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TITLE: DETERMINING THE APPROPRIATE TIME PERIOD OF TALL BUILDING HAVING BASEMENT WITH DIFFERENT CONDITIONS OF RETAINING WALL

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***ABSTRACT** - In present days, tall buildings are commonly seen in the big cities. The basement of the tall buildings are connected with retaining walls. Now, as per the code 1893-2016clause 7.6.1, the provision defining the height And dimension of the structure for calculating the time period is given for building with retaining wall connected four side and with retaining wall disconnected four sides. But in some buildings, the retaining walls will be not connected in two shorter sides or two longer sides or adjacent side or one shorter side. In Such conditions, structural designers face challenges to select the height and horizontal dimension of buildings as there are no provisions for such conditions in the IS1893 code. Further it creates confusions in the minds of the designer while entering the time period for static earthquake forces. So this study discusses the method to determine an appropriate time period considering the RCC retaining wall connecting the basement indifferent conditions. Response spectrum analysis is used in ETABS software.*

Key Words: Horizontal Dimensional, Retaining Wall , Earthquake Forces, Time Period

1. General

A time period (denoted by 'T') is the time required for one complete cycle of vibration to pass in a given point. As the frequency of a wave increases, the time period of the wave decreases. The unit for time period is 'seconds'. Frequency and time period are in a reciprocal relationship that can be expressed mathematically as: T = 1/f or as: f =1/T

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Retaining walls are relatively rigid walls used for supporting soil laterally so that it can be retained at different levels on the two sides.

1.1 Objectives

The objectives of this study can be listed as follows

- To study the earthquake response of tall building having basement connected to RCC retaining wall and basement without RCC Retaining wall
- To study the earthquake response of tall building having basement not connected to RCC retaining wall and basement without retaining wall.
- To study the earthquake response of tall building having basement, with three sides of RCC retaining wall connected to the basement.

- To identify which time period to be used in analyzing the tall buildings with an RCC retaining wall connecting basements in different conditions.

1.2 Present Study

This paper discusses the method to determine the appropriate Time period of Tall Building having Basement with different conditions of Retaining wall. As the Is 1893 - 2016 is not specified few conditions of retaining wall connecting the basements, so individual designer have different point of views in selection of Height and dimension for calculating the time period. This confusion will lead to improper estimation of horizontal forces (VB). Therefore in this study, we have tried to develop the method to get a clear view on calculation of time period for different conditions of retaining wall by using Response spectrum analysis

2. Response Spectrum Analysis

The procedure to compute the peak response of structure during the earthquake directly from the earthquake response spectrum without the need of time history analysis is called response spectrum analysis. A typical design response spectrum (IS-1893) is shown below in Figure-3.1

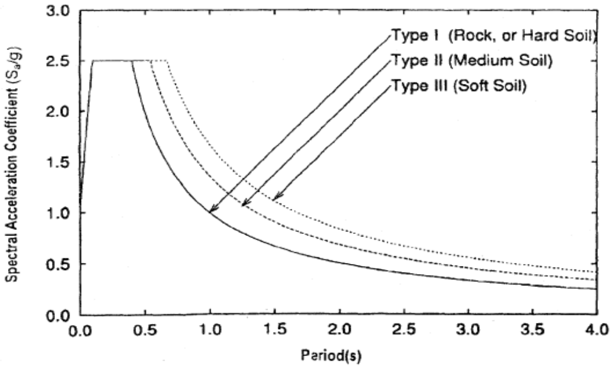

Fig 1.1: Design Response spectrum

Response spectrum is a plot of maximum response of a SDF for various value of the period for a given input. The IS-1893 gives an average Response spectrum can be employed in earthquake resistant design.

2.1 Strucural Model

For this study, building with eighteen storeys is considered. The Dimension of all the buildings is exactly same i.e. 63m x 35 m(non tower), 35m x 15m (tower area). The structural models have the same story height of 3m.and have a uniform mass distribution over their height. The horizontal beam spacing is 7m and vertical beam spacing is 5m. Building plan is shown is below Fig.3.2.a

<u>Objective 1models- T1.1,T1.2,T1.3,T1.4</u>

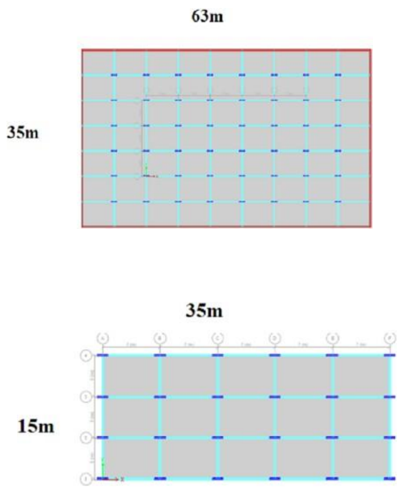

Fig.1.2.a Building plan (T1.1&1.2)

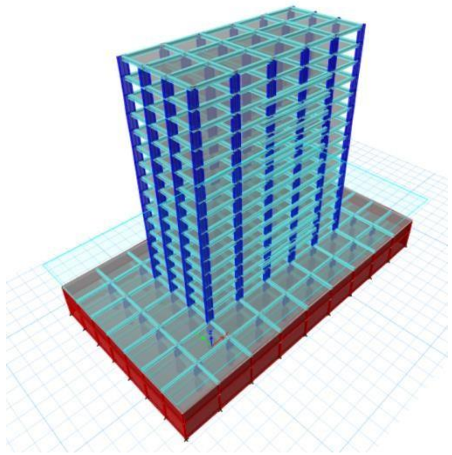

Fig.1.2.b RCC model 3D View(T1.1&T1.2)

