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"Computer Aided Analysis and Design of Multi-storeyed Frames"

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Abstract—*The principle objective of this project is to analyse and design a multi-storeyed building [G + 50 (3 dimensional frame)] using STAAD Pro. The design involves load calculations manually and analyzing the whole structure by STAAD Pro. The design methods used in STAAD-Pro analysis are Limit State Design conforming to Indian Standard Code of Practice. Initially we started with the analysis of simple 2 dimensional frames and manually checked the accuracy of the software with our results. The results proved to be very accurate.*

We analysed and designed building [2-D Frame] initially for all possible load combinations [dead, live, wind and seismic loads]. STAAD Pro has a very interactive user interface which allows the users to draw the frame and input the load values and dimensions. The structure was subjected to self weight, dead load, live load, wind load and seismic loads under the load case details of STAAD Pro. The wind load values were generated by STAAD Pro considering the given wind intensities at different heights and strictly abiding by the specifications of IS 875. Seismic load calculations were done following IS 1893-2000. STAAD Pro was used to analyse the structure and design the members.

In the post-processing mode, after completion of the design, we can work on the structure and study the bending moment and shear force values with the generated diagrams. We may also check the deflection of various members under the given loading combinations. The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes. Strict conformity to loading standards recommended in this code, it is hoped, will ensure the structural safety of the buildings which are being designed. Structure and structural elements were normally designed by Limit State Method.

Keywords: *Multi-Storeyed Frames, Loads, Structural Safety*.

1. INTRODUCTION

Our project involves analysis and design of multi-storeyed [G + 50] using a very popular designing software STAAD Pro. We have chosen STAAD Pro because of its following advantages: easy to use interface, conformation with the Indian Standard Codes, versatile nature of solving any type of problem, Accuracy of the solution. STAAD Pro 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, STAAD Pro is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

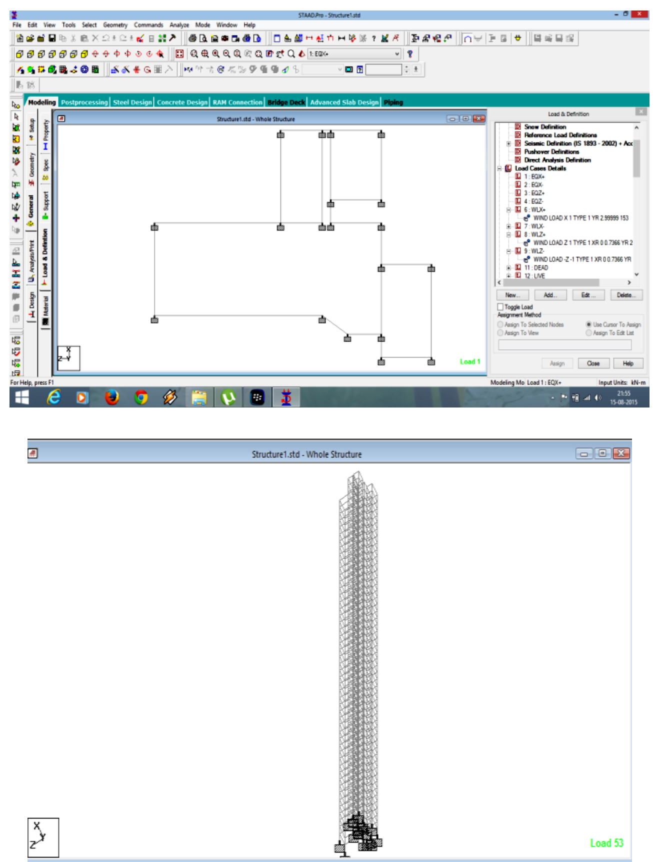

FIGURE 01 & 02: FRAME OF G+50 STOREYED BUILDING.

STAAD Pro consists of the following

The STAAD Pro Graphical User Interface: It is used to generate the model, which can then be analyzed using the

STAAD engine. After analysis and design is completed, the GUI can also be used to view the results graphically. ***The STAAD analysis and design engine****:* It is a general-purpose calculation engine for structural analysis and integrated Steel, Concrete, Timber and Aluminium design. To start with we have solved some sample problems using STAAD Pro and checked the accuracy of the results with manual calculations. The results were to satisfaction and were accurate. In the initial phase of our project we have done calculations regarding loadings on buildings and also considered seismic and wind loads. 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. 2 To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine dynamic response, stability and non-linear behaviour. The aim of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and adequate resistance to the effects of seismic and wind. Structure and structural elements shall normally be designed by Limit State Method. Account should be taken of accepted theories, experiment and experience and the need to design for durability. Design, including design for durability, construction and use in service should be considered as a whole. The realization of design objectives requires compliance with clearly defined standards for materials, production, workmanship and also maintenance and use of structure in service. The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes. The minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads, the structure would be required to bear. Strict conformity to loading standards recommended in this code, it is hoped, will not only ensure the structural safety of the buildings which are being designed.

2. LOADSCONSIDERED:

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.

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.

