 - 87.16X + 120.4 |
| Y | Y = 0.002X5 - 0.057X4 + 0.738X3 - 4.440X2 + 11.10X - 8.225 |
| Z | Y = 0.013X5 - 0.353X4 + 4.635X3 - 29.79X2 + 80.58X - 46.02 |

**5.37 MODE SHAPE**



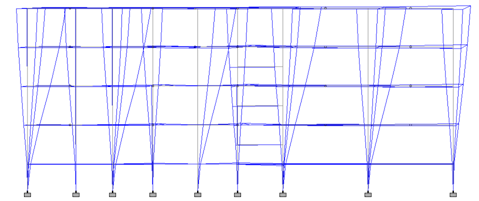


Fig 45, 46 MODE SHAPE

**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.

**REFERNCES**

1. **IS 1893 ( PART 1) : 2002**
2. http://framework.latimes.com/2011/02/09/sylmar-earthquake
3. **Valmundsson, E.V. and Nau, J.M.** (1997). “Seismic Response of Building Frames with Vertical Structural Irregularities”, *Journal of Structural Engineering*, *ASCE*, Vol. 123, No. 1, pp. 30-41
4. **Al-Ali, A.A.K. and Krawinkler, H.** (1998). “Effects of Vertical Irregularities on Seismic Behavior of Building Structures”, Report No. 130, *The John A. Blume Earthquake Engineering Center*, Department of Civil and Environmental Engineering, Stanford University, Stanford, U.S.A.
5. **Fragiadakis Michalis, Vamvatsikos Dimitrios and Papadrakakis Manolis**. (2006) Evaluation of the Influence of Vertical Irregularities on the Seismic Performance of a 9-storey steel frame.
6. **Das, S. and Nau, J.M.** (2003). “Seismic Design Aspects of Vertically Irregular Reinforced Concrete Buildings”, *Earthquake Spectra*, Vol. 19, No. 3, pp. 455-477
7. **Saleh Malekpour, Farhad Dashti and Amir Kiani** “Assessment of Equivalent Static Earthquake Analysis Procedure for Structures with Mass Irregularity in Height *6th National Congress on Civil Engineering*”, April 26-27, 2011, Semnan University, Semnan, Iran pp 1-10.
8. **Mohammad Hossein Cheraghi AFARANI, Ahmad NICKNAM** “Seismic Response of Mass Irregular Steel Moment Resisting Frames (SMRF) According to Performance Levels from IDA Approach”, *Gazi University Journal of Science GU J Sci* 25(3):751-760 (2012) pp 751-760.
9. **Mohammad Ali Hadianfard and Mahdieh Gadami**, “SEISMIC DEMAND OF STEEL STRUCTURES WITH MASS IRREGULARITY”, *Journal of Engineering and Technology* 135-154.
10. **Vinod K. Sadashiva, Gregory A. MacRae & Bruce L. Deam** “DETERMINATION OF STRUCTURAL IRREGULARITY LIMITS – MASS IRREGULARITY” *BULLETIN OF THE NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING*, Vol. 42, No. 4, December 2009 pp.288-301.
11. **Poncet, L. Trembly R** (2004),“INFLUENCE OF MASS IRREGULARITY ON THE SEISMIC DESIGN AND PERFORMANCE OF MULTI-STOREY BRACED STEEL FRAMES” *13th world conference on earthquake engineering, Vancover, B.C., Canada*, paper No. 2896.
12. **UNIVERSAL BUILDING CODE** (SECTION 1629)
13. **NEHRP CODE** (BSSC, 2003)
14. **IRANIAN SEISMIC CODE** (Standard 2800):
15. **INTERNATIONAL BUILDING CODE (IBC).** 2003. International Code Council.
16. **K.V.Vijayendra**, “Earthquake resistant design of structure (Subject code: 06CV834)” Department of Civil Engineering, BIT, Bangalore on VTU *learning*
17. **IS 875:1997**
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;

60 15.65 5.55 6.6; 61 9.05 5.55 9.7; 62 12.65 5.55 9.7; 63 0 5.55 13.2;

64 6.6 5.55 13.2; 65 15.65 5.55 9.7; 66 9.05 5.55 16.3; 67 12.65 5.55 16.3;

68 15.65 5.55 16.3; 69 9.05 5.55 19.8; 70 15.65 5.55 19.8; 71 0 5.55 19.8;

