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# Analysis and Design of Bank Building (G+5) Using ETABS

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**Abstract:** The main steps of any building construction and planning is drafting, analysing and designing the building. In the present days of improving science and technology, analysing and designing of a building has been made easy by using ETABS software. ETABS software helps civil engineers to make their work easy and decreases time necessary for planning. The project going to be done is design of a multi-storey building which is going to be used as a residential. The building plan has been drafted using the AutoCAD software by the requirement and available area. The super structure i.e. the building frame has been analysed and designed using the ETABS software. In the present project G+5 building consider to analysis and design for both gravity and lateral (wind) loads as per Indian standards. By using the software building can be analysed and we can check for any failures in the analysis and redesign them, so that we can prevent failures after construction. By using the output building can be constructed according to the design.

**Keywords:** Building, Wind in ETABS.

## I. INTRODUCTION

### A. General

A building is a man-made structure with a roof and walls standing more or less permanently in one place. Buildings come in a variety of shapes, sizes and functions, and have been adapted throughout history for a wide number of factors, from building materials available, to weather conditions, to land prices, ground conditions, specific uses and aesthetic reasons. To better understand the term building compares the list of structures. Buildings serve several needs of society – primarily as shelter from weather, security, living space, privacy, to store belongings, and to comfortably live and work. A building as a shelter represents a physical division of the human habitat (a place of comfort and safety) and the outside (a place that at times may be harsh and harmful). Ever since the first cave paintings, buildings have also become objects or canvases of artistic expression. In recent years, interest in sustainable planning and building practices has also become an intentional part of the design process of many new buildings. A slab is a flat two dimensional planar structural element having thickness small compared to its other two dimensions. It provides a working flat surface or a covering shelter in buildings. It primarily transfers the load by bending in one or two directions. Reinforced concrete slabs are used in floors, roofs and walls of buildings and as the decks of bridges. The floor system of a structure can take many forms such as in situ solid slab, ribbed slab or pre-cast units. Slabs may be supported on monolithic concrete beam, steel beams, walls or directly over the columns. Concrete slab behave primarily as flexural members and the design is similar to that of beams.

## II. CONVENTIONAL SYSTEM

The structural components in a typical multi-storey building, consists of a floor system which transfers the floor loads to a set of plane frames in one or both directions. The floor system also acts as a diaphragm to transfer lateral loads from wind or earthquakes. The frames consist of beams and columns and in some cases braces or even reinforced concrete shear walls. As the height of the building increases beyond ten stories (tall building), it becomes necessary to reduce the weight of the structure for both functionality and economy. Since concrete floors are functionally more suitable, have less vibration and more abrasion and fire resistance, the usual tendency is to make them act either with profiled steel decks and/or with steel beams to give a light weight floor system. Similarly masonry walls may be replaced with glazing and curtains or blinds to reduce the weight. The different types of floors used in steel-framed buildings are as follows:

- Concrete slabs supported by open-web joists
- One-way and two-way reinforced concrete slabs supported on steel beams
- Concrete slab and steel beam composite floors
- Profiled decking floors
- Precast concrete slab floors.

Steel forms or decks are usually attached to the joists by welding and concrete slabs are poured on top. This is one of the lightest types of concrete floors. For structures with light loading. These are much heavier than most of the newer light weight floor systems and they take more time to construct, thus negating the advantage of speed inherent in steel construction. This floor system is adopted for heavy loads. One way slabs are used when the longitudinal span is two or more times the short span. In one-way slabs, the short span direction is the direction in which loads get transferred from slab to the beams. Hence the main reinforcing bars are provided along this direction. However, temperature, shrinkage and distribution steel is provided along the longer direction. The two-way concrete slab is used when aspect ratio of the slab i.e. longitudinal span/transverse span is less than 2 and the slab is supported along all four edges. The main reinforcement runs in both the directions. A typical cross-section of a one-way slab floor with supporting steel beams. Also shown is the case when the steel beam is encased in concrete for fire protection.

