ANALYSIS AND DESIGN OF G+8 RCC BUILDING USING ETABS

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ABSTRACT:

Planning and designing a structure is an art to achieve safety, serviceability, durability and economy. The entire process of structural planning and designing requires not only imagination and conceptual thinking but also sound knowledgeof science of structural engineering besides knowledge of practical aspects, suchas relevant design codes and building by-laws backed up by example experience.The functional requirements and aspects of aesthetics are looked into normally by an architect while the aspect of safety, serviceability, durability and economy of the structure is attended by structural engineer.

For this purpose, a site is selected in which a building of eight-storey (G+8)is constructed. Each floor has four apartments consisting of all facilities requiredfor a residential house like bedroom, toilet, living, dining, and kitchen and store room. The present project deals with the analysis and design of the apartment building. For the purpose of analysis and design, only the dead load and live loadare considered. Effect of wind load is not considered as it is not significant for an eight-storey building. The values of dead loads are taken as per IS-875 (Part 1) and the live loads from IS-875(Part2). Here, AutoCAD is used to prepare a plan and elevation. It involves outer appearance of the plan and elevation.

E-Tabs software tool is used for the Analysis purpose. Design of structural components like slabs, beams, columns, footings etc. is done manually. In this project work, all building by-laws are followed and are going to be implemented.

The following codes are used for the design.

- Plain and Reinforced Concrete – Code of Practice (IS: 456-2000)
- Design Aids for Reinforced Concrete (SP-16)
- Code of Practice of Design loads (IS: 875 (Part1 and Part2)).

Key words: Analysis, Design, G+8, ETabs, IS.

I. INTRODUCTION

An apartment building is actually a single storey house and it's a part of amulti storey building, in which many houses are built. There are different types of apartments such as studio, alcove, convertible studio, loft, garden apartments etc. in which we are designing the garden type of apartment, which includes garden, lane in addition to living area, rooms, kitchen, bathroom, toilet, back yard,etc. This apartment is also called as FLAT or UNIT.

Due to growing population and less availability of land this multi storey buildings are constructed which serve many people in a limited area, more over the deforestation is avoided and its sense of development is an important indicatorof social progress of the country. On an average generally one spends his two thirdof his/her life time in the house. Nowadays the house building is a major work ofthe social progress of the country, daily new technique is developed for the construction of house economically, quickly and fulfilling the requirements of the community. Engineers do the planning, designing, planning layout etc.

The building is designed by considering only vertical loads. Because herewe are designing only G+8 where there is no necessity of considering the windload. The vertical load consists of dead load of structural components such as beam, column, slabs etc. and live load by using the code IS – 875(Part 1 and Part2). The building is designed as two-dimensional vertical frame and analyzed for the maximum bending moments and shear force as per IS 456-2000. The E Tabssoftware is used for analysis.

II. OBJECTIVES OF STUDY:

The main Objectives of this Project are:

1.To Complete analysis and design for a G+8 Structure.

2. Analysis of a structure is done for both gravity loads & lateral loads.
3.Analysis for gravity loads is done using substitute frame method and that of lateral loads can be done using two methods namely Static and Dynamic Analysis.
4.For the analysis of lateral loads, portal frame method is adopted. Coming to the Dynamic analysis Seismic Analysis are done.

