Analysis & Design of Residential Buildings Using E-TABS

SK MASTAN SHAREEF[1],
PG Scholar, Rise Krishna Sai Prakasam Group of Institutions, Ongole
P SRINIVASULU REDDY[2]
Assistant Professor, Rise Krishna Sai Prakasam Group of Institutions, Ongole

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—E-Tabs, Buildings, Structural Analysis AUTO CADD

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 days 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 analysed 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.

II. LITERATURE SURVEY

Varalakshmi V et.al (2014) analyzed a G+5 storey residential building and designed the various components like beam, slab, column and foundation. The loads namely dead load and live load were calculated as per IS 875(Part I & II)-1987 and HYSD bars i.e. Fe 415 are used as per IS 1986- 1985. They concluded that the safety of the reinforced concrete building depends upon the initial architectural and structural configuration of the total building, the quality of the structural analysis, design and reinforcement detailing of the building frame to achieve stability of elements and their ductile performance.

Chandrashekar et.al (2015) analyzed and designed the multi-storeyed building by using ETABS software. A G+5 storey building under the lateral loading effect of wind and earthquake was considered for this study and analysis is done by using ETABS. They have also considered the chances of occurrence of spread of fire and the importance of use of fire proof material up to highest possible standards of performance as well as reliability. They suggested that the wide chances of ETABS software which is very innovative and easier for high rise buildings so that time incurred for designing is reduced.

Balaji.U and Selvarasan M.E (2016) worked on analysis and design of multi-storeyed building under static and dynamic loading conditions using ETABS. In this work a G+13 storey residential building was studied for the earth quake loads using ETABS. They assumed that material property to be linear, static and dynamic analyses were performed. The non-linear analysis was carried out by considering severe seismic zones and the behaviour was assessed by considering type II soil condition. Different results like displacements, base shear were plotted and studied.

Geethuet.al(2016) made a comparative study on analysis and design of multi storied building by STAAD.Pro and ETABS softwares. They provided the details of both residential and commercial building design. The planning was made in accordance with the national building code and drafted using Auto CAD software. They concluded that while comparing both software results, ETABS software shows higher values of bending moment and axial force.

Ragy Jose, - Structural Analysis is a branch which involves in the determination of behaviour 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+3 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.

C.V.S. Lavanya in purpose of this software is to design multistoried building in a systematic process. The effective design and construction of earthquake resistant structures have great importance all over the world. This project presents multistoried residential building analyzed and designed with lateral loading effect of earthquake using ETABS. 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 behaviour is assessed by taking type-II Soil condition.

GOLAKOTI SURYA KARTEEK ETABS stands for Extended Three dimensional Analysis of Building Systems. ETABS is commonly used to analyze: Skyscrapers, parking garages, steel & concrete structures, low and high rise buildings, and portal frame structures. ETABS was used to create the mathematical model of the BurjKhalifa, designed by Skidmore, Owings and Merrill LLP (SOM). The input, output and numerical solution techniques of ETABS are specifically designed to take advantage of the unique physical and numerical characteristics associated with building type structures. On ETABS we can analyse and design any shape of R.C.C buildings like rectangular, T, C, L and I-shape. In this project, we mainly emphasizes on structural behaviour of multi-storey building for different plan configurations like T-shape and L-shape. Modelling of 10-storeys R.C.C. framed building is done on the ETABS Software for analysis. Post analysis of the structure, maximum shear forces, bending moments, and maximum storey displacement are computed and then compared for all the analyzed cases.

III. PROPOSED METHOD

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.

3.2 Loads Considered:

3.2.1 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.

3.2.2 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.

3.2.3 Seismic Load:

3.2.3.1 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.

3.2.3.2 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:

$$\mathbf{V_b = Ah\ W}$$

Where,

Ah = horizontal acceleration spectrum

W = seismic weight of all the floors

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 buildings

h = Height of building, in m. This excludes the basement storeys, 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:

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

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.

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 storeys 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.

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 Greaterthan 90 m in height in Zones II and 111.

b) *Irregular buildings* – All framed buildings higher than 12m in Zones IV and V and thosegreater 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 modelled 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)

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.

