Analysis and Design of Residential Building Using ETABS

V.MOUNUSHA[1], K.KARTHIK BABU[2], N.SIVAPRASADA RAO[3]
[1]PG Scholar, Department of Civil Engineering, RISE Krishna Sai Prakasam Group of Institutions
[2]Asst.Professor, Department of Civil Engineering, RISE Krishna Sai Prakasam Group of Institutions
[3]Assoc Professor& HOD, Department of Civil Engineering, RISE Krishna Sai Prakasam Group of Institutions

Abstract*—Structural Analysis is a branch which involves in the determination of behavior of structures in order to predict the responses of different structural components due to effect of loads. Each and every structure will be subjected to either one or the groups of loads, the various kinds of loads normally considered are dead load, live load, earth quake load and wind load. ETABS (Extended Three Dimensional Analysis of Building System) is a software which is incorporated with all the major analysis engines that is static, dynamic, Linear and non-linear, etc. and especially this Software is used to analyze and design the buildings. Our project "Analysis and Design of Commercial building using ETABS software" is an attempt to analyze and design a commercial building using ETABS. A G+5 storey building is considered for this study. Analysis is carried out by static method and design is done as per IS 456:2000 guidelines. Also an attempt has been made to design the structural elements manually. Drawing and detailing are done using Auto CAD as per SP 34.

***Index Terms*— G+5 storey building, ETABS software, SP 34, Auto CAD, Commercial building**

I.INTRODUCTION:

Major advances in both design and new material assisted roman architecture. Design was enhanced architectural developments in the construction of arches and roof domes. Arches improved the efficiency and capability of bridges and aqueducts (fewer supports columns were needed to support the structure), while domed roofs not only permitted the building of larger open areas undercover, but also lent the exterior an impressive. . he social unit that lives in a house is known as a household. Most commonly, a household is family unit of a same kind, though households can be other social groups, such as single person, or groups of unrelated individuals. Settled agrarian and industrial societies are composed of household units living permanently in housing of various types, according to a variety of farms of lands tenure. English-speaking people generally call any building there routinely occupy "home". Many people leave their houses during the day for work and recreation, and return to them to sleep or for other activities.

The term building in Civil Engineering is used to mean a structure having various components like foundation, walls, columns, floors, roofs, doors, windows, ventilators, stairs lifts, various types of surface finishes etc. Structural analysis and design is used to produce a structure capable of resisting all applied loads without failure during its intended life. Prior to the analysis and design of any structure, necessary information regarding supporting soil has to be collected by means of geotechnical investigation. A geotechnical site investigation is the process of collecting information and evaluating the conditions of the site for the purpose of designing and constructing the foundation for a structure. Structural engineers are facing the challenges of striving for most efficient and economical design with accuracy in solution while ensuring that the final design of a building and the building must be serviceable for its intended function over its design life time. Now a day's various software packages are available in market for analyzing and designing practically all types of structures viz. RISA, STAADPRO, ETABS, STRUDL, MIDAS, SAP and RAM etc.

ETABS is the present day leading design software in the market. Many design company's use this software for their project design purpose. So, this paper mainly deals with the comparative analysis of the results obtained from the analysis of a multi storied building structure when analyzed manually and using ETABS software. Structural response to earthquake depends on Dynamic characteristics of the structures and intensity, duration and frequency content of existing ground motion. Structural analysis means determination of the general shape and all the specific dimensions of a particular structure so that it perform the function for which it is created and will safely withstand the influences which will act on it throughout its useful life.

