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CODAL COMPARISON OF IS-875 (PART 3) 1987 AND IS-875 (PART 3) 2015 FOR WIND ANALYSIS OF HIGH RISE BUILDING USING ETABS

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Abstract - *Buildings are constructed to provide shelter for people and for commercial uses. Due to rapid increment in population and higher rate of growth in industries there is a large demand for land. In design practices, randomly varying phenomenon is a wind which is having significant dynamic effect on structures especially on flexible high rise building. The main objective of this paper is to compare Indian Standard code of practice for wind loads i.e. IS-875 (part 3) 1987and IS-875 (part 3) 2015 for dynamic loading on G+17 storey high rise building for zone 4 with terrain category 3 using ETABS software. It is performed on building to identify the gust factor, lateral force, intensity, storey drift and displacement, comparison of results which is obtained from software after assigning the data along both "X" and "Y" direction are plotted in graph i.e. storey level verses gust factor, storey level verses lateral load, storey level verses intensity, storey level verses storey drift, storey level verses displacement.*

Key Words: **Dynamic effect, Gust factor, Lateral load, Intensity, Storey drift, Displacement, High rise building, IS-875 (part 3) 1987, IS-875 (part 3) 2015**.

1. INTRODUCTION

In design practices, randomly varying phenomenon is a wind which is having significant dynamic effect on structures especially on flexible high rise building. In general, wind is considered for design of high rise building, when a building comes in contact with wind both positive and negative pressures will occurs simultaneously. The building must have sufficient strength to resist this pressure to prevent wind induced building failure

The nature of wind is very unpredictable, even for the same locality the wind speeds are extremely different and one may experience the effect of gusts lasting for few seconds. In convection current the radiation results acts in both direction i.e. upward and downward. Geographic location and obstruction near the structures are some of the factors on which the effect of wind on structure depends; much variation may causes due to air flow and also characteristics of building itself. For estimating dynamic effect on high rise structures, most of international codes and standards have utilized Gust Loading Factor (GLF). In 1967, Davenport was the first to introduce the concept of GLF. Wind loading is a complex live load which varies both in space and time. In dynamic interactions it may occurs between wind and structure. . Dynamic analysis of structure is essential for tall, long span and slender buildings, wind gust which causes fluctuation forces on structure which also includes large dynamic motion and oscillations.

2. METHODOLOGY

1. Geometric and material properties are defined.
2. Support conditions, loadings are assigned and analyse is carried out.
3. Wind force for the structure is calculated.
4. Lateral (wind) forces are assigned in both "X" and "Y" direction as per IS guidelines and analysis is carried out.

3. DESIGN PARAMETER

BASIC WIND SPEED	47 M/SEC
ZONE	IV
CITY	DELHI
TERRAIN CATEGORY	3
CLASS	C

4. MODEL

The Finite Element Model is created using ETABS software, for performing structural analysis.

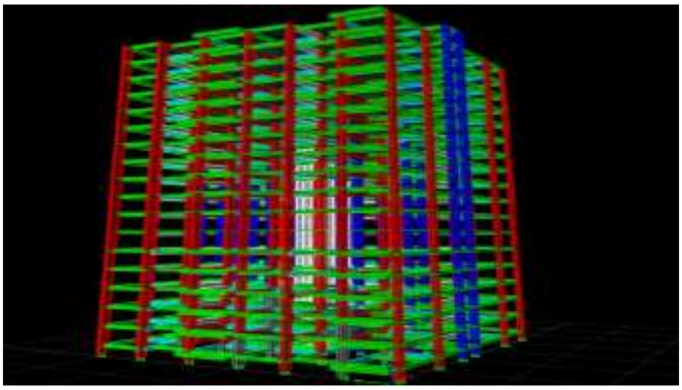

FIG 1: 3D model of G+17 building.

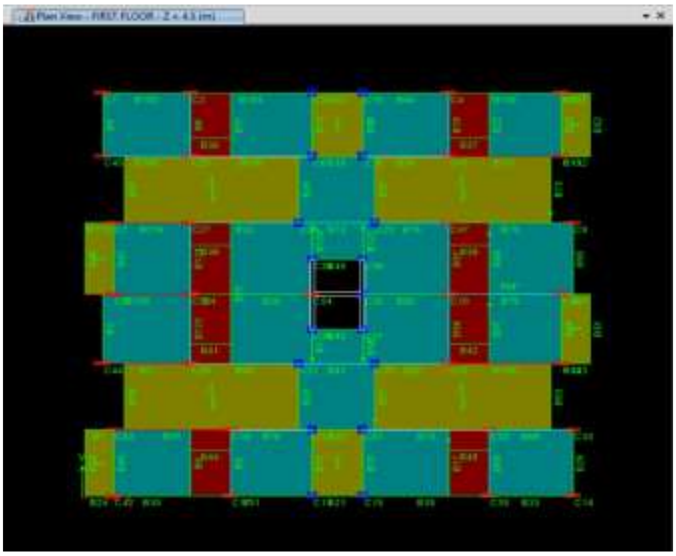

FIG 2: Plan of the building.