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:

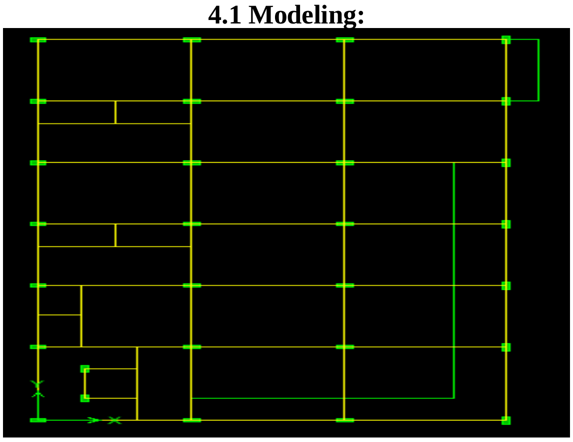


Fig 4.1: Plan of the building

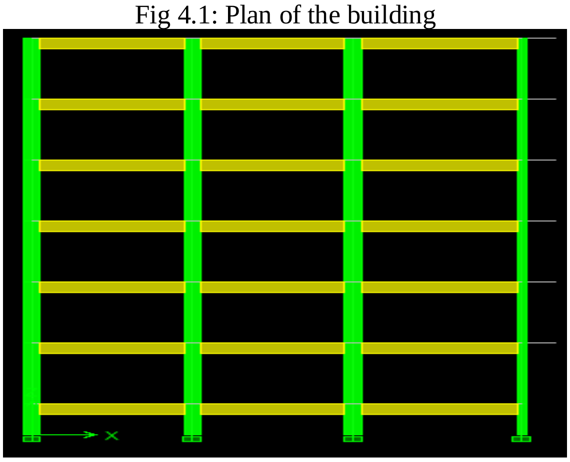
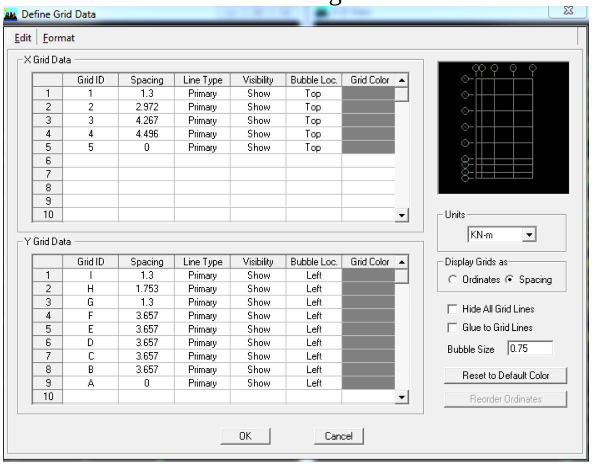


Fig 4.2: Elevation of the building



4.2 Material Property:

In this study use M25 grade concrete and Fe 500 grade of steel for design.

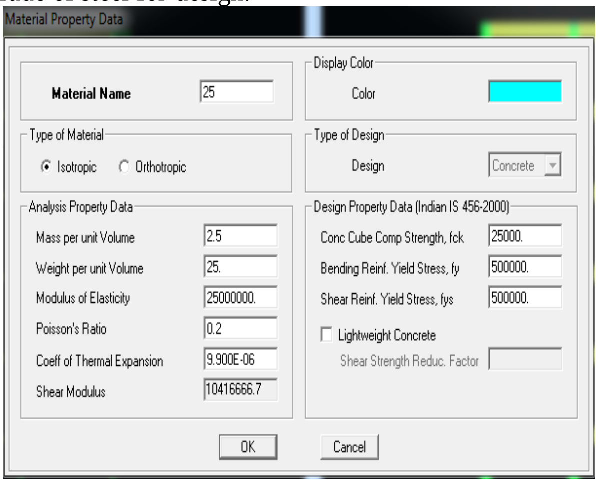


Fig 4.4: Define Material Property

4.3 Section Properties:

Size of column used in this study is 230x450 mm and size of the beam is 230x500 mm. The size of the plinth beam is 230x300 mm.