III. LITERATURE REVIEW:

The extensive literature review was carried out by referring standard journals, reference books, I.S. codes and conference proceeding. The major work carried out by different researchers is summarized below.
Sayyed A.Ahad, Hashmi S Afzal, Shivaj and Shaikh Ammar In this paper Analysis and Design of an apartment building having G+10 Storeys is done. Analysis is done by using the software ETABS, which proved to be premium of great potential in analysis and design of various sections. The structural elements like RCC frame. As per the soil investigation report, an Isolated footing is provided. All the structural components were designed manually and detailed using AutoCAD 2018. The analysis and design was done according to standard specifications to the possible extend. The various difficulties encountered in the design process and the various constraints faced by the structural engineer in designing up to the architectural drawing were also understood.
Ali Kadhim Sallal In this paper the value of DL, LL and FF loads obtained by the ETABS program are similar to the manually calculated values. The analysis results of the structural integrity of building in withstanding the design earthquake loadings was conducted and was judged to be safe. Various important results like bending moments, shear force and deflection results are similar to the manually calculated values.
R Sanjaynath, Mr. K. Prabin Kumar They did a study on "Planning, Analysis and Design of (G+20) multi-storey Residential Building using ETABS". Auto Cad is a designing and drafting software which is used for developing 2dimensional and 3- dimensional structures, developed and sold by Autodesk, Inc. It is a vector graphics drawing programmed. It uses primitive entities comparable to lines, polylines, circles, arcs and text as the foundation for the complex. Auto CAD's native file format, DWG, and to a lesser extent, its interchange file format, DXF has become the drawing and detailing works were done by creating use of Auto CAD 2014.

IV. METHODOLOGY

1. Inspection OF SITE
2. Planing of building
3. System design and numbering of grids
4. Preliminary design of beams, column, roof and floor slabs and footing
5. Modeling of 3d frames
6. Computation of loads
7. Analysis of 3d frames
8. Final design of beam,column and other elements
9. Structural detailing

V. PROBLEM STATEMENT

Utility of building: Apartment ComplexNumber of Stories: G+8
Number of Staircase for each floor: 2
Type of Wall: Bricks
Floor to Floor height: 3 m
The structure is modeled in ETABs software.

Table 1. INPUT PARAMETER OF ETABS MODELLING

Sr No.	Parameter	Details
1	Plinth Height	1.2m to 1.5m
2	Building type	RCC Framed Structure

3	Building designation	G+8 RCC Building
4	Plan of 8 storey Building	(35.20 X 15.35)m
5	Column Details	(230X600)
6	Beam Detail's	(230X450)
7	Slab Thickness	125
8	Grade of Concrete	M25
9	Grade of steel	Fe500
10	Safe bearing capacity of soil	300 KN /M2
11	Type of slab	Conventional one way &2-way slab
12	Zone as per seismic zones of map of India givenin IS 1893 (part 1):2016	III
13	Zone Factor Z as per Table 3 of IS 1893 (part1):2016	0.16
14	Types of soil	Medium Soil
15	Basic wind speed	39 m/s
16	Type of foundation	Pad Footing
17	Type of staircase	C Type