5. LOAD CALCULATION

A. Dead Load (DL)

Self weight of the building (Slab, Beam & columns) is automatically computed in the software. Floor Finish = 1.0kN/m^2, Additional DL = 0.5kN/m^2 applied as uniform area load on slabs.

B. Live Load (LL)

Live load on floors = 3kN/m^2
(As per IS: 875 Part II)

C. Wind Load (WL)

I. IS: 875 (PART3) 1987:

a. Design wind speed (Vz):
Design wind speed is given by the equation
$V_z = V_b\, K_1\, K_2\, K_3$
= 33.323m/sec.
Where,
Vb = 47m/sec (Basic wind speed in m/s)
K1 = 1, (Risk Coefficient)
K2 =0.709, (Terrain, height and structure size factor)
K3 = 1 (Topography factor)

Gust Factor as per IS-875 (part 3) 1987:
(Along "X" direction)

$$G = 1 + g_f r \sqrt{[B(1+\phi)^2 + SE/\beta]}$$

B = 0.78 (Back ground factor)
S = 0.054 (Size reduction factor)
E = 0.05 (Measure of available energy in the wind stream at the natural frequency of the structure)
Ø= This is considered only for the building height is less than 75m in terrain category 4 and height of the building is less than 25m in terrain category 3 and for all other type of building or structure it is considered as zero. Therefore Ø=0.
β = 0.016 (Damping coefficient)
G = 2.44 (Gust factor)

b. Wind load:
F= Cf Pz G Ae
= 143.15kN
Where,
Cf = 1.3, (Force coefficient)
Ae= 67.62m^2, (Effective frontal area)
Pz = 0.6 (Vz)^2 (Design wind pressure)
Pz = 0.66625 N/m^2
G = 2.44 (Gust factor)

Gust Factor as per IS-875 (part 3) 1987:
(Along "Y" direction)

$$G = 1 + g_f r \sqrt{[B(1+\phi)^2 + SE/\beta]}$$

B = 0.78 (Back ground factor)
S = 0.047 (Size reduction factor)
E = 0.05 (Measure of available energy in the wind stream at the natural frequency of the structure)
Ø= This is considered only for the building height is less than 75m in terrain category 4 and height of the building is less than 25m in terrain category 3 and for all other type of building or structure it is considered as zero. Therefore Ø=0.
β = 0.016 (Damping coefficient)
G = 2.46 (Gust factor)

c. Wind load:
F= Cf Pz G Ae
= 140.82kN
Where,
Cf = 1.27, (Force coefficient)
Ae= 62.73m^2, (Effective frontal area)
Pz = 0.6 (Vz)^2 (Design wind pressure)
Pz = 0.66625 N/m^2
G = 2.46 (Gust factor)

II. IS: 875 (PART 3) 2015:

a. Hourly mean wind speed (Vzh):
$V_{zd} = V_{zh}\, k_1\, k_3\, k_4$
= 33.585m/sec
Where,
Vz = 47m/sec (Design wind speed at height z, in m/s)
k1 = 1 (Terrain, height and structural size factor)
k2 = 0.715 (Terrain roughness and height facto)
k3 = 1 (Topography factor)
k4 = 1 (Importance factor for the cyclonic region)

Gust Factor as per IS-875 (part 3) 2015:
(Along "X" direction)

$$G = 1 + r\sqrt{\frac{g_v^2 B_s (1+Ø^2) + H_s g_R^2 SE}{\beta}}$$

Where,
r = 0.3605 (Roughness factor)

gv = 4 (peak factor for upwind velocity fluctuation, 3 for category 1 and 2 terrains and 4 for category 3 and 4 terrains)
Bs =0.9 (Background factor)
Ø = 0.342 (Factor to account for second order turbulence intensity)
Hs = 2 (Height factor for resonance response)
g_R = 4.034 (Peak factor for resonant response)
S = 0.043 (Size reduction factor)
E = 0.038 (Spectrum of turbulence)
β = 0.02 (Damping coefficient of the building or structure)
G = 2.922 (Gust factor)

b. Wind load:
F= Cf Pz G Ae
Where,
Cf = 1.3 (Force coefficient)
Ae= 67.62m^2 (Effective frontal area)
Pz =0.6 (Vzh)2 (Design wind pressure)
Pz = 0.676kN/m^2
G = 2.922 (Gust factor)