72 6.6 5.55 19.8; 73 0 5.55 26.4; 74 6.6 5.55 26.4; 75 9.05 5.55 26.4;

76 15.65 5.55 26.4; 77 6.6 5.55 33; 78 9.05 5.55 33; 79 15.65 5.55 33;

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;

85 6.6 5.55 16.3; 86 0 5.55 23.1; 87 6.6 5.55 23.1; 88 9.05 5.55 23.1;

89 15.65 5.55 23.1; 90 9.05 5.55 29.7; 91 15.65 5.55 29.7; 96 0 8.85 0;

97 6.6 8.85 0; 98 9.05 8.85 0; 99 15.65 8.85 0; 100 0 8.85 6.6;

101 6.6 8.85 6.6; 102 9.05 8.85 6.6; 104 0 8.85 3.3; 105 6.6 8.85 3.3;

108 9.05 8.85 9.7; 109 12.65 8.85 9.7; 110 0 8.85 13.2; 111 6.6 8.85 13.2;

112 0 8.85 9.7; 113 6.6 8.85 9.7; 114 15.65 8.85 6.6; 115 15.65 8.85 9.7;

116 9.05 8.85 16.3; 117 12.65 8.85 16.3; 118 15.65 8.85 16.3; 119 0 8.85 19.8;

120 6.6 8.85 19.8; 121 0 8.85 16.3; 122 6.6 8.85 16.3; 123 9.05 8.85 19.8;

124 15.65 8.85 19.8; 125 0 8.85 26.4; 126 6.6 8.85 26.4; 127 9.05 8.85 26.4;

128 15.65 8.85 26.4; 129 0 8.85 23.1; 130 6.6 8.85 23.1; 131 9.05 8.85 23.1;

132 15.65 8.85 23.1; 133 6.6 8.85 33; 134 9.05 8.85 29.7; 135 15.65 8.85 29.7;

136 9.05 8.85 33; 137 15.65 8.85 33; 139 0 12.15 0; 140 6.6 12.15 0;

141 9.05 12.15 0; 142 15.65 12.15 0; 143 0 12.15 6.6; 144 6.6 12.15 6.6;

145 9.05 12.15 6.6; 147 0 12.15 3.3; 148 6.6 12.15 3.3; 151 9.05 12.15 9.7;

153 0 12.15 13.2; 154 6.6 12.15 13.2; 155 0 12.15 9.7; 156 6.6 12.15 9.7;

157 15.65 12.15 6.6; 158 15.65 12.15 9.7; 159 9.05 12.15 16.3;

161 15.65 12.15 16.3; 162 0 12.15 19.8; 163 6.6 12.15 19.8; 164 0 12.15 16.3;

165 6.6 12.15 16.3; 166 9.05 12.15 19.8; 167 15.65 12.15 19.8;

168 0 12.15 26.4; 169 6.6 12.15 26.4; 170 9.05 12.15 26.4;

171 15.65 12.15 26.4; 172 0 12.15 23.1; 173 6.6 12.15 23.1;

174 9.05 12.15 23.1; 175 15.65 12.15 23.1; 176 6.6 12.15 33;

177 9.05 12.15 29.7; 178 15.65 12.15 29.7; 179 9.05 12.15 33;

180 15.65 12.15 33; 182 9.05 12.15 13; 183 15.65 12.15 13; 184 0 15.45 0;

185 6.6 15.45 0; 186 9.05 15.45 0; 187 15.65 15.45 0; 188 0 15.45 6.6;

189 6.6 15.45 6.6; 190 9.05 15.45 6.6; 192 0 15.45 3.3; 193 6.6 15.45 3.3;

196 0 15.45 13.2; 197 6.6 15.45 13.2; 198 0 15.45 9.7; 199 6.6 15.45 9.7;

200 9.05 15.45 9.7; 201 15.65 15.45 6.6; 202 15.65 15.45 9.7;

203 9.05 15.45 13; 204 0 15.45 19.8; 205 6.6 15.45 19.8; 206 0 15.45 16.3;

207 6.6 15.45 16.3; 208 9.05 15.45 16.3; 209 9.05 15.45 19.8;

210 15.65 15.45 16.3; 211 15.65 15.45 19.8; 212 0 15.45 26.4;

213 6.6 15.45 26.4; 214 9.05 15.45 26.4; 215 15.65 15.45 26.4;