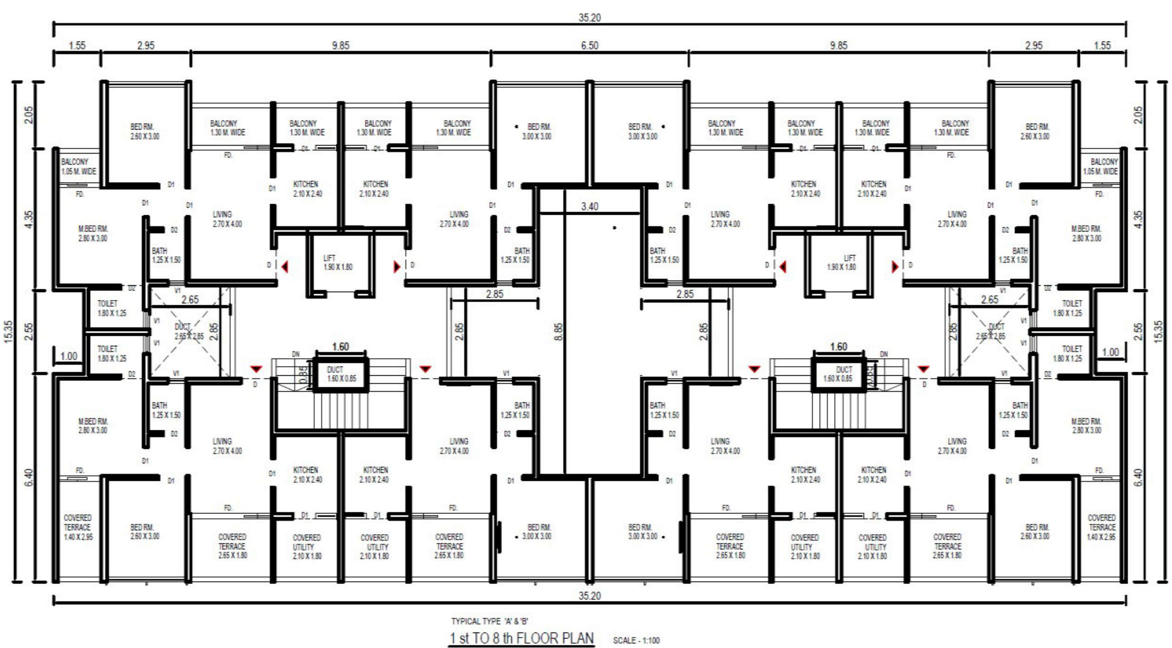


fig 1. 1Plan of the Building

VI. STEPS IN MODELLING OF 3D FRAME

Step by Step Procedure of ETAB modelling

Step 1) Grid formation along X & Y direction in order to develop the model ofthe building in grid pattern and input for storey data right from base to top storey.

Step 2) Define Material properties for concrete -M25

Step 3) Define material property of rebar-Fe500

Step 4) Define sectional properties for column, beam, slab & core wall

Step 5) Creation of slab & beam layout for typical story

Step 6) Define Load Patterns

Step 7) Define Load Combination

We are using different of load combinations in Etab software

1.5(DL+LL)	1.5(DL - ELX)
1.2(DL+LL+ELX)	1.5(DL+ELY)
1.2(DL+LL-ELX)	1.5(DL+ELX)
1.2(DL+LL+ELY)	0.9DL+1.5ELX
1.2(DL+LL-ELY)	0.9DL-1.5ELX
1.5(DL+ELX)	0.9DL+1.5ELY
0.9DL-1.5ELY	

Step 8) Assign the Loads

Step 9) Assign diaphragms to whole structure

Step 10) Assign meshing to slab elements & shear wall

Step 11) Define Mass source to complete structure (D.L. +0.25L.L.)

Since the live load class is 2 kN /sqm (< 3 kN /sqm), Only 25 % of the live loadis lumped at the floors. -As per Table 10 of IS1893(Part 1):2016

Total seismic weight of the structure = Σ n x floor area x (D.L.+0.25L.L.)Where n= no. of floors.

Step 12) Check Model before analysis

Step 13) Run analysis for static earthquake load combinations

Step 14) If base shear calculated by dynamic analysis is less than base shear in static analysis (i.e. RSX < EQX; RSY<EQY), all the response quantities are tobe scaled up as below:

Scale factor = (I x g)/2R x (0.8) x (Eq static base shear / Response spectrumBase shear)

Where I=Importance factor = 1g = Acceleration due to gravityR= Response reduction factor

Step 15) Final Run analysis using scale factor.

Step 16) Results are tabulated to study structural behaviors of building.

