INFLUENCE OF OPENINGS AND LOCAL SOIL CONDITIONS ON THE SEISMIC BEHAVIOR OF TUNNEL FORM BUILDINGS

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Abstract - *Multi-story reinforced concrete (RC) tunnel form buildings have been increasingly employed for mass construction industry in many countries. The main components of a tunnel form system are its relatively thinner shear-walls and flat-slabs compared to those of traditional RC buildings. Shear-walls in tunnel form buildings are utilized as the primary lateral load resisting and vertical load carrying members due to the absence of beams and columns. Recent studies show that the current seismic codes and guidelines do not provide sufficient requirements for seismic design of these structures. The quantification of the deterioration in the seismic performance of RC structures because of the presence of irregularities is constant area of research and needs rigorous Non-linear analysis. In the recent years, non-linear methods of seismic vulnerability assessment using Response Spectrum Analysis are gaining significant popularity.*

In the present study, an attempt is made to study the influence of openings and local soil conditions on the seismic performance of Tunnel form buildings using Response Spectrum Analysis. Analysis is carried out using ETABS software as per the guidelines of IS 1893. Attempts are made to study the effect of openings namely 0%, 6%, 22%, 50% and effects of soil having a safe bearing capacities namely 50, 100, 200, 250 of six story RC wall building. Seismic performance is analyzed by observing the parameters such as Time period, Maximum Story Displacement, Maximum Story Drift, Story Base shear.

Key Words: *Tunnel form building, Response spectrum, Time period, Maximum storey displacement, Maximum storey drift, Base shear.*

1.INTRODUCTION

From the past and present researches we concluded that the earthquakes are one of the most destructive compared to any other natural disasters. An earthquake as defines as a strong ground motion which is caused due to the forces generated under the surface of the earth (lithosphere).

This forces generated mainly due to the stresses which is produced during tectonic process, this mainly due to the interaction between the earth crust. Among the natural disasters, earthquake can cause more damages to the structural building because of its strong ground motion. To overcome from the forces developed by earthquakes. Structural engineer must use more modern designs and carefully analyze the seismic behavior of the buildings. The basic purpose of the design should be, consider the structures that perform well during suitable loading scenarios. Suitable design codes are used , the objective of these codes should be provide safety life to the structures during strong and frequent earthquakes.

In the project work, an RC wall building (Tunnel form building) is analyzed by considering earthquake parameter and the results will be compared with the same parameters. Consider a structure if it is performing well in earthquake, we must think that the structure is good in stiffness, torsional moment and strength. In this thesis, an six and three story RC wall building structures are perfectly designed and analyzed under earthquake and the results will be compared with the RC frame buildings. Response spectrum analysis will be implemented for seismic design of RC wall structures.

1.1 OBJECTIVES

- To study the seismic behaviour of tunnel form buildings and compare it with RC frame structures.
- To quantify the improvement in the seismic performance of tunnel form buildings in comparison to RC frame structure.
- To study the effect of structural irregularities in the form openings on the seismic performance of the tunnel form buildings.
- To study the effect of different local soil conditions on the seismic behaviour of tunnel form buildings.
- To study the above objective using response spectrum analysis with the help of ETABS software considering the parameter such as natural time period, base shear, displacement, mode shape etc.

1.2 METHODOLOGIES

- A through literature review to understand the seismic evaluation of the building structures and application of response spectrum analysis and time history analysis.
- Selecting a three and six storey building with RC frame and RC wall comparing the seismic behaviour. And also effect of openings and soil are studied for the RC wall buildings.

- Multi storey buildings will be analyzed as per Indian standards for dead load, Live load and earthquake load.
- Analyzed the structure with seismic analysis such as response spectrum analysis in Etabs 2015.
- Analyze the outcomes will arrive in conclusions.

1.3 ABOUT RC WALLS

Multi story reinforced concrete tunnel form buildings are nothing but a box type building. Now a days these buildings are increasingly constructed around the world wide for mass construction. The principle parts of a tunnel form frame work its moderately thinner shear walls and flat slabs. These shear wall resists the lateral load and carry the vertical load in the absence of beams and columns. Typical tunnel formwork framework structure system as shown in fig. The RC walls are continuous throughout the height of the building which helps to minimize the torsion and avoid local stress concentrations. Apart from these RC wall buildings offers more advance frame work technology, which helps to look building more attractive. Mivan framework system is used in the construction of RC wall buildings.

During construction, walls and slabs having same thickness are casted in a single operation. This helps to reduce the number of cold framed joints and assembly time. The casting of slabs, walls and cross walls takes place simultaneously resulting in monolithic structures. So these type structures provides good seismic performance at critical locations such as openings and slab-wall connections.

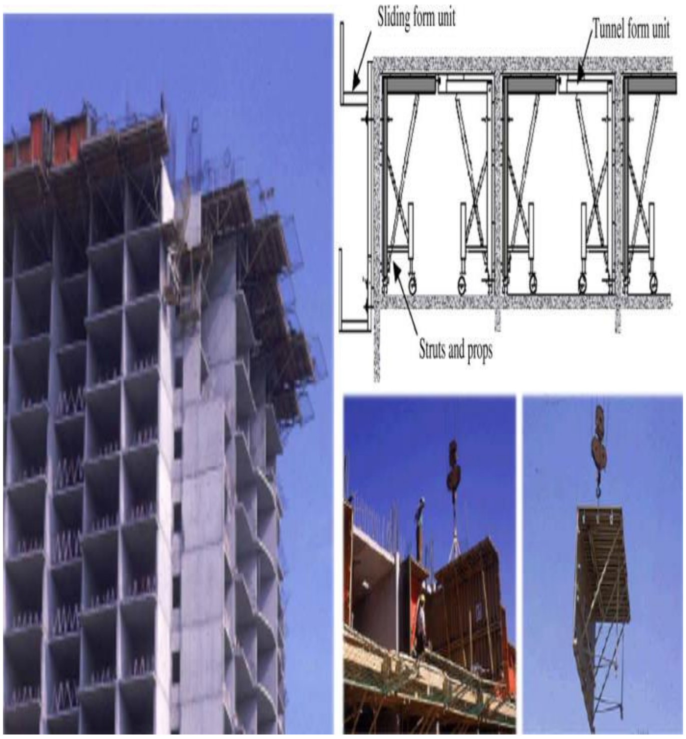

Fig: Tunnel Form Buildings and its Framework System

2. ABOUT ETABS SOFTWARE

ETABS 2015 abbreviated as extended three dimensional analysis of building program. A very useful software program matured by computers and structures. This is further improved by structural engineer's analysis and design capabilities. The power of the software stays in array of options and features and some part lies in how easy to use it. The basic idea of this software is very simple. Firstly user creates a model with the help of grid lines. And after that geometry , structural property, supports, loads and materials will be assigned. All dynamic properties such as mass source, mode shapes and direction of modes are specified and analysis can be performed based on either in a graphical or tabular form. The following topics define some of the important concepts in the analysis using ETABS 2015