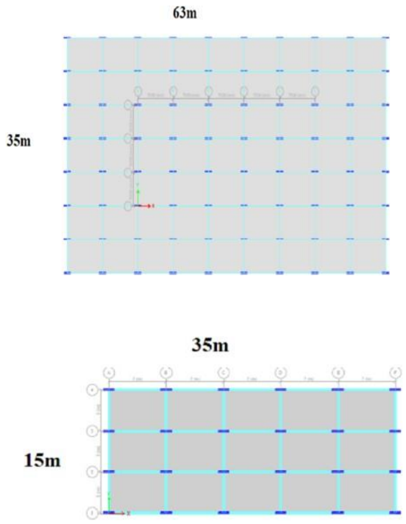

Fig.1.3.a Building plan (T1.3&1.4)

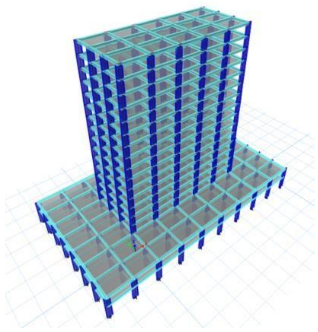

Fig.1.3.b RCC Model 3D View(T1.3&1.4)

Time period calculation for 1.1
X=35m H= 48m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.730
TY=1.115

Time period calculation for 1.2
X=63m H= 52.5m
Y=35m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
NOT as per IS 1893-2016 PART1
TX=0.595
TY=0.798

Time period calculation for 1.3
X=63m H= 52.5m
Y=35m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.595
TY=0.798

Time period calculation for 1.4
X=35m H= 48m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
Not as per IS 1893-2016 PART1
TX=0.730
TY=1.115

Objective 2models- T2.1,T2.2

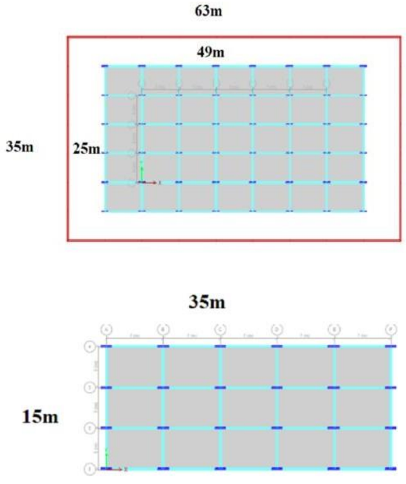

Fig.1.4.a Building plan (T2.1)

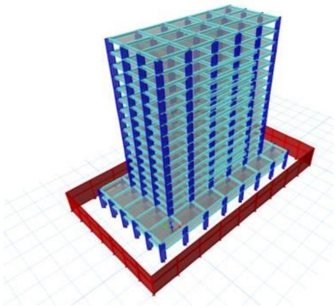

Fig.3.4.b RCC model 3D View(T2.1)

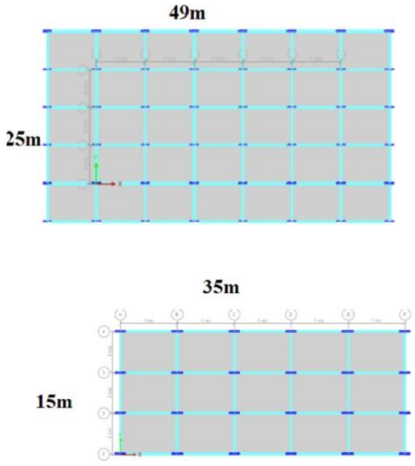

Fig.1.5.a Building plan (T2.2)

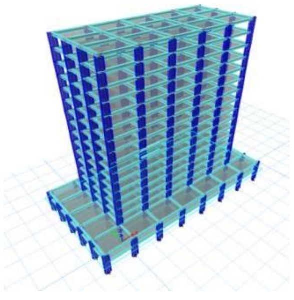

Fig.1.5.b RCC model 3D View(T2.1)

Time period calculation for 2.1
X=35m H= 48m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.730
TY=1.115

Time period calculation for 2.2
X=49m H= 52.5m
Y=25m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.675 TY=0.945

Objective 3models- T3.1,T3.2,T3.3,T3.4

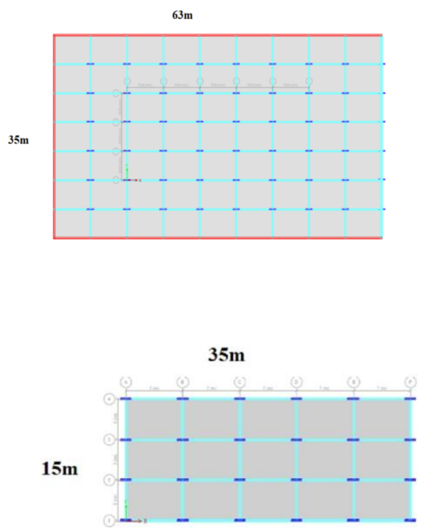

Fig.1.6.a Building plan (T3.1,3.2,3.3,3.4)

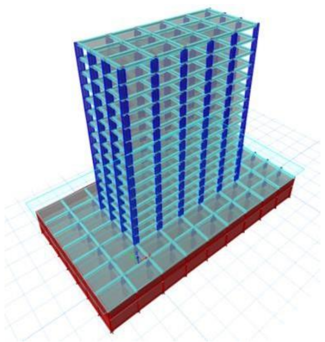

Fig.1.6.b RCC model 3DView (T3.1,3.2,3.3,3.4)

ETABS model will be same in all type of model (T3.1,T3.2,T3.3,T3.4) Only time period will change .