The effective design and construction of a earthquake resistant structures have great importance all over the world. Geographical statistics of India show that almost 54% of the land is vulnerable to earthquakes. This project presents analysis and design if multi storied residential building using ETABS software with lateral loading effect of Earthquake. This project is designed as per INDIAN CODES- IS 1893-part2:2002, IS 456:2000. This analysis is carried out by considering severe seismic zones and behavior is assessed by taking type-II Soil condition. In our project we are considering a plan under zone –IV. Seismic Intensity is Severe and Zone Factor is 0.24 at Panaji. The building is proposed to have Ordinary RC moment-resisting frame and the Response Reduction Factor(R) is 3.0 Design example of a six story building: In this paper, from the plinth to the certain height of the building the column size may differ that is it would be more when compared to the upper columns because to reduce the failure in the structure. The diaphragm is rigid.

The main beams rest on the columns to avoid local eccentricity. Comparison of analysis and design of regular and irregular configuration of multi storied building in various seismic zones using ETABS software. The center of mass is the unique point at the center of a distribution of mass in space. The center of mass is the mean location of a distribution of mass in space. Seismic Analysis of Multi-storied Building: As this project deals with the most economical column method in this project we have design the structure in an economical way by reducing the sizes in the sections. As the load is more at the bottom when compared to the top floors, there is no need of providing large sizes at the top. Economizing the column by means of column orientation is longer span longer direction will reduce the amount of bending as a result there are of the steel is reduced.

II. WORKING WITH ETABS AND LOADINGS:

2.1 ETABS:

ETABS is an engineering software product that caters to multi-story building analysis and design. Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance, modal and direct-integration time-history analyses may couple with P-Delta and Large Displacement effects. Nonlinear links and concentrated PMM or fiber hinges may capture material nonlinearity under monotonic or hysteretic behavior. Intuitive and integrated features make applications of any complexity practical to implement. Interoperability with a series of design and documentation platforms makes ETABS a coordinated and productive tool for designs which range from simple 2D frames to elaborate modern high-rises.

The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

From the start of design conception through the production of schematic drawings, ETABS integrates every aspect of the engineering design process. Creation of models has never been easier - intuitive drawing commands allow for the rapid generation of floor and elevation framing. CAD drawings can be converted directly into ETABS models or used as templates onto which ETABS objects may be overlaid. The state-of-the-art SAP Fire 64-bit solver allows extremely large and complex models to be rapidly analyzed, and supports nonlinear modeling techniques such as construction sequencing and time effects (e.g., creep and shrinkage).

Design of steel and concrete frames (with automated optimization), composite beams, composite columns, steel joists, and concrete and masonry shear walls is included, as is the capacity check for steel connections and base plates. Models may be realistically rendered, and all results can be shown directly on the structure. Comprehensive and customizable reports are available for all analysis and design output, and schematic construction drawings of framing plans, schedules, details, and cross-sections may be generated for concrete and steel structures.

ETABS provides an unequaled suite of tools for structural engineers designing buildings, whether they are working on one-story industrial structures or the tallest commercial high-rises. Immensely capable, yet easy-to-use, has been the hallmark of ETABS since its introduction decades ago, and this latest release continues that tradition by providing engineers with the technologically-advanced, yet intuitive, software they require to be their most productive.

2.2 LOADS CONSIDERED:

2.1 DEAD LOADS:

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m" and 25 kN/m" respectively

2.2 IMPOSED LOADS:

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

2.3 SEISMIC LOAD:

2.3.1 Design Lateral Force:

The design lateral force shall first be computed for the building as a whole. This design lateral force shall then 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.

2.3.2 Design Seismic Base Shear:

The total design lateral force or design seismic base shear (Vb) along any principal direction shall be determined by the following expression:

$$V_b = Ah\ W$$

Where,

Ah = horizontal acceleration spectrum

W = seismic weight of all the floors

2.3.3 Fundamental Natural Period:

The approximate fundamental natural period of vibration (T,), in seconds, of a moment-resisting frame building without brick in the panels may be estimated by the empirical expression:

$Ta=0.075\ h^{0.75}$ for RC frame building

$Ta=0.085\ h^{0.75}$ for steel frame

h = Height of building, in m. This excludes the basement storey's, where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storeys, when they are not so connected. The approximate fundamental natural period of vibration (T,), in seconds, of all other buildings, including moment-resisting frame buildings with brick lintel panels, may be estimated by the empirical Expression:

$$T=.09H/\sqrt{D}$$

Where,

h= Height of building

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

2.3.4 Distribution of Design Force:

Vertical Distribution of Base Shear to Different Floor Level

The design base shear (V) shall be distributed along the height of the building as per the following expression:

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

Qi=Design lateral force at floor i,

Wi=Seismic weight of floor i,

hi=Height of floor i measured from base, and

n=Number of storey's in the building is the number of levels at which the masses are located. Distribution of Horizontal Design Lateral Force to Different Lateral Force Resisting Elements in case of buildings whose floors are capable of providing rigid horizontal diaphragm action, the total shear in any horizontal plane shall be distributed to the various vertical elements of lateral force resisting system, assuming the floors to be infinitely rigid in the horizontal plane. In case of building whose floor diaphragms cannot be treated as infinitely rigid in their own plane, the lateral shear at each floor shall be distributed to the vertical elements resisting the lateral forces, considering the in-plane flexibility of the diagram.

III. Dynamic Analysis:

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following

Buildings:

a) *Regular buildings* -Those greater than 40 m in height in Zones IV and V and those Greater than 90 m in height in Zones II and 111.

b) *Irregular buildings* – All framed buildings higher than 12m in Zones IV and V and those greater than 40m in height in Zones 11 and III.

The analytical model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration. Buildings with plan irregularities cannot be modeled for dynamic analysis.

For irregular buildings, lesser than 40 m in height in Zones 11and III, dynamic analysis, even though not mandatory, is recommended. Dynamic analysis may be performed either by the Time History Method or by the Response Spectrum Method. However, in either method, the design base shear (VB) shall be compared with a base shear (VB)

3.1 Time History Method:

Time history method of analysis shall be based on an appropriate ground motion and shall be performed using accepted principles of dynamics.

3.2 Response Spectrum Method:

Response spectrum method of analysis shall be performed using the design spectrum specified, or by a site-specific design spectrum mentioned.

3.3 PHYSICAL PARAMETERS OF BUILDING:

- Live load on the floors is 4 kN/m^2
- Live load on the roof is 1.5 kN/m^2
- Column = 0.23 * 0.45 m
- Beams = 0.5 * 0.3 m
- All slabs = 0.125 m thick
- Parapet = 0.115 m thick
-

IV. MODELING AND ANALYSIS:

4.1 MODELING:

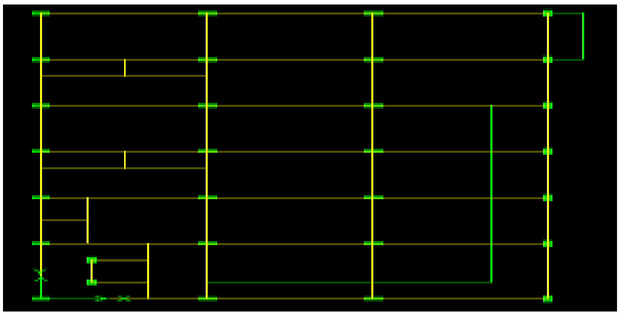

Fig 4.1: Plan of the building

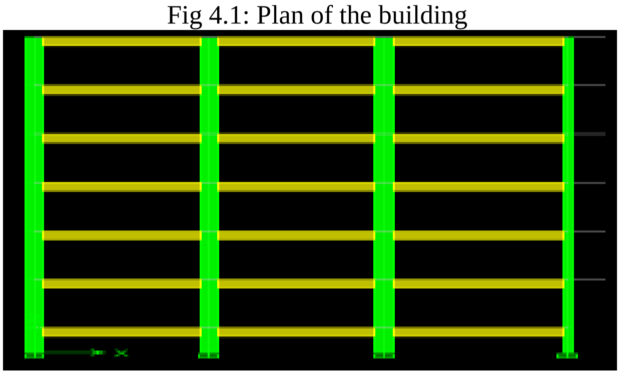

Fig 4.2: Elevation of the building

V. Wind Pressure Calculation:

Design Wind Pressure PZ = $0.6*(V_Z^2)$

Design Wind Speed Vz = Vb*K1*K2*K3

Risk Coefficient Factor "K1" = 1.08

(IS: 875-1987(part3), sec 5.3.1, Table -1)