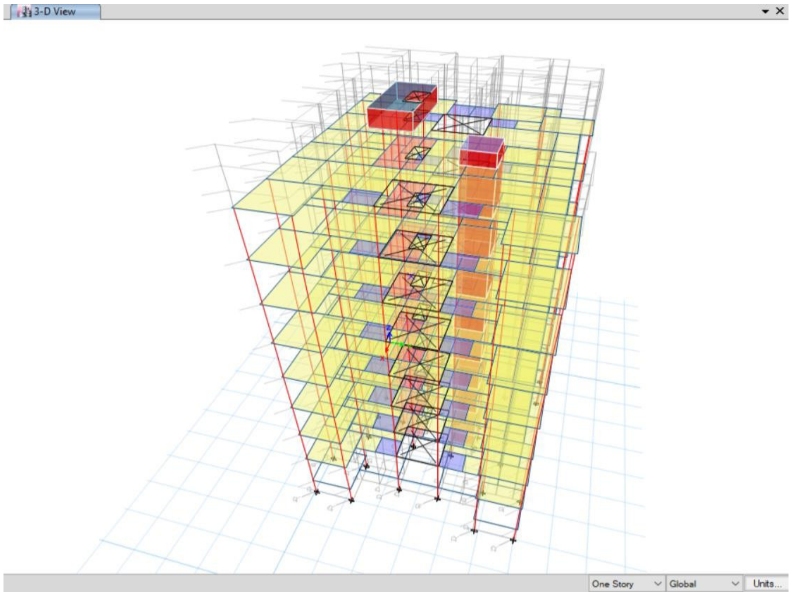


fig 2. 3D model view in ETABS

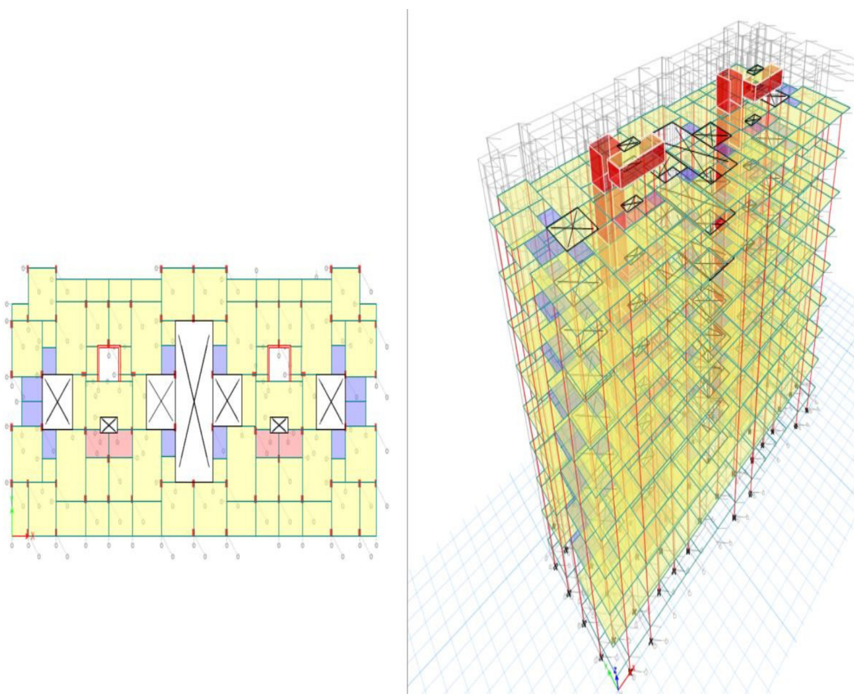


fig 3. Front elevation and isometric view

VII. COMPUTAION OF LOADS

A. Table 2 Properties of Member Sections

Member Sections	Dimensions (mm)
Slab Thickness	125
Beams	B230x450
Columns	C230x600

Load Calculation

The various loads considered for analysis were: -

1. Dead Loads

The dimensions of the cross section are to be assumed initially which enable to estimate the dead load from values of the unit weights of the structure. The valuesof the unit weight of the materials are specified in IS 875:1987(Part-I). As per IS875: 1987 (part I).