216 0 15.45 23.1; 217 6.6 15.45 23.1; 218 9.05 15.45 23.1;

219 15.65 15.45 23.1; 220 6.6 15.45 33; 221 9.05 15.45 29.7;

222 15.65 15.45 29.7; 223 9.05 15.45 33; 224 15.65 15.45 33;

226 15.65 15.45 13; 227 12.65 0 9.7; 228 12.65 0 16.3; 229 6.6 2.25 9.7;

230 6.6 2.25 16.3; 231 10.55 2.25 16.3; 232 10.55 2.25 19.8;

233 15.65 3.9 16.3; 234 15.65 3.9 19.8; 235 15.65 7.2 19.8; 236 15.65 7.2 16.3;

237 15.65 10.5 16.3; 238 15.65 10.5 19.8; 239 12.305 0 0; 240 12.305 0 3.74;

241 12.305 0 6.6; 242 15.65 0 3.74; 243 12.305 2.25 0; 244 12.305 2.25 3.74;

245 12.305 2.25 6.6; 246 15.65 2.25 3.74; 247 12.305 5.55 0;

248 12.305 5.55 3.74; 249 12.305 5.55 6.6; 250 15.65 5.55 3.74;

251 12.305 8.85 0; 252 12.305 8.85 3.74; 253 12.305 8.85 6.6;

254 15.65 8.85 3.74; 255 12.305 12.15 0; 256 12.305 12.15 3.74;

257 12.305 12.15 6.6; 258 15.65 12.15 3.74; 259 12.305 15.45 0;

260 12.305 15.45 3.74; 261 12.305 15.45 6.6; 262 15.65 15.45 3.74;

**MEMBER INCIDENCES**

1 26 27; 2 27 28; 3 28 243; 4 30 31; 5 32 245; 6 26 30; 7 27 31; 8 28 32;

9 29 246; 10 34 35; 11 36 37; 12 30 36; 13 31 229; 14 32 34; 15 33 38;

16 35 38; 17 39 231; 18 34 39; 19 35 40; 20 40 41; 21 44 45; 22 36 44;

23 37 230; 24 39 42; 25 41 43; 26 46 47; 27 48 49; 28 44 46; 29 45 47;

30 42 48; 31 43 49; 32 47 50; 33 48 51; 34 49 52; 35 50 51; 36 51 52; 37 1 26;

38 2 27; 39 3 28; 40 4 29; 41 5 30; 42 6 31; 43 7 32; 44 8 33; 45 9 34;

46 10 38; 47 11 36; 48 12 37; 49 13 39; 50 14 41; 51 17 44; 52 18 45; 53 15 42;

54 16 43; 55 21 46; 56 22 47; 57 19 48; 58 20 49; 59 25 50; 60 23 51; 61 24 52;

62 53 54; 63 54 55; 64 55 247; 65 57 58; 66 59 249; 67 53 80; 68 54 81;

69 55 59; 70 56 250; 71 61 62; 72 63 64; 73 57 82; 74 58 83; 75 59 61;

76 60 65; 77 62 65; 78 66 67; 79 61 66; 80 62 67; 81 67 68; 82 71 72; 83 63 84;

84 64 85; 85 66 69; 87 73 74; 88 75 76; 89 71 86; 90 72 87; 91 69 88; 92 70 89;

93 74 77; 94 75 90; 95 76 91; 96 77 78; 97 78 79; 98 26 53; 99 27 54;

100 28 55; 101 29 56; 102 30 57; 103 31 58; 104 32 59; 105 33 60; 106 34 61;

107 38 65; 108 36 63; 109 37 64; 110 39 66; 111 41 233; 112 44 71; 113 45 72;

114 42 69; 115 43 234; 116 46 73; 117 47 74; 118 48 75; 119 49 76; 120 50 77;

121 51 78; 122 52 79; 123 42 232; 124 69 70; 125 80 57; 126 81 58; 127 80 81;

128 82 63; 129 83 64; 130 84 71; 131 85 72; 132 86 73; 133 87 74; 134 88 75;

135 89 76; 136 90 78; 137 91 79; 138 82 83; 139 84 85; 140 86 87; 141 88 89;

142 90 91; 144 250 60; 147 249 60; 149 96 97; 150 97 98; 151 98 251;

