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Analysis of a G+5 Residential building using E-Tabs

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Abstract- **In the era of 21st century the buildings that are being constructed are gaining significance, in general, those with best possible outcomes with reference to optimal sizing and reinforcing of the structural elements, mainly beam and column members in multi–storey RC structures. This project paper presents multi-story residential building analyzed and designed with lateral loading effect of earthquake and wind, shear analysis of slab, shear force for the beam and area reinforcement for the frames depending upon the reaction, and on safe bearing capacity of soil due to stability using ETABS. This project is designed as per INDIAN STANDARD CODES. This analysis is carried out by considering several seismic zones. The entire procedure of structural planning along with design need not only conceptual thinking and imagination also in depth knowledge of science of structural engineering besides knowledge of practical aspects, such as byelaws and recent design codes, backed up by sufficient experience, intuition and judgement. It may be clarified that Code of practice, which is compendia of good practices drawn up by experienced engineers, is intended as guides to engineers and should never be allowed to replace the conscience and competence of the engineer's. The purpose of standards is to ensure and enhance the safety, keeping careful balance between economy and safety. My research includes storey forces and max/avg storey drifts, modal period and frequencies including Graphical presentation of this reading and charts showing the variation in drifts per storey. This paper also includes area reinforcement of frames, frame planning, beam and column shedules indicating all general information as well as the planning of shear wall for lift area. These results effect of Wind and Seismic forces. Shear forces and bending moments of beams and columns are observed and concluded that larger span have more shear forces and bending moment.**

Index Terms- **ETABS Software Tool, Seismic Analysis, Multi-Storied Residential Building.**

I. INTRODUCTION

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.

Fundamental to ETABS modeling is the generalization that multi-story buildings typically consist of identical or similar floor plans that repeat in the vertical direction. Modeling features that streamline analytical-model generation, and simulate advanced seismic systems, are listed as follows:

- Templates for global-system and local-element modeling
- Customized section geometry and constitutive behavior
- Grouping of frame and shell objects
- Link assignment for modeling isolators, dampers, and other advanced seismic systems
- Nonlinear hinge specification
- Automatic meshing with manual options
- Editing and assignment features for plan, elevation, and 3D views

Loading, Analysis, and Design

Once modeling is complete, ETABS automatically generates and assigns code-based loading conditions for gravity, seismic, wind, and thermal forces. Users may specify an unlimited number of load cases and combinations.

Analysis capabilities then offer advanced nonlinear methods for characterization of static-pushover and dynamic response. Dynamic considerations may include modal, response-spectrum, or time-history analysis. P-delta effect account for geometric nonlinearity.

Given enveloping specification, design features will automatically size elements and systems, design reinforcing schemes, and otherwise optimize the structure according to desired performance measures.

Aim- To carry out the Analysis of a 5 storey building using software E-TABS. This analysis is done by applying different load combinations of Dead load and live load according to the Indian standard provisional codes acting in different region of the floor.

Objectives-

a) To analyse and design G+ 5 Residential building using ETABS software.
b) To design structural components like beam, slab and column manually.
c) To check the stability of the structure and analyse the structure in E-tabs
d) To draw and give reinforcement details of structural components by using Auto CAD.

Scope of work- The scope of study is to produce good structural work for performing analysis and design for a residential building.