## III. BEHAVIOR OF STRUCTURE UNDER LATERAL LOADS

Recently there has been a considerable increase in the number of tall buildings, both residential and commercial, and the modern trend is towards taller and more slender structures. Thus the effects of lateral loads like wind loads, earthquake forces and blast forces etc, are assigning importance and almost every designer is faced with the problem of providing adequate strength and stability against lateral loads. This is a new development, as the earlier building designers usually designed for the vertical loads, and as an afterthought, checked the final design for lateral loads as well. Generally those buildings had sufficient strength against lateral loads due to numerous partitions and short span beams and cross beams and no modification in the design was needed. Now, the situation is quite different and a clear understanding of the effects of lateral loads on a building and the behaviour of various components under these loads, is essential. Shear walls are specially designed structural walls incorporated in the plane of the wall due to wind, earthquake and other forces. The term ‘shear wall’ is rather misleading as such walls behave more like flexural members. They are usually provided in tall buildings and have been found immense use to avoid total collapse of buildings under seismic forces. It is always advisable to incorporate them in buildings built in regions likely to experience earthquake of large intensity or high winds. Shear walls for wind are designed as simple concrete walls. The design of these walls for seismic forces requires special considerations as they should be safe under repeated loads. Shear walls are generally made of concrete or masonry.

They are usually provided between columns, in stairwells, lift wells, toilets, utility shafts, etc. tall buildings with flat slabs should invariably have shear walls. Such systems are compared to slabs with beams have very little resistance even to moderate lateral loads. Initially shear walls were used in reinforced concrete buildings to resist wind forces. These came into general practice only as late as 1940. With the introduction of shear walls, concrete construction can be used for tall buildings also. However, the most important property of shear walls for seismic design, as different from design for wind, is that it should have good ductility under reversible and repeated overloads. In planning shear walls, we should try to reduce the bending tensile stresses due to lateral loads as much as possible by loading them with as much gravity forces as it can safely take. They should be also laid symmetrically to avoid tensional stresses.

## IV. TYPES OF LOADS

The buildings are subjected to both vertical and horizontal loads. At the preliminary design stage all the components of buildings are designed for vertical loads only. Ideally an efficient system should not require an increase in the sizes of members when the effect of lateral load is also incorporated. Such designers are known as ‘premium free’ designers and may be different to achieve. Horizontal loads can be divided into the following three categories:

- Wind loads
- Earthquake loads

### A. Wind Loads

A mass of air moving at a certain velocity has a kinetic energy to 1/2MV*V, where M and V are the mass and velocity of air in motion. When an obstacle like a building is met in its path, a part of the kinetic energy of air in motion gets converted to potential energy of pressure. The actual intensity of wind pressure depends on a number of factors like angle of incidence of the wind, roughness of the surrounding area, effects of architecture features, i.e., shape of the structure etc. and lateral resistance of the structure. Apart from these, the maximum design wind pressure depends on the duration of the gusts and the probability of occurrence of an exceptional wind pressure. However, for most of the buildings, the wind pressure, specified in the code (Indian Standards, I.S 875-1964) are usually sufficient.

In every tall and slender building (not common in India) aerodynamic instability may develop. This is because of the fact that during a wind storm the building is constantly buffeted by gusts and starts vibrating in its fundamental mode. If the energy absorbed by the building is more than the energy it can dissipate by structural damping, the amplitude of the vibration goes on increasing till failure occurs. A detailed study supported by wind tunnel experiments is often necessary in these cases. Some useful details about dynamic wind loads on structure have been by Davenport.

### B. Earthquake Loads

An earthquake (also known as a quake, tremor or temblor) is the result of a sudden release of energy in the Earth'scrust that creates seismic waves. The seismicity, seismic or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. The moment magnitude is the most common scale on which earthquakes larger than approximately 5 are reported for the entire globe. The more numerous earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter scale. These two scales are numerically similar over their range of validity. Magnitude 3 or lower earthquakes are mostly almost imperceptible or weak and magnitudes 7 and over potentially cause serious damage over larger areas, depending on their depth. The largest earthquakes in historic times have been of magnitude slightly over 9, although there is no limit to the possible magnitude. The most recent large earthquake of magnitude 9.0 or larger was a 9.0 magnitude earthquake in Japan in 2011 (as of October 2012), and it was the largest Japanese earthquake since records began. Intensity of shaking is measured on the modified Mercalli scale. The shallower an earthquake, the more damage to structures it causes, all else being equal.