152 100 101; 153 102 253; 154 96 104; 155 97 105; 156 98 102; 157 99 254;

158 108 109; 159 110 111; 160 100 112; 161 101 113; 162 102 108; 163 114 115;

164 109 115; 165 116 117; 166 108 116; 167 109 117; 168 117 118; 169 119 120;

170 110 121; 171 111 122; 172 116 123; 174 125 126; 175 127 128; 176 119 129;

177 120 130; 178 123 131; 179 124 132; 180 126 133; 181 127 134; 182 128 135;

183 133 136; 184 136 137; 185 53 96; 186 54 97; 187 55 98; 188 56 99;

189 57 100; 190 58 101; 191 59 102; 192 60 114; 193 61 108; 194 65 115;

195 63 110; 196 64 111; 197 66 116; 198 68 236; 199 71 119; 200 72 120;

201 69 123; 202 70 235; 203 73 125; 204 74 126; 205 75 127; 206 76 128;

207 77 133; 208 78 136; 209 79 137; 210 123 124; 211 104 100; 212 105 101;

213 104 105; 214 112 110; 215 113 111; 216 121 119; 217 122 120; 218 129 125;

219 130 126; 220 131 127; 221 132 128; 222 134 136; 223 135 137; 224 112 113;

225 121 122; 226 129 130; 227 131 132; 228 134 135; 230 254 114; 233 253 114;

235 139 140; 236 140 141; 237 141 255; 238 143 144; 239 145 257; 240 139 147;

241 140 148; 242 141 145; 243 142 258; 245 153 154; 246 143 155; 247 144 156;

248 145 151; 249 157 158; 252 151 182; 255 162 163; 256 153 164; 257 154 165;

258 159 166; 260 168 169; 261 170 171; 262 162 172; 263 163 173; 264 166 174;

265 167 175; 266 169 176; 267 170 177; 268 171 178; 269 176 179; 270 179 180;

271 96 139; 272 97 140; 273 98 141; 274 99 142; 275 100 143; 276 101 144;

277 102 145; 278 114 157; 279 108 151; 280 115 158; 281 110 153; 282 111 154;

283 116 159; 284 118 237; 285 119 162; 286 120 163; 287 123 166; 288 124 238;

289 125 168; 290 126 169; 291 127 170; 292 128 171; 293 133 176; 294 136 179;

295 137 180; 296 166 167; 297 147 143; 298 148 144; 299 147 148; 300 155 153;

301 156 154; 302 164 162; 303 165 163; 304 172 168; 305 173 169; 306 174 170;

307 175 171; 308 177 179; 309 178 180; 310 155 156; 311 164 165; 312 172 173;

313 174 175; 314 177 178; 316 258 157; 319 257 157; 321 151 158; 322 159 161;

323 158 183; 324 182 159; 325 183 161; 326 182 183; 327 184 185; 328 185 186;

329 186 259; 330 188 189; 331 190 261; 332 184 192; 333 185 193; 334 186 190;

335 187 262; 336 196 197; 337 188 198; 338 189 199; 339 190 200; 340 201 202;

341 200 203; 342 204 205; 343 196 206; 344 197 207; 345 208 209; 346 210 211;

347 212 213; 348 214 215; 349 204 216; 350 205 217; 351 209 218; 352 211 219;

353 213 220; 354 214 221; 355 215 222; 356 220 223; 357 223 224; 358 139 184;

359 140 185; 360 141 186; 361 142 187; 362 143 188; 363 144 189; 364 145 190;

365 157 201; 366 151 200; 367 158 202; 368 153 196; 369 154 197; 370 159 208;

372 162 204; 373 163 205; 374 166 209; 376 168 212; 377 169 213; 378 170 214;

379 171 215; 380 176 220; 381 179 223; 382 180 224; 383 209 211; 384 192 188;

385 193 189; 386 192 193; 387 198 196; 388 199 197; 389 206 204; 390 207 205;

391 216 212; 392 217 213; 393 218 214; 394 219 215; 395 221 223; 396 222 224;

397 198 199; 398 206 207; 399 216 217; 400 218 219; 401 221 222; 403 262 201;

406 261 201; 408 200 202; 409 208 210; 410 202 226; 411 203 208; 412 226 210;

413 203 226; 414 227 35; 415 35 62; 416 62 109; 417 228 40; 418 40 67;