Gust Factor as per IS-875 (part 3) 2015:
(Along "Y" direction)

$$G = 1 + r\sqrt{\frac{g_v^2 B_s (1 + Ø^2) + H_s g_R^2 SE}{\beta}}$$

Where,
r = 0.3606 (Roughness factor)
gv = 4 (peak factor for upwind velocity fluctuation, 3 for category 1 and 2 terrains and 4 for category 3 and 4 terrains)
Bs =0.9 (Background factor)
Ø = 0.342 (Factor to account for second order turbulence intensity)
Hs = 2 (Height factor for resonance response)
g_R = 4.025 (Peak factor for resonant response)
S = 0.043 (Size reduction factor)
E = 0.039 (Spectrum of turbulence)
β = 0.02 (Damping coefficient of the building or structure)
G = 2.943 (Gust factor)

c. Wind load:
F= Cf Pz G Ae
= 158.68kNz
Where,
Cf = 1.27 (Force coefficient)
Ae= 62.738m^2 (Effective frontal area)
Pz =0.6 (Vzh)2 (Design wind pressure)
Pz = 0.676kN/m^2
G = 2.943 (Gust factor)

6. REVISION DETAILS IN NEW CODE

a. Aerodynamic roughness heights for each terrain categories had been explicitly included, and are used to derive turbulence depth and mean hourly wind seed profiles.
b. The preceding type of structures into B class & C class has been deleted and for that reason the k1 is renamed as terrain roughness and height aspect.
c. The values of k2 factor similar to preceding class A type structure are retained in this code.
d. An additional factor, termed as importance factor has been introduced for cyclonic area.
e. Easy empirical expressions were recommended for height variations of hourly mean wind speed and also turbulence intensity in distinct terrains.

7. RESULTS AND DISCUSSION

Results and discussions of different parameter such as Gust factor, Lateral force, Intensity, Storey Drift and displacement are shown with the help of graphs.

Gust factor:

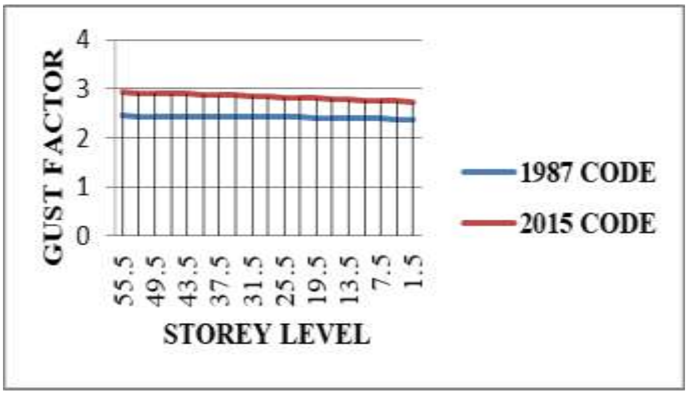

FIG 3: Variance in gust factor along "X" direction.

This gust effectiveness factor method is used to study the criticality of wind loads for the design of tall buildings. In the peak storey the gust factor along "X" direction for new code is 2.922 where as in old code gust factor is 2.44. The percentage of gust factor increase in new code when compared with the old code is 19.56%. FIG 3: shows the variance in the gust factor for both old and new code.

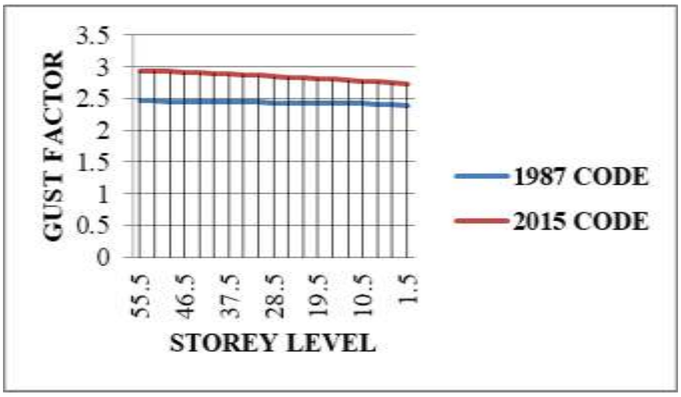

FIG 4: Variance in gust factor along "Y" direction.