## V. LATERAL LOAD RESISTING UNITS

In general a shear wall buildings, and for that matter any other structure, is designed to satisfy in basic structural and functioning requirements. The structural requirements are:

- Strength
- Stiffness
- Stability

The designed structure should be strong enough to withstand the entire lateral loads withoutexcess deformations or deflections and should be under the largest stipulated loads. The lateral deflection of the building under maximum load is to be controlled to a safe line. Committee 435 recommends a deflection limit of 1/500 of the height for tall buildings. Experience that buildings designed to satisfy this criterion ensure the comfort of the occupation and the stability of the structure as a whole. Three types of units are commonly used for resisting the lateral loads. These are:

- Frames
- Shear walls
- Tubes

Rigid frames have been used in the past for tall buildings and are still used up to certain heights. However, they are not so efficient for lateral loads and are being replaced by shear walls and tubes for taller buildings.

## VI. ETABS

In the last 30 years TABS and ETABS have set the international standards in structural analysis and design. They first took into consideration the characteristic properties of a building's mathematical model, thereby allowing the graphical creation of a building's model in the same sequence that will actually be constructed (slab by slab, floor by floor). Worldwide, ETABS is considered the most popular analysis and design software. The "Top Seismic Product of the 20th Century" (2006) and "Honour Award in Engineering Software" (2002) awards, establish it as the innovator in structural analysis and design and the reference point for the entire market.The latest version of ETABS continues in that tradition, incorporating structural element terminology that is used on a daily basis (Columns, Beams, Bracings, Shear Walls etc.), contrary to the common civil engineering programs that use terms such as nodes, members etc. Additionally, it offers many automatic functions for the formation, analysis and design of the structural system in an efficient, fast and easy way. The user can easily create a model, apply any kind of load to it and then take advantage of the superior capabilities of ETABS to perform a start or art analysis and design. ETABS is the solution, whether you are designing a simple 2D frame or performing a dynamic analysis of a complex high-rise that utilizes non-linear dampers for inter-story drift control.

## VII. MODELING OF THE STRUCTURE

### A. General

R.C moment resisting frame structure having G+5 storey is analysed for garvity and latral load (earth quake and wind loads). The effect of axial force, out of plane moments, lateral loads, shear force, storey drift, storey shear and tensile force are observed for different stories. The analysis is carried out using ETABS and data base is prepared for different storey levels as follows.

### B. Modelling Of R.C Moment Resisting Frame Structure

In this present study G+5 Bank building is considered. The constriction Technology is R.C.C frame structure and slabs. The modelling is done in ETABS as follows.

- The structure is divided into beam and column elements.
- The nodes are created as plan architect plan and node are connected through beam command, columns also connected. Boundary conditions are assigned to the nodes wherever it is required. Boundary conditions are assigned at the bottom of the structure i.e., at ground level where restraints should be against all movements to imitate the behavior of structure.
- The material properties are defined such as mass, weight, modulus of elasticity, Poisson's ratio, strength characteristics etc. The material properties used in the models.
- The geometric properties of the elements are dimensions for the section.
- Elements are assigned to structure.
- Loads are assigned to the joints as they will be applied in the real structure.
- The model should be ready to be analysed forces, stresses and displacements.