419 67 117; 420 31 32; 421 45 42; 422 47 48; 423 229 37; 424 230 45;

425 229 34; 426 230 39; 427 231 40; 428 232 43; 429 231 232; 430 58 59;

431 101 102; 432 144 145; 433 189 190; 434 83 61; 435 113 108; 436 156 151;

437 199 200; 438 72 69; 439 120 123; 440 163 166; 441 205 209; 442 74 75;

443 126 127; 444 169 170; 445 213 214; 446 85 66; 447 122 116; 448 165 159;

449 207 208; 450 233 68; 451 234 70; 452 235 124; 453 236 118; 454 237 161;

455 238 167; 458 233 234; 459 236 235; 460 237 238; 461 161 210; 462 167 211;

463 243 29; 464 246 33; 465 245 33; 466 243 244; 467 244 246; 468 244 245;

469 247 56; 470 247 248; 471 248 250; 472 248 249; 473 251 99; 474 251 252;

475 252 254; 476 252 253; 477 255 142; 478 255 256; 479 256 258; 480 256 257;

481 259 187; 482 259 260; 483 260 262; 484 260 261; 485 239 243; 486 243 247;

487 247 251; 488 251 255; 489 255 259; 490 240 244; 491 244 248; 492 248 252;

493 252 256; 494 256 260; 495 241 245; 496 245 249; 497 249 253; 498 253 257;

499 257 261; 500 242 246; 501 246 250; 502 250 254; 503 254 258; 504 258 262;

