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Effect of Wind on Commercial Multi Storied Building Using ETABS Software

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A B S T R A C T

This is a final year civil project report on EFFECT OF WIND ON COMMERCIAL MULTI STORIED BUILDING. The present project deals with the analysis of a multi storied commercial building of G+4 floors. This project is mostly based on software and it is essential to know the details about these software's. The software's used in this project are ETABS & Auto cad.

The principle objective of this project is to analysis and design of commercial building using Etabs. The design involves load calculations manually and analyzing the whole structure by ETABS. The design methods used in ETABS analysis are Limit State Design conforming to Indian Standard Code of Practice. ETABS features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, ETABS is the professional's choice

Keywords: wind, ETABS, design, model generation.

1. INTRODUCTION

1.1 GENERAL ASPECTS:

The main idea of every Structural Engineer is to improve his concept of analysis and design so that an economical structure is obtained consistent with safety and serviceability. Through laboratory research, field tests and computer simulations, several new concepts of analysis and designs have been identified.

A Structure must be designed on the basis of strength, serviceability and durability. Strength is assessed by plastic hinge theory. Serviceability requires that excessive deflection, cracking and local failures be avoided at service loads. Durability requirements are concerned with the determinations and decay of materials with age and environmental impact. The newly emerging Limit State Methods of Designs are oriented towards the simultaneous satisfaction of all these requirements. The limit state design now seeks to account for the various aspects in an orderly manner.

The limit state design adopts characteristic values for strength of steel and concrete. The term "Characteristic Strength" means that value of strength of material below which not more than 5% of the test results expected to fall. Further in a Structural Design, the Dead Load, Live Load, Wind Load, Creep, Temperature etc…are also taken into account. The term "Characteristic Load" means that the value of which has got a 95% probability of not being exceeded during the lifetime of the structure.

The characteristic value allows for inherent variations in the loads and material strength. There are additional factors such as overloads, under strength of materials unknown in analysis and design and loss of life due to failure of structural elements, which are to be considered in ensuring adequate safety of the structure. These are actually considered together in a single safety of the structure. For the limit state method, determination of these factors have been separated and designed as partial safety factors. The recommended value of partial safety factor for concrete is 1.5.

1.2 METHODS OF DESIGNING STRUCTURE:

There are three Methods or Philosophies for the design of Reinforced Concrete, Pre-Stressed Concrete as well as Steel Structures, namely:

Working stress method.

Ultimate load method.

Limit state method.

1.2.1 WORKING STRESS METHOD:

In this method it is assumed that concrete is elastic and both steel and concrete act together elastically and the relationship between loads and stress is linear right up to the failure of the structure.

The basis of the method is that the permissible stresses for concrete and steel are not exceeded anywhere in the structure when it is subjected to worst combination of working loads. The sections are designed in accordance with the elastic theory of bending, assuming that both materials obey the Hooke's law. The permissible stresses are prescribed to provide suitable factors of safety to allow for uncertainties in the estimation of working loads and variation in properties of materials.

IS: 456-2000 uses a factor of safety equal to 3 on the 28 days cube strength to obtain the permissible compressive stresses in bending concrete and equal to 1.78 on the yield strength of steel intention to obtain the permissible tensile stress in bending reinforcement.

The main draw backs of the working stress method are as follows:

Concrete is not elastic. The inelastic behavior of concrete starts right from very low stresses. A triangular stress diagram cannot describe the actual stress distribution in a concrete section.

Since factor of safety is on the stresses under working loads, there is no way to account for different degrees of uncertainty associated with different types of loads with elastic theory it is impossible to determine the actual factor of safety with respect to loads.

It is difficult for shrinkage and creep by calculation of elastic stress.

1.2.2 ULTIMATE LOAD METHOD:

In the Ultimate Load Method, the working loads are increased by suitable factors to obtain the ultimate loads. These factors are called Load Factors. The structures are then designed to resist the desired ultimate loads.

The knowledge of factor is more important than the knowledge of factor of safety. In the former case, the designer is able to predict the excess load, which a given structure can carry beyond the working load without collapse. The level of stress is in material.