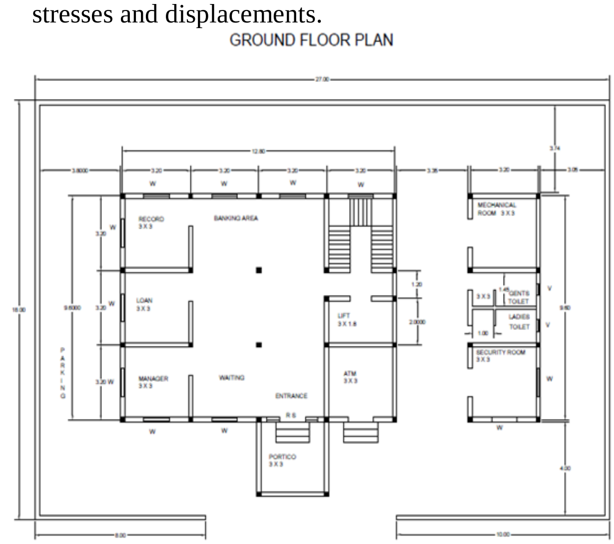


**Fig.1.**

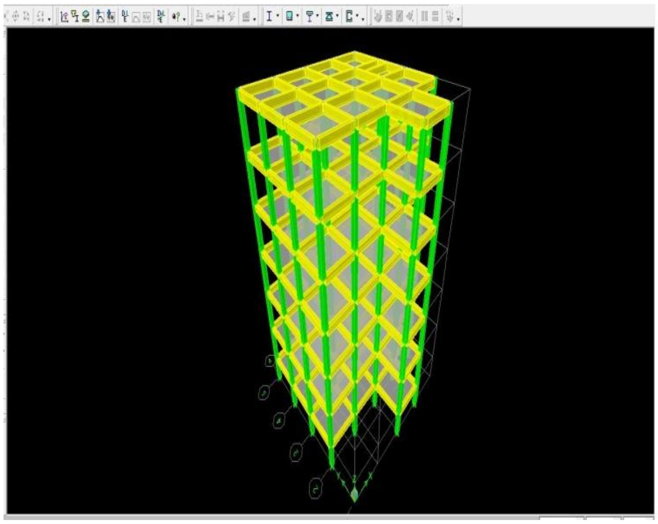

Fig.2. 3D view of the structure.

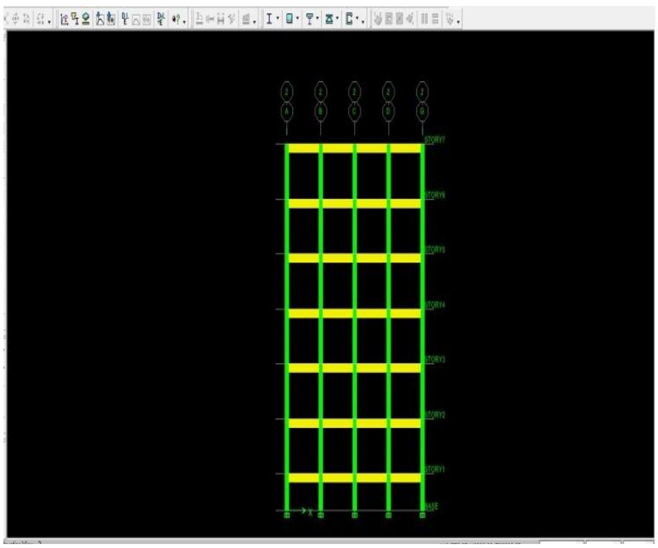

Fig.3. Elevation of the structure.

## VIII. ANALYSIS AND RESULT

### A. General

Structure having G+5 storey is analysed for garvity and latral loads (sesimic and wind load). The effect of axial force, out of plane moments, lateral loads, shear force, storey drift, storey shear and tensile force are observed for different stories. The analysis is carried out using ETABS and data base is prepared for different storey levels as follows.

### B. Load Cases And Load Combinations

In this present work consider both gravity and lateral load case (SESIMIC AND WIND). The load combinations as per the Indian standards are considered. The primary load cases and the load combinations are shown following tables respectively.

**TABLE I: Primary Load Cases**

| NUMBER | | NUMBER | |
|---|---|---|---|
| 1 | Dead load | 6 | EQ in Negative Y |
| 2 | Live load | 7 | WIND in X |
| 3 | EQ in X | 8 | WIND in Y |
| 4 | EQ in Y | 9 | WIND in Negative X |
| 5 | EQ Negative X | 10 | WIND in Negative Y |

