

Analysis and Design of Tall Building (G+21) Using ETABS

S. Gandhi^{*1}, Syed Rizwan²

^{*1} M.Tech student, Department of Civil Engineering, St.mark Educational Institution Society Group of Institutions, Anantapur, Andhra Pradesh, India

^{*2} Asst. Prof, Department of Civil Engineering, St.mark Educational Institution Society Group of Institutions, Anantapur, Andhra Pradesh, India

ABSTRACT

Humans has started rising higher due to lack in horizontal space, Building taller structures has become a common trend. But as this vertical limit is pushed the risk factor increase. Skyscraper has to be analysed for various loads to provide safety. Behaviour of a structure is most critical during earthquake thus it is important to analyse a structure for seismic resistance. Earthquake is an unpredictable hazard having power to bring a high raised structure to ground. Thus it is important to analysis a structure for seismic force. Seismic coefficient method can be used to analyse small and medium height structure up to 40m. It is a simple method of analysis and required less calculation. The behaviour of a structure depends critically on overall shape, size and geometry. As an asymmetrical structure behave more critically during earthquake as compared to a symmetrical structure. A study on the behaviour of symmetrical RC building during earthquake is done to understand different in seismic loading and difference in behaviour due to different shape. A 21 storey building with height of each floor 3m having different shape as symmetrical shape analyses by seismic method with the help of ETABS software.

Keywords: Skyscraper, Bending moment, Seismic, Symmetrical, Structural Analysis, Etabs

I. INTRODUCTION

Our project involves analysis and design of multi-storeyed [G + 21] using a very popular designing software ETABS. We have chosen ETABS because of its following advantages:

ETABS is sophisticated software for analysis and design program developed specifically for buildings systems. ETABS version-2013.1.5 features an intuitive and powerful graphical interface coupled with unmatched modelling, analytical, and design procedures, all integrated using common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviours, making it the tool of choice for structural engineers in the building industry.

The ETABS building is idealized as an assemblage of area, line and point objects. Those objects are used to represent wall, floor, column, beam, brace and link / spring physical members. The basic frame geometry is defined with reference to a simple three-dimensional

grid system. With relatively simple modelling techniques, very complex framing situations may be considered.

The building may be unsymmetrical and non-regular in plan, torsional behavior of the floors and understory compatibility of the floors are accurately reflected in the results. The solution enforces complete three-dimensional displacement compatibility, making it possible to capture tubular effects associated with the behavior of tall structures having relatively closely spaced columns.

Semi-rigid floor diaphragms may be modelled to capture the effects of in plane floor deformations. Floor objective may span between adjacent levels to create sloped floors (ramps), which can be useful for modelling parking garage structures.

II. MODELING FEATURES

The ETABS building is idealized as an assemblage of area, line and point objects. Those objects are used to

represent wall, floor, column, beam, brace and link / spring physical members. The basic frame geometry is defined with reference to a simple three-dimensional grid system. With relatively simple modelling techniques, very complex framing situations may be considered. The building may be unsymmetrical and non-regular in plan, torsional behaviour of the floors and understory compatibility of the floors are accurately reflected in the results. The solution enforces complete three-dimensional displacement compatibility, making it possible to capture tubular effects associated with the behaviour of tall structures having relatively closely spaced columns.

Semi-rigid floor diaphragms may be modelled to capture the effects of in plane floor deformations. Floor objective may span between adjacent levels to create sloped floors (ramps), which can be useful for modelling parking garage structures.

III. ANALYSIS FEATURES

Static analysis for user specified vertical and lateral floor on story loads are possible. If floor elements with plate bending capability are modelled, vertical uniform loads on the floor are transferred to the beams and columns through bending of the floor elements.

The program can automatically generate lateral wind and seismic load patterns to meet the requirements of various building codes. Three dimensional mode shapes and frequencies, model participation factors, direction factors and participating mass percentage are evaluated using Eigen vector or Ritz-vector analysis-Delta analysis effects may be included with static or dynamic analysis. Response spectrum analysis, linear time history analysis, nonlinear analysis and static nonlinear analysis are possible. The static nonlinear capabilities also allow you to perform incremental construction analysis, so that forces that arise as a result of construction sequence are included. Results from the various static load cases may be combined with each other or with the results from the dynamic response dynamic response spectrum or time history method. Output may be viewed graphically, displayed in tabular output, the types of output include reactions, member forces, mode shapes, participation factors, static and dynamic story displacements and story shears inter story drifts and joint displacements, time history traces and more.