Time period calculation for 3.1
SECTION A-A
X=35m H= 48m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.730
SECTION B-B
H=48
Y=15
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TY=1.115m

Time period calculation for 3.2
SECTION A-A
X=63m H=52.5m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.595
SECTION B-B
H=48m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TY=1.115

Time period calculation for 3.3
SECTION A-A
X=63m H= 48m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.544
SECTION B-B
H= 48m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TY=1.115

Time period calculation for 3.4
SECTION A-A
X=35m H=52.5 m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.798
SECTION B-B
H=48 m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TY=1.115

Objective 4models- T4.1,T4.2,T4.3,T4.4

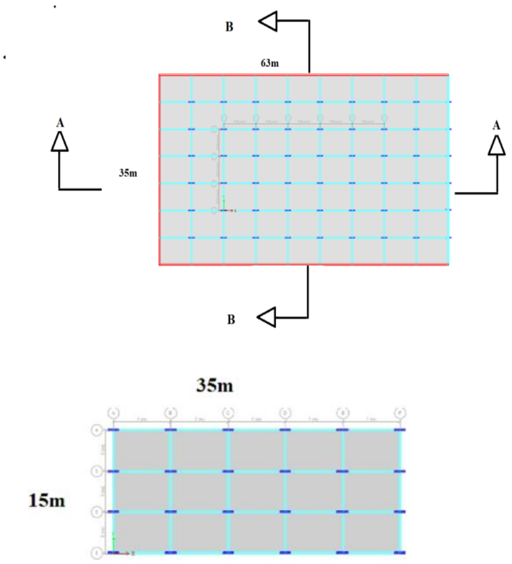

Fig.1.7.a Building plan (T4.1)

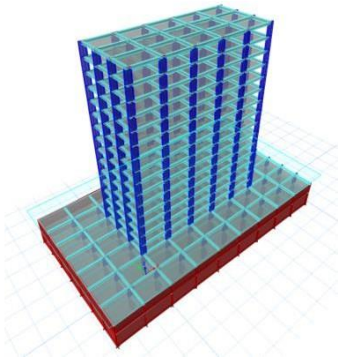

Fig.3.7.b RCC model 3D View(T4.1)

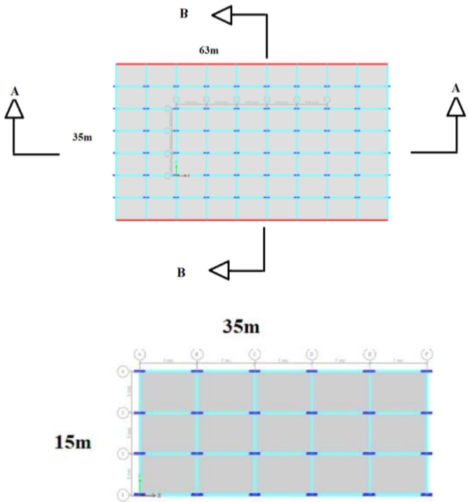

Fig.1.8.a Building plan (T4.2)

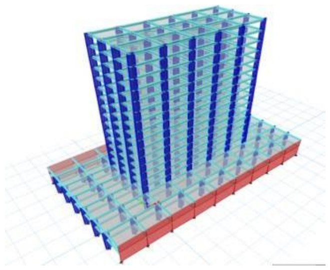

Fig.1.8.b RCC model 3D View(T4.2)

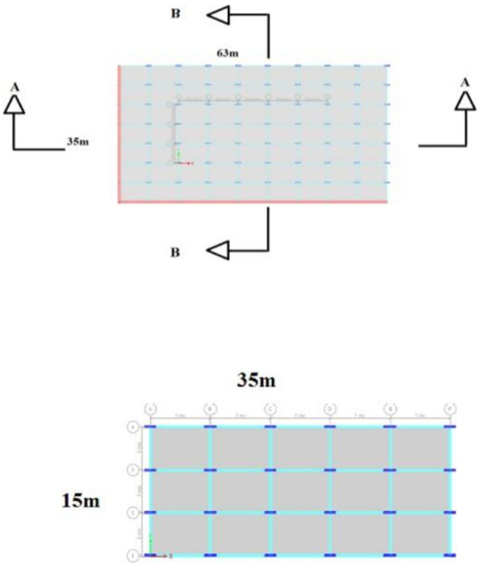

Fig.1.9.a Building plan (T4.3)

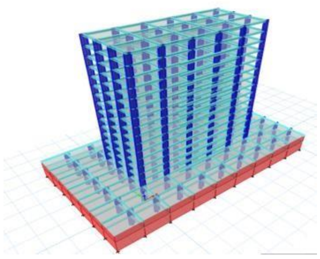

Fig.1.9.b RCC model 3D View(T4.3)

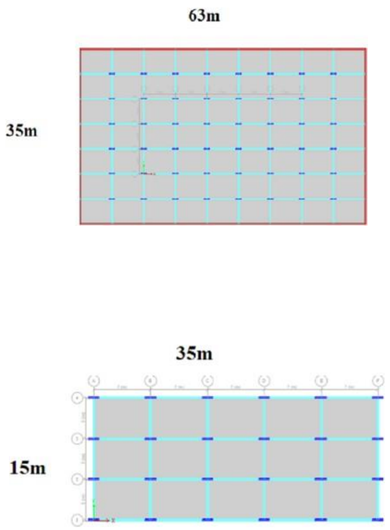

Fig.1.10.a Building plan (T4.4)