ADVANTAGES: A major advantage of this method over the working stress method is that the total safety factor of the structure thus found is nearer to its actual value. Further, the structure designed by the ultimate Load Method requires less reinforcement that those designed by the Working Stress Method.

DISADVANTAGES: Since load factor is used on the working loads, there is no way to account for different degrees of uncertainty associated with variation in material stress and there is a complete disregard for control against excessive deflections.

1.2.3 LIMIT STATE METHOD:

The acceptable limit of safety and serviceability requirement (such as limitations on deflection and cracking) before failure occurs is called "Limit State". In this method, the "Design Value" is derived from the characteristic values through the use of partial factors, one for the material strength and other for loads. Thus, it is a more scientific approach for the design of Reinforced Concrete Structures.

1.3 LIMIT STATE CONCEPTS:

The aim of limit state design is to ensure that the structure being designed remains safe and serviceability throughout its life and it does not become unfit for the use of which it is intended, i.e. it does not reach the limit state by violating one or more of the criteria governing its performances and use.

Limit State can be broadly classifieds into two main categories:

The limit associated with the maximum load carrying capacity of the structure, i.e. its safety is called the limit state of collapse or the ultimate limit state.

The limit associated with the performance of the structure (i.e. cracking and deflection) under safe loads is called the limit state of serviceability.

The collapse of structure may arise due to failure of one or more critical section due to instability of one or more members or due to overturning and /or sliding of the whole structure. Excessive deflection spoil the appearance of structural element affects the partition walls and footings and causes discomfort to the occupants. Structures are excepted to Visio static (i.e. without any visible deflections). Local damages may take the form of sapling and/or cracking of water tanks is by itself a functional failure.

There are other imposed by excessive vibration, fatigue, fire hazards, earthquakes and impact effects due to explosions. These are rare and unusual limit state and should be handled by experts in the respective fields. The limit state of collapse and serviceability are the most common one for the normal structures.

It is required to look upon that none of these limit states are reached during the useful life of the structure. Thus safety, serviceability, durability and economy have always been the hallmarks of good structural design. By the introduction of the Limit State Concepts all designers are now able to construct stable and safe structures.

4 NECESSITY OF ANALYSIS AND DESIGN:

Analysis is an integral property of the design. The primary objective of the Structural Engineering is to provide a designed structure. To design structure, one must know how it will respond to a given loading. The member properties play an important role in analyzing the response of a given structure. Conversely in the design member properties are chosen to result in special structure and the designer may often have to readjust his selection of properties in order to get the desired response from the structure. Modern methods of analysis and design lead us to the level at which various forces, moments etc…in the member of a frame are known, appropriate cross sections are chosen. Various methods of analysis have been developed in a scientific way. Some of the Methods used in multistoried analysis are as followed.

Slope Deflection Method

Moment Distribution Method

Kani’s Method

Column Analog Method

Matrix Method

Finite Element Method

Factor Method

Cantilever Method

Portal Frame Method

The last three methods deal with wind load analysis method.

2. LOADS CONSIDERED

2.1 INTRODUCTION:

For the purpose of computing the maximum stresses in any structural member the following loads are taken into account.

2.1.1 DEAD LOAD

The dead load in a building shall comprise of weight of all walls, partitions, floors and roofs and shall include the weight of all other permanent construction in the building schedule of unit weight of the building material given in IS: 875-1987(Part 1).

2.1.2 LIVE LOAD

The live load may be defined as that super imposed load which may not be acting on the structures at all the time. The categorization of live load is given in IS: 875-1987 (Part-2).

2.1.3 WIND LOAD

Wind is a natural phenomenon and is assumed to be acting horizontally. Intensity wind load effect is pronounced and shall be taken into account for analysis only when the ratio b/w height & breadth of the structure is greater than 2.

2.1.4 Snow Load and Seismic Load:

Snow load is not considered for the building when it is constructed in Karnataka and seismic loads are also not considered, as this place is not prone to earthquakes.