II. LITERATURE REVIEW

1. R.D.Deshpande, Manoj. N. Pai, N. Pawan, Aashish.P.Pednekar et.al[5] (2017)

Worked on “ANALYSIS, DESIGN AND ESTIMATION OF BASEMENT+G+2 RESIDENTIAL BUILDING” and studied that Structural analysis is a branch which involves determination of behavior of structures in order to predict the responses of real structures such as buildings, bridges, trusses etc, with economy, elegance, serviceability and durability of structure. Structural engineers are facing the challenge of striving for the most efficient and economical design with accuracy in solution, while ensuring that the final design of a building must be serviceable for its intended function over its design lifetime. This project attempts to understand the structural behavior of various components in the multi-storied building. Analysis, designing and estimation of multi-storied building has been taken up for Basement+G+2 Building, thereby depending on the suitability of plan, layout of beams and positions of columns are fixed. Dead loads are calculated based on material properties and live loads are considered according to the code IS875-part 2, footings are designed based on safe bearing capacity of soil. For the design of columns and beams frame analysis is done by limit state method to know the moments they are acted upon. Slab designing is done depending upon the type of slab (one way or two way), end conditions and the loading. From the slabs the loads are transferred to the beams, thereafter the loads from the beams are taken up by the columns and then to footing finally the section is checked for the components manually and using ETABS 15.0.0 software for the post analysis of structure, maximum shear force, bending moment and maximum storey displacement are computed. The quantitative estimation has been worked out.

2) Mohammed Tosif, Ahmed Syed Zameer, Mohammed fareed, Mohammed Nawaz et.al[3] (2017)

Worked on “Analysis of Multi-Storeyed Residential Building” saying that Urban regions are rapidly developing with huge buildings of different kind in which most common used is reinforced cement concrete framed structure. To have a safer stability of R.C.C structure the structural design should be run accordance with the codal provision with respective to the country. To understand the methodology and procedure for the analysis, a commercial multi-storied R.C.C building is of G+2 which is situated in sangareddy, dist is taken into consideration for the analysis. Manually the tributary loads distribution of floors to corresponding beams has been done, one of the frame of the building has been selected, and all the necessary loads have been worked out and distributed with respect to the storey levels. Manually linear static analysis has been done using KANI’S method of rotational contribution. The frame is also analyzed in SAP2000v17.3, and all the important results, such as major bending moment, major shear force and axial loads have been calculated and a comparison is made between manual calculations and SAP2000.

3) K. Naga Sai Gopal, N. Lingeshwaran et.al[2] (2017)

Worked on “Analysed and design of G+5 residential building using Etabs” and stated that we are living in the 21 designed to resists the Earthquake, W by the various software like ETABS, STAAD.Pro, TEKLA in this project we used the ETABS software stress analysis in slab, shear force for column and design the foundation depends upon the reaction and height of the foundation level depends upon site and safe bearing capacity of the soil stability purpose designed the retaining wall in this project.

Results of Analysis Shear Force for the analysis part Shear and bending moment diagrams are analytical tools analysis to help perform force and bending moment at a given point of a structural element such as a beam.

4) Md. Mustaq, Divya Bharathi et.al[4] (2016)

Worked on "Optimized Design of a G+20 Storied Building Using ETABS" giving information of the present scenario of construction industry, the buildings that are being constructed are gaining significance, in general, those with best possible outcomes with reference to optimal sizing and reinforcing of the structural elements, mainly beam and column members in multi-bay and multi storey RC structures. Optimal sizing incorporates optimal stiffness co-relation among structural members and results in cost savings over the typical state-of-the practice design solutions. "Optimization" means making things the best.

The race towards new heights and architecture has not been without challenges. When the building increases in height, the stiffness of the structure becomes more important. Tall structures have continued to climb higher and higher facing strange loading effects and very high loading values due to dominating lateral loads. The design criteria for tall buildings are strength, serviceability, stability and human comfort. Thus the effects of lateral loads like wind loads, earthquake forces are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength and stability against lateral loads.

Lateral load on tall buildings is most critical one to consider for the design. In order to observe the seismic effect and wind effect on tall building, a study on G + 20 storey's are taken for four different cases of structural system. The structural response due to lateral loads with load combinations is extracted. Effect of lateral load on moments, axial forces, shear force, base shear, maximum storey drift and tensile forces on structural system are studied.

5) Rinkesh R Bhandarkar, Utsav M Ratanpara, Mohammed Qureshi et.al[6] (2017)

Worked on **"Seismic Analysis & Design of Multistory Building Using Etabs"**

E-tabs are mostly used to analyze concrete& steel structure, low& high rise buildings, skyscrapers& portal frames structure. In this project we had studied structural behavior of multi-story building (G+7) on E-tabs.