**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

60 FX 175.18

61 FX 202.665

62 FX 243.027

63 FX 229.023

64 FX 249.606

65 FX 97.112

66 FX 255.836

67 FX 188.688

68 FX 34.91

69 FX 280.8

70 FX 142.003

71 FX 186.845

72 FX 214.141

73 FX 172.02

74 FX 305.407

75 FX 206.408

76 FX 179.647

77 FX 120.221

78 FX 178.379

79 FX 151.525

80 FX 159.922

81 FX 180.604

82 FX 146.778

83 FX 241.746

84 FX 145.938

85 FX 241.308

86 FX 202.448

87 FX 214.892

88 FX 178.075

89 FX 163.936

90 FX 225.228

91 FX 203.131

96 FX 152.751

97 FX 187.876

98 FX 243.372

99 FX 118.827

100 FX 200.466

101 FX 237.682

102 FX 298.979

104 FX 162.951

105 FX 186.159

108 FX 203.966

109 FX 228.178

110 FX 208.359

111 FX 230.553

112 FX 146.473

113 FX 241.898

114 FX 175.345

115 FX 98.809

116 FX 255.6

117 FX 177.331

118 FX 34.178

119 FX 212.736

120 FX 248.131

121 FX 145.764

122 FX 241.276

123 FX 272.383

124 FX 141.745

125 FX 153.349

126 FX 280.643

127 FX 239.527

128 FX 205.754

129 FX 162.093

130 FX 175.55

131 FX 180.835

132 FX 163.733

133 FX 121.132

134 FX 185.127

135 FX 162.572

136 FX 157.753

137 FX 132.653

139 FX 153.822

140 FX 186.866

141 FX 245.051

142 FX 118.8

143 FX 201.419

144 FX 235.098

145 FX 306.78

147 FX 162.154

148 FX 184.767

151 FX 231.431

153 FX 208.482

154 FX 229.493

155 FX 146.962

156 FX 230.098

157 FX 173.533

158 FX 236.428

159 FX 249.01

161 FX 148.556

162 FX 213.564

163 FX 246.861

164 FX 145.963

165 FX 235.852

166 FX 282.809

167 FX 147.317

168 FX 154.027

169 FX 282.036

170 FX 237.539

171 FX 206.697

172 FX 161.456

173 FX 175.309

174 FX 178.999

175 FX 163.493

176 FX 122.606

177 FX 184.175

178 FX 161.914

179 FX 156.807

180 FX 133.677

182 FX 176.964

183 FX 163.82

184 FX 115.836

185 FX 157.633

186 FX 137.288

187 FX 66.148

188 FX 168.337

189 FX 222.518

190 FX 175.381

192 FX 171.002

193 FX 196.994

196 FX 178.839

197 FX 201.811

198 FX 150.363

199 FX 254.797

200 FX 153.792

201 FX 94.701

202 FX 171.954

203 FX 194.295

204 FX 181.595

205 FX 219.397

206 FX 149.526

207 FX 250.487

208 FX 177.433

209 FX 214.969

210 FX 182.576

211 FX 181.356

212 FX 116.946

213 FX 218.958

214 FX 216.817

215 FX 175.017

216 FX 169.74

217 FX 183.067

218 FX 191.97

219 FX 166.297

220 FX 82.127

221 FX 196.039

222 FX 170.419

223 FX 159.795

224 FX 115.77

226 FX 166.669

227 FX 7.29

228 FX 7.29

229 FX 133.457

230 FX 136.832

231 FX 136.063

232 FX 273.146

233 FX 107.258

234 FX 105.716

235 FX 106.295

236 FX 106.679

237 FX 106.57

238 FX 106.404

239 FX 7.29

240 FX 7.29

241 FX 7.29

242 FX 7.29

243 FX 190.653

244 FX 254.359

245 FX 213.068

246 FX 175.922

247 FX 193.222

248 FX 256.407

249 FX 241.84

250 FX 200.034

251 FX 193.422

252 FX 256.701

253 FX 241.471

254 FX 199.964

255 FX 193.28

256 FX 256.505

257 FX 242.017

258 FX 200.257

259 FX 115.277

260 FX 156.177

261 FX 144.844

262 FX 113.516

1 FY 7.29

2 FY 7.29

3 FY 7.29

4 FY 7.29

5 FY 7.29

6 FY 7.29

7 FY 7.29

8 FY 7.29

9 FY 7.29

10 FY 7.29

11 FY 7.29

12 FY 7.29

13 FY 7.29

14 FY 7.29

15 FY 7.29

16 FY 7.29

17 FY 7.29

18 FY 7.29

19 FY 7.29

20 FY 7.29

21 FY 7.29

22 FY 7.29

23 FY 7.29

24 FY 7.29

25 FY 7.29

26 FY 220.187

27 FY 272.646

28 FY 236.409

29 FY 115.404

30 FY 352.938

31 FY 349.267

32 FY 293.953

33 FY 126.557

34 FY 242.602

35 FY 243.454

36 FY 369.985

37 FY 279.239

38 FY 93.671

39 FY 196.047

40 FY 198.889