In the peak storey the gust factor in "Y" direction for new code is 2.943 where as in old code gust factor is 2.461. The percentage of gust factor increase in new code when compared with the old code is 19.59%. FIG 4: shows the variance in the gust factor for both old and new code.

Lateral load:

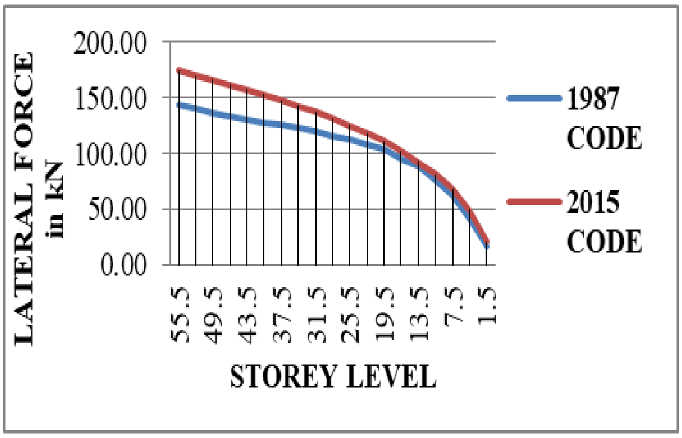

FIG 5: Variance in lateral force along "X" direction.

The Lateral force in the peak storey along "X" direction in new code is 173.85kN where as in old code the lateral force along "X" direction is 143.16kN. In lateral force the percentage of increase in new code when compared with the old code is 21.44%. FIG 5: shows the variance in lateral force for both old and new code.

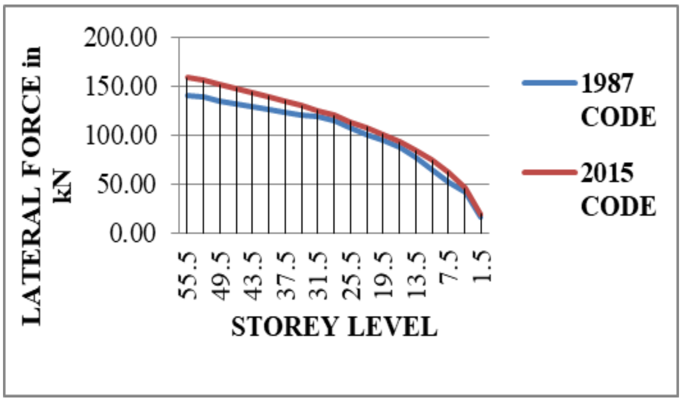

FIG 6: Variance in lateral force along "Y" direction.

The Lateral force in the peak storey along "Y" direction in new code is 158.68kN where as in old code the lateral force along "Y" direction is 140.82kN. In lateral force the percentage of increase in new code when compared with the old code is 12.68%. FIG 6: shows the variance in lateral force for both old and new code.

Intensity:

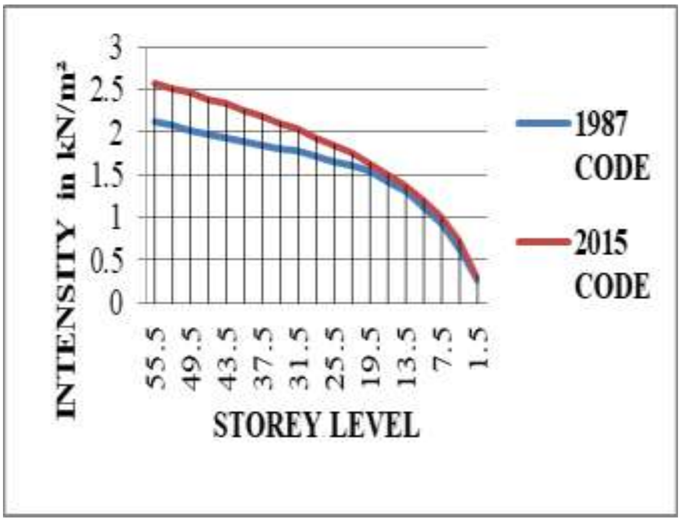

FIG 7: Variance in intensity along "X" direction.