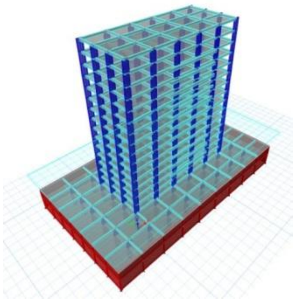

Fig.1.10.b RCC model 3D View(T4.4)

Time period calculation for 4.1
SECTION A-A
X=35m H= 52.5m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.798
SECTION B-B
H= 48m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TY=1.115

Time period calculation for 4.2
SECTION A-A
X=35m H=52.5 m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.798

SECTION B-B
$\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TY=1.115

Time period calculation for 4.3
SECTION A-A
X=35m H= 52.5m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.798
SECTION B-B
H= 48m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TY=1.115

Time period calculation for 4.4
SECTION A-A
X=35m H=48 m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TX=0.730
SECTION B-B
H=48 m
Y=15m
$T=\frac{0.09Xh}{\sqrt{d}}$ (sec)
as per IS 1893-2016 PART1
TY=1.115

2.2 Input Details

Structural Sections Detail

In all types of models, column ,beams and slab sizes are same .

Table 1-Seismic Loading Zone As Per Is:1893

DETAIL	VALUE
R	3
I	1.2
Z	.10
Sa/G	Type2

Z=Zone Sa/g=Soil type II,

R= response reduction factor I = Importance factor

Table 2-Material Properties

MODEL TYPE MATERIAL PROPERTIES	ALL Model
Column / Wall	**M40**
Beam	**M25**
Slab	**M25**

Density of concrete: 25 KN/m3
Density of brick masonry: 21.20 KN/m3
Slab thickness: 175mm
wall thickness: 200mm

2.3 Static Load Assignment

The loads considered are

Dead Load, Live Load, Floor Finish, and Earth Quake Load. All models consist of these loads.

Dead Load: The dead load of the structure is obtained from IS 875 – Part 1 – 1987. The permissible value for unit weight of reinforced concrete varies from 24.80kN/m^3 to 26.50 kN/m^3. From the table, the unit weight of concrete is taken as 25kN/m^3. The software has a inbuilt DL calculator

Self-weight of the structural elements
Floor finish = 1.5 kN/m^2 (floor)
Floor finish = 3.25 KN/m2(terrace floor)

Imposed Load: The imposed load on the floor is obtained from IS 875 (Part 2) – 1987. The uniformly distributed load on the floor of the building is assumed to be 4.0 kN/m^2 (for assembly areas, corridors, passages, restaurants business and office buildings, retail shops etc).

On roof 1.5 kN/m^2, and
On floors 4.0 kN/m^2

Earth Quake Load: The structure is assumed to be inZone-II as per IS 1893 – 2016. So the zone factor is taken as per Table 2 of IS 1893 – 2016. The damping is assumed to be 5%, for concrete as per Table 3 of IS 1893-2016.

Importance factor is taken as 1 as per Table 6 of IS 1893 – 2016.

Zone II, Soil type II, Importance factor =1.2

Response Reduction Factor, in this case the values of R are defined .R=3 is used .

Load combinations: The load combinations is obtained from page no13, clause 6.3.1.2 of. IS 1893 – 2002.
DLEQX=1.2 (DL+LL+SPECX)
DLEQY=1.2(DL+LL+SPECY)

Table 3-Analysis Input

TYPES OF MODELS	ALL MODEL
R VALUE	R=3
Function input	0.1
spectrum case name	spec1
structural and function damping	0.05
model combination	CQC
directional combination	SRSS
input response spectra	1.2*9.81/2*3
eccentricity ratio	0.05

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3. Analysis And Results

3.1 FREQUENCY AND TIME PERIOD

The value of T depends on the building flexibility and mass; more the flexibility, the longer is the period and more the mass, the longer is the period