2.1 ANALYSIS OF GRAVITY AND LATERAL LOADS IN ETABS 2015

The model is started with grid lines and depending upon size of the structure. Defining each component of the structure such as material, diaphragm etc. for further we apply the loads and applying the loading to boundary condition

2.2 RESPONSE SPECTRUM ANALYSIS USING ETABS 2015 SOFTWARE

As per IS 1893: 2002 part I seismic zone and its soil type considered in the response spectrum responses using ETABS 2015. Loading and modal combination will be specified from some available options in the analysis. Response spectrums have three directional local co ordinate systems that define excitation angles. According to code there is one sealing factor that defines while inputting the response spectrum either in X and Y direction.

$$SealingFactor = 1/2 \times I/R \times g$$

If base shear V_b is lesser than the static analyzed base shear V. we should impact sealing factor which is equal to product of scale factor i.e.,

$$ScalingFactor = 1/\ 2 \times I/R \times\ g \times V/V_b$$

3. MODELLING AND ANALYSIS

In the present paper an action is made on the seismic behavior of the multistory building by using diaphragm and there discontinuities. On the intention a regular four story and eight story building have analyzed and modeled by response spectrum analysis using ETABS 2015.lateral load analysis as per the seismic code IS: 1893 (Part 1)-2002 is carried out for regular building with rigid diaphragm by varying heights and even for the discontinuous diaphragm later an effort is made to study the effect of seismic loads and comparative study between the response spectrum analysis for both X and Y direction.

3.1 DESCRIPTION OF BUILDING

Description

Type of structure : Multi-storey RC wall structure
Occupancy : Commercial building
Number of floors : 4(G+3) and 7(G+6)
Ground floor height : 3.65
Intermediate storey height : 3.65
Type of soil : Medium soil
Sit location : Chennai
Siesmic zone : 4
Importance factor : 1
Response reduction factor : 3

Material

M-25 concrete
Fe-500 steel

Member dimensions

For 6 storey : Column size – 230x450mm
Beam sixe – 300x600mm
Slab thickness :150mm
Wall thickness : 150mm

Loads

Live load : 3kN/m2
Floor finish load : 1.5kN/m2
Wall load : 16kN/m

3.2 LOAD COMBINATIONS

The following load combinations are considered in the analysis and design as per IS-1893(part-1) 2002

Load Combinations	Load Factors
Gravity Analysis	1.5(DL+LL)
Equivalent Static Analysis	1.2(DL+LL±EQx)
	1.2(DL+LL±EQy)
	1.5(DL±EQx)
	1.5(DL±EQy)
	0.9DL±EQx
	0.9DL±EQY
Response Spectrum Analysis	1.2(DL+LL±RSx)
	1.2(DL+LL±RSy)
	1.5(DL±RSx)
	1.5(DL±RSy)

Where, DL is Dead load and LL is Live load.

EQx and EQy are Earthquake loads in X and Y directions respectively.

RSx and RSy are Earthquake spectrum in X and Y directions respectively.

Modeling is done for six story RC frame as shown in the fig 1 with plan and 3D model

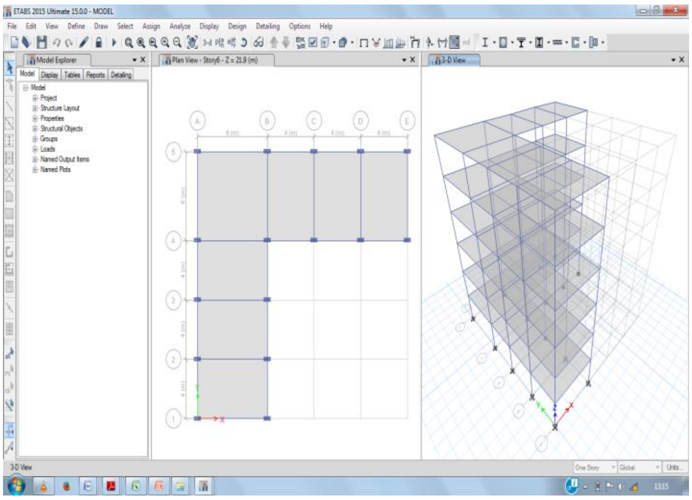

Fig 1: Plan and 3D model of six story RC frame building

Modeling is done for six story RC wall as shown in the fig 2 with plan and 3D model of 0% opening.

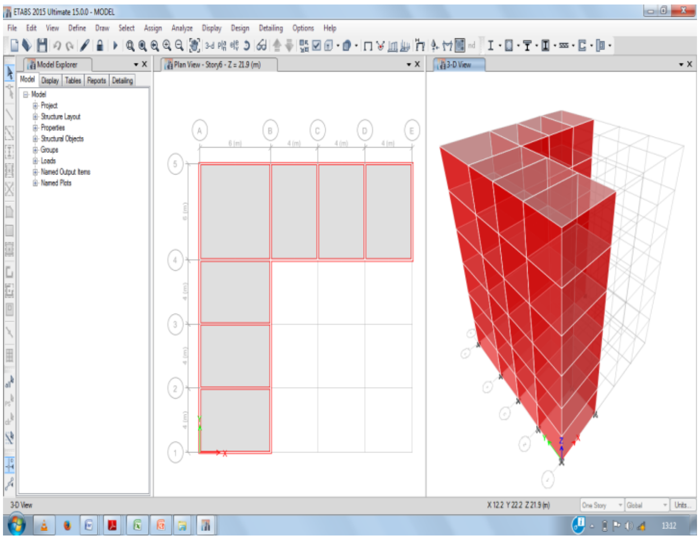

Fig 2: Plan and 3D model of six story RC wall building

Modeling is done for six story RC wall as shown in the below figures with 0%, 6%, 22% and 50% of opening.

