A Study on Drift Analysis for Lateral Stability of High Rise Building in Sylhet City Corporation Area.

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Abstract— **Sylhet city is third important city in Bangladesh after Dhaka and Chittagong. The population relocation rate is high in this district, enormous land cost and insufficiency of land, multipurpose now a day's high rise building is increased at significant in sylhet city. Previous record state that this region is affected by large ranges of earthquake at regular interval. For that Sylhet city is vulnerable to destructive earthquakes. The objective of this study is to analysis of drift or displacement of high-rise building. Lateral loads are mainly responsible for drift. After completion it is found that seismic load is more critical than wind load, for this basis here seismic load is considered as well as wind load. The Structural Engineer have a challenge to control the drift within allowable range due to lateral loads for stability of structure. Three types of rigid frame high rise structures such as R.C.C beam slab building, R.C.C flat slab building and R.C.C beam slab with shear wall building was considered for analysis of drift. Three approximate formula for manual calculation of drift with respect to stiffness of beam and column are used. The study confirmed that the stiffness of column was more than stiffness of beam in all cases. It can be concluded that the stiffness of shear wall was more than stiffness of column. The highest lateral drifts were within the allowable limits. The computer programming for frame structure (beam slab building) was developed and found the deviation from hand calculation was 2.02% (maximum).The outcome of the study is a feasible process for the calculation of drift of high rise building**.

Keywords— ***Drift, Earthquake, Lateral Loads, Lateral deflection, Stiffness,BNBC.***

I. INTRODUCTION

Drift is the lateral displacement of one level of a multistory structure relative to the level above or below due to lateral loads. Lateral loads are mainly responsible for drift. Due to lateral loads there will be a drift or sway on the high rise structures and it is the magnitude of displacement at the top of a building relative to its base. For a high rise building shear wall system is superior for resist lateral loads. Shear wall is a wall composed of shear panels to counter the gravity loads and also lateral load performing on a structure. Shear wall is concrete or masonry continuous vertical walls may serve both architecturally as partitions and structurally to carry gravity and lateral loading. Frame structure is the rigid joint structure between an assemblage of linear elements to from vertical and horizontal planes. The vertical planes consist of columns and girders mostly on rectangular grid, a similar organizational grid is used for horizontal planes consisting of beam and girders. In the high rise building flat slab is a typical type of construction in which a reinforcement concrete slab with or without drops is built monolithically with the supporting column and is reinforcement in two or more direction without any provision of beam, the flat slab thus transfers the load directly to the supporting columns suitably spaced below the slab. Unwarranted lateral displacements can create severe structural troubles. High rise structure should be capable for resist any type of lateral loads as well as gravity and live loads. Sustainability and expected service life is the very important matter to consider the design process of high-rise structures. Sylhet region is the most earthquake prone zone of Bangladesh. During the last 150 years three major earthquakes (magnitude larger than 7.5 on the Richter Scale) have occurred in this area. Current population of the city about 0.6 million. As a result of high migration rate, this number is increasing day by day. So, the city is growing at a high rate and obviously, due to lack of proper planning and high-rise buildings are making the city very crowded. A large portion of Sylhet City is susceptible to damaging levels of seismic hazards. Lateral stability of structure is a very important issue in designing and construction of high rise building in this area. The more height of a building that indicates more drift and the drift of the building decreases with increase in the width of the building. Drift often dictates the selection of structural systems for high rise buildings. In recent years, Sylhet has a growing trend towards construction of 10 to 20 storied buildings. Drift is one of the major key factor to design high rise building. So for the lateral stability of high rise building drift analysis is very important

II. OBJECTIVES OF THE STUDY

1) To calculate the drift of high-rise building structure due to lateral loads.
2) Comparison of the drift value of different types of buildings.
3) Development of computer programming for drift calculation of frame structure (beam slab building) and compare the drift value with hand calculation drift value.

III. METHODOLOGY

Lateral deformation of rigid frame due to bending of beam and column[1]

A significant portion of drift in rigid frames is caused by end rotations of beams and columns due to lateral loads. This phenomenon is commonly referred to as bent action. The lateral displacements of moment resistant frames can be determined by the simplified approximate methods which are as follows:

$$\Delta = \frac{(\Sigma V)i\,(hi)^2}{12\,E}\left[\frac{1}{(\Sigma Kg)i} + \frac{1}{(\Sigma Kc)i}\right]$$

here,

Δ = drift or deflection
E= modulus of elasticity of concrete
V= lateral load
h =story height.
Ic= moment of inertia of column
Ig= moment of inertia of beam
L_c =column height
L_g =girder span.
$K_c = \frac{Ic}{Lc}$ [for column]
$K_g = \frac{Ig}{Lg}$ [for beam]
i = story level

This formula was used to calculate lateral deformation rigid frame structure (beam slab building).