Phase -1

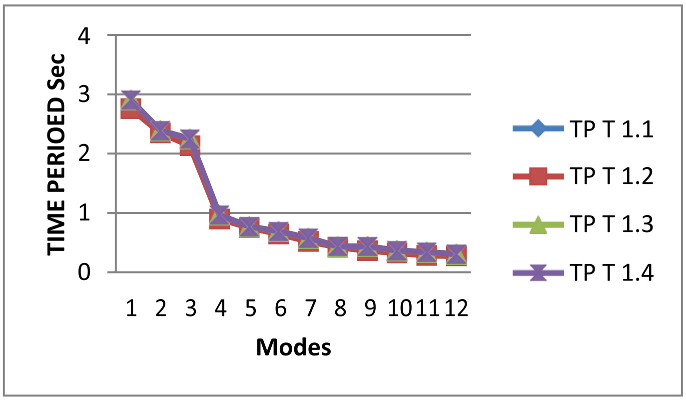

Fig -2.1.1: Time perioed vs modes

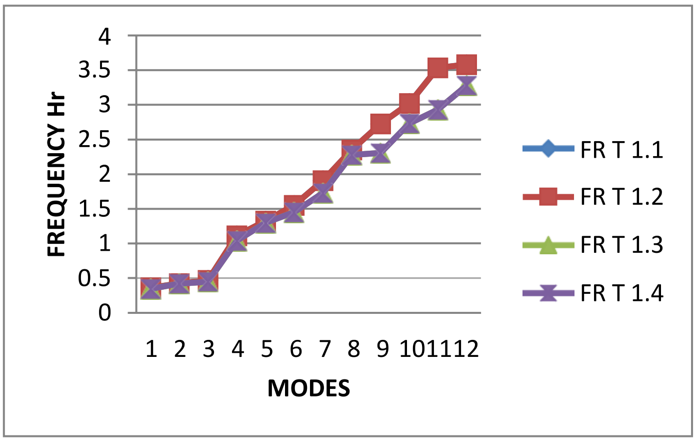

Fig -2.1.1(a): Frequency vs modes

Phase -2

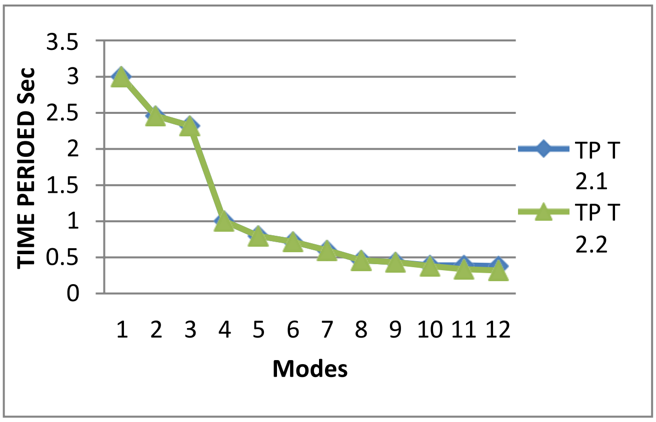

Fig -2.1.2: Time perioed vs modes

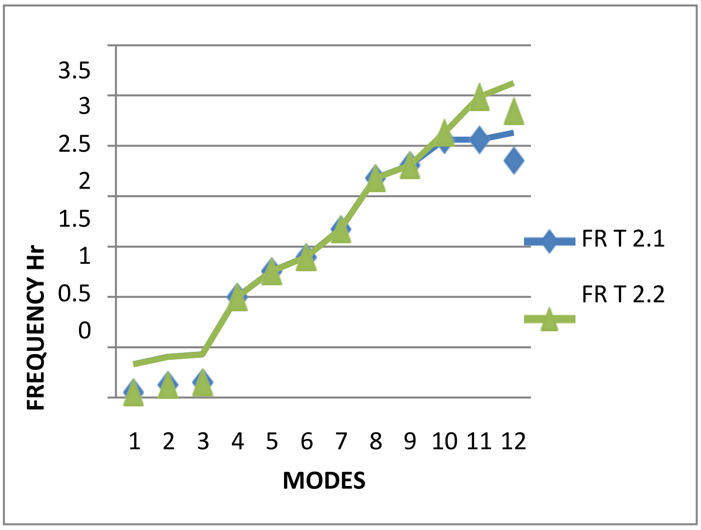

Fig -2.1.2(a): Frequency vs modes

Phase -3

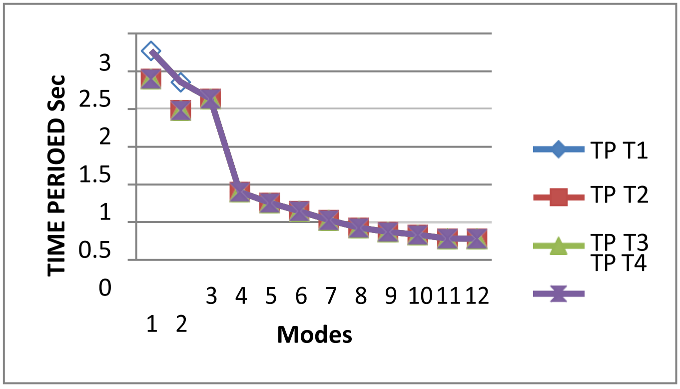

Fig -2.1.3: Time perioed vs modes

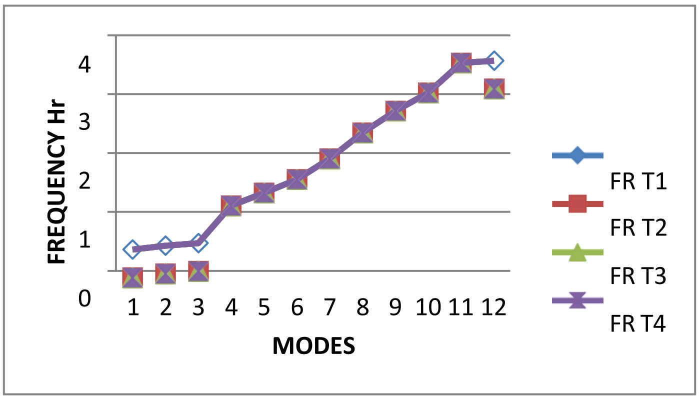

Fig -2.1.3(a): Frequency vs modes

Phase -4

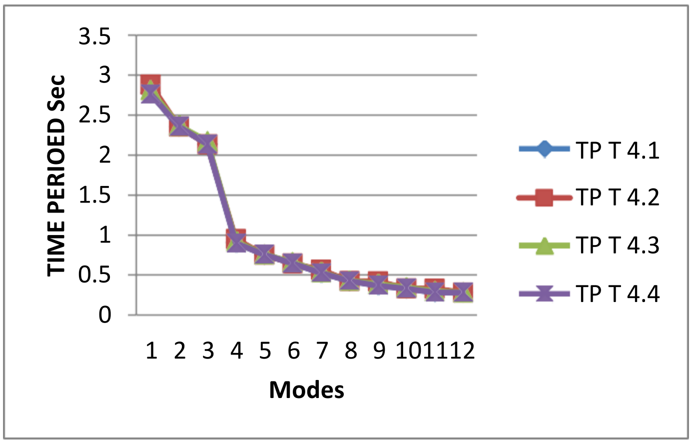

Fig -2.1.4: Time perioed vs modes

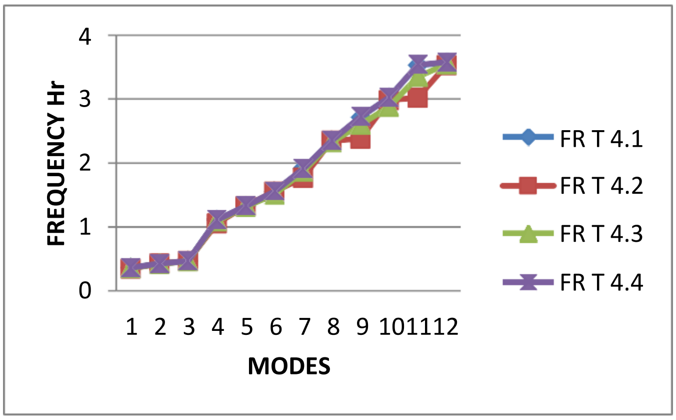

Fig -2.1.4(a): Frequency vs modes

3.2 DISPLACEMENT (mm)

The displacement is of interest with regard to structural stability, strength and human comfort.