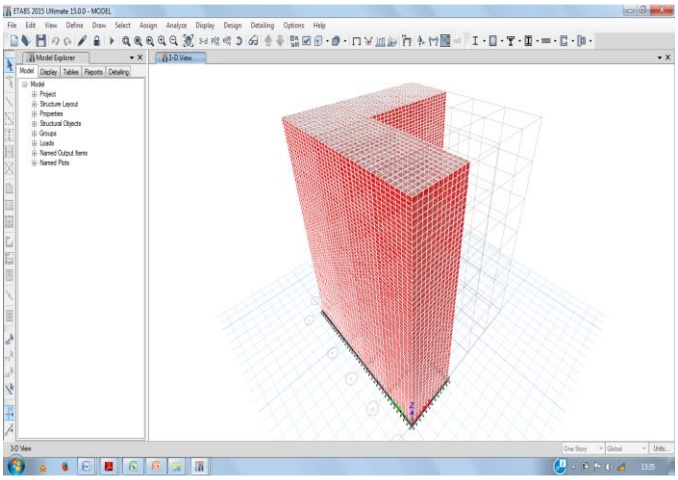

Fig 3: 3D Model of RC wall building with 0% of opening

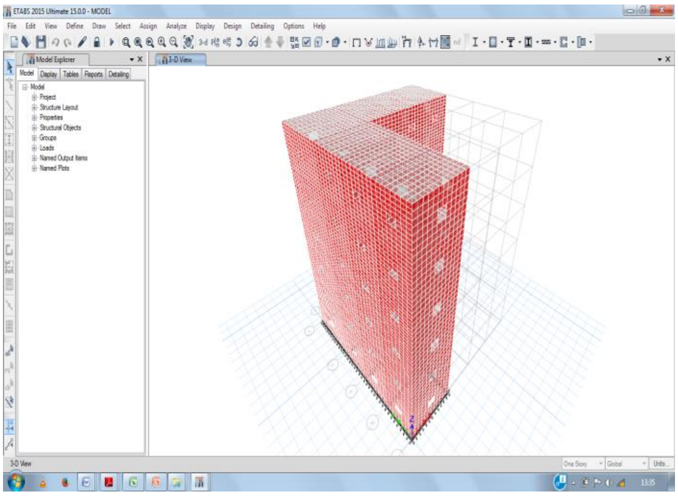

Fig 4: 3D Model of RC wall building with 6% openings

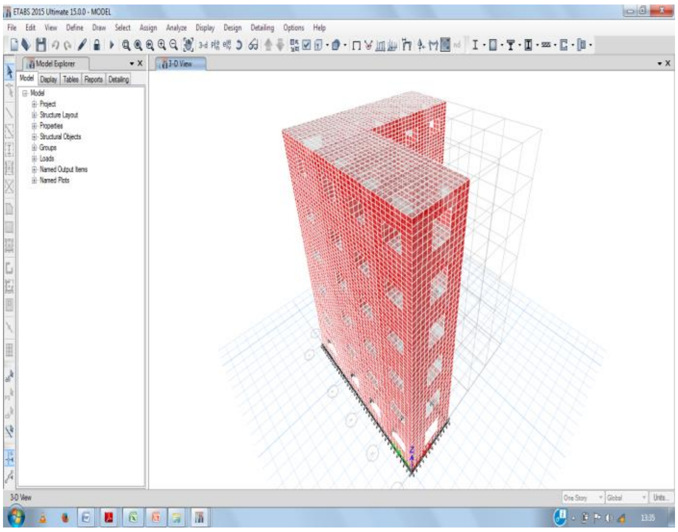

Fig 5: 3D Model of RC wall building with 22% openings

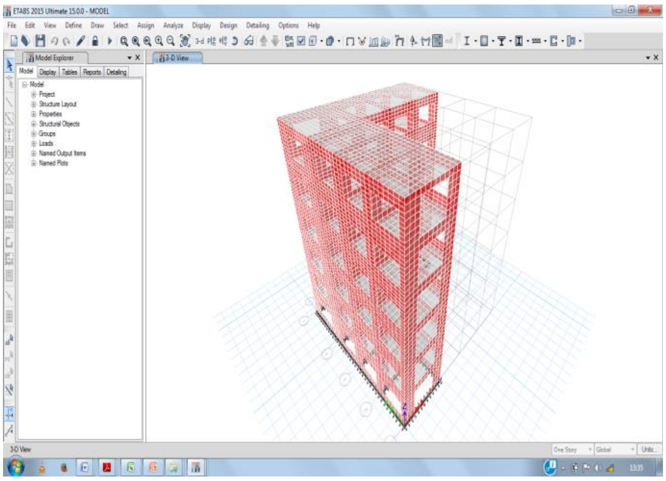

Fig 6: 3D Model of RC wall building with 50% openings

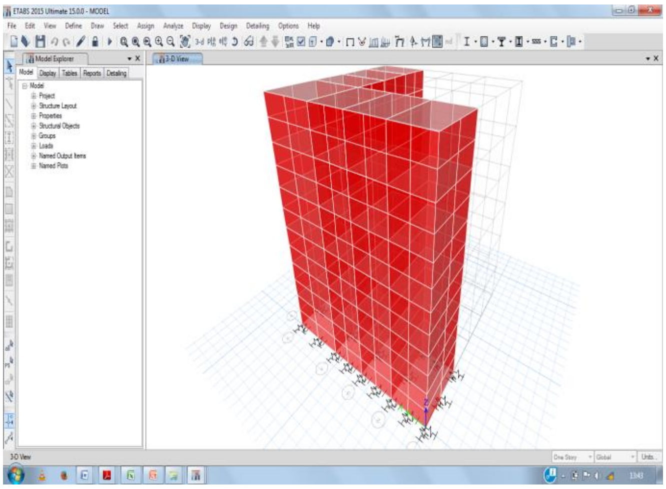

Fig 7: 3D Model of RC wall building with springs

3.3 RC FRAMES VS RC WALLS

3.3.1 NATURAL TIME PERIOD

The value of time period depends upon the building flexibility and mass; more the flexibility, the longer is the period and more the mass, the longer is the period. The codes Is1893 part-1 2002`and analytical in ETABS 2015 has fundamental natural period of the building are shown in the table. The fig shows that the time period for the RC wall buildings has performed well while compared the RC frame. About 94% time period is decreased for three and 93% decreased for 6 story RC wall buildings.

Table 1: Comparison of Natural Time period of 6 story Buildings

Mode no	6 story	
	RC frame	RC wall
1	2.068	0.129
2	1.762	0.117
3	1.539	0.087
4	0.669	0.037

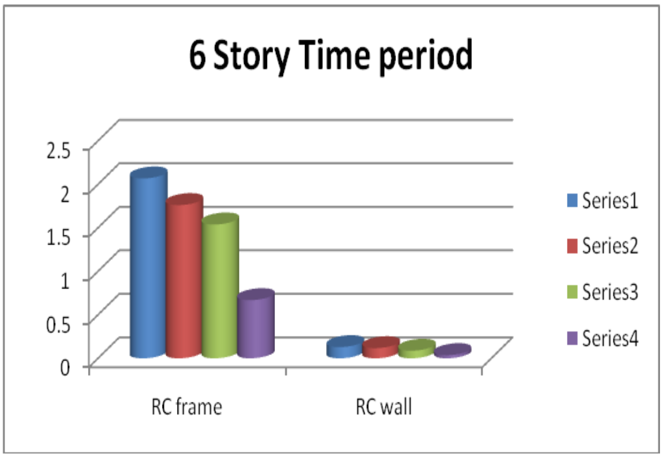

Chart 1: Comparison different modes for 6 story buildings.

