

COMPARISON OF SEISMIC AND WIND ANALYSIS OF G+5 AND G+10 BUILDINGS

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ABSTRACT

Every multi-storey building must be designed to resist lateral loads in addition to gravity loads, and in India the two principal sources of lateral load are earthquakes and wind. The magnitude of each depends on different factors. Seismic load depends mainly on the mass of the building, its stiffness, the seismic zone, and the soil type, while wind load depends on the basic wind speed, terrain, building height, and exposed area. For a given site and building, either of these may govern the design, and designers need to know which one controls the member sizes and reinforcement. The present study compares seismic and wind analysis for two RCC buildings of different heights.

Two RCC moment-resisting frame buildings, a G+5 and a G+10, with the same plan of 20 m by 16 m are modelled in STAAD.Pro. Both buildings are assumed to be located in Seismic Zone III on medium soil and in a region with a basic wind speed of 44 m/s. Seismic loads are calculated according to IS 1893 (Part 1):2016 by the equivalent static and response spectrum methods, and wind loads are calculated according to IS 875 (Part 3):2015 for terrain category 3. Dead and live loads follow IS 875 (Parts 1 and 2).

The buildings are analysed for gravity, seismic, and wind load combinations as specified in IS 456:2000 and IS 1893, and the results are compared in terms of storey displacement, storey drift, storey shear, base shear, overturning moment, and forces in critical columns. The members are designed according to IS 456:2000 so that the governing load combination for each member can be identified.

The results show that for the G+5 building seismic load governs, giving a higher base shear, larger storey drift, and larger column moments than wind load. For the G+10 building, the wind base shear increases considerably because of the larger exposed height and the increase of design wind speed with height, and wind becomes comparable to or greater than seismic load in the upper storeys. Seismic storey shear is concentrated near the top because of the parabolic distribution, while wind shear increases more uniformly towards the base.

The study concludes that both load types must be examined for buildings of medium height and that the controlling load changes with height, zone, and wind speed. The comparison provides a practical reference for students and designers who need to decide how much attention each load type requires at the preliminary design stage of multi-storey buildings.

I. INTRODUCTION

Lateral loads are the main concern in the design of multi-storey buildings. Gravity loads act vertically and are carried directly by columns to the foundation, but lateral loads produce bending in columns and beams, sway of the whole frame, and overturning moments that increase rapidly with height. As buildings become taller, the members must be sized not only for strength but also to limit lateral displacement

and inter-storey drift so that non-structural elements, finishes, and occupants are not adversely affected.

Earthquake load on a building arises from the inertia of its mass when the ground beneath it moves. IS 1893 (Part 1):2016 expresses this load through a design horizontal seismic coefficient that depends on the zone factor, importance factor, response reduction factor, and spectral acceleration corresponding to the building period. The design base shear is proportional to the seismic weight and is distributed over the height in proportion to the product of floor weight and the square of floor height. Heavier and stiffer buildings therefore attract larger seismic forces.

Wind load arises from the pressure of moving air on the exposed faces of the building. IS 875 (Part 3):2015 gives the basic wind speed for different parts of the country and modification factors for risk, terrain and height, topography, and importance, together with factors for directionality, area averaging, and combination of pressures. Because wind speed increases with height above ground, taller buildings experience a higher pressure at their upper storeys in addition to having a larger exposed area. Unlike seismic load, wind load does not depend on the mass of the building.

Because the two load types depend on different parameters, it is not obvious which will control the design of a particular building. For low-rise heavy RCC buildings in moderate and high seismic zones, seismic load usually governs, while for tall and light buildings in high wind regions, wind may govern. The present study compares the effect of seismic and wind loading on a G+5 and a G+10 RCC building of identical plan using STAAD.Pro, in order to show how the controlling load changes with building height and to highlight the response parameters that are most affected.

II. LITERATURE SURVEY

The comparison of seismic and wind effects on buildings has been a subject of interest for designers because the two loads are specified in separate codes and are applied independently, with the more critical governing the design. Studies on low-rise and medium-rise RCC buildings in India have generally reported that seismic load governs for buildings up to about six to eight storeys in Zones III to V, because the seismic weight of a concrete building is large compared with its exposed area. Researchers have noted, however, that this conclusion depends strongly on the assumed basic wind speed. For buildings located in coastal regions with basic wind speeds of 47 to 55 m/s, wind can govern even for medium height buildings, especially in Zone II and Zone III. Authors have therefore recommended that designers perform both analyses routinely rather than assuming in advance that one of them will control, and several studies have presented tables of the height at which the governing load changes for different combinations of zone and wind speed.

Parametric studies using STAAD.Pro and ETABS have examined how the ratio of wind to seismic base shear changes with the number of storeys. Researchers modelling buildings from G+3 to G+20 in the same location have reported that seismic base shear increases roughly in proportion to the seismic weight but is moderated by the decrease in spectral acceleration as the period lengthens. Wind base shear, in contrast, increases faster than linearly with height because both the exposed area and the design wind pressure increase. The two curves therefore cross at a certain height, above which wind governs. Studies have also shown that the distribution of storey shear differs between the two loads. Seismic storey shear, distributed according to the square of floor height, produces relatively large forces near the top, whereas

wind shear accumulates more gradually from top to bottom, which affects the design of beams and columns at different levels differently.

Research on the provisions of IS 875 (Part 3):2015 has highlighted the changes made in the revised code compared with the earlier 1987 version. The revised code introduced the wind directionality factor, area averaging factor, and combination factor, and revised the terrain and height multipliers for different terrain categories. Studies comparing the two versions have found that the design wind pressure on tall buildings may increase or decrease depending on the terrain category and the size of the building, and that the gust factor method becomes necessary for buildings whose height exceeds the limits for the static method or whose natural frequency is low. Authors have pointed out that for buildings up to about 50 m in height and with regular shapes, the static method remains appropriate and gives results suitable for design, which is the case for both buildings in the present study.

Studies on the seismic analysis of RCC buildings according to IS 1893 (Part 1):2016 have examined the differences between the equivalent static and response spectrum methods for buildings of different heights. For regular buildings of moderate height, the two methods give similar base shears once the dynamic results are scaled to the static base shear as required by the code. The response spectrum method, however, captures higher mode effects and gives a more realistic distribution of storey shear in taller buildings. Researchers have also noted the effect of the 2016 revision, which introduced a minimum design base shear, changed the treatment of the approximate period to include the effect of infill walls, and required the use of cracked section properties in some cases. These changes generally increased the design seismic forces for many buildings compared with earlier practice.

Drift and displacement limits have been identified in several studies as the critical requirement for taller buildings. IS 1893 (Part 1):2016 limits the storey drift under seismic load to 0.004 times the storey height, while for wind load a limit on the total lateral displacement of about $H/500$ is commonly used in practice. Researchers have found that the drift limit under seismic load often governs member sizes in higher zones, while the wind displacement limit becomes important for slender buildings in high wind regions. Studies comparing G+5, G+10, and G+15 buildings have shown that column sizes adequate for strength may need to be increased to satisfy drift limits under whichever load produces larger displacement.

III. SYSTEM ANALYSIS

The structural problem studied is the comparison of the effects of seismic and wind loads on RCC framed buildings of two different heights. Two buildings, a G+5 of 18 m height and a G+10 of 33 m height, are considered, both with a plan of 20 m by 16 m, a bay spacing of 4 m by 4 m, and a storey height of 3 m. Column sizes are 450 mm by 450 mm for the G+5 building and 500 mm by 600 mm in the lower storeys of the G+10 building, beams are 300 mm by 450 mm, and slabs are 150 mm thick, with M25 concrete and Fe500 steel. Dead load includes self-weight, floor finish of 1 kN/m², and wall loads, and live load is taken as 3 kN/m² according to IS 875 (Part 2). Seismic loads correspond to Zone III, medium soil, importance factor 1.0, and response reduction factor 5. Wind loads correspond to a basic wind speed of 44 m/s, terrain category 3, and a risk coefficient of 1.0. The parameters compared are displacement, drift, storey shear, base shear, overturning moment, and column forces.

Existing System

In conventional design of medium height buildings, lateral loads are often handled in a simplified manner. Designers frequently compute only the seismic load by the equivalent static method and assume that it governs, particularly for concrete buildings, without calculating wind load at all. When wind load is calculated, it is usually done by hand using the design wind pressure at a few height ranges, and the resulting forces are applied as point loads on a plane frame. Seismic forces are distributed over the height by the parabolic formula and applied to the same plane frame, and the frame is analysed separately for each load by approximate methods such as the portal or cantilever method. Load combinations involving dead, live, seismic, and wind loads in both directions are assembled manually, which makes it difficult to identify the governing combination for each member. Storey drift is rarely checked at every level for both load types, and the transition in controlling load with building height is not examined systematically.

Disadvantages of Existing System

- Seismic load is often assumed to govern without checking wind load.
- Wind pressure is computed at only a few height ranges by hand.
- Approximate portal and cantilever methods give only rough member forces.
- Plane frame analysis ignores three-dimensional distribution of lateral loads.
- Manual combination of dead, live, seismic, and wind loads is lengthy.
- The governing load combination for each member is difficult to identify.
- Storey drift is not checked at every level for both load types.
- Results for seismic and wind loads are not compared in a consistent format.

Proposed System

The proposed approach models both buildings as three-dimensional frames in STAAD.Pro and applies seismic and wind loads through the built-in code procedures. Beams and columns are modelled as frame members, slabs are represented by floor loads and rigid diaphragm action, and supports are fixed at the foundation. Gravity loads are applied according to IS 875 (Parts 1 and 2). Seismic loads are defined according to IS 1893 (Part 1):2016 in both horizontal directions using the equivalent static method, and a response spectrum analysis is also carried out and scaled to the static base shear. Wind loads are generated according to IS 875 (Part 3):2015 by defining the basic wind speed, terrain category, and exposure surfaces, so that the pressure at each floor level is computed from the height variation of the design wind speed. Load combinations of IS 456:2000 and IS 1893 are created. The analysis gives storey displacement, drift, storey shear, and member forces for each load type, and concrete design identifies the governing combination for every member.

Advantages of Proposed System

- Both seismic and wind loads are generated from code procedures for the same model.
- Wind pressure varies continuously with height as specified in IS 875 (Part 3).
- Three-dimensional analysis distributes lateral loads correctly to all frames.
- Response spectrum analysis captures higher mode effects in the taller building.
- All load combinations are generated and evaluated consistently.
- The governing load combination for every member is reported by the design module.
- Storey drift and displacement are available at every level for both load types.
- Storey shear and overturning moment can be compared directly between loads.

IV. METHODOLOGY

The methodology begins with the selection of the building plan, storey height, member sizes, and site parameters for both buildings. The G+5 model is created in STAAD.Pro by generating the grid and assigning beams and columns with their section properties and material properties for M25 concrete and Fe500 steel. Fixed supports are assigned at the base. Dead, floor finish, wall, and live loads are applied according to IS 875 (Parts 1 and 2). The seismic definition is specified with the zone factor, soil type, importance factor, response reduction factor, and time period, and seismic load cases are created in the X and Z directions. The wind definition is created with the basic wind speed, terrain category, and exposure factors, and wind load cases are generated in both directions. Load combinations are formed for limit state design. The model is analysed, and displacement, drift, storey shear, base shear, and column forces are extracted for each load. The same steps are repeated for the G+10 model. Finally, members are designed to IS 456:2000 and the seismic and wind results are compared for both heights.

SYSTEM ARCHITECTURE

The workflow of the study is organised as a sequence of stages. The Data Collection stage fixes the plan, storey heights, material grades, seismic zone, soil type, basic wind speed, and terrain category. The Geometry Modelling stage creates the G+5 and G+10 frames in STAAD.Pro. The Material and Section stage assigns properties to beams and columns. The Gravity Load stage applies dead and live loads according to IS 875 (Parts 1 and 2). The Seismic Load stage defines equivalent static and response spectrum cases according to IS 1893 (Part 1):2016. The Wind Load stage computes and applies design wind pressure according to IS 875 (Part 3):2015. The Load Combination stage creates the design combinations. The Analysis and Design stage solves both models and designs members according to IS 456:2000. The Result Comparison stage compares displacement, drift, storey shear, base shear, overturning moment, and column forces between seismic and wind loading for both buildings. The comparison is presented storey by storey, so that the level at which the controlling load changes can be located clearly for each building height.