41 FY 78.968

42 FY 137.696

43 FY 253.012

44 FY 326.209

45 FY 333.074

46 FY 220.614

47 FY 362.96

48 FY 384.079

49 FY 329.414

50 FY 111.796

51 FY 238.803

52 FY 199.885

53 FY 155.291

54 FY 189.936

55 FY 244.505

56 FY 118.872

57 FY 201.572

58 FY 236.769

59 FY 301.155

60 FY 175.18

61 FY 202.665

62 FY 243.027

63 FY 229.023

64 FY 249.606

65 FY 97.112

66 FY 255.836

67 FY 188.688

68 FY 34.91

69 FY 280.8

70 FY 142.003

71 FY 186.845

72 FY 214.141

73 FY 172.02

74 FY 305.407

75 FY 206.408

76 FY 179.647

77 FY 120.221

78 FY 178.379

79 FY 151.525

80 FY 159.922

81 FY 180.604

82 FY 146.778

83 FY 241.746

84 FY 145.938

85 FY 241.308

86 FY 202.448

87 FY 214.892

88 FY 178.075

89 FY 163.936

90 FY 225.228

91 FY 203.131

96 FY 152.751

97 FY 187.876

98 FY 243.372

99 FY 118.827

100 FY 200.466

101 FY 237.682

102 FY 298.979

104 FY 162.951

105 FY 186.159

108 FY 203.966

109 FY 228.178

110 FY 208.359

111 FY 230.553

112 FY 146.473

113 FY 241.898

114 FY 175.345

115 FY 98.809

116 FY 255.6

117 FY 177.331

118 FY 34.178

119 FY 212.736

120 FY 248.131

121 FY 145.764

122 FY 241.276

123 FY 272.383

124 FY 141.745

125 FY 153.349

126 FY 280.643

127 FY 239.527

128 FY 205.754

129 FY 162.093

130 FY 175.55

131 FY 180.835

132 FY 163.733

133 FY 121.132

134 FY 185.127

135 FY 162.572

136 FY 157.753

137 FY 132.653

139 FY 153.822

140 FY 186.866

141 FY 245.051

142 FY 118.8

143 FY 201.419

144 FY 235.098

145 FY 306.78

147 FY 162.154

148 FY 184.767

151 FY 231.431

153 FY 208.482

154 FY 229.493

155 FY 146.962

156 FY 230.098

157 FY 173.533

158 FY 236.428

159 FY 249.01

161 FY 148.556

162 FY 213.564

163 FY 246.861

164 FY 145.963

165 FY 235.852

166 FY 282.809

167 FY 147.317

168 FY 154.027

169 FY 282.036

170 FY 237.539

171 FY 206.697

172 FY 161.456

173 FY 175.309

174 FY 178.999

175 FY 163.493

176 FY 122.606

177 FY 184.175

178 FY 161.914

179 FY 156.807

180 FY 133.677

182 FY 176.964

183 FY 163.82

184 FY 115.836

185 FY 157.633

186 FY 137.288

187 FY 66.148

188 FY 168.337

189 FY 222.518

190 FY 175.381

192 FY 171.002

193 FY 196.994

196 FY 178.839

197 FY 201.811

198 FY 150.363

199 FY 254.797

200 FY 153.792

201 FY 94.701

202 FY 171.954

203 FY 194.295

204 FY 181.595

205 FY 219.397

206 FY 149.526

207 FY 250.487

208 FY 177.433

209 FY 214.969

210 FY 182.576

211 FY 181.356

212 FY 116.946

213 FY 218.958

214 FY 216.817

215 FY 175.017

216 FY 169.74

217 FY 183.067

218 FY 191.97

219 FY 166.297

220 FY 82.127

221 FY 196.039

222 FY 170.419

223 FY 159.795

224 FY 115.77

226 FY 166.669

227 FY 7.29

228 FY 7.29

229 FY 133.457

230 FY 136.832

231 FY 136.063

232 FY 273.146

233 FY 107.258

234 FY 105.716

235 FY 106.295

236 FY 106.679

237 FY 106.57

238 FY 106.404

239 FY 7.29

240 FY 7.29

241 FY 7.29

242 FY 7.29

243 FY 190.653

244 FY 254.359

245 FY 213.068

246 FY 175.922

247 FY 193.222

248 FY 256.407

249 FY 241.84

250 FY 200.034

251 FY 193.422

252 FY 256.701

253 FY 241.471

254 FY 199.964

255 FY 193.28

256 FY 256.505

257 FY 242.017

258 FY 200.257

259 FY 115.277

260 FY 156.177

261 FY 144.844

262 FY 113.516

1 FZ 7.29

2 FZ 7.29

3 FZ 7.29

4 FZ 7.29

5 FZ 7.29

6 FZ 7.29

7 FZ 7.29

8 FZ 7.29

9 FZ 7.29

10 FZ 7.29

11 FZ 7.29

12 FZ 7.29

13 FZ 7.29

14 FZ 7.29

15 FZ 7.29

16 FZ 7.29

17 FZ 7.29

18 FZ 7.29

19 FZ 7.29

20 FZ 7.29

21 FZ 7.29

22 FZ 7.29

23 FZ 7.29

24 FZ 7.29

25 FZ 7.29