EARTH QUAKE IN X-DIRECTION

Phase -1

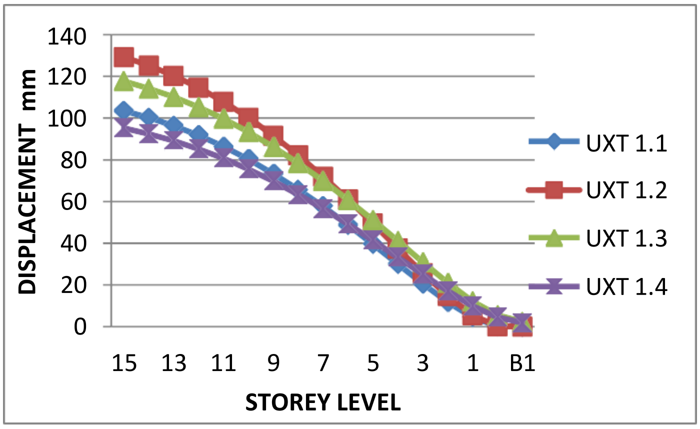

Fig 2.2.1: Displacement-x vs Storey level

Phase -2

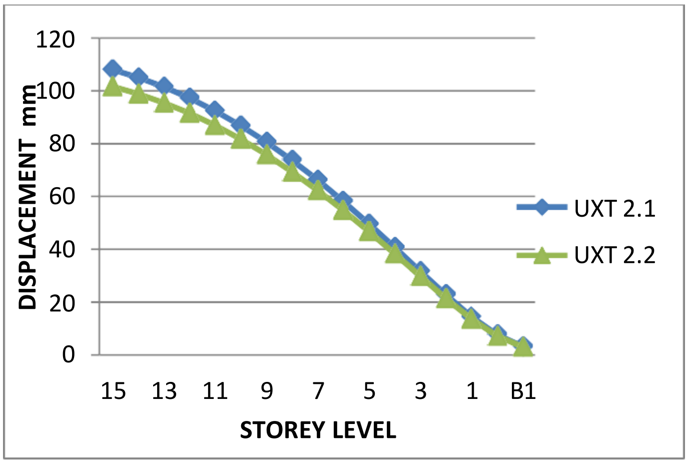

Fig 2.2.2: Displacement-x vs Storey level

Phase -3

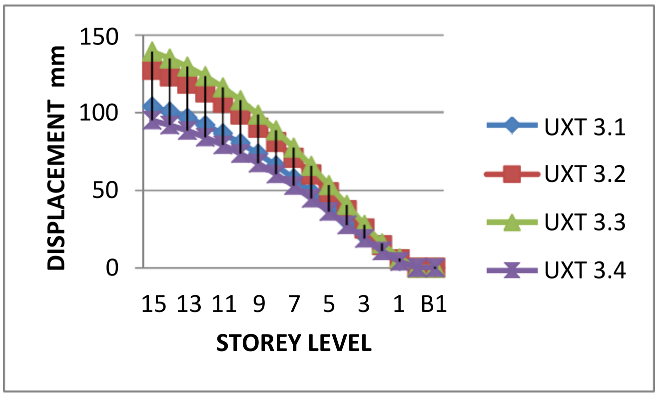

Fig 2.2.3: Displacement-x vs Storey level

Phase -4

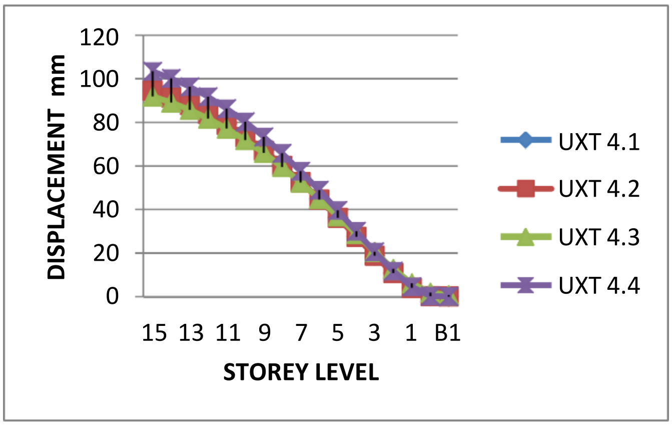

Fig 2.2.4: Displacement-x vs Storey level

3.3 STORY DRIFT RATIO

It is the displacement of one level relative to the other level above or below.
The building may collapse due to different response quantities. For eg., at local levels such as strains, curvatures, rotations and at global levels such as interior story drifts.