In above table it is found that the intensity will increases with the increase in the height of the structure. Intensity for new code is 2.57kN/m^2 and intensity for old code is 2.12kN/m^2 i.e. 21.23 % of intensity has been increased and consequence stress will be more in the new code FIG 7: shows the variance in Intensity for both old and new code.

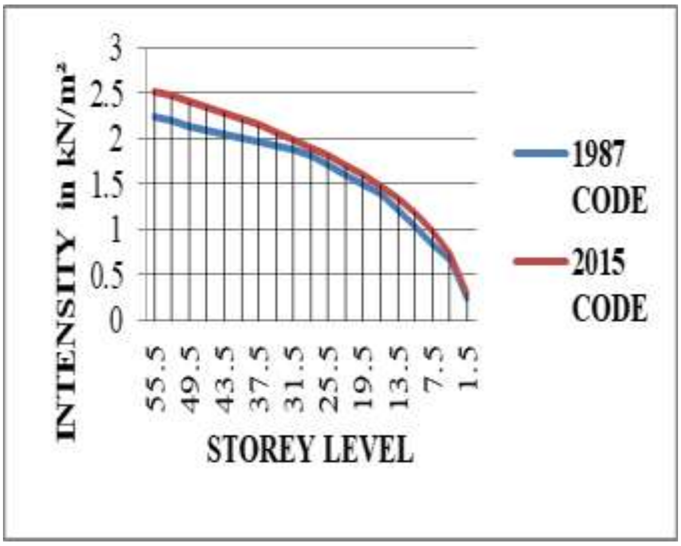

FIG 8: Variance in intensity along "Y" direction.

In above table it is found that the intensity will increases with the increase in the height of the structure. Intensity for new code is 2.53kN/m^2 and intensity for old code is 2.24kN/m^2 i.e. 12.95 % of intensity has been increased and consequence stress will be more in the new code FIG 8: shows the variance in Intensity for both old and new code.

Storey drift:

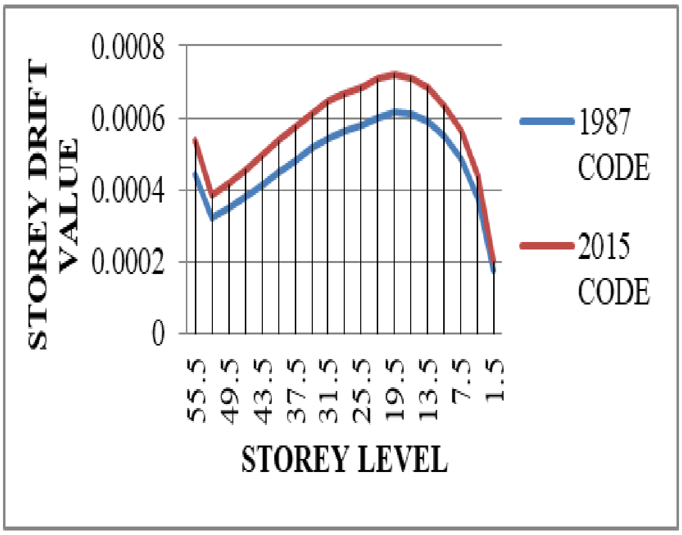

FIG 9: Variance in storey drift along "X" direction.

Peak storey drift in old code storey drift along "X" direction is 0.000444mm and in new code storey drift along "X" direction is 0.000535mm.In storey drift the percentage of increase in new code when compared with the old code is 20.50%. FIG 9: shows the variance in storey drift along "X" direction.

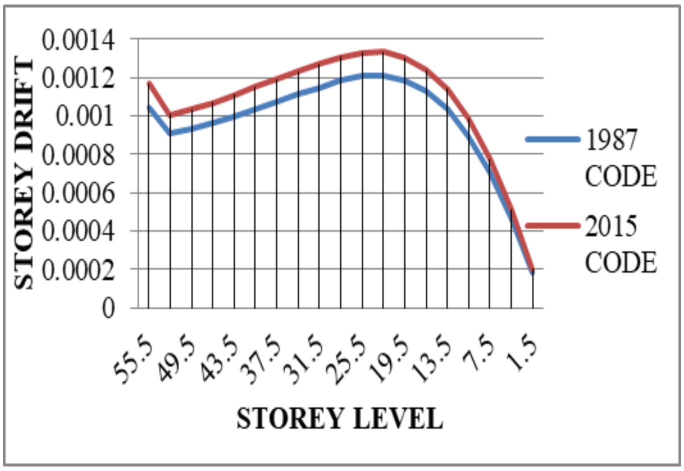

FIG 10: Variance in storey drift along "Y" direction.