**TABLE II: Load Combinations**

| COMBINATION NUMBER | LOAD COMBINATION | COMBINATION NUMBER | LOAD COMBINATION |
|---|---|---|---|
| COMB1 | D.L+L.L | COMB26 | D.L+WNY |
| COMB2 | 1.5(D.L+L.L) | COMB27 | 1.5(D.L+WX) |
| COMB3 | 1.5(D.L+EQX) | COMB28 | 1.5(D.L+WY) |
| COMB4 | 1.5(D.L+EQY) | COMB29 | 1.5(D.L+WNX) |
| COMB5 | 1.5(D.L+EQNX) | COMB30 | 1.5(D.L+WNY) |
| COMB6 | 1.5(D.L+EQNY) | COMB31 | 1.2(D.L+L.L+WX) |
| COMB7 | 1.2(D.L.+L.L+EQX) | COMB32 | 1.2(D.L+L.L+WY) |
| COMB8 | 1.2(D.L.+L.L+EQY) | COMB33 | 1.2(D.L+L.L+WNX) |
| COMB9 | 1.2(D.L.+L.L+EQNX) | COMB34 | 1.2(D.L+L.L+WNY) |
| COMB10 | 1.2(D.L.+L.L+EQNY) | COMB35 | 1.5(D.L+L.L)+WX |
| COMB11 | 0.9D.L+1.5EQX | COMB36 | 1.5(D.L+L.L)+WY |
| COMB12 | 0.9D.L+1.5EQY | COMB37 | 1.5(D.L+L.L)+WNX |
| COMB13 | 0.9D.L+1.EQNX | COMB38 | 1.5(D.L+L.L)+WNY |
| COMB14 | 0.9D.L+1.5EQNY | COMB22 | D.L+L.L+WNY |
| COMB15 | D.L+L.L+EQX | COMB23 | D.L+WX |
| COMB16 | D.L+L.L+EQY | COMB24 | D.L+WY |
| COMB17 | D.L+L.L+EQNX | COMB25 | D.L+WNX |
| COMB18 | D.L+L.L+EQNY | COMB39 | 1.5(D.L+L.L+WX) |
| COMB19 | D.L+L.L+WX | COMB40 | 1.5(D.L+L.L+WY) |
| COMB20 | D.L+L.L+WY | COMB41 | 1.5(D.L+L.L+WNX) |
| COMB21 | D.L+L.L+WNX | COMB42 | 1.5(D.L+L.L+WNY) |

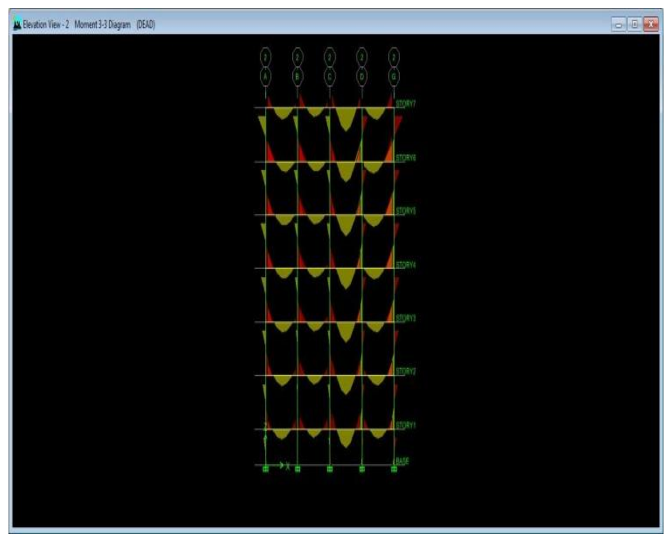

Fig.4. Bending moment Diagram.

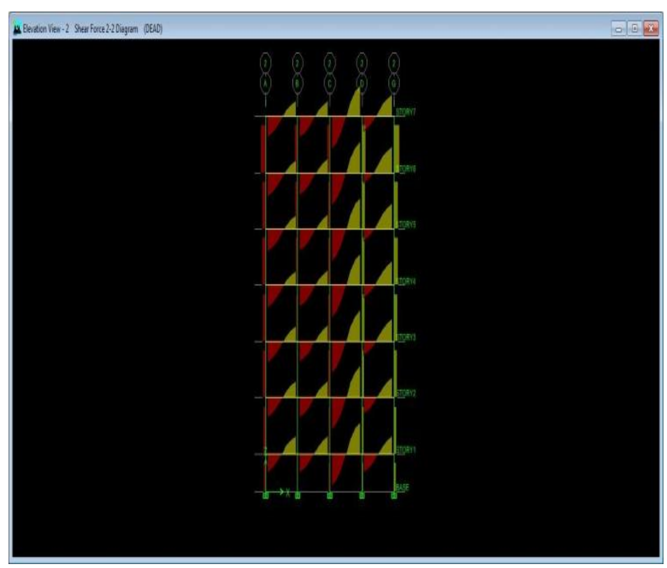

Fig.5. Shear Force moment Diagram.