2.2 Load Calculation on Slab:

Calculation of Dead Load:

Calculation of load /m run-on the slab

Dead load of the slab	=1×0.15×25	=3.75KN/m2
Dead Load due to Floor finish	= 1×0.05×22	=1.1KN/m2
(IS: 875, Part-1, 1987, page 10, table1, Sl. No.37)		
Total ad Load		=4.85KN/m2

2.3 LOADS ON MAIN BEAM FROM SECONDARY BEAM

The load from secondary beam is transformed to the main beam as concentrated load.

2.4 LOADS ON FOOTING

The SBC of soil at the building site is 200 KN/m2 .The sum of column load and 10% of the column load gives the load on footings.

2.5 LOAD COMBINATIONS

Load combinations as per IS 875 Part 5 are taken into consideration.

A judicious combination of the loads (specified in IS 875 Parts 1 to 4 of this standard and earthquake), keeping in view the probability of:

a) Their acting together, and

b) Their disposition in relation to other loads and severity of stresses or

c) Deformations caused by combinations of the various loads are necessary to ensure the required safety and economy in the design of a structure.

Load Combinations **-** The various loads should, therefore, be combined in accordance with the stipulations in the relevant design codes. In the absence of such recommendations, the following loading combinations, whichever combination produces the most unfavourable effect in the building, foundation or structural member concerned may be adopted (as a general guidance).

It should also be recognized in load combinations that the simultaneous occurrence of maximum values of wind, earthquake, imposed and snow loads is not likely: -

1) 1.5 (DL)
2) 1.5 (DL + LL)
3) 1.2 (DL+LL±WL)

Where,

DL = Dead Load

LL = Live Load

WL = Wind Load

The negative sign in the above load combinations shows the directions opposite to the defined case.

3. METHODOLOGY

3.1 GENERAL:

In this chapter, the analysis of typical frames has been carried out. The analysis and the results obtained for all frames have been shown in detail. Bending Moment and Shear Force Diagrams are also shown.

3.2 STRUCTURAL ANALYSIS AND ITS OBJECTIVES:

The phases of the design effort which involves the computation of forces (External Reactions, Shear, Moment, and Internal Shears) and Displacements (Deflections and Rotations) developed in the structure analysis, which forms a major quantitative part of design process.

3.3 METHOD OF INDETERMINATE ANALYSIS:

There are basically two fundamental methods of indeterminate analysis

The Force Method or Flexibility Method

Displacement Method or Stiffness Method

In the Force Method, the unknown are in the form of forces (External Reactions or Moments) where as in the Displacement method, certain displacements (Linear and Angular) are taken as the unknowns. However, the method employed in the analysis of the hyper static structure as specified in introduction are listed below:

Method of Consistent Deformation

Strain Energy

3.4 ANALYSIS

3.6 TYPICAL CALCULATION OF LOADS FOR THE ANALYSIS OF FRAMES:

Load Calculation on Slab:

Calculation of Dead Load:

Calculation of load /m run-on the slab

Dead load of the slab =1×0.15×25 =3.75KN/m

Dead Load due to Floor finish = 1×0.02×26.5 =0.53KN/m

(IS: 875, Part-1, 1987, page 10, table1, Sl. No. 37)

Dead load due to 12mm thick Ceiling =1×0.012×20.4 =0.25KN/m

3.7 Supports:

Supports are specified as PINNED, FIXED, or FIXED with different releases (known as FIXED BUT). A pinned support has restraints against all translational movement and none against rotational movement. In other words, a pinned support will have reactions for all forces but will resist no moments. A fixed support has restraints against all directions of movement. Translational and rotational springs can also be specified. The springs are represented in terms of their spring constants. A translational spring constant is defined as the force to displace a support joint one length unit in the specified global direction. Similarly, a rotational spring constant is defined as the force to rotate the support joint one degree around the specified global direction.

3.8 Loads:

Loads in a structure can be specified as joint load, member load, temperature load and fixed-end member load. Any fraction of this self weight can also be applied in any desired direction.