Individual stories may exhibit excessive lateral displacement. Therefore it can be concluded that by decreasing the story drifts of structure, the probability of collapse of the building can be reduced.

EARTH QUAKE IN X-DIRECTION

PHASE-1

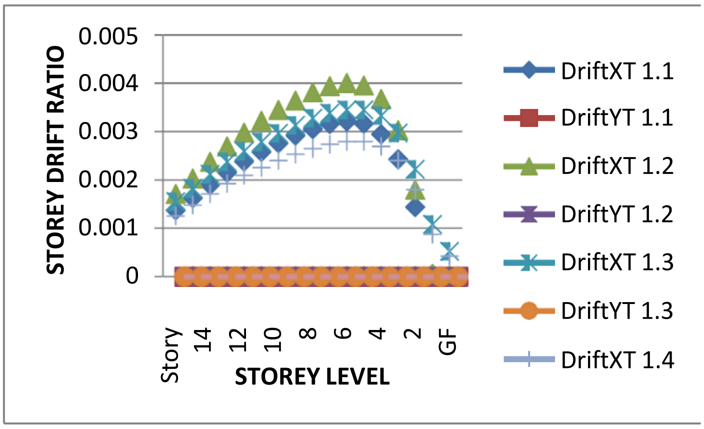

Fig 2.3.1: storey drift ratiot-x vs Storey level

PHASE-2

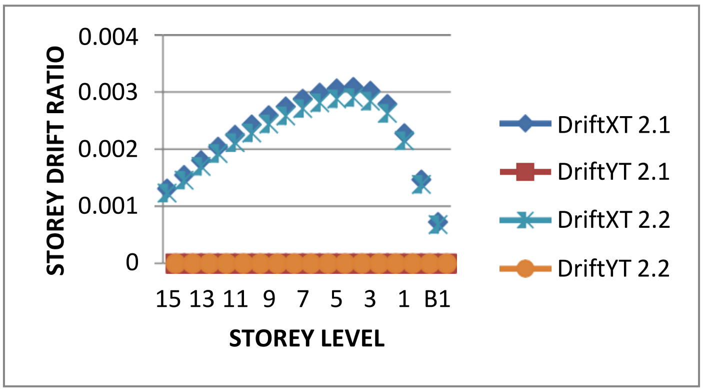

Fig 2.3.2: storey drift ratiot-x vs Storey level

PHASE-3

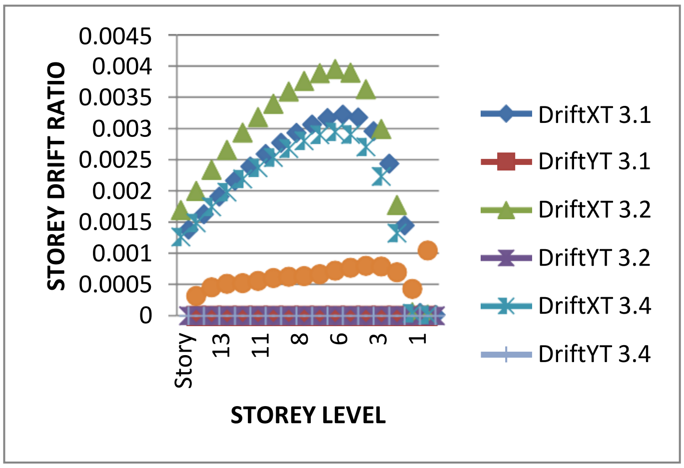

Fig 2.3.3: storey drift ratiot-x vs Storey level

PHASE-4

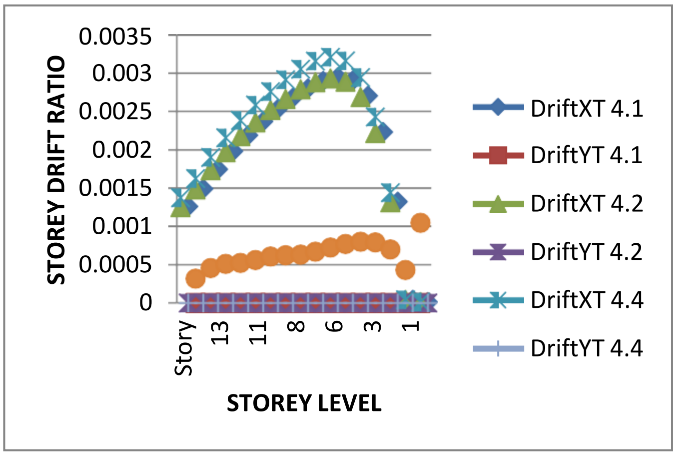

Fig 2.3.4: storey drift ratiot-x vs Storey level

3.4 STORY SHEAR (kN)

It is the sum of design lateral forces at all levels above the storey under consideration.