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behaviour of structures. Structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.

IV. LOADS AND LOAD COMBINATIONS

Gravity loads act in the same direction as gravity (i.e., downward or vertically) and include dead, live, and snow loads. They are generally static in nature and usually considered a uniformly distributed or concentrated load. Thus, determining a gravity load on a beam or column is a relatively simple exercise that uses the concept of tributary areas to assign loads to structural elements, including the dead load (i.e., weight of the construction) and any applied loads (i.e., live load).

Wind uplift forces are generated by negative (suction) pressures acting in an outward direction from the surface of the roof in response to the aerodynamics of wind flowing over and around the building.

Dead loads: Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. Dead load is the total load of all of the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc. In Etabs assignment of dead load is automatically done by giving the property of the member. In load case we have option called self-weight which automatically calculates weights using the properties of material. Here for the multi-storey building we need to define the loads distributed by the *masonry wall*.

Imposed Loads: Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. The uniform and concentrated live loads should not be applied simultaneously a structural evaluation. Concentrated loads should be applied to a small area or surface consistent with the application and should be

located or directed to give the maximum load effect possible in endues conditions. For example, the stair load should be applied to the centre of the stair tread between supports.

- $Floor\ load = 2.125KN/m^2$ (as per IS 875 Part 2) (for residential building including floor finish)
- $Plate/Element\ Load = 2KN/m^2$ (Imposed/live load on slab)

V. EARTHQUAKE LOADS

Earthquake or seismic load on a building depends upon its geographical location, lateral stiffness and mass, and is reversible. Its effect should be considered along both axes of a building taken one at a time. A force is defined as the product of mass and acceleration. During an earthquake, the mass is imparted by the building whereas the acceleration is imparted by ground disturbances. In order to have a minimum force, the mass of the building should be as low as possible. There can be no control on the ground acceleration as it is an act of God! The point of application of this internal force is the center of gravity of the mass on each floor of the building. Once there is a force, there has to be an equal and opposite reaction to balance the force. The inertial force is resisted by the building and the resisting force acts at the center of rigidity at each floor of the building or shear center of the building at each storey.

VI. DEFINE MATERIAL PROPERTY

The material properties of each object in the model are specified in the appropriate form. The material used is concrete, the grade of concrete, the properties of concrete such as Mass per unit volume, Modulus of Elasticity of concrete, Poisson ratio are specified and for steel yield strength is specified.

Material property data form

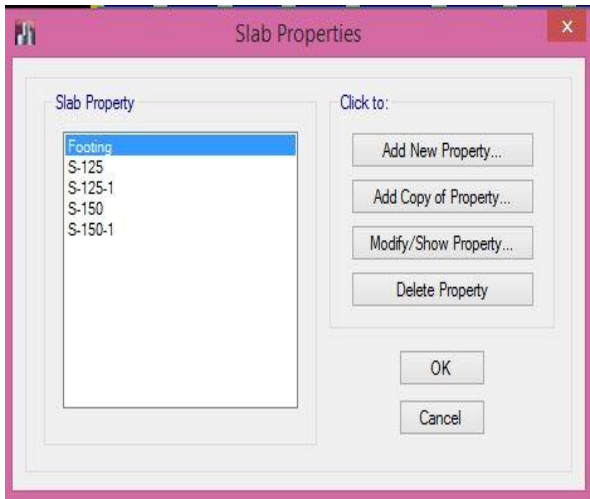
VII. DEFINE FRAME SECTION

Assign the frame section such as Column and Beam. Select the section property as Rectangle and define the depth, width and reinforcement details, cover provisions. Similarly for various sections like circular pipe, steel joist sections also assigned with suitable data.

Section properties and Reinforcement details

VIII. DEFINE WALL OR SLAB SECTION

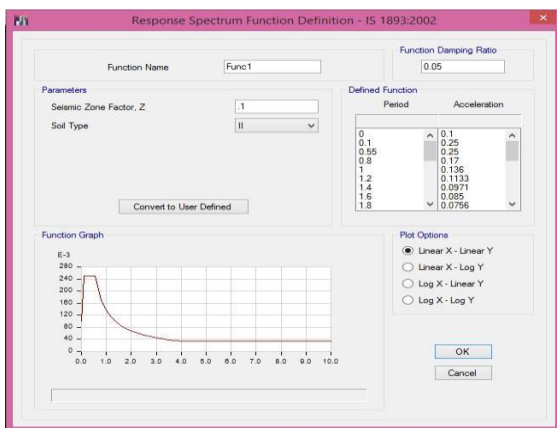
Assign the slab or wall section then assign the section name, thickness, material used, type and reinforcement details.



