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A Detailed Study on the Design and Seismic Analysis of G+18 Floors Multistoried Building by Using Etabs 2013

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ABSTRACT

One of the major problems that the country facing is the rapidly growing population, which necessities more facilities in the restricted availability of land. This can be solved to a certain extent with the construction of multistoried building, which can serve many people in available limited area. Hence it is the necessary requirement of multistoried building with all facilities. Earthquake Engineering was developed a lot from the early days and seismically analyzing the structures requires specialized explicit finite element analysis software, which divides the element into very small slices and models the actual physics. The seismic analysis of the proposed building was done in the software ETABS 2 13, which is one of the most advanced software in the structural design field. The loads applied on the structure was based on IS:875 (part I)-1987 [dead load], IS:875 (part II)-1987 [live load], IS:875 (part III)-1987 [wind load], IS:1893-2 [Earthquake load]. Scale factor is calculated from the design base shear (Vb) to the base shear calculated using fundamental time period (Ta). Once the analysis was completed all the structural components were designed according to Indian standard code IS:456-2. Footing, columns, beams, slab, staircase and shear wall were designed. Ductile detailing of the structural elements were done as per code IS:1392 -1993.

Keywords : ETABS, Earthquake load, Reinforced Cement Concrete, AutoCAD

I. INTRODUCTION

Civil engineering is the oldest engineering among all the engineering branches. For the past two decades information technology has bought revolutionary changes in engineering, civil engineering in not exceptional. Many softwares which are useful for civil engineering were developed such as Autocad, Staad, Etabs, SAP2 , Midas, Teckla Structures, etc. For analysis design, planning and detailing of the structures. In the contemporary engineering field it is necessary to have strong fundamental knowledge regarding the subject and relative software's for economical and safe design of engineering structures.

Therefore, in the present study a G+2 residential Reinforced Cement Concrete (RCC) structure have been analyzed, designed for earthquake loads using software's ETABS 2 13, AUTOCAD. Loads coming on to the structure were considered from IS 875:1987 and IS 1893-2 2(I) and the structure was designed in accordance with IS 456: 2.

The objectives of the present study include:

1. Finalized plan and elevation of the structure
2. Analysis and design of structural elements using software's: ETABS 2 13
3. Detailing of structural elements using AutoCAD.

Study on earthquake response of structure.

Earthquake forces are generated by the dynamic response of the building to earthquake induced ground motion. Thus the earthquake forces imposed are directly influenced by the dynamic inelastic characteristics of the structure itself. The importance of dynamic effects in structural response depends on the rate of change of external forces and the dynamic properties of structures. Dynamic responses are stresses, strains, displacement, acceleration etc. The design of buildings for seismic loads is special, when compares to the design for gravity loads (dead loads and live loads). Gravity loads are relatively constant, in terms of their magnitude and are treated as 'static' loads. In contrast, seismic loads are predominantly horizontal (lateral), reversible (the forces are back-and-forth), dynamic (the forces rapidly vary with time) and of very short duration. In order to make a building seismo-resistant, it should have good building configuration, lateral strength, lateral stiffness, ductility, stability and integrity. In recent years due to the development of design technology and material qualities in civil engineering, the structures (high rise buildings, long span bridges) have become more light and slender. This will cause the structure to develop the initial vibrations. Earthquakes are the Earth's natural means of releasing stress. When the Earth's plates move against each other, stress is put on the lithosphere. When this stress is great enough, the lithosphere breaks or shifts.

II. INTRODUCTION TO STEEL DESIGN

Exact seismic analysis of the structure is highly complex and to tackle this complexity, number of researches has been done with an aim to counter the complex dynamic effect of seismic induced forces in structures. This re-examination and continuous effort has resulted in several revisions of Indian Standard: 1893 (1962, 1966, 197 , 1975, 1984 and 2 2) code of practice on —Criteria for earthquake resistant design of structuresby the Bureau of Indian Standards (BIS), New Delhi. Many of the analysis techniques are being used in design and incorporated in codes of practices of many countries. However, since in the present study our main focus is on the IS a codal provision, the method of analysis described in IS 1893 (Part 1): 2 2 are presented in this chapter.

2.1 DESIGN LATERAL FORCE:

The procedure recommended for the determination of lateral force in IS: 1893-2 2(Part 1) performing are based on the approximation that effects of yielding can be accounted for by linear analysis of the building using design spectrum. This analysis is carried out by either equivalent lateral force procedure or dynamic analysis procedure given in the clause 7.8 of IS: 1893-2 2 (Part 1). The main difference between the two procedures lies in the magnitude and distribution of lateral forces over the height of the building. In the dynamic analysis procedure, the lateral forces are based on properties of the natural vibration modes of the building which are determined by distribution of mass and stiffness over the height. In the equivalent lateral force procedure the magnitude of forces is based on an estimation of the fundamental period and on the distribution of forces as given by a simple empirical formula that is appropriate only for regular buildings. The following sections will discuss in detail the above mentioned procedures of seismic analysis.