6. C.V.S. Lavanya, Emily.P.Pailey, Md. Mansha Sabreen et.al[1] (2017)

Worked on "ANALYSIS AND DESIGN OF G+4 RESIDENTIAL BUILDING USING ETABS"

ETABS stands for Extended Three Dimensional Analysis of Building Systems. The main purpose of this software is to design multi-storeyed building in a systematic process. The effective design and construction of an earthquake resistant structures have great importance all over the world. This project presents multi-storeyed residential building analysed 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.

III. METHODOLOGY

Steps

The centre line diagram is prepared and imported to ETAB model, and the following step by step procedures are followed:

Step - 1: Initial setup of Standard Codes and Country codes

Step - 2: Creation of Grid points & Generation of structure

After getting opened with ETABS we select a new model and a window appears where we had entered the grid dimensions and story dimensions of our building.

Step - 3: Defining of property

Here we had first defined the material property by selecting define menu material properties. We add new material for our structural components (beams, columns, slabs) by giving the specified details in defining. After that we define section size by selecting frame sections as shown below & added the required section for beams, columns etc.

Step - 4: Assigning of Property

After defining the property, we draw the structural components using command menu. Draw line for beam for beams and create columns in region for columns by which property assigning is completed for beams and columns.

Step - 5: Assigning of Supports

By keeping the selection at the base of the structure and selecting all the columns we assigned supports by going to assign menu joint\frame Restraints (supports) fixed.

Step - 6: Defining of loads

In ETABS all the load considerations are first defined

Grade of concrete	25
Grade of steel	Fe 500
Live loads	2kN/m^2
SDL (floor finish)	1.5kN/m^2
SDL (wall loads inner and outer respectively)	9 kN/m^2 and 14kN/m^2
Beam size	115mm x 450mm 230mm x 450mm 300mm x 450mm 400mm x 600mm 510mm x 720mm 570mm x 780mm
Column size	300mm x 600mm
Slab depth	115mm, 150mm
Zone	3
Soil type	II
Importance factor	1
Terrain category	2
Time period - Ty	0.0206
Time period - Tx	0.0207
Vb	39
Ecc. ratio (all diaph.)	0.05
Sesmic zone factor, Z	0.24
Response Reduction factor R	5

and then assigned. The loads in ETABS are defined as using static load cases command in define menu.

Step - 7: Assigning of Dead loads

After defining all the loads. Dead loads are assigned for external walls, internal walls instead but in E-TABS automatically taken care by the software i.e., inbuilt

Step - 8: Assigning of Live loads

Live loads are assigned for the entire structure including floor finishing.

Step - 9: Assigning of wind loads

Wind loads are defined and assigned as per IS 875 1987 PART 3 by giving wind speed and wind angle. But since this is a G+5 Residential Building having total height less than 16 meters there is no need of assigning of wind loads or earth quake loads.

Step - 10: Assigning of Seismic loads

Seismic loads are defined and assigned as per IS 1893: 2002 by giving z one, soil type, and response reduction factor in X and Y directions. But since this is a G+5 Residential Building having total height less than 15 meters there is no need of assigning Seismic loads.

Step - 11: Assigning of load combinations

Using load combinations com mand in define menu 1.5 times of dead load and live load will be taken as mentioned in above.

Step - 12: Analysis

After the completion of all the above steps we have performed the analysis and checked for errors.

Step - 13: Design

After the completion of analysis, we had performed concrete design on the structure as per IS 456:2000. ETABS performs the design for every structural element.

IV. DATA COLLECTION

Building detail- To carry out the work in ETABS software the properties of the materials such as concrete and steel should be defined. Similarly the loads should be defined such as live load, super dead loads.

Description of Loads

- All moving loads come under live loads.