Lateral deformation of rigid frame due to bending of beam, column and shear wall Shear wall (concrete structure)[3]

$$\text{Drift } \Delta = \frac{1}{0.35} \times \frac{X\,R\,K^j\,(\varepsilon_c + \varepsilon_y)L^2}{3(2X-j^2+j)\,d}$$

Simplifying equation are following:

$$\text{Drift } \Delta = \frac{1}{0.35} \times \frac{L^2\,(2N+1)\,(\varepsilon_c + \varepsilon_y)}{18\,(d)}$$

Here

Δ = deflection
ε_c = concrete yield strain, considering value =0.003
ε_y = steel yield strain, considering value =0.00207
L = story height
d= depth of shear wall, 0.90h
N=number of story
X=degree of freedom
K=stiffness of one story
R=coefficient due to lateral load

Drift limitation according to BNBC[5].

Storey drift is the displacement of one level relative to the level above or below due the design lateral forces. According to BNBC code drift limitation is:

i) $\Delta \le 0.04h/R \le 0.005h$ for T< 0.70 second.
ii) $\Delta \le 0.03h/R \le 0.004h$ for $T \ge 0.70$ second.
iii) $\Delta \le 0.0025$ (for unreinforced masonry structure)

Where, h= height of the building or structure

The period T used in this calculation shall be the same as the base shear

Table 1 : The allowable stores drift for stability of building.[7]

Building Type	Occupancy category		
	I or II	III	IV
Building, other than masonry shear wall or masonry wall frame building, four stories or less in height with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the story drifts	0.025 h_{sx}	0.020 h_{sx}	0.015 h_{sx}
Masonry cantilever shear wall building	0.010 h_{sx}	0.010 h_{sx}	0.010 h_{sx}
Other Masonry cantilever shear wall building	0.007 h_{sx}	0.007 h_{sx}	0.007 h_{sx}
All other buildings	0.020 h_{sx}	0.015 h_{sx}	0.010 h_{sx}

** h_{sx} = the story height below level x

IV. RESULT AND DISCUSSIONS

Lateral deformation of rigid frame due to bending of beam and column:

The formula is used to calculate lateral deformation of Building due to bending of beam and column. It is clear from analysis that the column stiffness is more than beam stiffness. It indicates stability of building based on code. It is evident from the analysis that maximum drift is found 4.84 inch. According to code for 10 storey building the permissible drift is 4.80 so the calculated drift is near than the permissible limit.

Table 2: column stiffness

Column Type	Total Number of Column	b (in)	h (in)	$I=\frac{b(h)3}{12}$ (in^4)	Story height	$(\frac{Ic}{Lc})$ in^3	Total $(\frac{Ic}{Lc})$ in^3
C1	20	15"	20"	10.00x10^3	10'-0"	83.34	1666.80
C2	20	18"	24"	20.73x103	10'-0"	172.75	3455
						Total=	5121.80

Table 3: Beam stiffness

Beam Type	Total Number of Beam	b (in)	h (in)	I= $\frac{b(h)3}{12}$ (in^4)	Length of Beam	$(\frac{Ig}{Lg})$ in^3	Total $(\frac{Ig}{Lg})$ in^3
B1	2	12"	18"	5832	215'-0"	2.26	4.52
B1	2	12"	18"	5832	60'-0"	8.10	16.20
B2	2	12"	20"	8000	215'-0"	3.10	6.20
B2	8	12"	20"	8000	60'-0"	11.12	88.96
						Total=	115.88

Table 4 : story drift on various floor

Level	Story height (h) ft	∑h (in)	Lateral Load (kip)	$\frac{1}{(\Sigma Kg)}$ in3	$\frac{1}{(\Sigma Kc)}$ in3	Δ drift (in)
10	10 ft	1200	183.00	8.63x10^{-4}	1.95x10^{-5}	4.84
9	10 ft	1080	165.00	9.58x10^{-4}	2.16x10^{-5}	3.93
8	10 ft	960	145.00	1.07x10^{-3}	2.44x10^{-5}	3.07
7	10 ft	840	129.00	1.23x10^{-3}	2.78x10^{-5}	2.39
6	10 ft	720	110.00	1.43x10^{-3}	3.25x10^{-5}	1.75
5	10 ft	600	92.00	1.72x10^{-3}	3.90x10^{-5}	1.22
4	10 ft	480	74.00	2.15x10^{-3}	4.88x10^{-5}	0.78
3	10 ft	360	55.00	2.87x10^{-3}	6.50x10^{-5}	0.44
2	10 ft	240	37.00	4.31x10^{-3}	9.76x10^{-5}	0.20
1	10 ft	120	19.00	8.62x10^{-3}	1.95x10^{-4}	0.05