3.3.2 MAXIMU STORY DISPLACEMENT

Maximum displacement is an optimum displacement cornered in the floor slab. In the six story building, the displacement of RC wall is decreased to 97% in x-direction and 98% in y-direction compared to RC frame building.

Table 2: Comparison of Maximum Story Displacement for 6 Story

Maximum Story Displacement for 6 Story					
Story height	Elevation(m)	X-Direction		Y-Direction	
		RC frame	RC wall	RC frame	RC wall
story6	21.9	30.1	0.5	44.7	0.5
stort5	18.25	27.5	0.4	41.1	0.4
story4	14.6	23.4	0.3	35.2	0.3
story3	10.95	17.9	0.2	27.3	0.2
story2	7.3	11.3	0.1	17.8	0.1
story1	3.65	4.3	0.1	7.3	0.1
Base	0	0	0	0	0

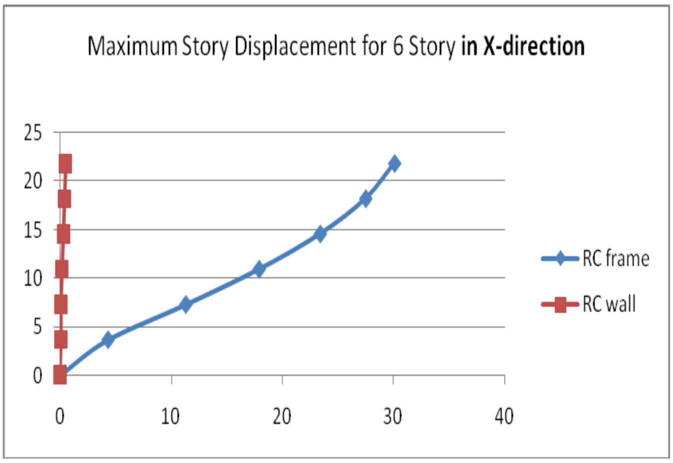

Chart 2: Comparison Maximum Story displacement in X-direction

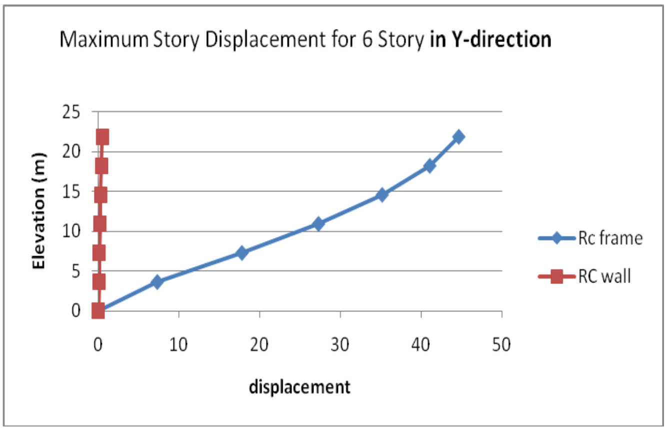

Chart 3: Comparison Maximum Story displacement in Y-direction

3.3.3 MAXIMUM STORY DRIFT

Maximum story drift is an optimum drift occurred in the floor slab. In the six story RC wall buildings the drift has been decreased of about 97% in x and 98% in y directions compared to RC frame building.

Table 3: comparison of Maximum Story Drift for 6 story

Maximum Drift for 6 Story					
Story height	Elevation(m)	X-Direction		Y-Direction	
		RC frame	RC wall	RC frame	RC wall
story6	21.9	0.00088	0.00002	0.001238	0.00002
stort5	18.25	0.001304	0.000023	0.001894	0.000023
story4	14.6	0.001622	0.000026	0.002356	0.000026
story3	10.95	0.001857	0.000026	0.002708	0.000026
story2	7.3	0.001914	0.000023	0.002887	0.000023
story1	3.65	0.001175	0.000017	0.002006	0.000017
base	0	0	0	0	0

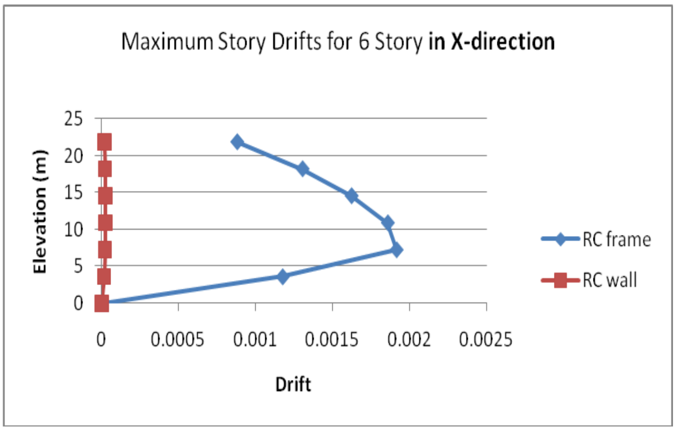

Chart 4: Comparison of maximum Story Drift for 6 story in X-direction

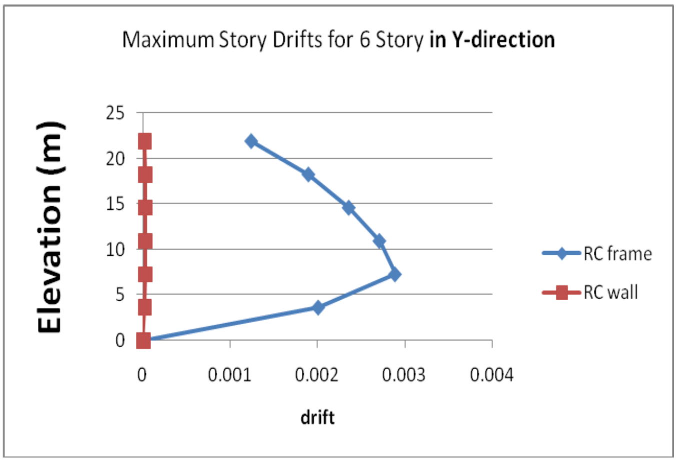

Chart 5: Comparison of maximum Story Drift for 6 story in Y-direction

3.3.4 STORY BASE SHEAR

Base shear is nothing but an estimation of the total horizontal seismic load acting on the structure in a static time. In the six story the base shear of RC wall is increased of about 36% and 385 in X and Y directions respectively. The RC wall has ultimate base shear is around 792KN.