Terrain & Height Factor "K2" = varies with height (table 3.1)

(IS: 875-1987(part3), sec 5.3.2, Table -2)

According To Table -2"K2" = 1.1055

** "K2" Values are linearly interpolated **

Topography Factor "K3" =1.00

(IS: 875-part-3, sec 5.3.3.1)

Basic Wind speed

V_B=50 m/sec (Vizag)

Design Wind Speed

Vz = Vb*K1*K2*K3 = 50*1.08*1.1055*1.00*1 = 59.697m/sec

Design Wind Pressure PZ = 0.6 (V_Z^2) = 0.6* $(59.697)^2$ = 2.13 KN/m^2

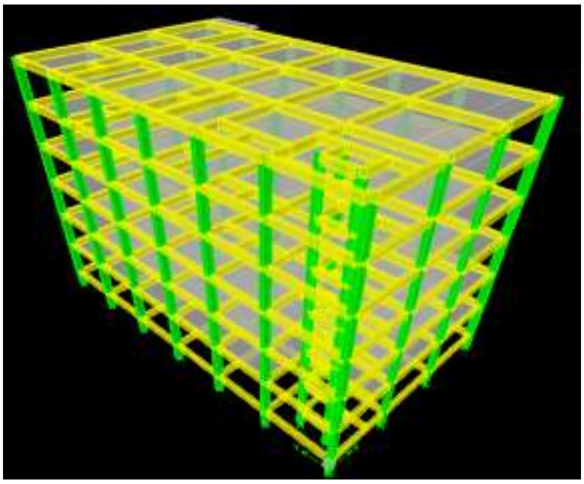

Fig 5.1: 3D- Modeling of the Building

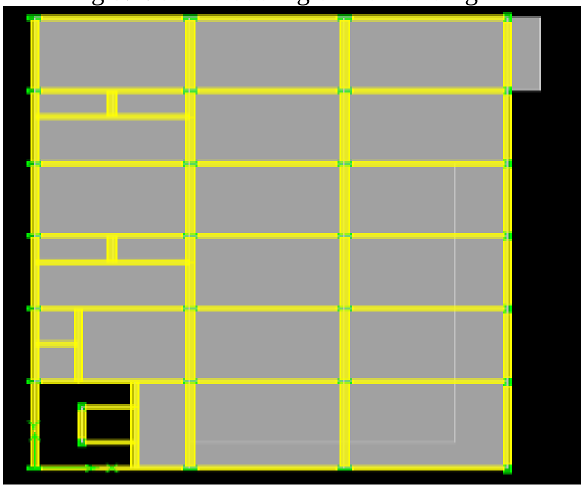

Fig 5.2: 3D- Modeling of the Building Plan

VI. ANALYSIS AND RESULTS:

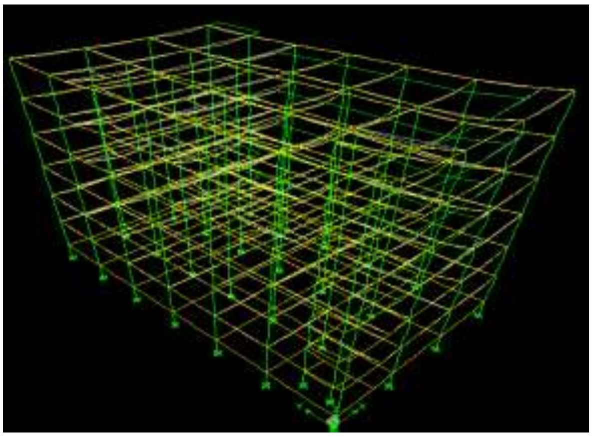

Fig 6.1 Deform Shape of the Building

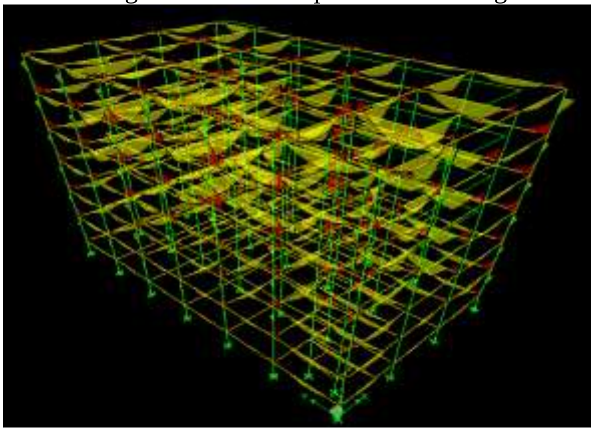

Fig 6.2: Bending Moment of the Beams

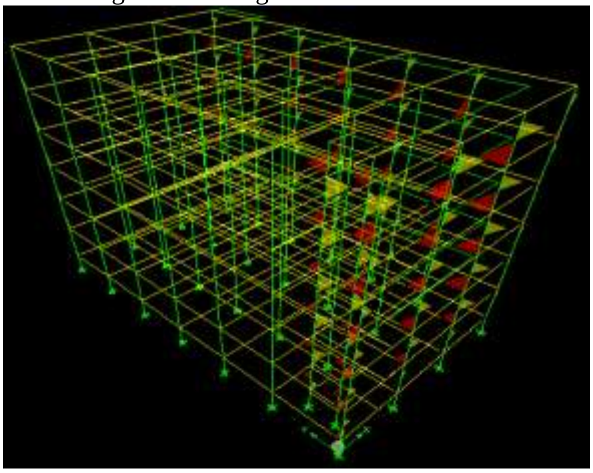

Fig 6.3: Bending Moment of the Columns

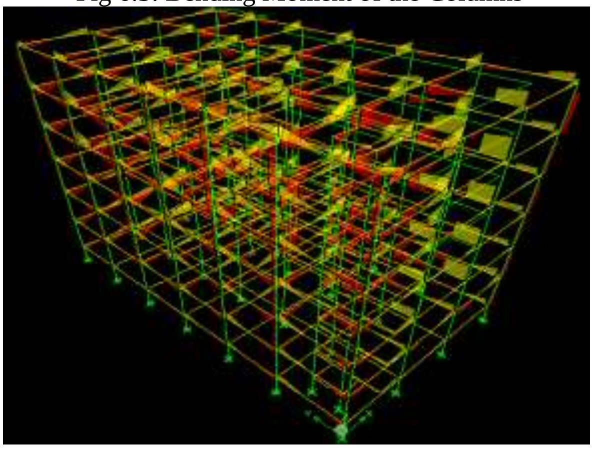

Fig 6.4: Shear Force of the Beams

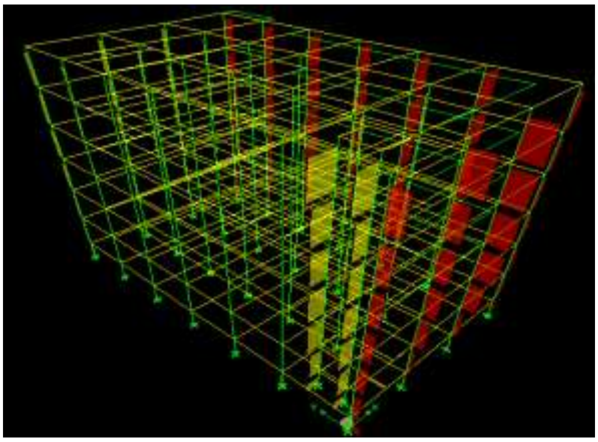

Fig 6.5: Shear Force of the Columns

6.1 RESULTS FROM ETABS:

DESIGN OF SINGLY REINFORCED BEAM:
Depth of beam D = 500mm
B = 230mm
Maximum positive bending moment at left support
= 107.66KN-m
Maximum positive bending moment at mid span =64.89KN-m
Maximum negative bending moment at right support = 129.88KN-m
Shear force = $\frac{wl}{2} = \frac{38.1x6.21}{2} =$
Depth from bending moment consideration
d = 216.92mm
d<D, therefore single reinforced beam
d = 555mm
D = 555+40 =595 = 600mm

6.2 DESIGN OF DOUBLY REINFORCED BEAM:
Taking b=230mmD=450mm