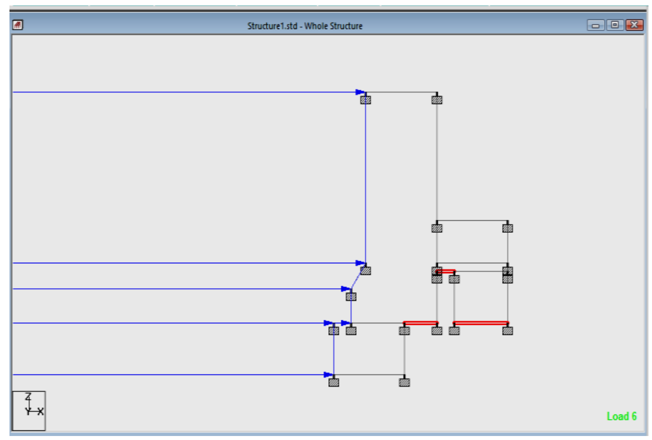

FIGURE 03: ASSIGNING OF WIND LOAD

WIND LOAD: 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 speeds are assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 metres above ground.

Design Wind Speed(V,) The basic wind speed (V,) for any site shall be obtained from and shall be modified to include the following effects to get design wind velocity at any height (V,) for the chosen structure: a) Risk level; b) Terrain roughness, height and size of structure; and 5 c) Local topography. It can be mathematically expressed as follows: Where: **V = Vb * kl * k* ks,**Vb = design wind speed at any height z in m/s; kl = probability factor (risk coefficient) k = terrain, height and structure size factor and ks = topography factor

Risk Coefficient(kI Factor) gives basic wind speeds for terrain Category 2 as applicable at 10 m above ground level based on 50 years mean return period. In the design of all buildings and structures, a regional basic wind speed having a mean return period of 50 years shall be used.

Terrain, Height and Structure Size Factor(k Factor) Terrain - Selection of terrain categories shall be made with due regard to the effect of obstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may vary depending on the direction of wind under consideration. Wherever sufficient meteorological information is available about the nature of wind direction, the orientation of any building or structure may be suitably planned.

Topography(ks Factor) - The basic wind speed Vb takes account of the general level of site above sea level. This does not allow for local topographic features such as hills, valleys, cliffs, escarpments, or ridges which can significantly affect wind speed in their vicinity. The effect of topography is to accelerate wind near the summits of hills or crests of cliffs, escarpments or ridges and decelerate the wind in valleys or near the foot of cliff, steep escarpments, or ridges.

3. WIND PRESSURES AND FORCES ON BUILDINGS/STRUCTURES

The wind load on a building shall be calculated for: a) The building as a whole, b) Individual structural elements as roofs and walls, and c) Individual cladding units including glazing and their fixings.

Pressure Coefficients - The pressure coefficients are always given for a particular surface or part of the surface of a building. The wind load acting normal to a surface is obtained by multiplying the area of that surface or its appropriate portion by the pressure coefficient (C,) and the design wind pressure at the height of the surface from the ground. The average values of these pressure coefficients for some building shapes Average values of pressure coefficients are given for critical wind directions in one or more quadrants. In order to determine the maximum wind load on the building, the total load should be calculated for each of the critical directions shown from all quadrants. Where considerable variation of pressure occurs over a surface, it has been subdivided and mean pressure coefficients given for each of its several parts. Then the wind load, F, acting in a direction normal to the individual structural element or Cladding unit is:

F= (Cpe – Cpi) A Pd, Where Cpe= external pressure coefficient, Cpi= internal pressure- coefficient, A = surface area of structural or cladding unit, and Pd = design wind pressure element

4. SEISMICLOAD

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.

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:

Vb= Ah W 7 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 h0.75 for RC frame building Ta=0.085 h0.75 for steel frame building Where, 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: **T=.09H/√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: Qi=Design lateral force at floor i, Wi=Seismic weight of floor i, hi=Height of floor i measured from base, and 8 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,

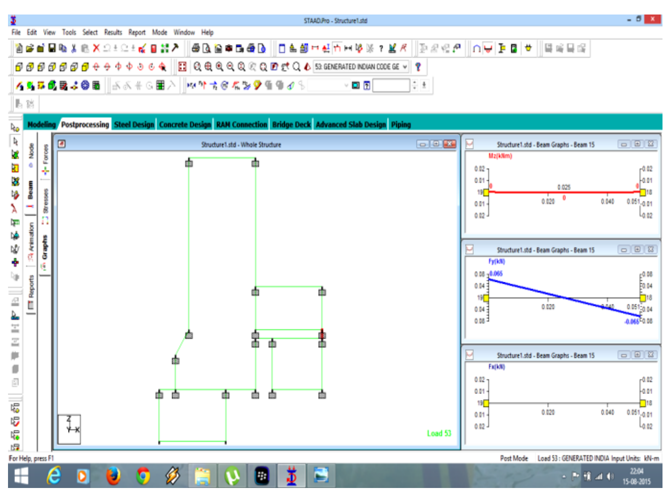

FIGURE 04: BEAM GRAPH OF STRUCTURE

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 Greater than 90 m in height in Zones II and 111. b) *Irregular buildings* – All framed buildings higher than 12m in Zones IV and V and those greater 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.

5. CONCLUSION

Our paper is based on an analysis done on a multi-storeyed frame (G+50F) using a commercial software STAAD Pro.

Here we applied different kinds of load on the frame viz. Seismic, wind, dead, live and the respective load combinations.

We found that our program did compile with zero errors.

Upon analysis, the displacement found was very negligible, the structure showed negligible signs of deflection under various 'LOAD' leaps.

Thus, it was concluded that the with the help of commercially available software'slike STAAD Pro, etc. it is possible to construct a stable and a safe structure in conformity with the loads provided.

STAAD Pro provides us a fast, efficient, easy to use and accurate platform for analysing and designing structures.

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