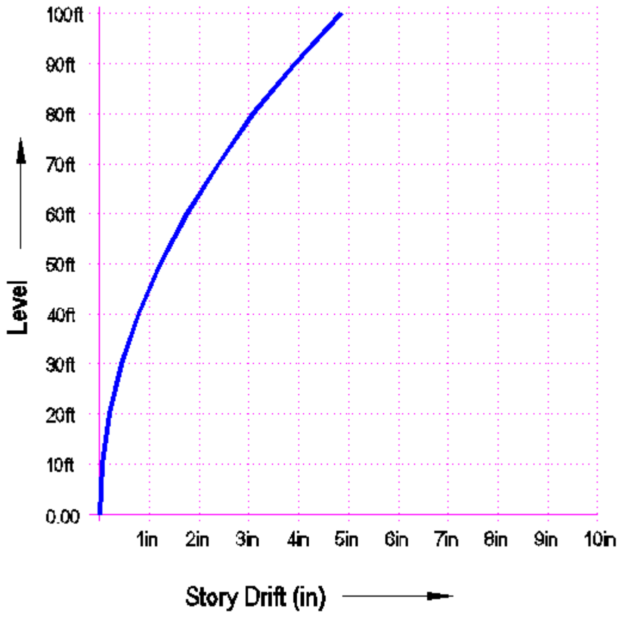

Figure 1 : Level vs drift of building

Story wise drift is calculated using equation for lateral deformation. Graphical representation of story wise drift is shown in figure, The shape of level Vs drift is coincide with the standard shape.

Table 5: the table shows comparison between story drift by hand calculation and computer programming:

Level	Story height (h) ft	Δ drift (in) by hand calculation	Δ drift (in) by computer programming
10	10 ft	4.84	4.847638
9	10 ft	3.93	3.933739
8	10 ft	3.07	3.072820
7	10 ft	2.39	2.392031
6	10 ft	1.75	1.748928
5	10 ft	1.22	1.218532
4	10 ft	0.78	0.784099
3	10 ft	0.44	0.437082
2	10 ft	0.20	0.196025
1	10 ft	0.05	0.050331

It is clear from table, that the computer based drift is almost equal with hand calculation. The maximum deviation is 2.02%, so this computer programming can be used for drift calculation of frame structured building (beam slab structure)

Lateral deformation building (concrete structure)

The formula is used to calculate lateral deformation of building due to bending of beam, column and shear wall. It is clear from analysis that the column stiffness is more than beam stiffness and shear wall stiffness is more than column. It indicates stability of building based on code. It is evident from the analysis that maximum drift is found 4.33 in by the rigid frame shear wall (concrete structure) equation. According to code for 20 storey building the permissible drift is 9.60in so the calculated drift is less than the permissible limit.

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Table 6: Story drift on various floor

level or number of story N	story height (m)	lateral load (kip)	depth of shear wall d (m)	concrete yield strain ε_c	steel yield strain ε_y	drift (in)
20	3.00	150.00	2.70	0.003	0.00207	4.33
19	3.00	142.50	2.70	0.003	0.00207	4.12
18	3.00	135.00	2.70	0.003	0.00207	3.91
17	3.00	127.50	2.70	0.003	0.00207	3.70
16	3.00	120.00	2.70	0.003	0.00207	3.48
15	3.00	112.50	2.70	0.003	0.00207	3.27
14	3.00	105.00	2.70	0.003	0.00207	3.06
13	3.00	97.50	2.70	0.003	0.00207	2.85
12	3.00	90.00	2.70	0.003	0.00207	2.64
11	3.00	82.50	2.70	0.003	0.00207	2.43
10	3.00	75.00	2.70	0.003	0.00207	2.22
9	3.00	67.50	2.70	0.003	0.00207	2.01
8	3.00	60.00	2.70	0.003	0.00207	1.79
7	3.00	52.50	2.70	0.003	0.00207	1.58
6	3.00	45.00	2.70	0.003	0.00207	1.37
5	3.00	37.50	2.70	0.003	0.00207	1.16
4	3.00	30.00	2.70	0.003	0.00207	0.95
3	3.00	22.50	2.70	0.003	0.00207	0.74
2	3.00	15.00	2.70	0.003	0.00207	0.53
1	3.00	7.50	2.70	0.003	0.00207	0.32