Member load:

Three types of member loads may be applied directly to a member of a structure. These loads are uniformly distributed loads, concentrated loads, and linearly varying loads (including trapezoidal). Uniform loads act on the full or partial length of a member. Concentrated loads act at any intermediate, specified point. Linearly varying loads act over the full length of a member. Trapezoidal linearly varying loads act over the full or partial length of a member. Trapezoidal loads are converted into a uniform load and several concentrated loads. Any number of loads may be specified to act upon a member in any independent loading condition. Member loads can be specified in the member coordinate system or the global coordinate system. Uniformly distributed member loads provided in the global coordinate system may be specified to act along the full or projected member length.

Area/floor load:

Many times a floor (bound by X-Y plane) is subjected to a uniformly distributed load. It could require a lot of work to calculate the member load for individual members in that floor. However, with the AREA or FLOOR LOAD command, the user can specify the area loads (unit load per unit square area) for members. The program will calculate the tributary area for these members and provide the proper member loads. The Area Load is used for one way distributions and the Floor Load is used for two way distributions.

3.9 Section Types for Concrete Design:

The following types of cross sections for concrete members can be designed. For Beams Prismatic (Rectangular & Square) & T-shape

For Columns Prismatic (Rectangular, Square and Circular)

3.10 Design Parameters:

The program contains a number of parameters that are needed to perform design as per IS 13920. It accepts all parameters that are needed to perform design as per IS: 456. Over and above it has some other parameters that are required only when designed is performed as per IS: 13920. Default parameter values have been selected such that they are frequently used numbers for conventional design requirements. These values may be changed to suit the particular design being performed by this manual contains a complete list of the available parameters and their default values. It is necessary to declare length and force units as Millimeter and Newton before performing the concrete design.

3.11 Beam Design:

Beams are designed for flexure, shear and torsion. If required the effect of the axial force may be taken into consideration. For all these forces, all active beam loadings are pre scanned to identify the critical load cases at different sections of the beams. For design to be performed as per IS: 13920 the width of the member shall not be less than 200mm. Also the member shall preferably have a width-to depth ratio of more than 0.3.

Design for Flexure:

Design procedure is same as that for IS 456. However while designing following criteria are satisfied as per IS-13920:

1. The minimum grade of concrete shall preferably be M20.
2. Steel reinforcements of grade Fe415 or less only shall be used.
3. The minimum tension steel ratio on any face, at any section, is given by:

$$\rho min = 0.24\sqrt{fck}/fy$$

The maximum steel ratio on any face, at any section, is given by $\rho max = 0.025$

4. The positive steel ratio at a joint face must be at least equal to half the negative steel at that face.
5. The steel provided at each of the top and bottom face, at any section, shall at least be equal to one-fourth of the maximum negative moment steel provided at the face of either joint.

Design for Shear:

The shear force to be resisted by vertical hoops is guided by the IS 13920:1993 revision. Elastic sagging and hogging moments of resistance of the beam section at ends are considered while calculating shear force. Plastic sagging and hogging moments of resistance can also be considered for shear design if PLASTIC parameter is mentioned in the input file. Shear reinforcement is calculated to resist both shear forces and torsional moments.