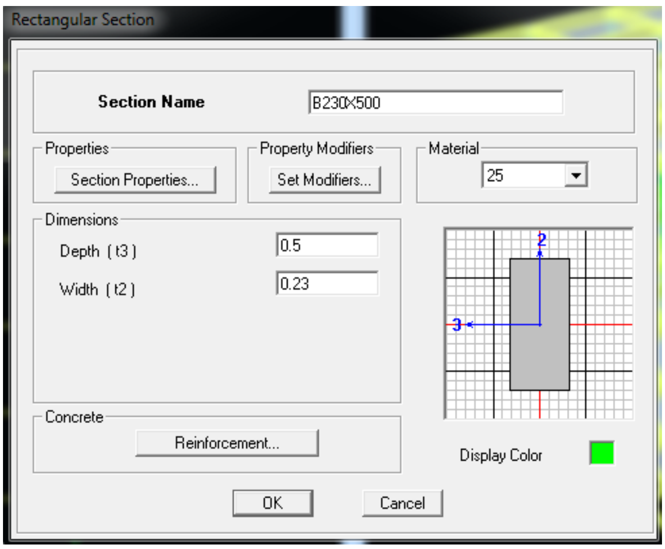


Fig 4.5: Define Beam Section Property

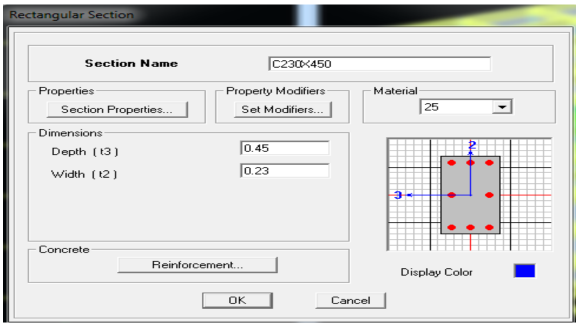


Fig 4.6: Define Column Section Property

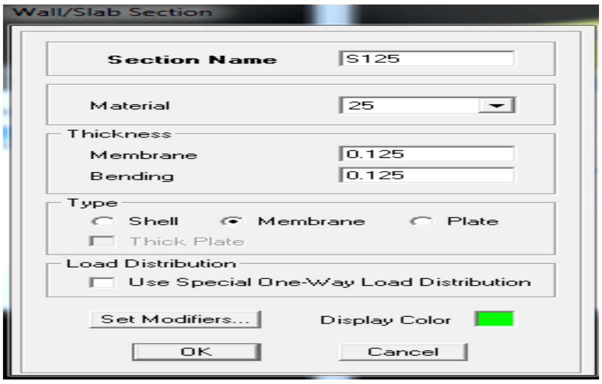


Fig 4.7: Define Slab Thickness Property

4.4 Loads And Load Cases:

In this study we consider the dead load, live load, wind load and seismic loads are consider to analyze the residential building. The Dead load of the building is considered from IS 875 – Part-1. Live load of the building was considered from IS 875 – Part-2.

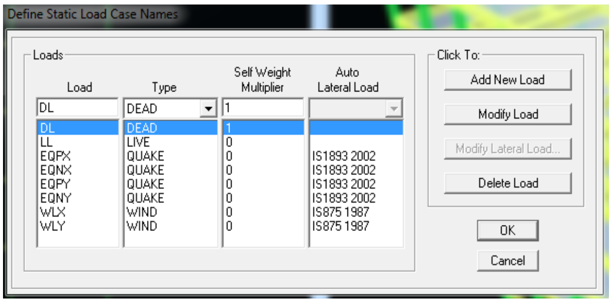


Fig 4.8: Define Load Cases

The Seismic weight of the buildig was claculated as per IS 1893-2002.