Table 4: Comparison of Base shear for 6 story

Base shear response for 6 Story building						
Story height	Elevation(m)	X-Direction		Y-Direction		
		RC frame	RC wall	RC frame	RC wall	
story6	21.9	192.8797	188.4796	182.7345	188.4796	
stort5	18.25	292.4059	400.1028	279.4683	400.1028	
story4	14.6	352.7307	563.832	337.7073	563.832	
story3	10.95	405.8102	682.2531	386.4961	682.2531	
story2	7.3	464.0898	757.7827	439.4598	757.7827	
story1	3.65	506.2389	792.4734	484.4309	792.4734	
base	0	0	0	0	0	

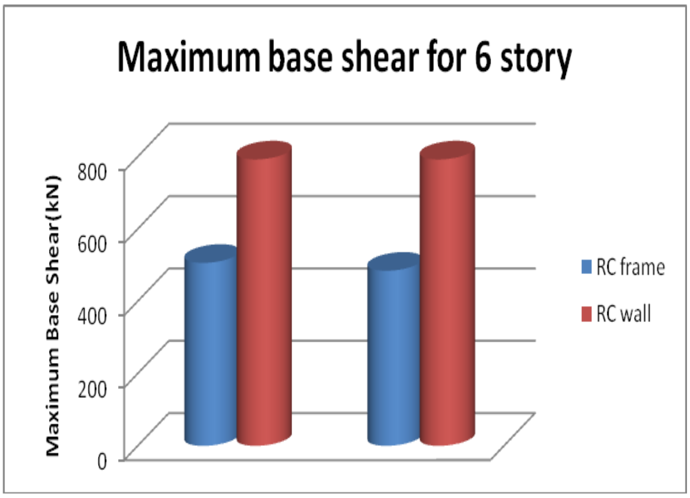

Chart 6: Comparison of Base shear for 6 Story building both RC frame and RC wall

3.4 EFFECT OF OPENINGS

Total area of the building for each floor = (10*6*3.65) + (12*4*3.65) = 394.2 sq.m

Total area for six floor = (6*394.2) =2365.2 sq.m

For 1m x 1m opening

$$\% \text{ of opening} = \frac{(22*1*1)}{area} * 100 = 6\%$$

$$\% \text{ of opening} = \frac{(22*2*2)}{area} * 100 = 22\%$$

$$\% \text{ of opening} = \frac{(22*3*3)}{area} * 100 = 50\%$$

The parameters such as natural time period, displacement , drifts and story shear are calculated for 0%, 6%, 22% and 50% openings respectively.

3.4.1 NATRAL TIME PERIOD

In the six story building, the time period has been increased about 4%, 17% and 40% in respective openings compared to no openings.

Table 5: Comparison of Time period for 6 Story building with different openings

Time period in seconds for 6 Story				
Mode no	0% Opening	6% opening	22% Opening	50% Opening
1	0.134	0.141	0.17	0.284
2	0.121	0.129	0.163	0.259
3	0.088	0.094	0.119	0.196
4	0.055	0.057	0.062	0.089

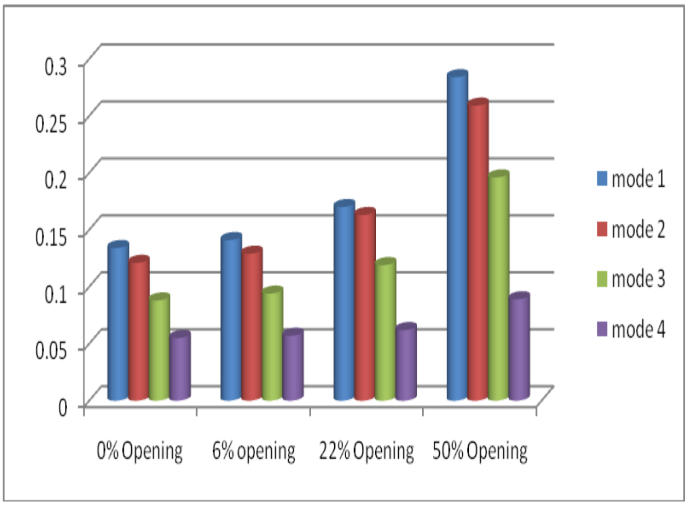

Chart 7: Comparison of Time period for different modes with different openings

3.4.2 MAXIMU STORY DISPLACEMENT

In the 50% opening, the building deflected more and maximum deflection is 2.6mm. About 16%,33% and 65% is increased in subsequent openings due to eccentric loading in X direction.

Table 6: Comparison of Maximum Story Displacement for 6 Story with different openings

Maximum story Displacement In X-direction for differenr openings 6 story					
Story	Elevation(m)	0% Opening	6% opening	22% Opening	50% Opening
story6	21.9	0.5	0.6	0.9	2.6
stort5	18.25	0.5	0.5	0.8	2.3
story4	14.6	0.4	0.4	0.7	1.9
story3	10.95	0.3	0.3	0.5	1.4
story2	7.3	0.2	0.2	0.3	0.9
story1	3.65	0.1	0.1	0.1	0.4
base	0	0	0	0	0

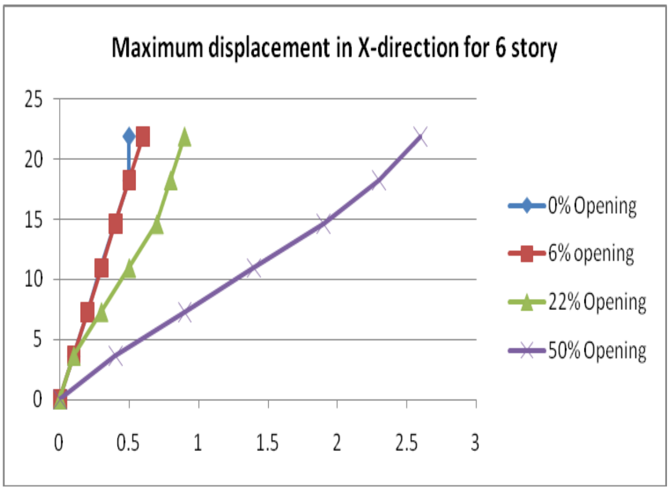

Chart 8: Comparison Maximum Story displacement in X-direction

Table 7: Comparison of Maximum Story Displacement for 6 Story with different openings

