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Analysis of drift due to wind loads and earthquake loads on tall structures by programming language c

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Abstract— Recently there has been a considerable increase in the number of tall buildings, both residential and commercial, and the modern trend is towards taller and more slender structures. Thus the effects of lateral loads like winds loads, earthquake forces are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength and stability against lateral loads. For this reason in recent years wind and earthquake loading have become determining factors in high-rise building design. This lateral loads are mainly responsible for drift. So the design of tall structures must take into consideration of the drift. Although there are no specific requirements in the effects of drift, it is an important issue which may significantly impact the buildings structural behavior and economy. This paper aims to analyze the drift for lateral loads and comparison on drift for earthquake and wind loads on tall structures. To analyze the drift, we used programming with C (version C++ 4.5). Mainly we analyzed three types of high rise structures such as rigid frame , couple shear wall and wall frame structures. Strength, serviceability and stability in tall structures have to include in design criteria. Strength is satisfied by limit stresses, while serviceability is satisfied by drift limits in the range of H/500 to H/1000.On the other hand stability is satisfied by sufficient factor of safety against buckling and P-Delta effects.

Index Terms— Tall Structures, wind load, earthquake load, analysis, drift value, C programming.

1 INTRODUCTION

The tallness of a structure is relative and cannot be defined in absolute terms either in relation to height or the number of stories. The council of Tall Buildings and Urban Habitat considers building having 9 or more stories as high-rise structures [1]. But, from a structural engineer's point of view the tall structure or multi-storied building can be defined as one that, by virtue of its height, is affected by lateral forces due to wind or earthquake or both to an extent. Lateral loads can develop high stresses, produce sway movement or cause vibration [2]. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. So lateral forces due to wind or seismic loading must be considered for tall building design along with gravity forces. Tall and slender buildings are strongly wind sensitive [3] and wind forces are applied to the exposed surfaces of the building, whereas seismic forces are inertial (body forces), which result from the distortion of the ground and the inertial resistance of the building. These forces cause horizontal deflection in a multi-storey building called drift. Lateral deflection is the predicted movement of a structure under lateral loads and story drift is defined as the difference in lateral deflection between two adjacent stories. Lateral deflection and drift have three effects on a structure; the movement can affect the structural elements (such as beams and columns); the movements can affect non-structural elements (such as the windows and cladding); and the movements can affect adjacent structures [4]. Without proper consideration during the design process, large deflections and drifts can have adverse effects on structural elements, nonstructural elements, and adjacent structures. When the initial sizes of the frame members have been selected, an approximate check on the horizontal drift of the structures can be made. The drift in the non-slender rigid frame is mainly caused by racking. This racking may be considered as comprising two components: the first is due to rotation of the joints, as allowed by the double bending of the girders, while the second is caused by double bending of the columns. If the rigid frame is slender, a contribution to drift caused by the overall bending of the frame, resulting from axial deformations of the columns, may be significant. If the frame has a height width ratio less than 4:1, the contribution of overall bending to the total drift at the top of the structure is usually less than 10% of that due to racking. [2]. The following method of calculation for drift allows the separate determination of the components attributable to beam bending, and overall cantilever action.

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2 OBJECTIVES OF THE STUDY

The objectives of the study are summarized below:

- Drift analysis on high-rise structure due to wind loads and earthquake loads.
- To observe the longitudinal impact on high-rise structure.

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- The analysis of drift of different types of tall structures and also calculation of drift by hand and programming with c
- To compare the drift value for both types of loading on different types of tall buildings.

3 METHODOLOGY

Drift problem as the horizontal displacement of all tall buildings is one of the most serious issues in tall building design, relating to the dynamic characteristics of the building during earthquakes and strong winds. Drift shall be caused by the accumulated deformations of each member, such as a beam, column and shear wall. In this study analysis is done with changing structural parameters to observe the effect on the drift (lateral deflection) of the tall building due to both wind and earthquake loading. There are three major types of structures were identified in this study, such as rigid frame, coupled shear wall and wall frame structures. Lateral floor displacements and inter-storey drift for each of three building were made by using C programming. A program made by using C programming to analyze the lateral displacement for different height with structural elements.