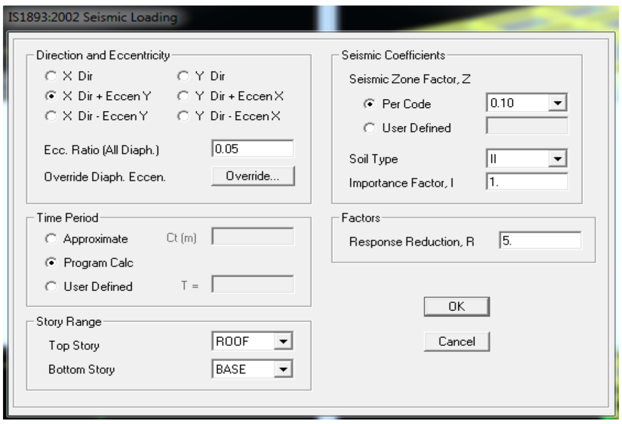


Fig 4.9: Define Earth Quake Load Cases

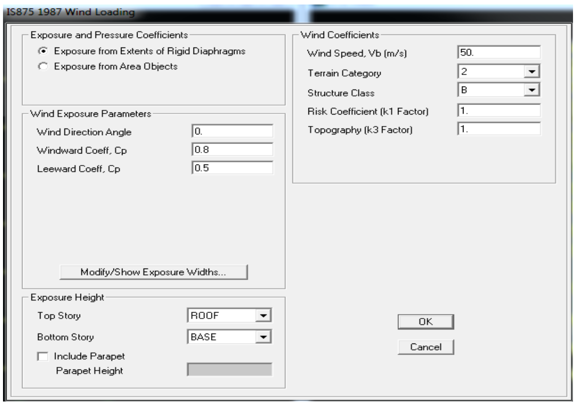


Fig 4.9: Define Wind Load Cases

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

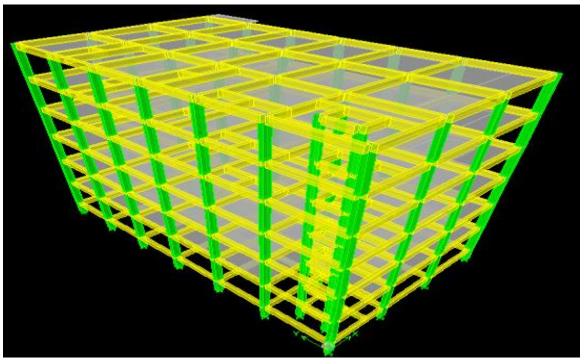


Fig 4.10: 3D- Modeling of the Building

V.ANALYSIS AND RESULTS

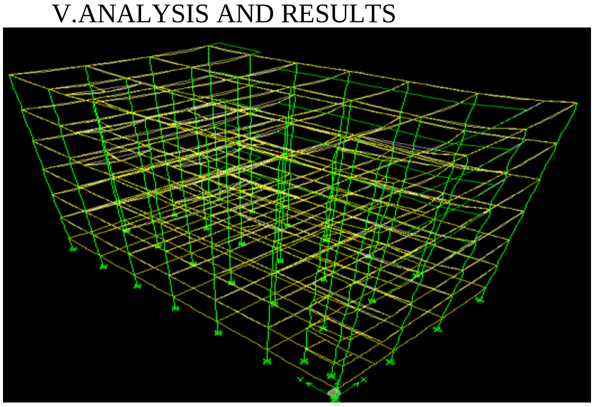


Fig 5.1 Deform Shape of the Building

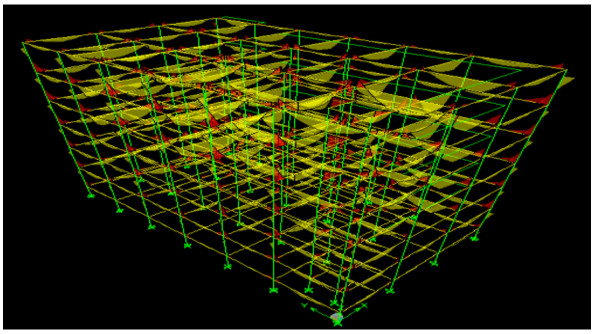


Fig 5.2: Bending Moment of the Beams

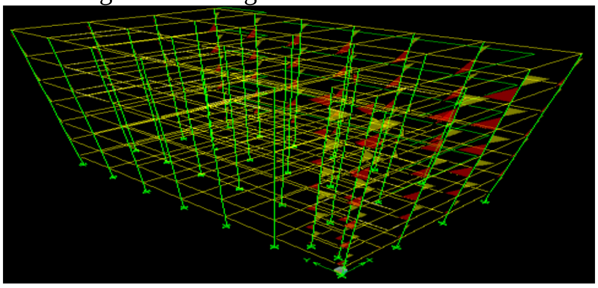


Fig 5.3: Bending Moment of the Columns

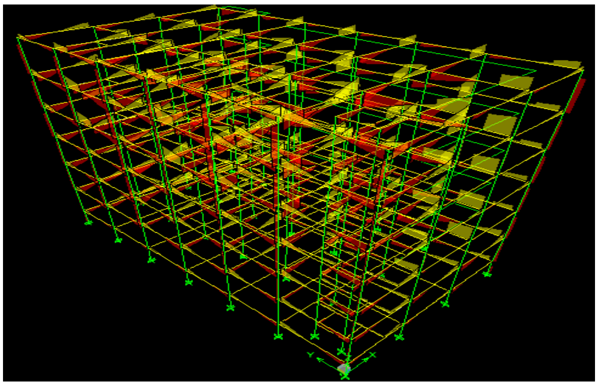


Fig 5.4: Shear Force of the Beams

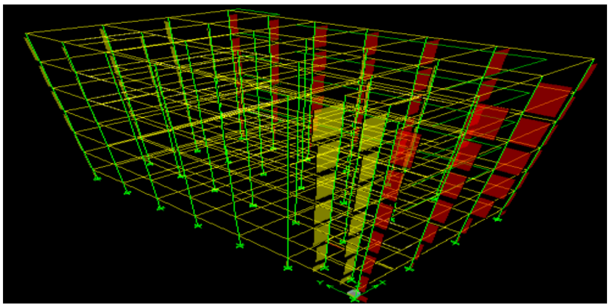


Fig 5.5: Shear Force of the Columns

VI. 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.
[9]. IS 1893 (Part 1):2002, Indian Standard Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi.