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Analysis, Design and 3d Modelling of Reinforced Concrete Frames of Multistory Building for Different Wind Speeds

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ABSTRACT:
This study addresses the 3D modeling, analysis and design of reinforced concrete frames of multi-storey building for different wind speeds. Two multi-storey reinforced concrete buildings having a height of 20.6m and 47.6m consisting of 6 and 15 storey's respectively have been analyzed for 3 different wind speeds of 44, 50 and 55m/sec. The purpose of this study is to show how the beam and column design is affected by height of the building. Comparison of Volume of concrete and Quantity of steel is done for the whole building and also comparisons made for the internal forces like support reactions, bending moment, beam sizes, column sizes, percentage of reinforcement and total cost of the building for different wind speeds. In this study, four types of footings were adopted such as sloped with and without pedestal, flat and stepped were compared for volume of concrete and quantity of steel.

1 INTRODUCTION:
Windstorms present several harms in buildings, especially in tall buildings leading concerns for owners, insurers and engineers all the same. Hurricane winds play the major role in causing economic and insured losses because of natural calamities, far more ahead of floods and earthquakes. The locality of a building cannot be disregarded in designing for wind. The affect of surrounding buildings and configuration of land on the sway response of the building can be considered significant. Those occupying the top floors are concerned about the sway at the top of a tall building due to wind, which may not be visible to a passerby. There is adequate evidence that winds, except those of a tornado or hurricane, have lead to large structural loss to new structures.All buildings sway because of windstorms, but the movement in earlier tall buildings with heavy full-height partitions have been commonly undetectable and certainly had not been a great concern. The stiffness, mass, and damping characteristics of modern buildings are decreased by the lightweight construction technology and structural innovations. In buildings prone to motion of wind issues, objects may shake, doors and chandeliers may sway, pictures may lean, and books may drop off from racks. If the building exhibit a twisting action, the people living in the building may get an delusionary sense that the external environment is moving, leading to signs of vertigo and disorientation. In large violent storms, windows may crack, causing pedestrian safety problem below the building. Now and then, people in the building may hear weird and frightening sounds from elevators, strains of floors and walls and the whistles over the sides of the building.

The criterions that are essential in designing for wind are given below:

1. Stability and Strength.
2. Connections because of fluctuating wind loads and Fatigue in structural members.
3. Massive lateral deflection that may lead to cracking of internal partitions and external cladding, misalignment of mechanical systems, and probable permanent deformation of nonstructural elements.

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4. Amplitude and frequency of sway that can lead to uneasiness to the people of tall and flexible buildings.
5. Possible buffeting that may rise the magnitude of wind speeds on the surrounding buildings.
6. Wind-induced uneasiness in pedestrian locations due to severe surface winds.
7. Acoustical disturbances that is annoying.
8. Resonance caused by oscillations of the building with vibrations of hoist ropes of elevator.

2 LITERATURE:

Swati D Ambadkar and Vipul S. Bawer[1](2012) investigated the behavior of multi-storied building under the effect of wind load. The Wind phenomenon is very complex due to various cases resulting from the collision of wind with structures. In this wind loads are considered as per IS 875(part-3)-1987[2]. The analysis of G+11 building is done by using STAAD Pro. Various variations are considered and analysis is done for three different wind speeds (44 m/s, 47 m/s, 50 m/s).In this study they considered a multi-storied building of length 28m,width 12m and height 40m. From the analysis maximum moment, maximum force and maximum displacement is taken for various categories and openings. They concluded that as the wind speed increases M_y, M_z values increases according to the category, as compared M_z values M_y values increases more rapidly. The F_y, F_z values increases as the wind speed increases according to the category, F_y values increases more rapidly than F_z values. As the wind speed increases, displacement also increases according to various categories.

L. Halder and S.C. Dutta[3] (2010) investigated the wind effects on multi-storied buildings: A critical review of Indian codal provisions with special reference to American standard. The wind force on a structure varies with the site parameters and structural parameters should be known for preliminary design of the structure. The design is done based on Indian code, proposed draft Indian code and American standard code. The wind forces are compared for three codes and an exhaustive comparison of wind forces obtained by force coefficient predicated static analysis and gust factor predicated dynamic analysis interpreting where which method should be utilized for better protection. In this study seven different aspect ratios and for each aspect ratio eight buildings with varying height are considered, the change in the base shear and storey shear is considering due to variation. Analysis has been done by both the force coefficient method and gust factor method for all buildings considering all the terrain categories. As function of the number of stories, the results of these analyses obtained by Gust factor method and the force coefficient method have been plotted as the ratio of base shears and the ratio of storey shears. To assess the salient features of similarity and dissimilarity has been carried out for Indian wind code, proposed Indian code and American standard code. In the terrain category 4 for all buildings with all heights the force coefficient method gives conservative results.

The ratio of the base shear and the ratio of the storey shear is less than 1 obtained by the Gust factor method to the force coefficient method. The buildings with aspect ratio less than 0.5 and number of storey's more than 25 in terrain category 3 are sensitive to the dynamic effect of wind. The buildings with aspect ratio less than one and storey's more than 15 should be analyzed by the Gust factor method in terrain categories 1 and 2. The response of the buildings under the action of wind for aspect ratio greater than 1 force coefficient method gives safe values. The base shear by Indian wind code IS 875(part-3) -1987[2] is 1.30-1.90 times the ASCE 7-02[4], estimated for low to high rise buildings. For proposed draft of the same code is 1.34 - 1.45 times. The study shows that tall structures behaving with low aspect ratio, flexibility providing larger wind facing side may have the severest dynamic effect if situated in terrain category 1 and 2 implying less number of tall structure in the surroundings.

J Lakshminarasimhan, B H Lakshmana Gowda and Ch Sivannarayana[5](2005) has investigated on Interference effects on wind pressures on low-rise and high-rise square structures in side-by-side arrangement. They investigated experimentally on the effects of interference on three-dimensional bluff bodies with square cross-section placed in side-by-side arrangement for a low rise body and a high-rise body. The extent of interference effects are brought out by varying the spacing between the bodies. The surface bodies are exposed to an air stream and the pressure distributions are measured. The pressure distribution on rear side and interference side is greatly affected for low-rise body when interfered by a high-rise body in close proximity. The interference effects are seen to influence not only the magnitude of the wind loads but also the wind movement on the surfaces of a prismatic body. Particularly on the roof and the side surface very steep pressure gradient occurs on a low-rise body. On a high-rise body due to the interference from a shorter body the wind pressure gradients are not affected. A.G Davenport[6] 1967 devised the gust factor method and this method has been widely used for wind calculations during the past three decades. Following Davenports formulation, several researches suggested various modifications to the gust factor method.

COMPARISON OF VOLUME OF CONCRETE AND QUANTITY OF STEEL FOR DIFFERENT TYPES OF FOOTINGS:

The variation of support reactions at each location of the column and the percentage difference for different wind speeds with respect to gravity loads for 6 and 15 storied building is represented in the tables and figures. It is observed that in exterior columns, variations are 3.63, 4.68 and 5.67% between gravity load to wind speeds 44, 50, 55m/s respectively for 6 storied and 15 storied building. In edge columns in X direction, the variations are 1.83, 2.35 and 2.85% and in Z direction, the variations are 2.99, 3.89 and 4.69% between gravity load to wind speeds 44, 50, 55m/s respectively for 6 storied and 15 storied building. The variation is very small in interior columns.

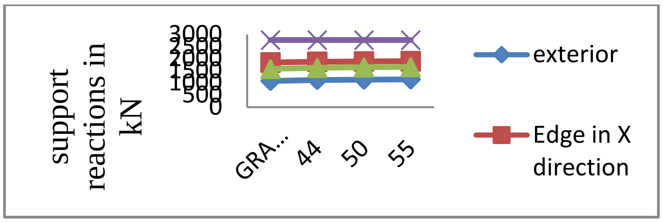

Fig 5.1: Variation of support reactions for 6 storied building

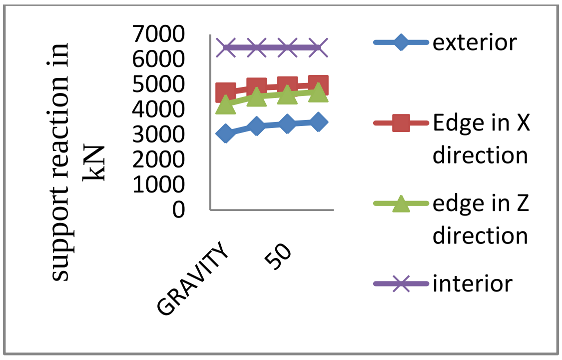

Fig 5.2: Variation of support reactions for 15 storied building

The variation in volume of concrete and quantity of steel of the interior column footing as shown in table and the percentage difference with respect to the sloped footing (without pedestal) as shown in the table.

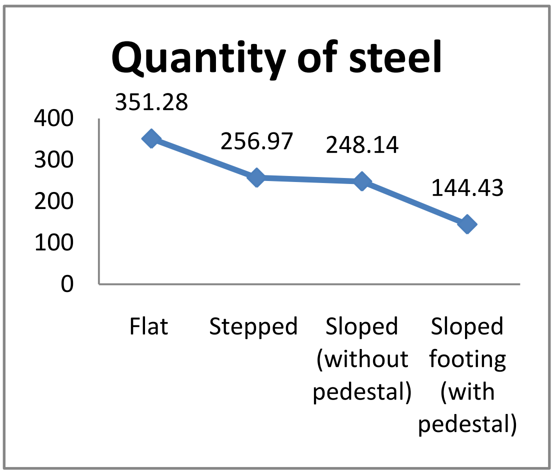

Fig 5.3: Variation of volume of concrete

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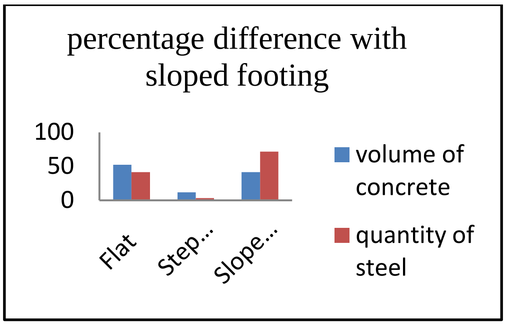

Fig 5.5: Variation of percentage difference with sloped footing

5.3 COMPARISON OF VOLUME OF CONCRETE IN FOOTINGS FOR DIFFERENT WIND SPEEDS:

The variation of volume of concrete at each location of the column footing and the percentage difference with gravity loads for three different wind speeds is represented in table and Fig. It is observed that in exterior column footing, variations are 18.0, 24.14 and 32.95% in 6 storied building and 34.73, 44.72 and 54.43% in 15 storied building between gravity load to three different wind speeds respectively. In edge column footing in X direction, variation are 7.23,9.40 and 11.93% in 6 storied building and 9.89,13.38 and 15.37% in 15 storied building between gravity load to three different wind speeds respectively. In edge column footing in Z direction, variations are 14.09, 18.50 and 21.81% between gravity load to three different wind speeds respectively. The variation in interior column footings are 5.07, 6.63 and 8.29% in 6 storied building and 6.69, 8.80 and 10.54% in 15 storied building

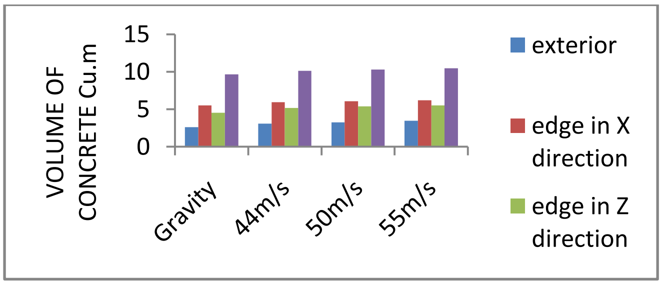

Fig. 5.6: Variation of volume of concrete in footings for 6 storied building

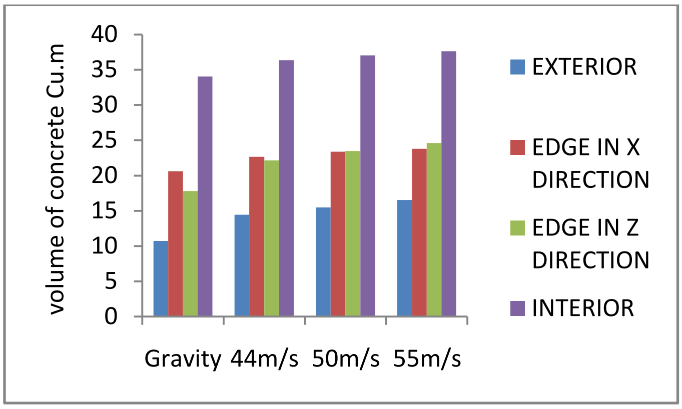

Fig 5.7: Variation of volume of concrete in footing for 15 storied building

5.4 COMPARISON OF WEIGHT OF STEEL IN FOOTING FOR DIFFERENT WIND SPEEDS:

The variation of weight of steel in column footing at each location and the percentage difference with gravity loads for three different wind speeds is represented in table and fig. It is observed that in exterior column footing, the variation are 13.85,24.17 and 34.21% in 6 storied building and 47.73,62.34 and 77.05% between gravity load to three different wind speeds respectively. In edge column footing in X direction, the variations are 7.46, 13.15 and 18.91% in 6 storied building and 12.82, 14.06 and 17.99% in 15 storied building between gravity load to three different wind speeds. In edge column footing in Z direction, the variations are 16.79, 21.25 and 25.39% in 6 storied building and 36.69, 47.08 and 53.05% in 15 storied building between gravity load to three different wind speeds respectively. The variation in interior column footing is 6.91, 7.54 and 8.18% in 6 storied building and 8.84, 9.46 and 12.48% in 15 storied building.

CONCLUSIONS AND SCOPE FOR FURTHER RESEARCH:

CONCLUSIONS:

The variation of support reactions in exterior columns increasing from 3.6% to 5.7% and in edge columns in X-direction increasing from 1.8% to 2.9% and in Z direction increasing from 2.9% to 4.7% for three different wind speeds in 6 and 15 storied building. However the variations of support reactions are very small in interior columns. The bending moment of beams in left hand side and right hand side has increased at level-I and at level III and VI is almost same in all three wind speeds in 6 storey building and maximum values at level III in 15 storey building . At middle of the beam is same in all three different wind speeds. Percentage variation of total concrete quantity for the whole structure, between gravity load and three different wind speeds varies as 1.77, 2.30 and 2.80% in 6 storey building and 3.63, 4.73 and 5.55% in 15 storied building respectively. Percentage variation of total steel quantity for the whole structure, between gravity load and three different wind speeds varies as 10.58, 11.32 and 13.24% in 6 storey building and 21.03, 24.88 and 28.12% in 15 storied building respectively. It is observed that the percentage variation of cost for the whole structure, between gravity load and three different wind speeds varies as 4.98, 5.56 and 6.62% in 6 storey building and 9.82, 11.89 and 13.57% in 15 storied building respectively.