Define slab sections

IX. RESPNS SPECTRUM FUNCTION

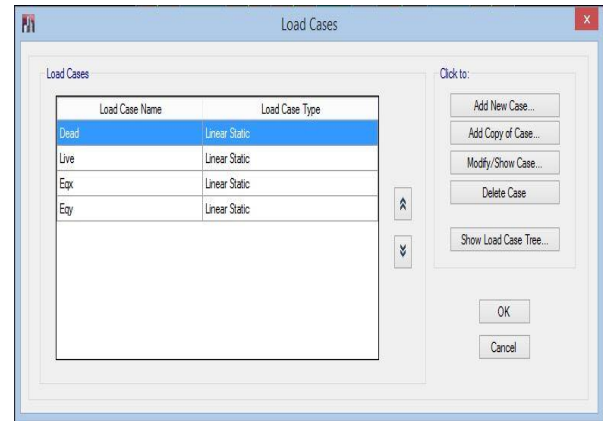
Response spectrum functions are pseudo spectral acceleration versus period functions for use in response spectrum analysis. In this program the acceleration values to be normalized; that is, the functions themselves are not assumed to have units.



Response spectrum function graph

X. STATIC LOAD CASES

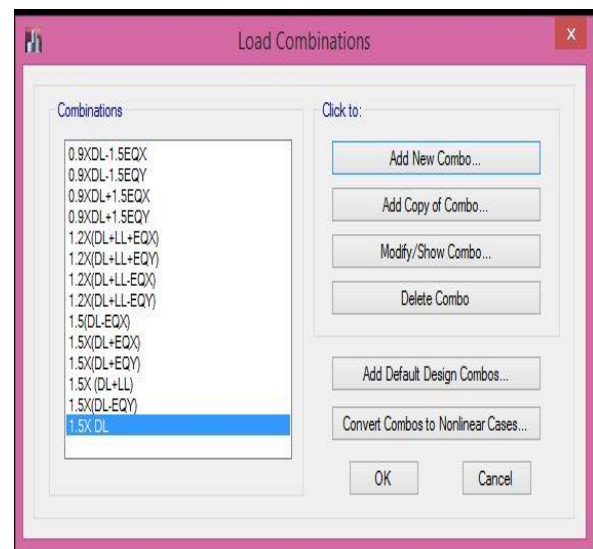
Loads represent the actions upon the structure, such as force, pressure, support displacement, thermal effects and others. A spatial distribution of loads upon the structure is called static load case. Define as many load cases as needed. Typically separate load case definitions would be used for dead load, live load, static earthquake load, wind load, snow load, and Thermal load.



Define static load case

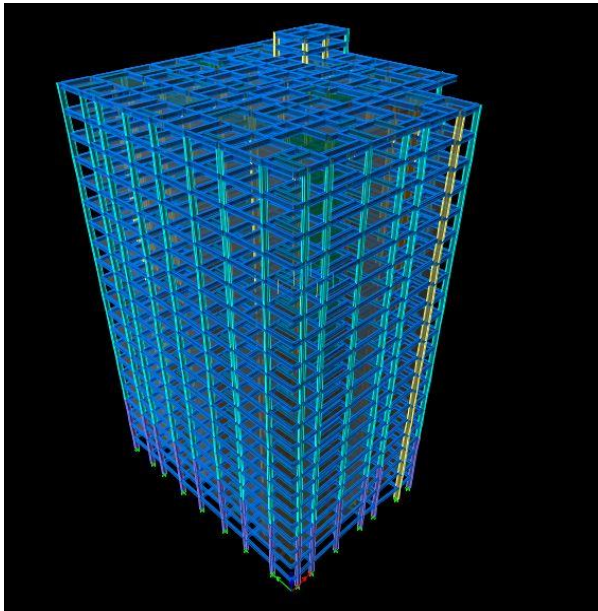
XI. DEFINE LOAD COMBINATIONS

Define the load combinations in the appropriate form; Select the Add new combo option, then enter the load combination name, assign the loads with suitable scale factor. When the combination is defined, it applies to the results for every object in the model.