Live load (on floors): 2kN/m^2, (IS 875:1987 – Part -2)

Live load (on roof): 1kN/m^2, (IS 875:1987 – Part -2)

- Floor finishes are the super imposed dead loads.

Floor Finishes (on floors): 1.5kN/m^2

Floor Finishes (on roof): 2kN/m^2

- Wall loads are the loads of bricks used in construction.

For 10” wall (outer wall): 14kN/m^2

(wall thickness*height of the floor*density of brick = 0.26*3*18)

V. ARCHITECTURE PLAN

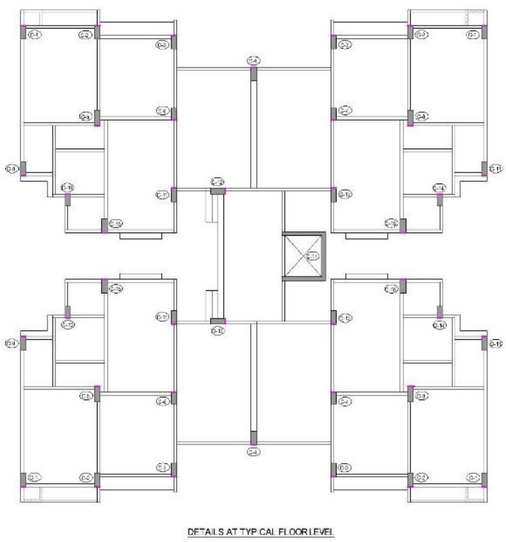


Fig 1: Architecture plan

VI. RESULTS

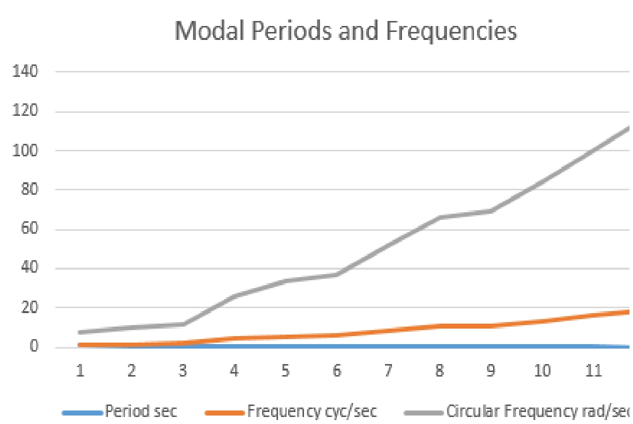
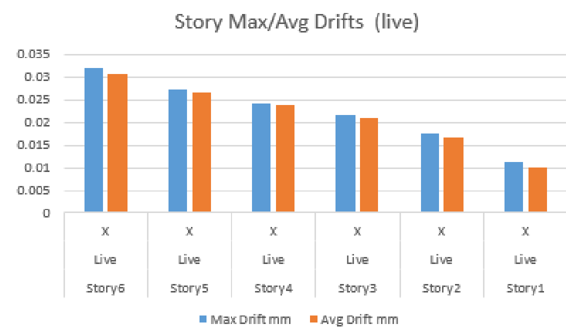
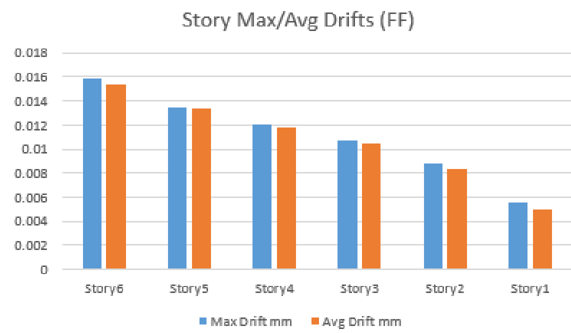
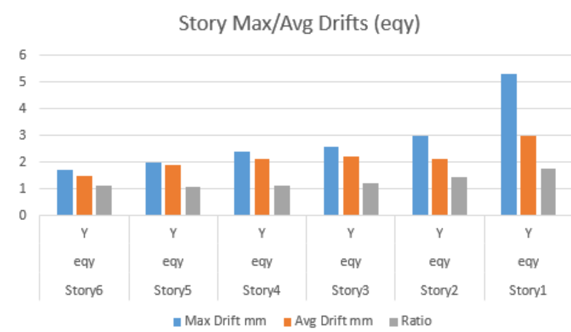