EARTH QUAKE IN X-DIRECTION

PHASE-1

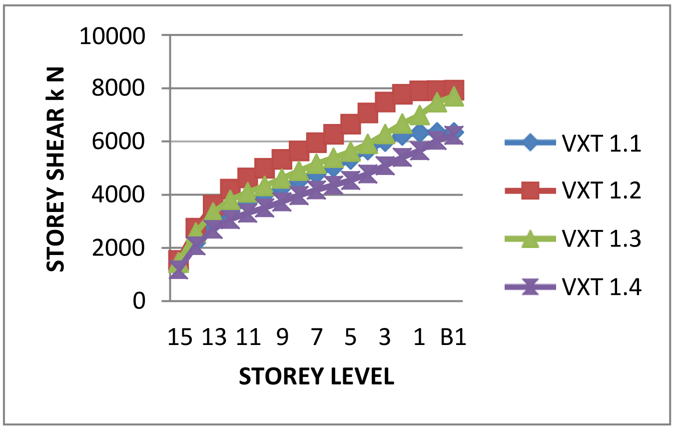

Fig 2.4.1: storey shear-x vs Storey level

PHASE-2

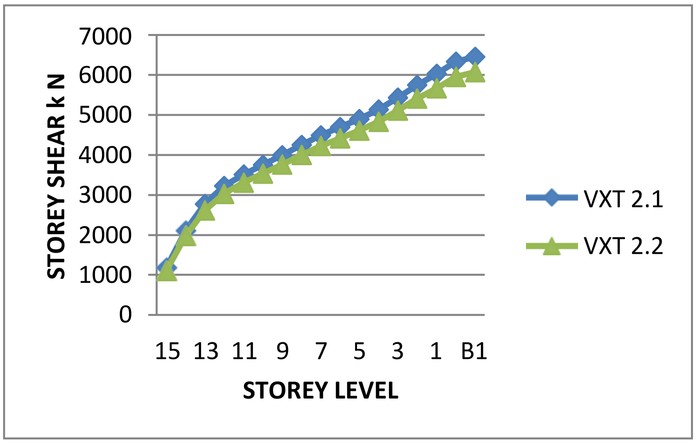

Fig 2.4.2: storey shear-y vs Storey level

PHASE-3

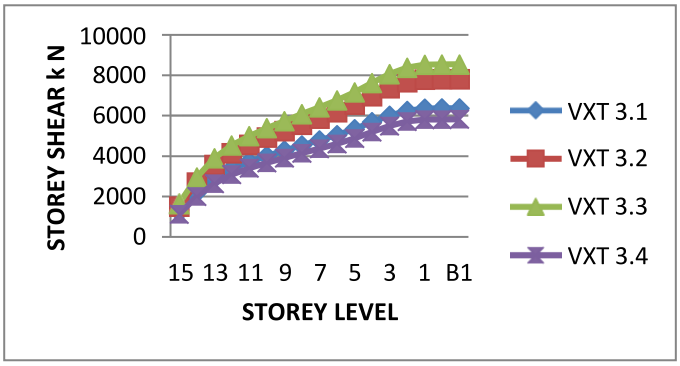

Fig 2.4.3: storey shear-y vs Storey level

PHASE-4

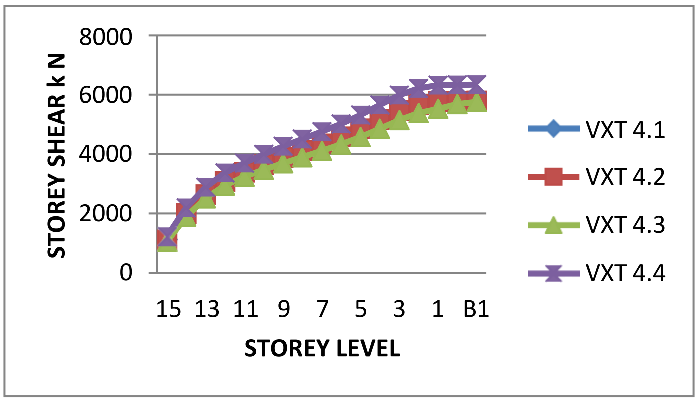

Fig 2.4.4: storey shear-y vs Storey level

4 CONCLUSIONS

In phase 1, the earth quake response of the tall building is studied and found that the RCC retaining wall connected to the basement will increase the stiffness of lower stores. This is the reason IS1893-2016 PART 1 has suggested to take the height and dimension from ground floor.

In phase 2, the earth quake response of the tall building is studied and found that the RCC retaining wall which are not connected to the basement will not increase the stiffness of lower stores. This is the reason IS1893-2016 PART 1 has suggested to take the height and dimension from basement floor.

In phase 3, the earth quake response of the tall building having 3 sides connected with RCC retaining wall and other one side is not connected is studied and found that in horizontal direction of plan , the height can be taken from basement and the dimension can be taken from ground floor. This will give the proper estimation of Horizontal forces. In vertical direction of plan ,the height and dimension can be taken from ground floor itself as the walls are connected to basement.

In phase 4, the finalized phase 3 concept is used to study the earth quake response of the tall building having basements with different conditions of retaining wall. It is` observed that all conditions of retaining wall except mentioned in the codes, shows significant reduction in time period, displacements & drift ratio.

Thus the work shows that the appropriate estimation of horizontal forces by a using phase 3 method.

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