Wind Analysis of Multistory Building: A Review

Vikrant Trivedi, Sumit Pahwa

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Abstract*:* Structural Analysis and design are predominant in finding out significant threats to integrity and stability of a structure. Multi storied structures, when designed, are made to fulfill basic aspects and serviceability. Since Robustness of structure depends on loads imposed, it requires attention. All the challenges faced by structural engineers were taken as opportunities to develop software's such as STAAD PRO, ETABS & SAFE, SAP etc., with ease of use. Software such as STAAD-pro is leading commercial software worldwide for structural analysis. The design results using STAAD PRO of a rectangular RCC building, for both regular and irregular plan configuration, are used. Reinforced Concrete (RC) building frames are most common types of constructions in urban India. These are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to wind load. This study presents a review of the previous work done on multistoried buildings about wind load analysis. It focuses on static and dynamic analysis of buildings.

Keywords: Wind Load, STAAD pro, wind load, Deflection, High rise building, RCC frame.

INTRODUCTION

Many researches and studies have been done in order to mitigate excitations and improve the performance of tall building against wind loads. An extremely important and effective design approach among these methods is aerodynamic modifications, including, modifications of buildings corner geometry and its cross-sectional shape. Tall buildings are gigantic projects demanding incredible logistics and management, and require enormous financial investment. A careful coordination of the structural elements and the shape of a building which minimize the lateral displacement, may offer considerable savings. Nowadays, the challenge of designing an efficient tall building has considerable changed. The conventional approach to tall building design in the past was to limit the forms of the building to a rectangular shape mostly, but today, much more complicated building geometries could be utilized. It has been concluded that the principal reasons of failure may be attributed to soft stories, floating columns, mass irregularities, poor quality of construction materials and faulty construction practices, inconsistent wind force response, soil and foundation, effect of pounding of adjacent structures. All over world, there is high demand for construction of tall buildings due to increasing urbanization and spiraling population, and wind loads have the potential for causing the greatest damages to tall structures. Since wind forces are random in nature, the engineering tools need to be sharpened for analyzing structures under the action of these forces.

REINFORCED CONCRETE

Reinforced concrete is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength and ductility. The reinforcement is usually embedded passively in the concrete before the concrete sets. The reinforcement needs to have the following properties at least for the strong and durable construction:

- High relative strength
- High toleration of tensile strain
- Good bond to the concrete, irrespective of pH, moisture, and similar factor.
- Thermal compatibility, not causing unacceptable stresses in response to changing temperatures.

STAAD-Pro Vi8.

One of the most famous analysis methods for analysis is "Moment Distribution Method", which is based on the concept of transferring the loads on the beams to the supports at their ends. Each support will take portion of the load according to its K; K is the stiffness factor, which equals (EI/L). E, and L is constant per span, the only variable is I; moment of inertia. I depend on the cross section of the member. To use the moment distribution method, you have to assume a cross section for the spans of the continuous beam. To analyze the frame, "Stiffness Matrix Method" is used which depends upon matrices. The main formula of this method is [P] = [K] x [Δ]. [P] is the force matrix = Dead Load, Live Load, Wind Load, etc. [K] is the stiffness factor matrix. K= (EI/L). [Δ] is the displacement matrix.

STAAD was the first structural software which adopted Matrix Methods for analysis. The stiffness analysis implemented in STAAD is based on the matrix displacement method. In the matrix analysis of structures by the displacement method, the structure is first idealized into an assembly of discrete structural components (frame members or finite elements). Each component has an assumed form of displacement in a manner which satisfies the force equilibrium and displacement compatibility y at the joints.

STAAD stands for Structural Analysis and Design. STAAD-Pro is a general purpose structural analysis and design program with applications primarily in the building industry – commercial buildings, bridges and highways structures, and industrial structures etc. The program hence consists of the following facilities to enable this task:-

- Graphical model generation utilities as well as text editor based commands for creating the mathematical model. Beam and column members are represented using lines. Walls, slabs and panel type entities are represented using triangular and quadrilateral finite elements. Solid blocks are represented using brick elements. These utilities allow the user to create the geometry, assign properties, orient cross sections as desired, assign materials like steel, concrete, timber, aluminium, specify supports, apply loads explicitly as well as have the program generate loads, design parameters etc.