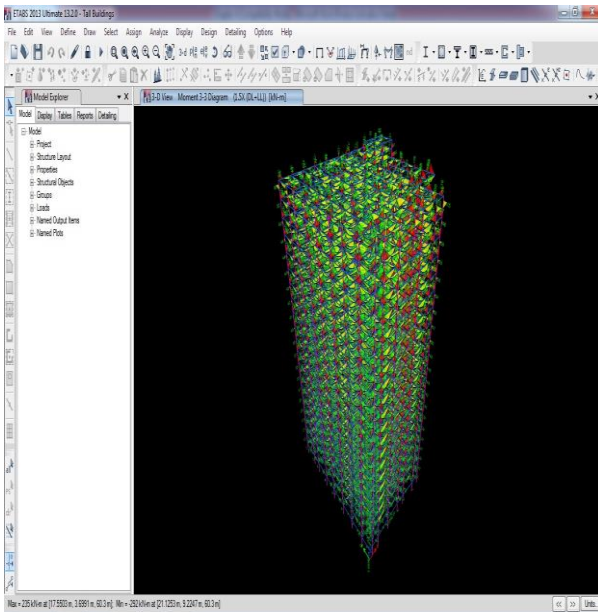
XII. MODEL OUTPUT

A) OUTPUT: 3D-MODEL OF A RC FRAME



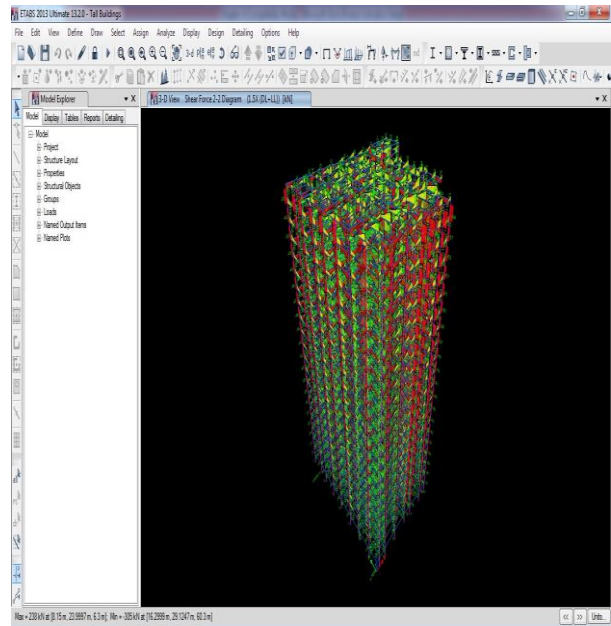
3D model of RC frame

B) BENDING MOMENT DIAGRAM FROM ANALYSIS

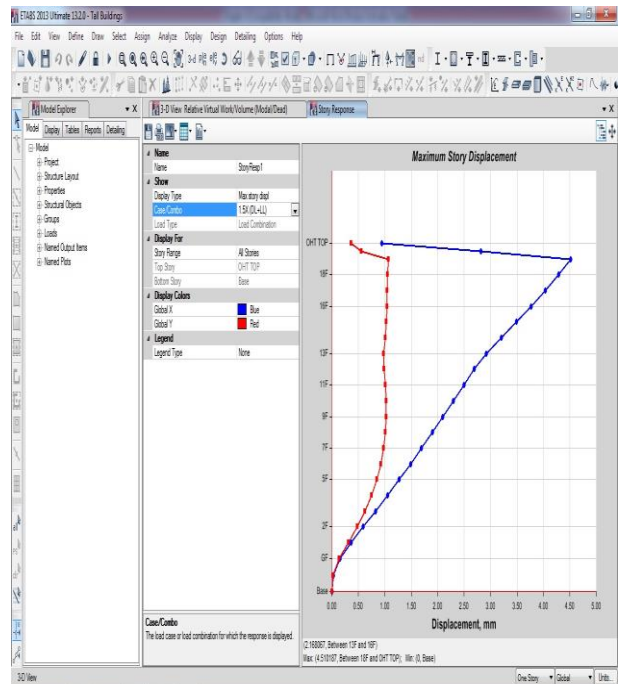


Bending Moment from analysis

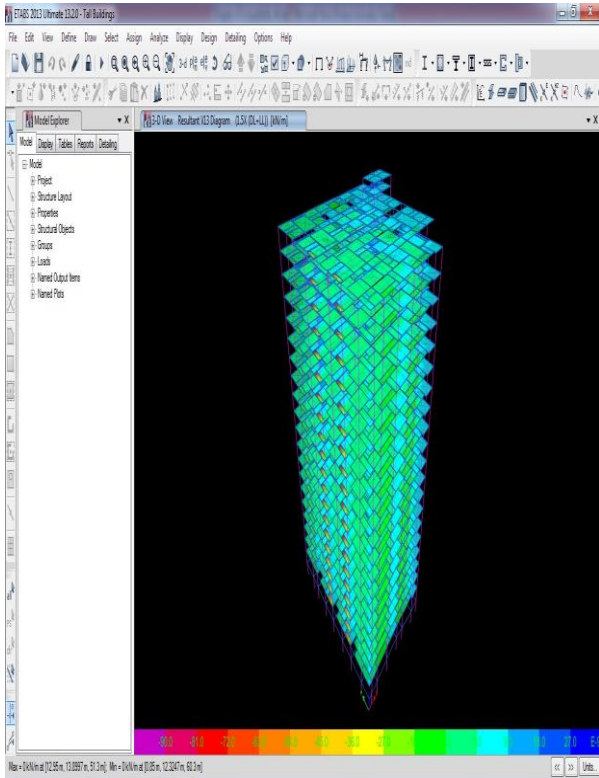
C) SHEAR FORCE FROM ANALYSIS



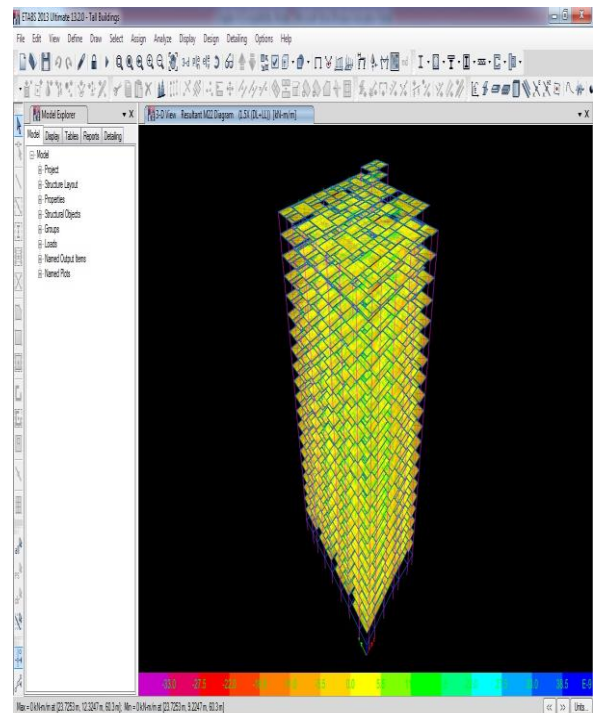
Shear Force from analysis



Story Displacement Curve Under Factored Dead Load + Live Load



Resultant V13 Under Factored Dead Load+ Live Load



Resultant M22 Under Factored Dead Load+ Live Load

XIII. CONCLUSION:

The Residential Tall building was designed with the earthquake resistant design consideration. Seismic analysis and design were done by using ETABS software as per IS 1893-2002. The detailing of the structural elements were done as per IS 13920-1993 (Ductile detailing for Earthquake resistant structures).

To conclude a complete design involving several parameters so as to result the earthquake has been done.

XIV. REFERENCES

- [1]. IS: 875 (part 1)-1987 – Code for practice for Design loads for Buildings and Structures [Dead load calculation]
- [2]. IS: 875 (part 2)-1987 – Code for practice for Design loads for Buildings and Structures [Live load calculation]
- [3]. IS: 875 (part 3)-1987 – Code for practice for Design loads for buildings and Structures [Wind load calculation]
- [4]. IS: 456-2000 for Plain and Reinforced Concrete code for practice (IV th Revision)
- [5]. IS: 1893-2002 – Criteria for Earthquake Resistant Design of structures [Seismic load calculation]
- [6]. IS: 13920-1993 –Ductile Detailing of Reinforced Concrete Structures subjected to seismic forces.
- [7]. SP: 16- Design Aids for Reinforcement concrete to IS: 456-1978
- [8]. ETABS – Integrated Building Design software manual by Computers and Structures Inc.
- [9]. Design of Reinforced Concrete Structures by Mr.Unnikrihna Pillai and Mr. Devadoss.
- [10]. Design of Reinforced Concrete Elements by Mr. Krishna Raju and Mr.R.N.Pranesh.