2.2 EQUIVALENT LATERALFORCE METHOD

The total design lateral force or design base shear along any principal direction is given in terms of design horizontal seismic coefficient and seismic weight of the structure. Design horizontal seismic coefficient depends on the zone factor of the site, importance of the structure, response reduction factor of the lateral load resisting elements and the fundamental period of the structure. The procedure generally used for the equivalent static analysis is explained below:

(i) Determination of fundamental natural period (Ta)of the buildings

T_a = . 75h $^{.75}$ Moment resisting RC frame building without brick infill wall

T_a = . 85h $^{.75}$ Moment resisting steel frame building without brick infill walls

Where,

h -is the height of building in m

d - is the base of building at plinth level in m, along the considered direction of lateral force.

(ii) Determination of base shear (VB) of the building

$$V_B = A_h \times W$$

$$\text{Where,} \quad A_h = \frac{ZI\,Sa}{2Rg}$$

Is the design horizontal seismic coefficient, which depends on the seismic zone factor (Z), importance factor (I), response reduction factor (R) and the average response acceleration coefficients (Sa/g). Sa/g in turn depends on the nature of foundation soil (rock, medium or soft soil sites), natural period and the damping of the structure.

(iii) Distribution of design base shear

The design base shear V_B thus obtained shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B * \frac{W_i h_i{}^2}{\sum_{i=1}^{n} W_i h_i{}^2}$$

Where, Q_i is the design lateral force, W_i is the seismic weight, h_i is the height of the 1thfloor measured from base and n is the number of stories in the building.

2.3 RESPONSE SPECTRUM METHOD:

The response spectrum technique is really a simplified special case of modal analysis. The modes of vibration are determined in period and shape in the usual way and the maximum response magnitudes corresponding to each mode are found by reference to a response spectrum. The response spectrum method has the great virtues of speed and cheapness. There are two major disadvantages of using this approach. First, the method produces a large amount of output information that can require an enormous amount of computational effort to conduct all possible design checks as a function of time. Second, the analysis must be repeated for several different earthquake motions in order to assure that all the significant modes are excited, since a response spectrum for one earthquake, in a specified direction, is not a smooth function.

According to the code, dynamic analysis may be performed using either response spectrum method or the time history method. In either method, the design base shear $\bar{V}_B$ is compared with a base shear $V_B$calculated using the fundamental period Ta. It suggests that when $\bar{V}_B$ is less than V_B, all the response quantities (for example member forces, displacements, Storey force, Storey shears and base reactions) must be suitably scaled by multiplying with $V_B/\bar{V}_B$.

As per IS: 1893-2 2 (PART 1) provisions, 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 4 m in height in Zones IV and V, and those greater than 9 m in height in Zones II and III.
B. Irregular buildings: All framed buildings higher than 12m in Zones IV and V, and those greater than 4 m in height in Zones II and III.

2.4 NON-LINEAR STATIC ANALYSIS:

Pushover analysis is one of the methods available to understand the behaviour of structures subjected to earthquake forces. As the name implies, it is the process of pushing horizontally with a prescribed loading pattern incrementally until the structure reaches a limit state [ATC- 4 1996]. The static approximation consists of applying a vertical distribution of lateral loads to a model which captures the material non - linearity of an existing or previously designed structure, and monotonically increasing those loads until the peak response of the structure is obtained on a base shear vs. roof displacement plot.

The Selection of Lateral load pattern for a performance evaluation is likely to be more critical than the accurate determination of the target displacement. It plays an important role due to the fact that it is supposed to deform the structure in a similar manner experienced in earthquake occurrence. Conventionally, as shown in fig below an inverted triangular or uniform shape is used consistent with the codified static lateral force distribution but use of adaptive load shape is on the increase. The importance of the loading shape increases when the response is not dominated by the single mode.

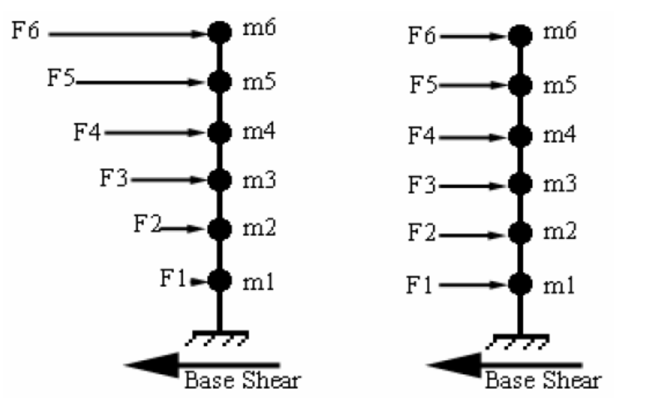

Figure 1. Conventional lateral load distribution

III. STAGES IN STRUCTURAL PLANNING

A. COLUMN POSITIONING:

The guide principles, which help in deciding position of column, are Column should perfectly located at or near the corner of building and at intersections of walls because basically the function of the column is to support beams , which are placed under the walls to support them.

When the centre distance between the intersections of walls is larger or where there are not cross wall, the spacing between the two columns is governed by limitations on span of the beam. As the span of the beam increases. Therefore large span of beam should be avoided for economy reasons and from the consideration of controlling the deflection and cracking.

Column should avoid in a big hall as it mars the functional utility and the appearance and obstructs the clear view and usable space.

Large spacing of columns not only increases the span and the cost of the beams but it increases the load on the column on each floor posing problem of stocky column in storied of multi-storeyed building.

B. ORIENTATION OF COLUMNS:

Columns provided in a building are rectangular with width of column not less than the width of the supported beam for effective load transfer. According to requirements of aesthetic and utility, projection of column outside the wall. In the room should be avoided as they not only give bad appearance but also obstruct the usage of corners and create problems in placing furniture flush with the wall. The depth of column should be in the plane of the wall to avoid such offsets. When a column is rigidly connected to beams at rigid angles. It is required to carry moments in additional to axial load in such cases, the column should be so oriented that the depth of column perpendicular to major axis of building so as to get moment resisting capacity. The size of columns which has been used for design of residential building are 23 *4 , 23 *45 , 23 *5 , 23 *55 , 3 *55 mm and 3 *6 mm.

C. POSITION OF BEAMS:

Following are some of the guidelines for beams.

Beams shall normally be provided under the walls or below a heavy concentrated load to avoid these loads directly coming on to slabs.

Since beams are primarily provided to support slabs, its spacing shall be decided by the maximum spans of slabs.

D.SPANNING OF SLABS:

This is decided by the positions of supporting beams or walls.

When the supports are only opposite sides or only one direction, when the slab act as a one way supported slab. However the two way action of slab does depend only on the manner in which it supported but also on the aspect ratio or reinforcement in two directions and boundary conditions.

E. LAYOUT OF STAIRS:

The available size of staircase rooms and positions of beams and column along the boundary of staircase govern the type of stair and its layout.

F. CHOICE OF FOOTING TYPE:

Among the various types of footings the suitable type of footing required for the structure shall be based on the applies loads, moments. Force and the induced reactions are to ensure that settlement of any kind shall be as uniform as possible. For trained structures\, isolated column footings are usually preferred, except in the case soil with low bearing capacity of soil with low raft foundation is used. If any column of a structure is near to the property line. Combined footing or strap footing may be provided.

IV. TYPES OF LOADS

4.1 LIVE LOAD: (AS PER IS-875-Part-2)

These are non-permanent or moving loads. This type of load includes the following.

Imposed loads (fixed) weight of fixed beams in auditoriums. Fixed machinery, partition walls. These loads though, fixed in positions cannot relied up on to act permanently through-out the life of the structure. Imposed loads (not fixed) these loads can change either in magnitude or position very often such as traffic loads weight of furniture etc..,

4.2 LOADING STANDARDS:

The loads that are consider in the design are based on IS-875-1964

DEAD LOADS:

R.C.C	25 kN/m^3
P.C.C	24 kN/m^3
Brick masonry	22 kN/m^3
Floor finishes	.7 kN/m^3

LIVE LOADS:

On floors	4 kN/m^2
On roofs	2 kN/m^2
On stairs	5 kN/m^2

V. ABOUT ETABS

ETABS is sophisticated software for analysis and design program developed specifically for buildings systems. ETABS version-2 13.1.5 features an in 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.

5.1 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-regulator 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.

5.2 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.

5.3 WIND LOAD CALCULATION

Wind is air in motion relative to the surface of the earth. The primary cause of wind is traced to earth's rotation and differences in terrestrial radiation. The radiation effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizontal to the ground at high wind speeds. Since vertical components of atmospheric motion are relatively small, the term 'wind' denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speed is assessed with the aid of anemometers or anemographs.

5.4 BASIC WIND SPEED:

Basic wind speed is based on peak gust velocity averaged over a short time interval of about three seconds and corresponds to mean heights above ground level in an open terrain. Basic wind speed given in figure1 in IS 875(part):1987.

VI. MODELLING AND ANALYSIS

6.1 DEFINE GEOMETRY:

The Building Plan Grid System and Storey Data form is used to specify horizontal and vertical grid line spacing, storey data, storey elevation and units. They automatically add the structural objects with appropriate properties to the model.

Figure 2. Building Plan Grid System and Storey Data Definition

6.2 DEFINE MATERIAL PROPERTY:

The material properties of each object in the model is 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.

6.3 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.

VII. CONCLUSION

The New Residential building was designed with the earthquake resistant design consideration. Seismic analysis and design were done by using ETABS software. The detailing of the structural elements were done as per IS 1392 -1993 (Ductile detailing for Earthquake resistant structures). To conclude a complete design involving several parameters so as to result the earthquake has been done.

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