- Unit weight of brick = 18 kN/m
- Unit weight of concrete = 25 kN/m3Here a sample calculation is shown:

Wall Load

1. External wall load

Thickness of wall = 230 mm

Wall load = unit weight of brick x thickness of wall x(floor height –beam depth)

=15 x 0.23 x 3

= 10.35 kN/m

2. Internal wall load

Thickness of wall = 150mm

Wall load = 15 x 0.15 x 3 = 6.75 kN/m

Floor Load

Thickness of slab = 125 mm

Slab load (s1) = 0.075 x 20 = 1.5 kN/m2 Floor finish = 1 kN/m2 (as per IS 875 part

1)Total floor load = 2.5 kN

Slunk Slab

Thickness of Slab =150

Slab load = 0.23x20=4.6 kN/M2

Staircase Slab = 0.15 x20=3.75kn/m

Beam Load

Beam Load = 25 x b x D

= 25 x 0.23 x 0.45

= 2.587 kN/m

Live Load

Live Loads are also known as imposed loads and consist of all loads other than the dead loads of the structure. The standard values are stipulatedin IS875:1987 (part II).

Table 3. Live Loads

Area	Live Load (kn/m2)
Lobby	3
Corridors	3

Lift	2
Bedroom	2
Kitchen	2
Living Room	3
Terrace Floor	3
LMR	2

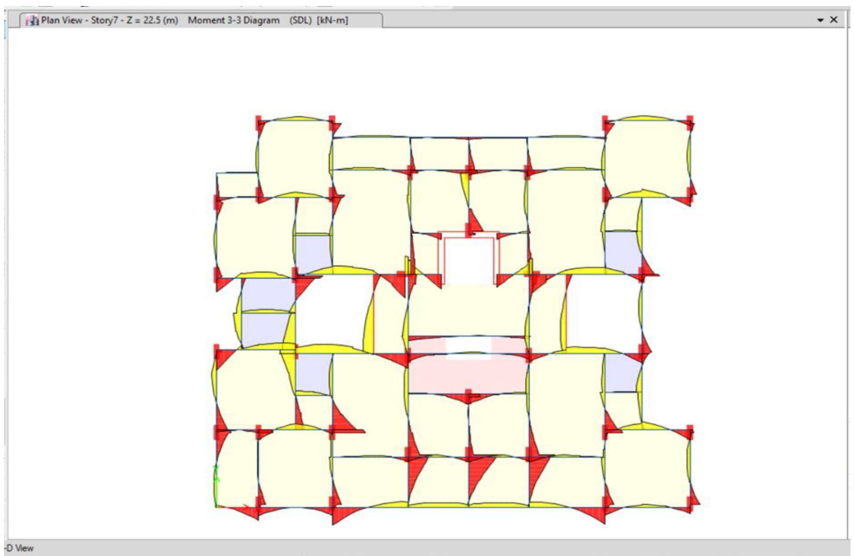


fig 4 SFD AND BMD

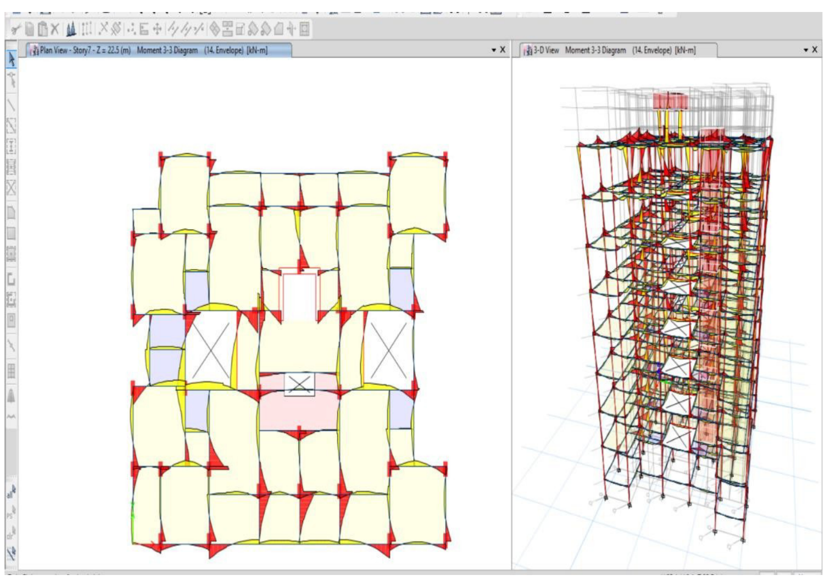


fig 5. All Load combination

Design of Slab Floor Systems

The (horizontal) floor system resists the gravity loads (dead loads and live loads) acting on it and transmits these to the vertical framing system. In this process, the floor system is subjected primarily to flexure and transverse shear, whereas the vertical frame elements are generally subjected to axial compression, often coupled with flexure and shear. The floor also serves as a horizontal diaphragm connecting together and stiffening the various vertical frame elements. Under the action of lateral loads, the floor diaphragm behaves rigidly (owing to its high in-plane flexural stiffness), and effectively distributes the lateral load effects to the various vertical frame elements and shear walls. In cast-in-situ reinforced concrete construction, the floor system usually consists of one of the following:

Wall-Supported or Beam Slab System:

In this system, the floor slabs, generally are supported on load-bearing walls (masonry) or on beams. The slab panels are usually rectangular in shape, and can be supported in a number of ways.