26 FZ 220.187

27 FZ 272.646

28 FZ 236.409

29 FZ 115.404

30 FZ 352.938

31 FZ 349.267

32 FZ 293.953

33 FZ 126.557

34 FZ 242.602

35 FZ 243.454

36 FZ 369.985

37 FZ 279.239

38 FZ 93.671

39 FZ 196.047

40 FZ 198.889

41 FZ 78.968

42 FZ 137.696

43 FZ 253.012

44 FZ 326.209

45 FZ 333.074

46 FZ 220.614

47 FZ 362.96

48 FZ 384.079

49 FZ 329.414

50 FZ 111.796

51 FZ 238.803

52 FZ 199.885

53 FZ 155.291

54 FZ 189.936

55 FZ 244.505

56 FZ 118.872

57 FZ 201.572

58 FZ 236.769

59 FZ 301.155

60 FZ 175.18

61 FZ 202.665

62 FZ 243.027

63 FZ 229.023

64 FZ 249.606

65 FZ 97.112

66 FZ 255.836

67 FZ 188.688

68 FZ 34.91

69 FZ 280.8

70 FZ 142.003

71 FZ 186.845

72 FZ 214.141

73 FZ 172.02

74 FZ 305.407

75 FZ 206.408

76 FZ 179.647

77 FZ 120.221

78 FZ 178.379

79 FZ 151.525

80 FZ 159.922

81 FZ 180.604

82 FZ 146.778

83 FZ 241.746

84 FZ 145.938

85 FZ 241.308

86 FZ 202.448

87 FZ 214.892

88 FZ 178.075

89 FZ 163.936

90 FZ 225.228

91 FZ 203.131

96 FZ 152.751

97 FZ 187.876

98 FZ 243.372

99 FZ 118.827

100 FZ 200.466

101 FZ 237.682

102 FZ 298.979

104 FZ 162.951

105 FZ 186.159

108 FZ 203.966

109 FZ 228.178

110 FZ 208.359

111 FZ 230.553

112 FZ 146.473

113 FZ 241.898

114 FZ 175.345

115 FZ 98.809

116 FZ 255.6

117 FZ 177.331

118 FZ 34.178

119 FZ 212.736

120 FZ 248.131

121 FZ 145.764

122 FZ 241.276

123 FZ 272.383

124 FZ 141.745

125 FZ 153.349

126 FZ 280.643

127 FZ 239.527

128 FZ 205.754

129 FZ 162.093

130 FZ 175.55

131 FZ 180.835

132 FZ 163.733

133 FZ 121.132

134 FZ 185.127

135 FZ 162.572

136 FZ 157.753

137 FZ 132.653

139 FZ 153.822

140 FZ 186.866

141 FZ 245.051

142 FZ 118.8

143 FZ 201.419

144 FZ 235.098

145 FZ 306.78

147 FZ 162.154

148 FZ 184.767

151 FZ 231.431

153 FZ 208.482

154 FZ 229.493

155 FZ 146.962

156 FZ 230.098

157 FZ 173.533

158 FZ 236.428

159 FZ 249.01

161 FZ 148.556

162 FZ 213.564

163 FZ 246.861

164 FZ 145.963

165 FZ 235.852

166 FZ 282.809

167 FZ 147.317

168 FZ 154.027

169 FZ 282.036

170 FZ 237.539

171 FZ 206.697

172 FZ 161.456

173 FZ 175.309

174 FZ 178.999

175 FZ 163.493

176 FZ 122.606

177 FZ 184.175

178 FZ 161.914

179 FZ 156.807

180 FZ 133.677

182 FZ 176.964

183 FZ 163.82

184 FZ 115.836

185 FZ 157.633

186 FZ 137.288

187 FZ 66.148

188 FZ 168.337

189 FZ 222.518

190 FZ 175.381

192 FZ 171.002

193 FZ 196.994

196 FZ 178.839

197 FZ 201.811

198 FZ 150.363

199 FZ 254.797

200 FZ 153.792

201 FZ 94.701

202 FZ 171.954

203 FZ 194.295

204 FZ 181.595

205 FZ 219.397

206 FZ 149.526

207 FZ 250.487

208 FZ 177.433

209 FZ 214.969

210 FZ 182.576

211 FZ 181.356

212 FZ 116.946

213 FZ 218.958

214 FZ 216.817

215 FZ 175.017

216 FZ 169.74

217 FZ 183.067

218 FZ 191.97

219 FZ 166.297

220 FZ 82.127

221 FZ 196.039

222 FZ 170.419

223 FZ 159.795

224 FZ 115.77

226 FZ 166.669

227 FZ 7.29

228 FZ 7.29

229 FZ 133.457

230 FZ 136.832

231 FZ 136.063

232 FZ 273.146

233 FZ 107.258

234 FZ 105.716

235 FZ 106.295

236 FZ 106.679

237 FZ 106.57

238 FZ 106.404

239 FZ 7.29

240 FZ 7.29

241 FZ 7.29

242 FZ 7.29

243 FZ 190.653

244 FZ 254.359

245 FZ 213.068

246 FZ 175.922

247 FZ 193.222

248 FZ 256.407

249 FZ 241.84

250 FZ 200.034

251 FZ 193.422

252 FZ 256.701

253 FZ 241.471

254 FZ 199.964

255 FZ 193.28

256 FZ 256.505

257 FZ 242.017

258 FZ 200.257

259 FZ 115.277

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

**END CONCRETE DESIGN**

**PRINT STORY DRIFT**

**FINISH**