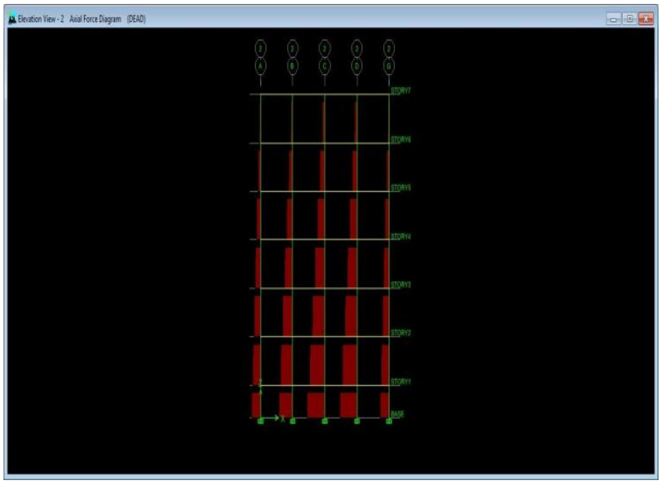

**Fig.6. Axial Force Diagram.**

**TABLE III: Centers of Cumulative Mass Centers of Rogidity**

| Story | Diaphragm | MassX | MassY | XCM | YCM | CumMassX | CumMassY | XCCM | YCCM | XCR | YCR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STORY7 | D1 | 259.03 | 259.03 | 6.589 | 7.453 | 259.0287 | 259.0287 | 6.59 | 7.45 | 7.13 | 7.52 |
| STORY6 | D1 | 367.02 | 367.02 | 6.626 | 7.419 | 626.0467 | 626.0467 | 6.61 | 7.43 | 7.13 | 7.5 |
| STORY5 | D1 | 367.02 | 367.02 | 6.626 | 7.419 | 993.0647 | 993.0647 | 6.62 | 7.43 | 7.13 | 7.49 |
| STORY4 | D1 | 367.02 | 367.02 | 6.626 | 7.419 | 1360.0828 | 1360.083 | 6.62 | 7.43 | 7.13 | 7.48 |
| STORY3 | D1 | 367.02 | 367.02 | 6.626 | 7.419 | 1727.1008 | 1727.101 | 6.62 | 7.42 | 7.13 | 7.47 |
| STORY2 | D1 | 367.02 | 367.02 | 6.626 | 7.419 | 2094.1188 | 2094.119 | 6.62 | 7.42 | 7.1 | 7.45 |
| STORY1 | D1 | 359.95 | 359.95 | 6.62 | 7.42 | 2454.0731 | 2454.073 | 6.62 | 7.42 | 7.03 | 7.41 |