When the slab is supported only on two opposite sides, the slab bends in one direction only; hence, it is called a one-way slab. When the slab is supported on all four sides, and the plan dimensions of length and breadth are comparable to each other, the slab bends in two directions (along the length and along the breadth); hence, it is called a two-way slab.

However, if the plan is a long rectangle (length greater than about twice the width), the bending along the longitudinal direction is negligible in comparison with that along the transverse (short-span) direction, and the resulting slab action is effectively one-way. If the wall extends above the floor level, the slab is no more simply supported; the partial fixity at the support introduces hogging moments in the slab. Furthermore, twisting moments are also introduced at the corners that are restrained (not free to lift up).

Generally, slabs are cast in panels that are continuous over several wall supports, and are called one-way continuous or two-way continuous slabs, depending on whether the bending is predominantly along one direction or two directions. Hogging moments are induced in the slab in the region adjacent to the continuous support. In this building the slabs are designed as two-way slabs supported on beams with different end conditions and these designs.

Design of Beam

A beam is a structural element that primarily resists loads applied laterally to the beam's axis. Its mode of deflection is primarily by bending. The loads applied to the beam result in reaction forces at the beam's support points. The total effect of all the forces acting on the beam is to produce shear forces and bending moments within the beam, that in turn induce internal stresses, strains and deflections of the beam. Beams are characterized by their manner of support, profile (shape of cross-section), equilibrium conditions and their material.

Classification of beams based on supports:

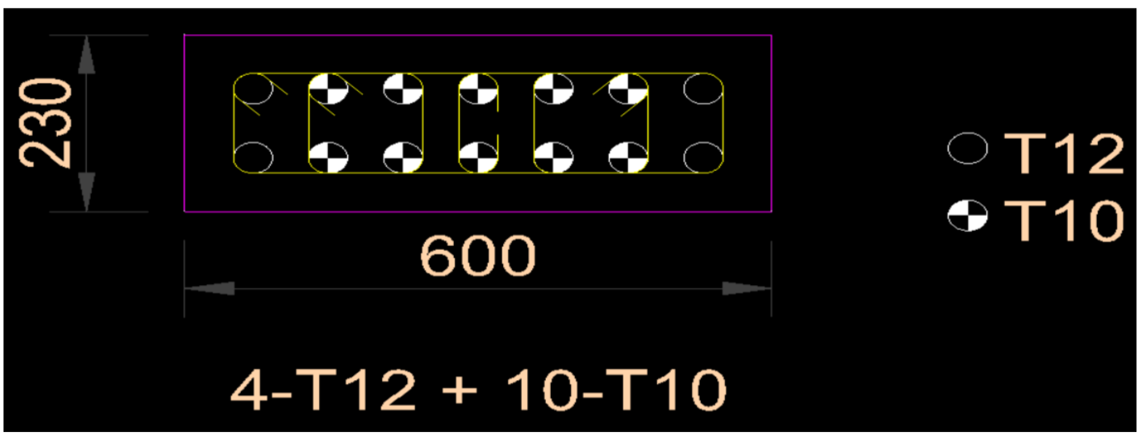
1. Simply supported – a beam supported on the ends which are free to rotate and have no moment resistance.
2. Fixed – a beam supported on both ends and restrained from rotation.
3. Over hanging – a simple beam extending beyond its support on one end.
4. Double overhanging – a simple beam with both ends extending beyond its supports on both ends.
5. Continuous – a beam extending over more than two supports.