Fig 2: Modal period and frequencies







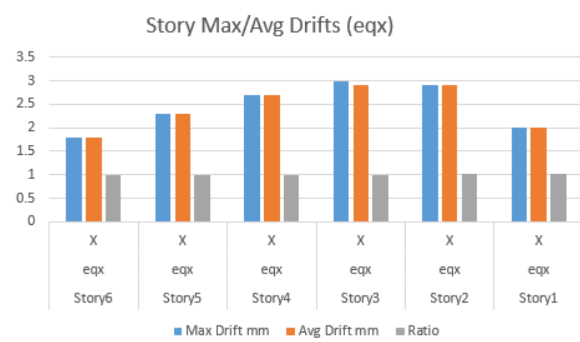


Fig 3: Story max/avg displacement

Design of column

Calculation of loads: (Approximate method)

1) Roof (terrace slab) :
   Self weight of Slab = D x density of concrete = 0.15 x 25 = 3.75 KN/m^2
   L.L. = 1 KN/m^2
   Roof finish = 2 KN/m^2
   Total load = 6.75 KN/m^2
   Total factored load = 9.375 KN/m^2

2) Typical floor:
   Self weight of Slab = D x density of concrete = 0.15 x 25 = 3.75 KN/m^2
   L.L. = 2 KN/m^2
   Roof finish = 1.5 KN/m^2
   Total load = 6.75 KN/m^2
   Total factored load = 10.125 KN/m^2

3) Walls:
   Wt. of internal wall = 0.3 x 2.85 x 20 = 8.55 KN/m^2
   Factored weight = 12.825 KN/m^2

4) Main beam
   Size = 570 x 780
   Wt. = 0.57 x 0.78 x 25 = 11.11 KN/m^2
   Factored Wt. = 16.67 KN/m^2

5) Secondary beam
   Size = 400 x 600
   Wt. = 0.4 x 0.6 x 25 = 6 KN/m^2
   Factored Wt. = 9 KN/m^2

Floor area transferring to column = 4.08m^2
Length of wall = (2.4 x 1.7) + 2/2(3) = 7.1m
Length of main beam = 5.2m
Length of secondary beam = 1.49m

Loads on a column:

1) **Roof and 5th floor:**
   Roof slab = 4.08 x 9.375 = 38.25
   Walls = 7.1 x 12.825 = 91.05
   Main beam = 4.1 x 16.67 = 68.34
   Secondary beam = 1.49 x 9 = 13.41
   Total = 38.25 + 91.05 + 91.05 + 7.137 = 211.05

2) **5th and 4th floor:**
   Roof slab = 4.08 x 10.125 = 41.31
   Walls = 7.1 x 12.825 = 91.05
   Main beam = 4.1 x 16.67 = 68.34
   Secondary beam = 1.49 x 9 = 13.41
   Total = 41.31 + 91.05 + 68.34 + 13.41 = 214.11
   Load from above floor = 211.05+ 214.11= 425.16

3) **4th and 3rd floor:**
   Roof slab = 4.08 x 10.125 = 41.31
   Walls = 7.1 x 12.825 = 91.05
   Main beam = 4.1 x 16.67 = 68.34
   Secondary beam = 1.49 x 9 = 13.41
   Total = 41.31 + 91.05 + 68.34 + 13.41 = 214.11
   Load from above floor = 211.05+ 2(214.11) = 639.27