**TABLE IV: Building Output**

| STOREY | LOACTION | P | VX | VY | T | MX | MY |
|---|---|---|---|---|---|---|---|
| Storey 07 | Top | 45731.2 | 1605.94 | 1605.94 | 20567.8 | 389323 | 5780.47 |
| | Bottom | 46606.9 | 1605.94 | 1605.94 | 20567.8 | 396666 | 8219.17 |
| Storey 06 | Top | 55845.1 | 1777.34 | 1777.34 | 22755.1 | 475695 | 8219.17 |
| | Bottom | 56719.9 | 1777.34 | 1777.34 | 22755.1 | 483038 | 10901 |
| Storey 05 | Top | 65959 | 1901.18 | 1901.18 | 24335.4 | 562067 | 10901 |
| | Bottom | 66833.8 | 1901.18 | 1901.18 | 24335.4 | 569410 | 13797.7 |
| Storey 04 | Top | 76073 | 1985.17 | 1985.17 | 25444.5 | 648439 | 13797.7 |
| | Bottom | 76947.8 | 1985.17 | 1985.17 | 25444.5 | 655782 | 16898.8 |
| Storey 03 | Top | 86203.5 | 2037.11 | 2037.11 | 27457.8 | 734882 | 16898.8 |
| | Bottom | 87078.3 | 2037.11 | 2037.11 | 27454.8 | 742225 | 20199.5 |
| Storey 02 | Top | 96333.9 | 2064.58 | 2064.58 | 29346.9 | 821324 | 20199.5 |
| | Bottom | 97208.7 | 2064.58 | 2064.58 | 29346.9 | 828667 | 23693.1 |
| Storey 01 | Top | 106442 | 2075.28 | 2075.28 | 30778.6 | 907256 | 23693.1 |
| | Bottom | 107317 | 2075.28 | 2075.28 | 30778.6 | 914599 | 27355.6 |
| Plinth | Top | 108920 | 2075.69 | 2075.69 | 30860.1 | 929611 | 27355.6 |
| | Bottom | 109503 | 2075.69 | 2075.69 | 30860.1 | 934507 | 29855 |

**TABLE V: Building Modes And Time Period**

| MODE NUMBER | TIME PERIOD (SECOND) |
|---|---|
| 1 | 1.9309 |
| 2 | 1.4671 |
| 3 | 1.3254 |
| 4 | 0.6652 |
| 5 | 0.5043 |
| 6 | 0.4486 |
| 7 | 0.3850 |
| 8 | 0.2927 |
| 9 | 0.2611 |
| 10 | 0.2587 |

**TABLE VI: Storey Drift Envelops**

| Storey | Direction | Max drift |
|---|---|---|
| Storey 07 | X | 0.00121 |
| Storey 07 | Y | 0.00222 |
| Storey 06 | X | 0.00129 |
| Storey 06 | Y | 0.00236 |
| Storey 05 | X | 0.00136 |
| Storey 05 | Y | 0.00249 |
| Storey 04 | X | 0.00141 |
| Storey 04 | Y | 0.00261 |
| Storey 03 | X | 0.00145 |
| Storey 03 | Y | 0.00271 |
| Storey 02 | X | 0.00145 |
| Storey 02 | Y | 0.00274 |
| Storey 01 | X | 0.0012 |
| Storey 01 | Y | 0.00222 |
| Plinth | X | 0.00054 |
| plinth | Y | 0.00071 |

## IX. CONCLUSION

### A. Design for Flexure

Maximum sagging (creating tensile stress at the bottom face of the beam) and hogging (creating tensile stress at the top face) moments are calculated for all active load cases at each of the above mentioned sections. Each of these sections are designed to resist both of these critical sagging and hogging moments. Where ever the rectangular section is inadequate as singly reinforced section, doubly reinforced section is tried.

### B. Design for Shear

Shear reinforcement is calculated to resist both shear forces and torsional moments. Shear capacity calculation at different sections without the shear reinforcement is based on the actual tensile reinforcement provided by ETAB program. Two-legged stirrups are provided to take care of the balance shear forces acting on these sections.

### C. Beam Design Output

The default design output of the beam contains flexural and shear reinforcement provided along the length of the beam.

### D. Column Design

Columns are designed for axial forces and biaxial moments at the ends. All active load cases are tested to calculate reinforcement. The loading which yield maximum reinforcement is called the critical load. Column design is done for square section. Square columns are designed with reinforcement distributed on each side equally for the sections under biaxial moments and with reinforcement distributed equally in two faces for sections under uni-axial moment. All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS: 456 have been taken care of in the column design of ETABS.

## X. REFERENCESS

We have used a number of books and code as a reference for carrying out this project work. Some of the books (s) that we refer are mentioned below.

**Indian Standard Code:**

- Is Code 456-2000
- Is Code 875-1987 Part I
- Is Code 875-1987 Part Ii
- Is Code 875-1987 Part Iii
- Design Aids To Is -456-2000 ( Sp 16 )
- Arrangement Of Reinforcement Using Sp 34

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