- Analysis engines for performing linear elastic and p-delta analysis, finite element analysis, frequency extraction and dynamic response.

- Design engines for code checking and optimization of steel, aluminium and timber members. Reinforcement calculations for concrete beams, columns, slabs and shear walls. Design of shear and moment calculations for steel members.

- Result viewing, result verification and report generation tools for examining displacement diagrams, bending moment and shear force diagrams, beam, plate and solid tress contours, etc.

- Peripheral tools for activities like import and export of the data from and to other widely accepted formats, links with other popular software's for footing design, steel connection design, etc.

Literature study

The geometrical properties of reinforced concrete members vary many a times. This variability is a consequence of inaccuracies in construction. In some cases the variability is of a more systematic type but most frequently it is random. These variations must be considered when dealing with structural safety aspects because they could present major uncertainties in a structure. The geometrical variations of reinforced concrete members can also greatly influence the cost of construction. In this chapter an extensive review of the literature connected with several aspects, such as construction errors, tolerances, deterioration of structures, structural safety and reliability aspects, is presented.

A E. Hassaballa et. al. (2013) Seismic analysis of a multi-story RC frame in Khartoum city was analyzed under moderate earthquake loads as an application of seismic hazard, and in accordance with the seismic provisions proposed for Sudan to investigate the performance of existing buildings if exposed to seismic loads. The frame was analyzed using the response spectrum method to calculate the seismic displacements and stresses. The results obtained, clearly, show that the nodal displacements caused drifts in excess of approximately 2 to 3 times the allowable drifts. The horizontal motion has a greater effect on the axial compression loads of the exterior columns compared to the interior columns and the compressive stresses in ground floor columns were about 1.2 to 2 times the tensile stresses. The maximum values of compressive and tensile stresses in beams are approximately equal. Bending moments in beams and columns due to seismic excitation showed much larger values compared to that due to static loads.

A. kumar N. et. al. (2017) analyzed the plan of hospital building by using software techniques. The design of hospital building should be developed with following disciplinary activities. The design was followed up by using IS (Indian standard) codes for better output of design considerations. Here the hospital building was designed and analyzed for G+3 storey structure. Nowadays, the software techniques were highly involved in a construction field for quick and better accuracy of an analysis report to execute the given project successfully. In this paper, STAAD.PRO V8i has been used for designing and analysis purposes mainly for the reult of shear force and maximum bending moment. RCC detailing is important for clear in executing the reinforcement work on the site without any complexity.

B. Gireesh Babu (2017) studied the seismic response of the structures is investigated under earthquake excitation expressed in the form of member forces, joint displacement, support reaction and story drift. The response is investigated for g+7 building structures by using STAAD PRO designing software. We observed the response reduction of cases Ordinary moment resisting frame. In this case, we have taken earthquake zone 2, response factor 3 for Ordinary moment resisting frame and importance factor. Initially, they started with the designing of simple 2-dimensional frames and manually checked the accuracy of the software with our results. Then according to the specified criteria assigned it analyses the structure and designs the members with reinforcement details for G+7 residential building RCC frames.

Gaurav Kumar et. al. (2016) Analyzed seismic response of a building is to design and build a structure in which the damage to the structure and its structure component by earth quake is minimized. The study aims towards the review of study of dynamic structural behavior of simple configuration and complex configuration multi storey building with floating column conducted by various authors in the past. The analysis is done on building models having different numbers of storey of RCC with simple and complex floor plan with floating columns. Finite element base software namely ETABS, Staad pro v8i, for the analysis which can easily determine the parameter such as lateral forces, bending moment, shear force, axial force, storey shear, storey drift, base shear. Time history method or response spectrum method is used for the dynamic analysis for simple and complex building configuration.

Gauri G. Kakpure et. al. (2016) studied about the previous work done on multistoried buildings vis-à-vis earthquake analysis. It focuses on static and dynamic analysis of buildings. Reinforced Concrete (RC) building frames are most common types of constructions in urban India. These are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to earthquake.