Max negative bending moment at left support =122.17kN
Max positive bending moment at mid span=67.56mm
Max negative bending moment at right support =134.11KN
Maximum shear force=151.03kN
Depth from bending moment consideration:-
D=460mm
Hence it is a doubly reinforcement beam
Taking d=420mm D=450mm

6.3 ANANLYSIS AND DESIGN OF FOOTING:
The analysis and design of footing can be broadly divided in the following steps:

- Determination of the area of footing.
- Determination of bending moments and shears at critical section and fixing the depth of footing.
- Determination of the area reinforcement.
- Check for development length at critical section.

6. 4 DESIGN OF SLAB:
The slab can be made to span in one direction (one way) or two direction (two way), depending on support conditions, aspect ratio is Ly/Lx, ratio of reinforcement in two directions. The designer is free to decide as to whether slab should be designed as one way or two ways. The points to be considered in making a decision i.e., whether slab should be designed as one way or two ways.

a) The slab acts as two way slab when $(L_y/L_x)<2$
A slab acts as one way when $(L_y/L_x)>2$
b) A two way slab is economical compare to one way slab, because steel along with directions acts as main steel and transfers loads to all supports, while in one way slab, main steel is provided along short span only and load is transferred to either of two supports.
c) Two way is advantageous, essentially for large spans (greater then 3m) and for live loads greater than 3 KN/Sqm. for short and light loads steel require for two way slab does not appreciably differ as compare to steel for one way slab because of requirement of main steel