Maximum Story Displacement in Y-direction for different openings 6 story					
Story	Elevation(m)	0% Opening	6% opening	22% Opening	50% Opening
story6	21.9	0.5	0.6	0.9	2.6
stort5	18.25	0.5	0.5	0.8	2.3
story4	14.6	0.4	0.4	0.7	1.9
story3	10.95	0.3	0.3	0.5	1.4
story2	7.3	0.2	0.2	0.3	0.9
story1	3.65	0.1	0.1	0.1	0.4
base	0	0	0	0	0

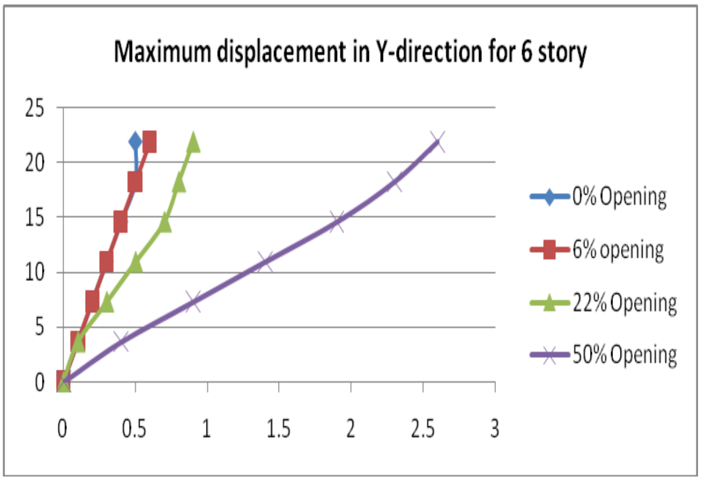

Chart 9: Comparison Maximum Story displacement in Y-direction

3.4.3 MAXIMUM STORY DRIFT

In the six story building, the maximum drift occurred for 50% opening.

Table 8: comparison of Maximum Story Drift for 6 story with different openings

Maximum Drifts in X-direction for different Openings 6 story					
Story	Elevation(m)	0% Opening	6% opening	22% Opening	50% Opening
story6	21.9	0.000024	0.000026	0.000038	0.000091
stort5	18.25	0.000027	0.00003	0.000044	0.000112
story4	14.6	0.000029	0.000032	0.000049	0.000136
story3	10.95	0.000028	0.000032	0.00005	0.000151
story2	7.3	0.000025	0.000028	0.000046	0.000144
story1	3.65	0.000018	0.000021	0.000033	0.000088
base	0	0	0	0	0

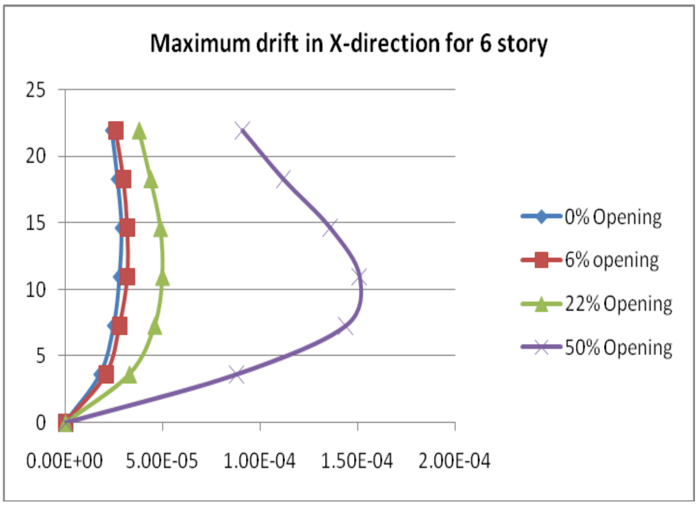

Chart 10: Comparison of Maximum Story Drift for 6 story in X-direction

Table 9: comparison of Maximum Story Drift for 6 story with different openings

Maximum Drifts in Y-direction for different Openings in 6 story					
Story	Elevation(m)	0% Opening	6% opening	22% Opening	50% Opening
story6	21.9	0.000024	0.000026	0.000038	0.000091
stort5	18.25	0.000027	0.00003	0.000044	0.000112
story4	14.6	0.000029	0.000032	0.000049	0.000136
story3	10.95	0.000028	0.000032	0.00005	0.000151
story2	7.3	0.000025	0.000028	0.000046	0.000144
story1	3.65	0.000018	0.000021	0.000033	0.000088
base	0	0	0	0	0

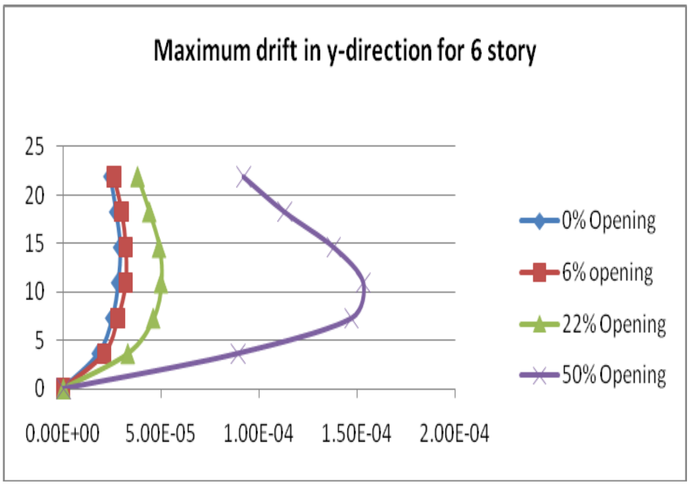

Chart 11: Comparison of Maximum Story Drift for 6 story in Y-direction

3.4.4 BASE SHEAR

In the six story RC wall building, the maximum base shear occur for no openings when compared to other openings. The ultimate base shear occur at first floor is around 793KN.

Table 10: comparison of Maximum Base Shear for 6 story with different openings..