Gourav Sachdeva et. al. (2016) evaluated the performance of RCC frame building with different position of floating column along with the seismic analysis. Different models are structured up, each being sub-divided into various sub-models, showing the different positions of floating column at each storey. Through this analysis, the best position of the floating column is located in each case on the basis of Parameters taken. Also the equations are formulated such that the Maximum Displacement (in X & Z direction) along with Minimum Reaction (in Y direction) can be calculated up to 6 storeys SMRF (Special moment resisting frame) Building. The above building models are generated using the software STAAD Pro V8i.

Harman et. al. (2017) studied the effect of different cross-section i.e. rectangle, square & circular) of column on symmetrical R.C.C. frame structure. For this study, G+3, G+7, G+11 storey buildings were developed with different section of column and then it was analyzed by using Staad.pro for gravity loads as well as seismic forces by using the codal provisions given in IS-456:2000 and IS-1893:2002. After optimizing the structure in software, results are recorded in terms of cost of concrete and steel. The results of the analysis show that for G+3 storey building, total cost of building (i.e. total cost of concrete and steel) is minimum for Square cross-section. For G+7 store building, total cost of building is minimum for square cross-section. For G+11 storey building, total cost of building is minimum for square cross section.

K Venu Manikanta, et. al. (2016) a detailed analysis on simulation tools ETABS and STAAD PRO, which have been used for analysis and design of rectangular Plan with vertical regular and rectangular Plan with Vertical geometrically irregular multi-storey building. This study is focused on bringing out advantages of using ETABS over current practices of STAAD PRO versions to light. It was observed that ETABS is more user friendly, accurate, compatible for analysing design results and many more advantages to be discussed in this study over STAADPRO. The design results using STAAD PRO and ETABS of a rectangular RCC building, for both regular and irregular plan configuration, are obtained and compared.

Kavita K. Ghogare (2015) studied the seismic analysis and design of RCC building subjected to dead load, live load and earthquake load. For paper work the equivalent static analysis is carried out for multi-storey RCC building is done. The seismic analysis & design of multi-storey RCC building is carried out using Software Computer Aided Design i.e., (STAAD PRO 2007) .The main parameters consider for comparing seismic performance of buildings are bending moment ,shear force ,deflection and axial force. The seismic design of building frame presented in this paper is based on IS: 1893:2002 and IS: 456:2000 .The building consists of four (GF+3) storey. The selection of arbitrary sections has been done following a standard procedure.

M. R. Patel et. al. (2017) the effect of wind velocity and structural response of building frame on sloping ground has been studied. Considering various frame geometries. Combination of static and wind loads are considered. For combination, 10 cases in different wind zones are analyzed. STAAD-Pro v8i software has been used for analysis purpose. Results are collected in terms of axial force, Shear force, moment, Storey-wise drift and Displacement which are critically analyzed to quantify the effects of various heights of structure.

Mohit Sharma et. al. (2014) Experimental study performed on G+ 30 storied regular building model in STAAD Pro. These buildings have the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation is 2.4 m. & total height of chosen building including depth of foundation is 114 m. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the IS-1893- 2002-Part-1 for the zones- 2 and 3 and the post processing result obtained has summarized.

F. N. Pachchigar et. al. (2016) performed experimental analysis on Multi-Storeyed RCC Building Model with Soft Storey in STAAD PRO. The buildings with soft storey are very susceptible under earthquake load which create disasters. Due to uses of vehicles and their movements at ground levels infill walls are generally avoided in parking plot, which creates soft storey effect. It should be noted that 70 to 80 % of buildings of urban areas in India fall under the classification of soft storey structure according to IS 1893 (2002) Part-I. The open ground storey or soft storey is both a soft and a weak storey. For proper assessment of the storey stiffness of buildings with soft storey, different models G+5 and G+11 will be analyzing using software.