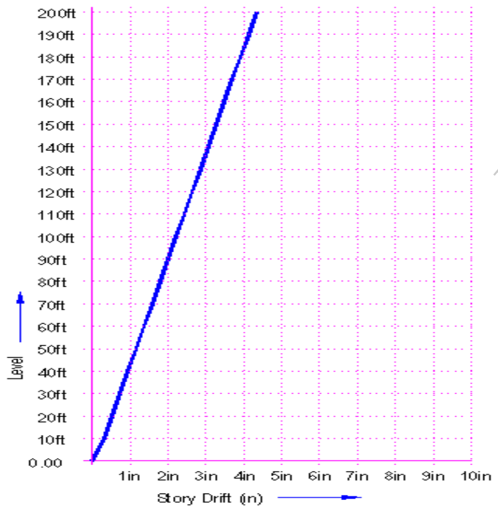

Figure 2 : Level vs drift of building

Story wise drift is calculated using concrete structure equation for lateral deformation. Graphical representation of story wise drift is shown in figure, The shape of level Vs drift is coincide with the standard shape.

Table 7: Comparison of story drift with beam slab, flat slab and beam slab with shear wall building.

Level	story height	maximum drift value according to BNBC (in)	drift (in) for beam slab building	drift (in) for beam slab with shear wall building
10	10ft	4.80	4.84	2.22
9	10ft	4.32	3.93	2.01
8	10ft	3.84	3.07	1.79
7	10ft	3.36	2.39	1.58
6	10ft	2.88	1.75	1.37
5	10ft	2.40	1.22	1.16
4	10ft	1.92	0.78	0.95
3	10ft	1.44	0.44	0.74
2	10ft	0.96	0.20	0.53
1	10ft	0.48	0.05	0.32

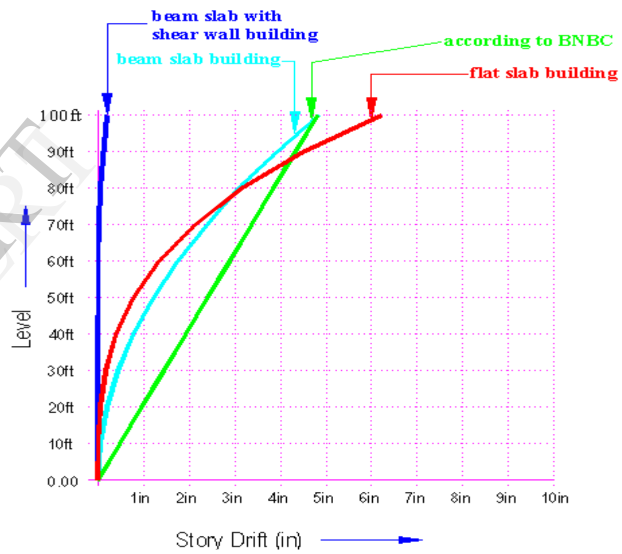

Figure 3 : Level Vs drift (showing type of building)

Story wise drift is calculated type of structure by different equation for lateral deformation. Graphical representation of story wise drift is shown in figure, The shape of level Vs drift is coincide with the standard shape.

CONCLUSION

All buildings will be designed and constructed to sustain within the allowable drift limitations specified in the code. The study presents practical procedure for calculation of drift value of different types of building. From this study it was found that the most sustainable approach of reduction of drift to provide shear walls because shear wall provides significant resistance to lateral deflection of buildings.

MAJOR FINDINGS OF THIS STUDY

A theoretical study has been made finding of drift value for high rise building due to lateral loads. The following conclusions can be drawn from this study:

1. The drift value of the building increases with increase in the height of the building. The drift value of 10-storey and 20 storey is increased due to increase in the height of the building.

2. The drift at the same level of flat slab building is more than the beam slab building.

3. The drift at the same level of beam slab building is more than the beam slab with shear wall building.

4. The drift value of hand calculation and programming results are almost equal. The program developed in this study is proposed to focuses on beam slab building because this structural system are commonly in high rise building.

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