Base shear response in KN in X-direction for different openings 6 story					
Story	Elevation(m)	0% Opening	6% opening	22% Opening	50% Opening
story6	21.9	188.2376	185.4113	174.6712	159.3875
stort5	18.25	399.9575	392.7216	366.566	327.5851
story4	14.6	563.6925	553.1851	516.5486	461.2622
story3	10.95	682.4476	669.86	627.0002	562.396
story2	7.3	758.5357	744.9533	698.9785	629.9016
story1	3.65	793.4312	779.6162	732.1374	660.0234
base	0	0	0	0	0

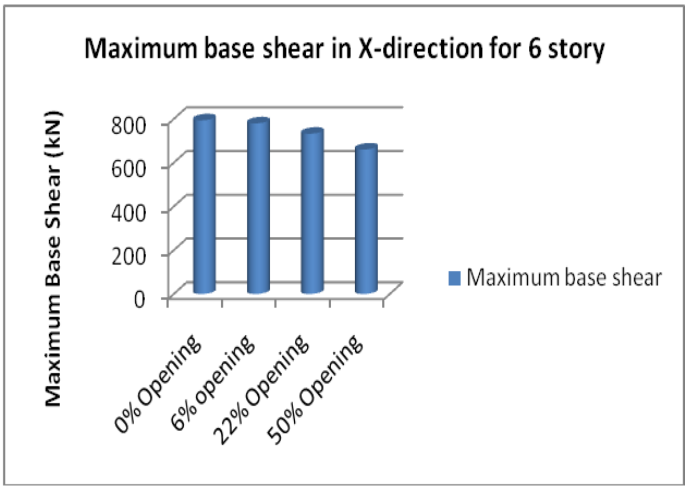

Chart 12: Comparison of Maximum Base Shear for 6 story in X-direction

Table 11: comparison of Maximum Base Shear for 6 story with different opening

Base shear response in KN in Y-direction for different openings 6 story					
Story	Elevation(m)	0% Opening	6% opening	22% Opening	50% Opening
story6	21.9	188.2375	185.4599	174.6712	150.4098
stort5	18.25	399.9576	392.8103	366.5661	309.0346
story4	14.6	563.6924	553.3279	516.5485	435.1705
story3	10.95	682.4476	670.0404	627.0002	530.6307
story2	7.3	758.5357	745.1376	698.9785	594.3552
story1	3.65	793.4312	779.8062	732.1374	622.8414
base	0	0	0	0	0

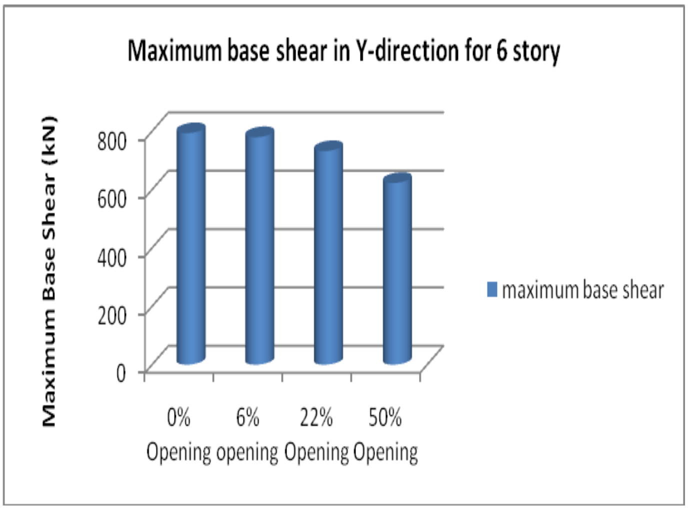

Chart 13: Comparison of Maximum Base Shear for 6 story in Y-direction

3.5 EFFECT OF SOIL FLEXIBILITY

Modulus of Sub-grade Reaction = 40*SB*FOS*Area

For SBC=50 MOR= 40*50*3*4 = 24000kN/m
For SBC=100 MOR= 40*100*3*4 = 48000kN/m

For SBC=200 MOR= 40*200*3*4 = 96000kN/m
For SBC=250 MOR= 40*250*3*4 = 120000kN/m

3.5.1 TIME PERIOD

In the six story building, the time period is more soft soil(SBC 50) when compared to other safe bearing capacities of soil. About 32% time period is decreased compared to other soils having different SBC.

Table 12: comparison of Time period for 6 story with different SBC

Time period in seconds 6 story				
Mode no	SBC 50	SBC 100	SBC 200	SBC 250
1	0.96	0.649	0.47	0.425
2	0.589	0.429	0.318	0.291
3	0.301	0.231	0.182	0.17
4	0.138	0.102	0.085	0.085

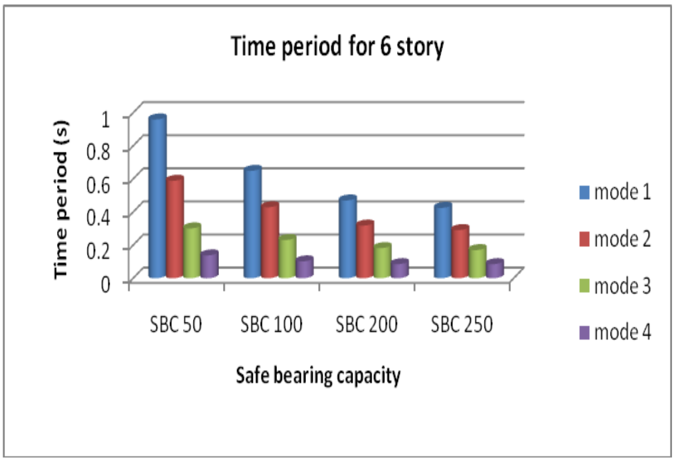

Chart 13: Comparison of time period for six story

3.5.2 MAXIMUM STORY DISPLACEMENT

In the six story building, the building with SBC 50 has maximum deflection when compared to other soils. The building with SBC 250 has performed well by having least displacement.

Table 13: Comparison of maximum displacement for different SBC

Maximum displacement in X-direction for different SBC 6 story					
Story	Elevation(m)	SBC 50	SBC 100	SBC 200	SBC 250
story6	21.9	10.8	7.5	4.5	3.7
stort5	18.25	9.1	6.3	3.8	3.1
story4	14.6	7.5	5.2	3.1	2.6
story3	10.95	5.9	4	2.4	2
story2	7.3	4.2	2.9	1.7	1.4
story1	3.65	2.6	1.8	1	0.9
base	0	1.1	0.7	0.4	0.3

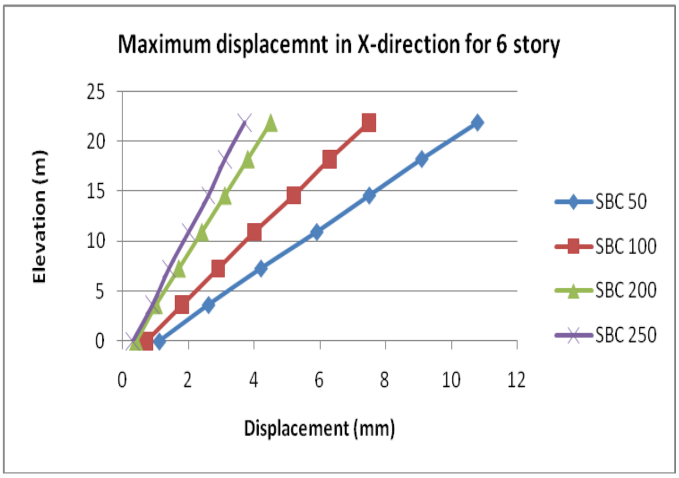

Chart 14: Comparison of Maximum Story Displacement for 6 story in X-direction

Table 14: comparison of Maximum Story Displacement for 6 story with different SBC