Pathan Irfan Khan et. al. (2016) performed seismic analysis of RCC buildings with mass irregularity at different floor level are carried out. This study highlights the effect of mass irregularity on different floor in RCC buildings with as Response Spectrum analysis was performed on regular and various irregular buildings using STAAD-Pro. The lateral displacement of the building is reduced as the percentage of irregularity increase. It was found that mass irregular building frames experience larger base shear than similar regular building frames.

Priyanka Soni et. al. (2016) studied and analyzed of various research works involved in enhancement of shear walls and their behaviour towards lateral loads. As shear walls resists major portions of lateral loads in the lower portion of the buildings and the frame supports the lateral loads in the upper portions of building which is suited for soft storey high rise building, building which are similar in nature constructed in India, As in India base floors are used for parking and garages or officers and upper floors are used for residential purposes. Shear walls are structural systems which provide stability to structures from lateral loads like wind, seismic loads. These structural systems are constructed by reinforced concrete, plywood/timber unreinforced masonry, reinforced masonry at which these systems are sub divided into coupled shear walls, shear wall frames, shear panels and staggered walls

R. Vishwakarma et. al. (2017) analyzed using Staad Pro comparison between sloping ground, with different slope and plain ground building using Response Spectrum Method as per IS 1893-2000 The dynamic response, Maximum displacement in columns are analyzed with different configurations of sloping ground. The hilly areas in north east India contained seismic activity. Due to hilly areas building are required to be constructed on sloping ground due to lack of plain ground. The buildings are irregularly situated on hilly slopes in earthquake areas therefore many damages occurred when earthquake are affected, this may be causes lot human disaster and also affect the economic growth of these areas.

S. P. Sharma et. al. (2015) studied of multi-storey RC frame structure with lateral load resisting systems such as shear wall and diagrid system. The present work concerned with the comparative study of seismic analysis of multi-storied building with shear wall and bracing, analysis of multi-storey structure of different shear wall locations and heights and proper location of shear wall in the multi-storey building etc. This study reports on research development on seismic behavior of structure by using shear wall or diagrid. Some researchers have concluded that the shear wall, diagrid and hexagrid system do not interfere in the vertical load resisting system for RC structure but they affects the lateral load resisting system of the same due to its stiffness and mass.

S.K. Dubey et. al. (2015) the main objective of study is to design and build a structure in such a way that the damage to the structure and its structural component during an earthquake is minimized. Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building. It should be performed for both regular and irregular building. To perform dynamic analysis this are provision laid down in IS 1893 (part 1) 2002, with respect to height of building and according to irregularity of the building. In regular building greater than 40m height in zone IV and V is required and greater than 90m height in zone II and III. In irregular building greater than 12m height in zone IV and V is required and greater than 40m height in zone II and III.

S. Behera et. al. (2017) investigated earthquake behaviour of buildings with and without shear wall using STAAD Pro. In this study, reinforced concrete buildings are analyzed by changing the various position of shear wall with different locations considering various parameters such as story drift, lateral displacement and others. In the present study, G+10 building has been designed with seismic loading by using equivalent static method. The building is modeled as 3D space frame by STAAD pro software. The dead load, live load, wind loads are calculated by using IS 875(Part 1Part 2 Part 3): 1987 and seismic load as per the IS 1893:2002.

R. K Sharma et. al. (2016) studies the analysis of G+5, G+7, G+9, G+11 and G+13 storey building with floating column and without floating is carried out. The analysis is done by using Staad Pro V8i software by using Response spectrum analysis. The study deals with the results variation in displacement of structure, base shear, Seismic weight calculation of building from manual calculation and STAAD pro V8i. The study is carried out to find whether the floating column structures are safe or unsafe when built in seismically prone areas, and also find out commercial aspects of floating column building either it is economical or uneconomical.

S. M. Harle et. al. (2017) The analysis and design of multi storey building is carried out usually in the software packages which are very strong in analysis. In the present paper the STAAD-PRO is used for the purpose of analysis and design of a building. The building was analyzed for the seismic behavior. Shear force, bending moment, deflections are calculated using the software, the reinforcement details are also available through the design. The coding of STAAD editor is also included in this paper. The design of slab, beam, column and footing are carried out by the programming of MATLAB. The objective of this study was to check the programming language for these structural elements.

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