VII. CONCLUSION:
Analysis and design of a residential building having G+ 5 storeys is done. Analysis is done by using the software ETABS V9.2, which proved to be premium of great potential in analysis and design of various sections. The structural elements like RCC frame and retaining walls are also provided. As per the soil investigation report, an isolated footing is provided. The design of RCC frame members like beam and column was done using ETABS. 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.

REFERENCES

[1]. Reinforced Concrete Design- N. Krishna Raju and R.N. Pranesh
[2]. Limit State Theory And Design Of Reinforced Concrete- Dr. V. L. Shah and Dr. S. R.Karve
[3]. Theory Of Structures- S Ramamrutham.
[4]. Limit State Design- Dr. Ramchandra
[5]. IS. 456: 2000, Indian Standard Plain and Reinforced Concrete - Code of Practice, Bureau of Indian Standards, New Delhi.
[6]. IS: 875 (Part I) - 1987, Indian Standard Code of Practice for Design Loads (Other than Earthquake) (Dead Loads) for Buildings and Structures, Bureau of Indian Standards, New Delhi.
[7]. IS: 875 (Part 2) - 1987, Indian Standard Code of Practice for Design Loads (Other than Earthquake) (Imposed Loads) for Buildings and Structures, Bureau of Indian Standards, New Delhi.
[8]. IS: 875 (Part 3) - 1987, Indian Standard Code of practice for design loads (other than earthquake) (Wind Loads) for buildings and structures, Bureau of Indian Standards, New Delhi.