4) **3rd and 2nd floor:**
   Roof slab = 4.08 x 10.125 = 41.31
   Walls = 7.1 x 12.825 = 91.05
   Main beam = 4.1 x 16.67 = 68.34
   Secondary beam = 1.49 x 9 = 13.41
   Total = 41.31 + 91.05 + 68.34 + 13.41 = 214.11
   Load from above floor = 211.05+ 3(214.11) = 853.38

5) **2nd and 1st floor:**
Roof slab = 4.08 x 10.125 = 41.31
Walls = 7.1 x 12.825 = 91.05
Main beam = 4.1 x 16.67 = 68.34
Secondary beam = 1.49 x 9 = 13.41
Total = 41.31 + 91.05 + 68.34 + 13.41 = 214.11
Load from above floor = 211.05+ 4(214.11) = 1067.49

6) **1st and plinth level :**
Roof slab = 4.08 x 10.125 = 41.31
Walls = 7.1 x 12.825 = 91.05
Main beam = 4.1 x 16.67 = 68.34
Secondary beam = 1.49 x 9 = 13.41
Total = 41.31 + 91.05 + 68.34 + 13.41 = 214.11
Load from above floor = 211.05+ 5(214.11) = 1281.6

7) **Column between plinth and footing :**
Assume no floor slab at plinth and consider only plinth beam, no wall.
Weight of plinth main beam = 4.1 x 16.67 = 68.34
Weight of secondary beam = 1.49 x 9 = 13.41
Weight of column = 2.85 x 0.3 x 0.6 x 25 = 12.825
Total = 68.34 + 13.41 + 12.825 = 94.575
Load from above floor = 211.05+ 5(214.11) + 94.575 = 1376.175

Design of column at ground floor :

Pu = 1376.175 KN
Assume effective cover = 50mm
Assume 1-2% steel (min 0.8%)
A_g = 300 x 600 = 180000mm^2
A_{sc} = 0.02 x 180000 = 3600
Consider 14mm dia bar
a_{st} = 153.86
No. of bars = 1376.17/153.86 = 8.90 ~ 10 bars
$Asc_{prov.}$ = 1538.38mm^2

- Provide 10 nos. of 14mm dia bars with $Asc_{prov.}$ = 1538.38mm^2

Diameter of lateral ties :

It should be maximum of

1) ¼ x 14 = 3.5
2) 6mm

Diameter = 6mm
Take 10 mm dia bars
Pitch of lateral ties
It should be minimum of

1) Least lateral dimension = 300
2) 16 x 14 = 224
3) 300mm

Pitch = 200 mm

- Provide 10mm dia ties @ 200mm c/c.

i) Column scheduling:

	E tabs design	Mannual design
Column dimension	300 x 600	300 x 600
No. of bars	12	10
Reinforcement bars	(8 -14) + (4 - 16)	(10 -14)
Ast	2035.75 mm^2	1539.38 mm^2
Grade of concrete	M25	M25
Grade of steel	HYSD500	HYSD500
Reinforcing of ties A	10 @ 100mm	10 @ 200mm
Reinforcing of ties B	10 @ 100mm	10 @ 200mm
Reinforcing of ties C	10 @ 100mm	10 @ 200mm

ii) Shear wall :

Story	End bar	Edge bar	Edge bar spacing
Story 1	16	16	250
Story 2	16	16	250
Story 3	16	16	250
Story 4	16	16	250
Story 5	16	16	250
Story 6	16	16	250

VII. CONCLUSION

- The structure is based on the E-TABS, and the theory of LIMIT STATE METHOD which provide adequate strength, serviceability, and durability besides economy.

- The displacement, shear force, bending moment variation has been shown. If any beam fails, the dimension of beam and column should be changed and reinforcement detailing can be produced.
- Our project deals with provision of earthquake resistant structure which is also economic.
- By using ETABS, the analysis and design work can be completed within the stipulated time.
- The analysis and design results obtained from software are safe when compared with manual calculations and design.
- There is a gradual increase in the value of lateral forces from bottom floor to top floor in software analysis.

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