For rigid frame structures, to isolate the effect of girder bending, assume the columns are flexural rigid and again to isolate the effect of column bending, assume the girder are flexural rigid. The total frame shear deflection is given by Δ_s

$$\theta_i = \frac{\text{Total moment carried by the joints}}{\text{Total rotational stiffness of the joints}}$$

$$\Delta_s = \Delta_c + \Delta_g = \frac{V_i h_i^2}{12}\{(h_i)/((\Sigma EI)_{col}) + \frac{I}{(\Sigma EI/L)_{beam}}\}$$

For coupled-shear wall structure, consider the plane coupled-wall structure subjected to distributed lateral loading if intensity w per unit height. A general form of loading is used to illustrate the derivation of the governing differential equation, before solutions are derived for common standard design load cases [2]. The lateral deflection for coupled-shear wall structure is

$$\propto^2 = \frac{12 I_c L^2}{b^3 h I}$$

$$k^2 = 1 + \frac{AI}{A_1 A_2 L^2}$$

$$y = \frac{wH^4}{EI}[\frac{1}{24}\{\left(1-\frac{z}{H}\right)^4 + \frac{4z}{H} - 1\right\} + \frac{1}{k^2}\{1/2(k\alpha H)^2 \, [\,\frac{2z}{H} -$$

$$(z/H)^2 \;] - \frac{1}{24}[\left(1 - z/H\right)^4 + \frac{4z}{H} - 1\right] - \frac{1}{(k\alpha H)^4}\cosh k\alpha H\,[1 +$$

$$k\alpha H \sinh k\alpha H - \cosh k\alpha H - k\alpha H \sinh k\alpha H - z\}$$

For wall-frame structure, the planer wall frame may be taken to represent either a structure with walls and frames interacting in the same plane, or one with walls and frames in parallel planes. Since, in a no-twisting structure, parallel walls and frames translate identically, they may be simulated by a planar linked model. The analytical solution requires the structure to be presented by a uniform continuous model. The derivative general equation for laterally deflection is

$$\propto^2 = \frac{(GA)}{EI}$$

$$\propto H = H\sqrt{\frac{(GA)}{EI}}$$

$$y(z) = \frac{wH^4}{EI}\{\frac{1}{(\alpha H)^4}\left[\frac{\alpha H \sinh \alpha H + 1}{\cosh \alpha H}(\cosh \alpha z - 1) - \alpha H \sinh \alpha z\right.$$

$$\left. + (\alpha H)^2\left[\frac{z}{H} - \frac{1}{2}\left(\frac{z}{H}\right)^2\right]\right]$$

4 ANALYSIS AND DISCUSSION

Tall buildings can be analyzed by idealizing the structure into simple two-dimensional or more refined three-dimensional continuums. Drift is an important consideration for tall structure design and often dictates the selection of structural system. In the present study, three types of tall structures were analyzed for lateral loads, with the parameters varied being number of bays, bay width, number of stories and stiffness (e.g., dimensions of beams and columns). To bring the drift down to allowable limits, cross sectional dimension of beams and columns have to be increased. So the structural characterization and drift minimization of tall building frames under lateral load is very important [5]. For rigid frame structures, the drift are depended on total building height, number of spans, cross sectional length and width of girder, cross sectional length and width of column, shear value of girder and shear value of column. It is very clear from Fig. 1. that the value of drift increases with increases building height. The value of drift decreases with increases number of span shown in Fig. 2. Fig. 3. describes the value of drift decreases with increases dimension of beam and column. And Fig. 4. describes the value of drift increases with increase value of shear force on beam and column. By using the programming with C (version C++ 4.5), we get the different value of drift are summarized below:

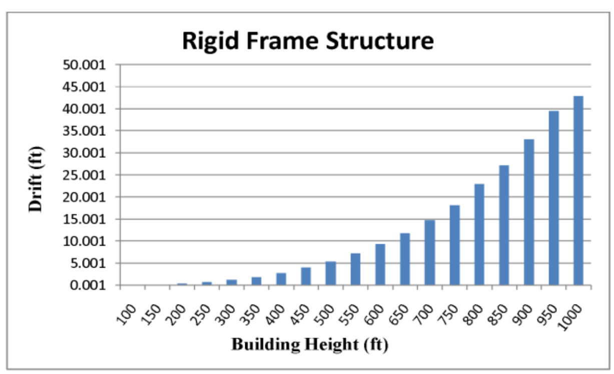

Fig. 1. Variation of drift with building height

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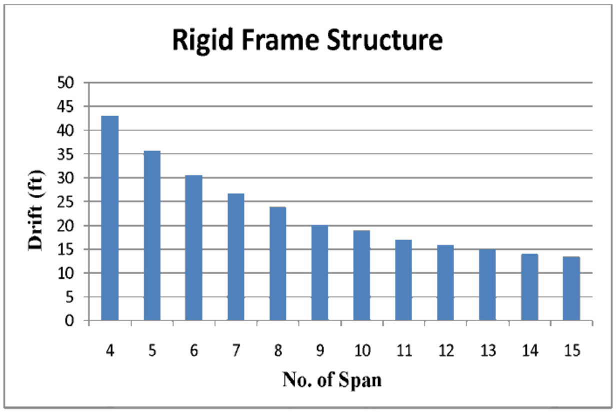

Fig. 2. Variation of drift with number of span

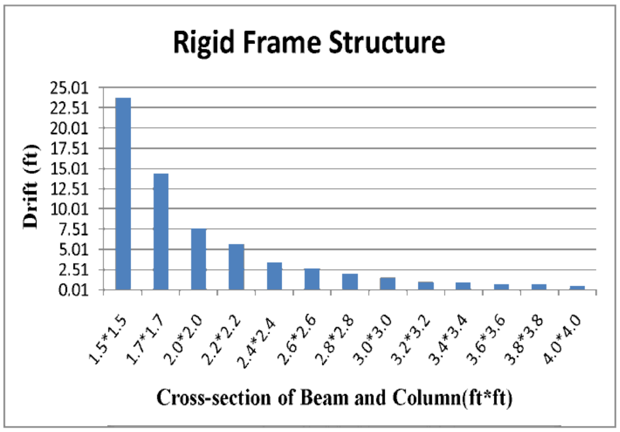

Fig. 3. Variation of drift with dimension of beam and column

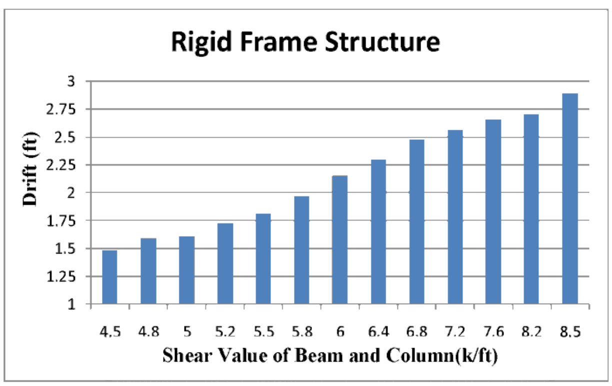

Fig. 4. Variation of drift with shear value on beam and column

In tall buildings, lateral forces, induced by wind and earthquake, are generally resisted by shear walls. Coupled shear wall is a system of interconnected shear walls, usually continuous down to the area to which they are rigidly attached to form vertical cantilevers [6]. Due to their high resistance to lateral forces, shear walls have become very popular in tall buildings. For couple shear wall structures, the drift are depended on total building height, length of wall, width of wall, load intensity on wall. By using the programming with C (version C++ 4.5), we get the different value of drift are summarized below:

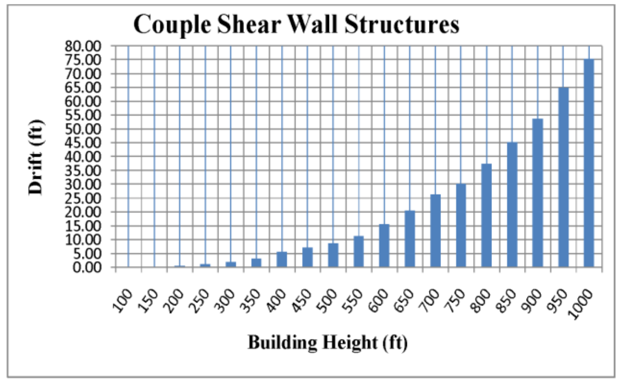

Fig. 5. Variation of drift with building height

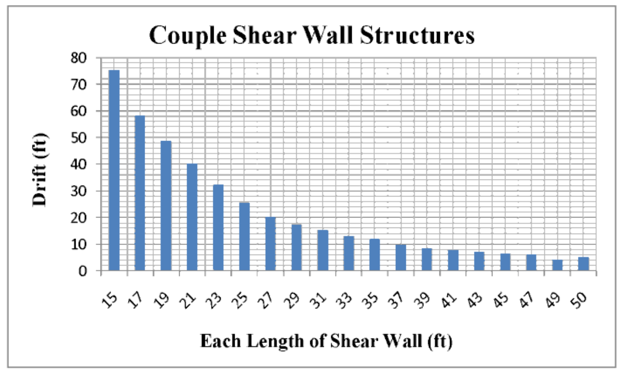

Figure 6: Variation of drift with length of wall

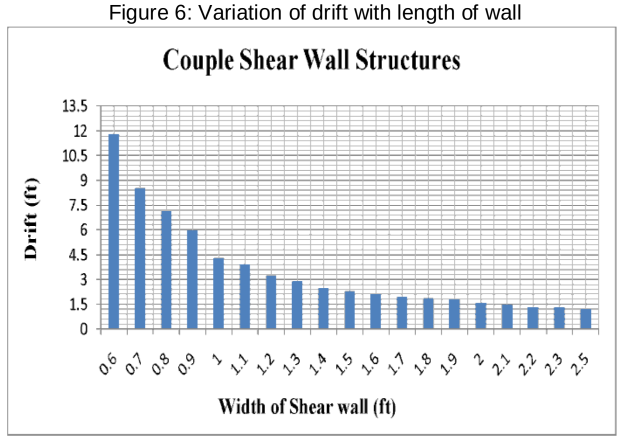

Fig. 7. Variation of drift with width of wall

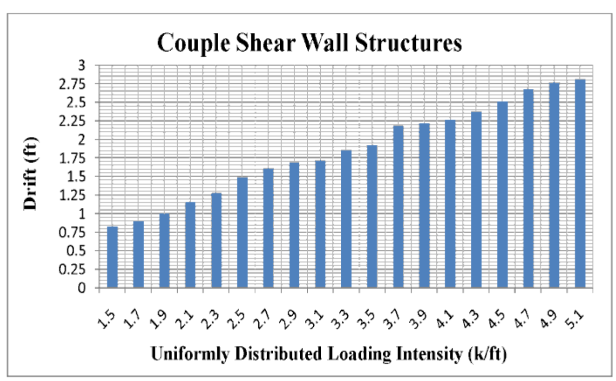

Fig. 8. Variation of drift with load intensity on wall

A structure whose resistance to horizontal loading is provided by a combination of shear walls and rigid frames categorized as a wall-frame structure. For wall-frame structures, the drift are depended on total building height, length of span, dimension of cross section of beam and column, intensity of load.. By using the programming with C (version C++ 4.5), we get the different value of drift are summarized below:

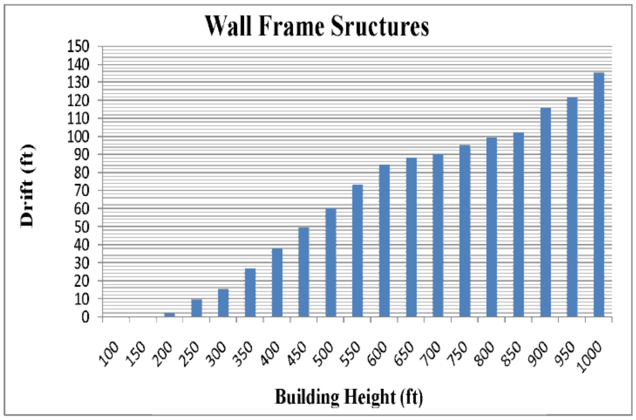

Fig. 9. Variation of drift with building height

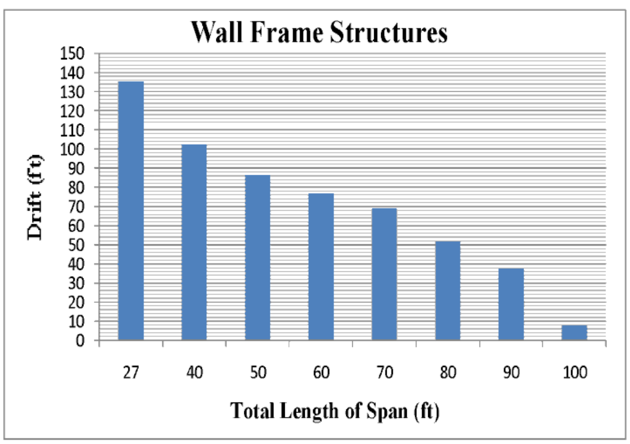

Fig. 10. Variation of drift with number of span

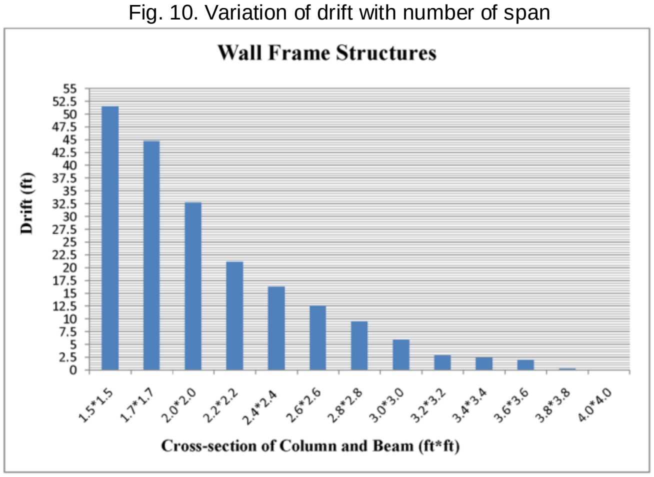

Fig. 11. Variation of drift with dimension of beam and column

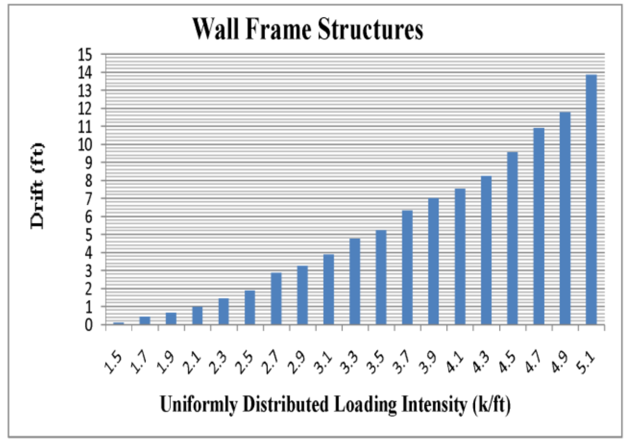

Fig. 12. Variation of drift with loading intensity

5 Conclusion And Recommendation

Bangladesh is most vulnerable to several natural disasters. The major problems concerned here is occurrence of flood, cyclone and monsoon wind form the Bay of Bengal and earthquake. Bangladesh lies on an active seismic zone and is prone to major earthquakes. It has experienced some catastrophic earthquakes and different cyclones in the last century. According to the specialist, there is possibility to occurrence of earthquake. In our country, the numbers of high rise building is increasing here day by day due to increasing population. Drift is a common phenomenon for high rise and this may hamper the integrity of the structure and cause serious loss of life and properties in case of a major earthquake. So every high rise structure should consider the effect of drift. Then the loss of life and property will be attenuated. In these study regular shaped structures has been considered only. Estimation of drift is carried out for rigid frame structure, coupled shear wall structure and wall frame structure. This study indicates that the drift on high rise structures has to be considered as it has a notable magnitude. So every tall structure should include the drift due to earthquake load as well as wind load.

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