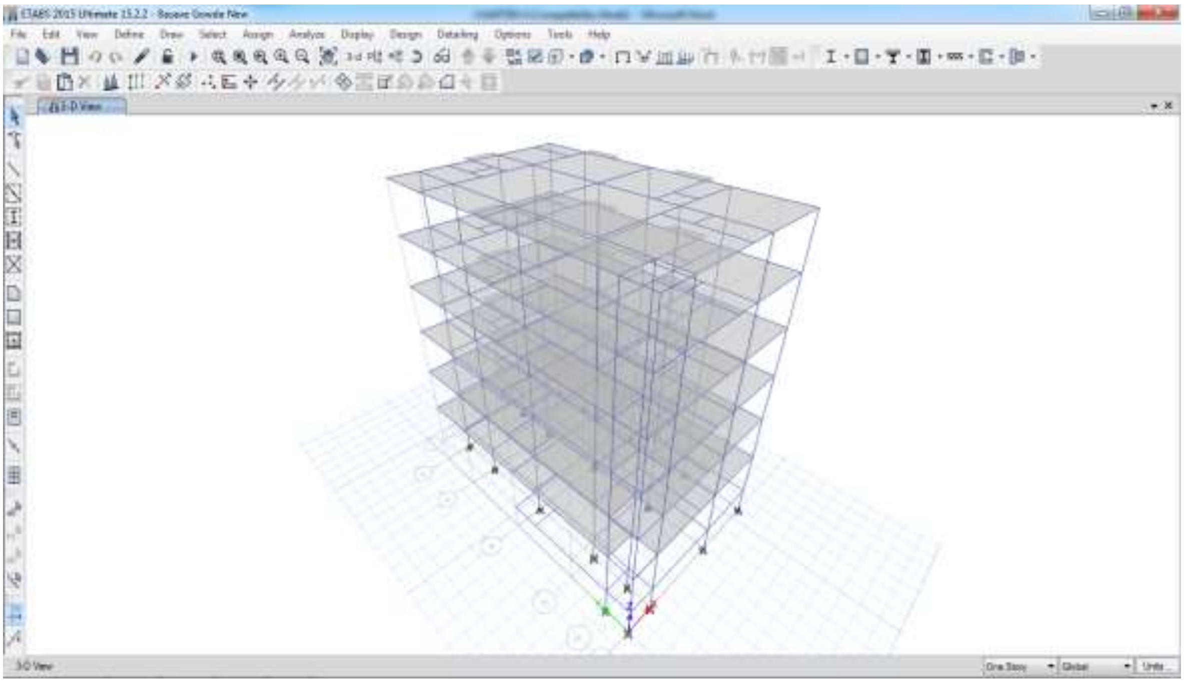
3.12 Column Design:

Columns are designed for axial forces and biaxial moments per IS 456:2000. Columns are also designed for shear forces. All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS: 456 have been taken care of in the column design. However following clauses have been satisfied to incorporate provisions of IS 13920:

1. The minimum grade of concrete shall preferably be M20
2. Steel reinforcements of grade Fe415 or less only shall be used.
3. The minimum dimension of column member shall not be less than 200 mm. For columns having unsupported length exceeding 4m, the shortest dimension of column shall not be less than 300 mm.
4. The ratio of the shortest cross-sectional dimension to the perpendicular dimension shall preferably be not less than 0. The spacing of hoops shall not exceed half the least lateral dimension of the column, except where special confining reinforcement is provided.
5. Special confining reinforcement shall be provided over a length lo from each joint face, towards mid span, and on either side of any section, where flexural yielding may occur. The length lo shall not be less than a) larger lateral dimension of the member at the section where yielding occurs, b) 1/6 of clear span of the member, and c) 450 mm.
6. The spacing of hoops used as special confining reinforcement shall not exceed ¼ of minimum member dimension but need not be less than 75 mm nor more than 100 mm.

4. ANALYSIS OF FRAMES

4.0 ANALYSIS OF RCC FRAMES



5.2.1 Beam Design

ETABS 2015 Concrete Frame Design

IS 456:2000 Beam Section Design

Beam Element Details Type: Ductile Frame (Summary)

Section Properties

Material Properties

Design Code Parameters

γ_C	γ_S
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-4.3078	3.366	27.5052	0

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-4.3078	6.435	2.1272	-12.0916

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-12.0916		193	0	69	193
Bottom (-2 Axis)		2.1272	193	12	0	193

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	**Shear V_c kN**	**Shear V_s kN**	**Shear V_p kN**	**Rebar A_{sv} /s mm²/m**
27.5052	28.5757	32.8	0	221.69

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	**V_u kN**	**Core b_1 mm**	**Core d_1 mm**	**Rebar A_{svt} /s mm²/m**
3.366	27.5052	140	390	249.01

CONCLUSION

1. This project is mainly concentrated with the analysis and design of multi-storied commercial building with all possible cases of the loadings using ETABS Meeting the design challenges are described in conceptual way.
2. We may also check the deflection of various members under the given loading combinations.
3. Further in case of rectification it is simple to change the values at the place where error occurred and the obtained results are generated in the output.
4. Very less space is required for the storage of the data.

ETABS is an advanced software which provides us a fast, efficient, easy to use and accurate platform for analyzing and designing structures

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