Peak storey drift in old code storey drift along "Y" direction is 0.001045mm and in new code storey drift along "Y" direction is 0.001165mm. In storey drift the percentage of increase in new code when compared with the old code is 11.48%. FIG 10: shows the variance in storey drift along "Y" direction.

Displacement:

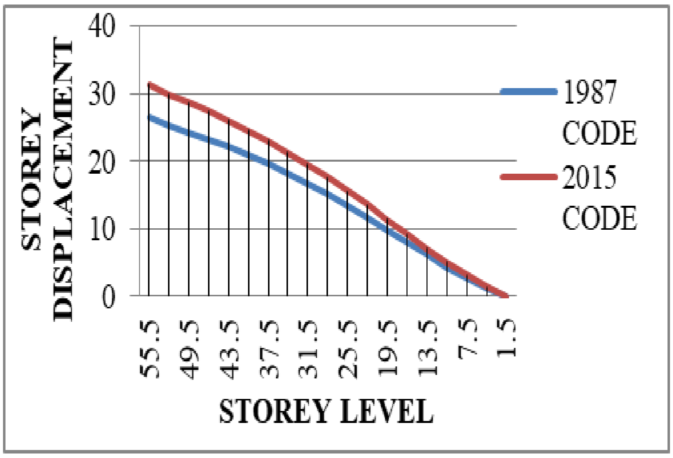

FIG 11: Variance in displacement along "X" direction.

Peak storey displacement in old code storey drift along "X" direction is 26.5mm and in new code storey drift along "X" direction is 31.4mm.In storey displacement the percentage of increase in new code when compared with the old code is 18.05%. FIG 11: shows the variance in storey displacement along "X" direction.

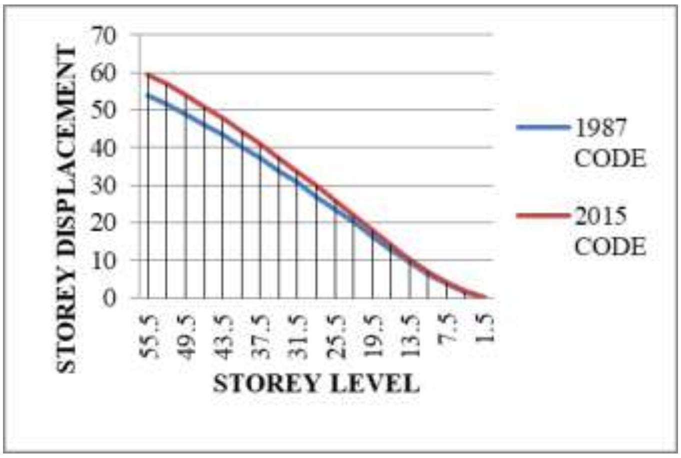

FIG 12: Variance in displacement along "Y" direction.

Peak storey displacement in old code storey drift along "Y" direction is 53.9mm and in new code storey drift along "Y" direction is 59.3mm.In storey displacement the percentage of increase in new code when compared with the old code is 10.39%. FIG 12: shows the variance in storey displacement along "Y" direction.

8. CONCLUSIONS

From the obtained results we can concluded that:

1. **Gust factor** has been increased for [IS: 875 (Part 3) 2015] as compared to [IS: 875 (Part 3) 1987].

2. **Lateral force** has been increased as per the new code [IS: 875 (Part 3) 2015] due to the increase in the gust factor. Percentage increased is 21.44% along "X" direction and 12.68% along "Y" direction.
3. **Intensity** has been increased as per the new code [IS: 875 (Part 3) 2015]. Percentage increased is 21.23% along "X" direction and 12.95% along "Y" direction.
4. **Displacement** for the top most storey of G+17 storey building as per new code 18.05% as been increased along "X" direction and along "Y" direction as per new code 10.39% as been increased in new code when compared with old code
5. **Storey drift** for the top most storey of G+17 storey building as per new code 20.50% along "X" direction as been increased and along "Y" direction as per new code 11.48% as been increased in new code when compared with old code
6. From the above results it can be concluded that new IS Code [IS: 875 – (Part 3) – 2015] will provide high safety to the structure for dynamic analysis as compared to Old IS Code because IS 875 (part 3): 2015 included mathematical expressions for different parameters such as terrain factor (K2), background factor (Bs), size reduction factor (S), roughness factor (r) etc.

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