Comparison of Seismic and Wind Analysis of G+5 and G+10 Buildings

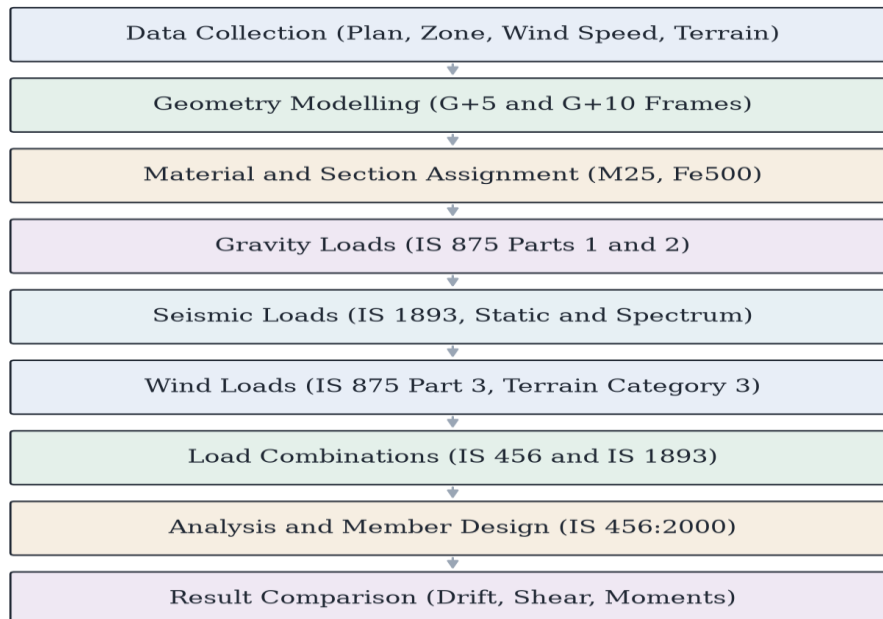


Fig. 1 System Architecture

V. RESULT AND OUTPUT

Comparison of Seismic and Wind Analysis of G+5 and G+10 Buildings Performance Evaluation under Lateral Loads



VI. CONCLUSION

This study compared the effects of seismic and wind loads on G+5 and G+10 RCC framed buildings of identical plan using STAAD.Pro. Seismic loads were calculated according to IS 1893 (Part 1):2016 for Zone III and wind loads according to IS 875 (Part 3):2015 for a basic wind speed of 44 m/s, and both buildings were designed according to IS 456:2000. The comparison was made in terms of displacement, drift, storey shear, base shear, overturning moment, and column forces.

For the G+5 building, seismic load clearly governed. The seismic base shear was considerably larger than the wind base shear, and the storey drift and column moments due to seismic load exceeded those due to wind at every level. This is consistent with the large seismic weight and the relatively small exposed area of a low-rise concrete building.

For the G+10 building, the wind base shear increased substantially because of the larger exposed height and the increase of design wind speed with height, and it approached the seismic base shear. In the upper storeys, wind storey shear was comparable to seismic storey shear, while in the lower storeys seismic effects remained slightly higher in this location. The distribution of shear over height differed between the two loads, with seismic shear concentrated near the top and wind shear increasing more uniformly towards the base. Storey drift remained within the limit of 0.004 times the storey height for both buildings.

The study confirms that both lateral loads must be examined for medium height buildings and that the governing load depends on height, seismic zone, and wind speed. Future work may extend the comparison to taller buildings using the gust factor method, to coastal locations with higher wind speeds, to other seismic zones and soil types, and to buildings with shear walls or other lateral load resisting systems. The effect of infill stiffness on the fundamental period, and hence on seismic base shear, could also be examined, since it is likely to shift the height at which wind begins to govern.

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