6. Cantilever – a projecting beam fixed only at one end.

This building consists of continuous beams, simply supported beam andcantilever beam

Design of Columns

Columns are basically rigid vertical structural members designed primarily to support axial compressive loads coming from beams and slabs and then transfer it to ground through footing. These are skeletal structural elements, whose cross-sectional shapes may be rectangular, square, circular, L-shaped, etc. — often as specified by the architect. The size of the column section is dictated, from a structural viewpoint, by its height and the loads acting on it — which, in turn, depend on the type of floor system, spacing of columns, number of storeys, etc. The column is generally designed to resist axial compression combined with (biaxial) bending moments that are induced by 'frame action' under gravity and lateral loads. These load effects are more pronounced in the lower storeys of tallbuildings; hence, high strength concrete (up to 50 MPa) with high reinforcementarea (up to 4 percent of the concrete area) is frequently adopted in such cases, tominimize the column size. In some situations, the column height between floor slabs may be excessive (more than one storey height); in such cases, it is structurally desirable to reduce the unsupported length of the column by providing appropriate tie beams; otherwise, the columns should be properly designed as slender columns. The design of rectangular biaxial columns in the given building is shown below



B. fig 6. Column Reinforcement Arrangements (230X600)

Design of Footings

In a typical structure built on ground, that part of the structure which is located above ground is generally referred to as the superstructure, and the part which lies below ground is referred to as the substructure or the 'foundation structure' (or simply, foundation).

The purpose of the foundation is to effectively support the superstructure by

1. Transmitting the applied load effects (reactions in the form of vertical and horizontal forces and moments) to the soil below, without exceeding the 'safebearing capacity' of the soil, and

2. Ensuring that the settlement of the structure is within tolerable limits, and asnearly uniform as possible.

Further, the foundation should provide adequate safety against possible instability due to overturning or sliding and/or possible pull-out. Design against forces inducing overturning and sliding are of special importance in the design ofretaining walls, whose very purpose is to provide lateral support to earth fill / embankment in order to retain the side of the earth fill in a vertical position. The choice of the type of foundation depends not only on the type of the superstructure and the magnitudes and types of reactions induced at the base of the superstructure, but also on the nature of the soil strata on top of which the substructure is to be founded. There are different types of footing they are,

1. Pad footing.
2. Isolated footing.
3. Combined footing.
4. Wall footing.

Pad Footing- Foundations which carry and spread concentrated loads to the soil from superstructures is called pad foundation. They are usually placed to transfer point loads from the column or framed structures and consists of a concrete block or concrete pad. Pad foundations may be square, rectangular or circular in shape. If the padis subjected to a heavy loaded structure, the pad footing may be stepped. The loads from the structure are simply distributed by the pad to the bearing layer of soil. Pad foundations are also used to support ground beams.

Followings are the types of pad foundation used in construction

1. Plain Concrete Pad Foundation
2. Reinforced Concrete Pad Foundation
3. Combined Pad Foundation
4. Continuous Pad Foundation
5. Pad Foundations with Ground Beam

VIII. CONCLUSION:

Planning, analysis and design of G+8 multi-storey Apartment building was done. The analysis was done according to standard specifications using ETABS for different loads. The dimensions of structural members were specifiedand dead load and live load were applied. All the structural components were designed manually and detailed using AutoCAD 2018. Beams, columns and slabswere designed for bending moment, axial loads, shear and checked for deflection.The design was safe and economical design was achieved. Through this project enough analysis and design knowledge was gained.

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