Maximum displacement in Y-direction for different SBC 6 story					
Story	Elevation(m)	SBC 50	SBC 100	SBC 200	SBC 250
story6	21.9	10.8	7.5	4.5	3.7
stort5	18.25	9.1	6.3	3.8	3.1
story4	14.6	7.5	5.2	3.1	2.6
story3	10.95	5.9	4	2.4	2
story2	7.3	4.2	2.9	1.7	1.4
story1	3.65	2.6	1.8	1	0.9
base	0	1.1	0.7	0.4	0.3

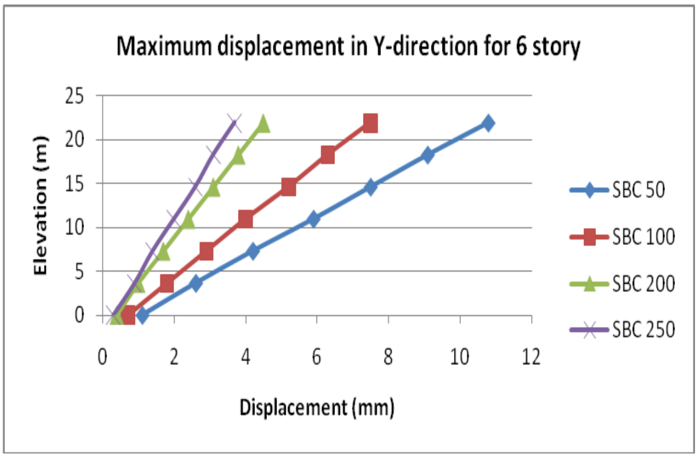

Chart 15: Comparison of Maximum Story Displacement for 6 story in Y-direction

3.5.3 MAXIMUM STORY DRIFT

Table 15: comparison of Maximum Story Drift for 6 story with different SBC

Maximum story drifts in X-direction for different SBC					
Story	Elevation(m)	SBC 50	SBC 100	SBC 200	SBC 250
story6	21.9	0.000448	0.000313	0.000187	0.000155

stort5	18.25	0.000449	0.000315	0.000189	0.000157
story4	14.6	0.000451	0.000316	0.000191	0.000159
story3	10.95	0.000451	0.000315	0.00019	0.000157
story2	7.3	0.000451	0.000315	0.000189	0.000156
story1	3.65	0.000648	0.000447	0.000269	0.000223
Base	0	0	0	0	0

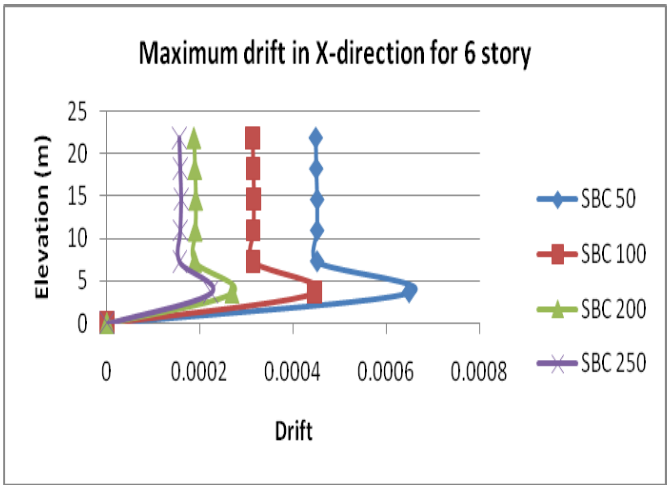

Chart 16: Comparison of Maximum Story Drift for 6 story in X-direction

Table 16: comparison of Maximum Story Drift for 6 story with different SBC

Maximum story drifts in Y-direction for different SBC					
Story	Elevation(m)	SBC 50	SBC 100	SBC 200	SBC 250
story6	21.9	0.000448	0.000313	0.000187	0.000155
stort5	18.25	0.000449	0.000315	0.000189	0.000157
story4	14.6	0.000451	0.000316	0.000191	0.000159
story3	10.95	0.000451	0.000315	0.00019	0.000157
story2	7.3	0.000451	0.000315	0.000189	0.000156
story1	3.65	0.000648	0.000447	0.000269	0.000223
Base	0	0	0	0	0

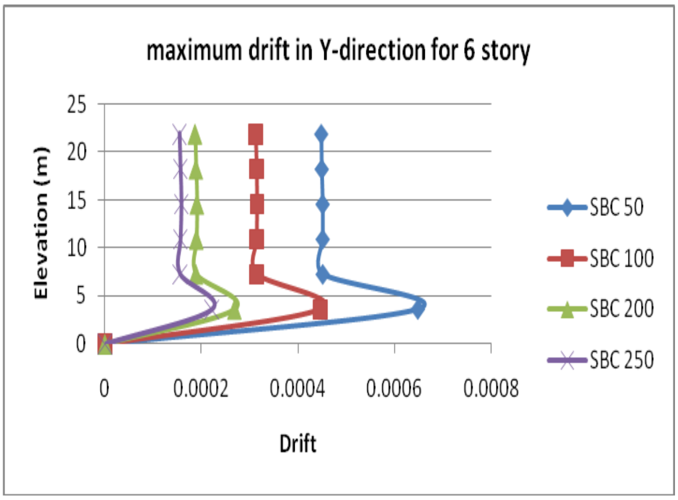

Chart 17: Comparison of Maximum Story Drift for 6 story in Y-direction

3.5.4 BASE SHEAR

Table 17: comparison of Maximum Base Shear for 6 story with different SBC

Base shear response in KN in X-direction for different SBC					
Story	Elevation(m)	SBC 50	SBC 100	SBC 200	SBC 250
story6	21.9	167.9982	194.1917	203.2199	202.5116
stort5	18.25	356.3538	414.3452	436.057	434.6979
story4	14.6	505.0341	589.7942	623.2639	621.5729
story3	10.95	619.835	725.724	768.6667	766.7037
story2	7.3	709.0315	829.2687	877.5204	875.0356
story1	3.65	783.0357	908.4396	954.5909	950.5973
Base	0	0	0	0	0

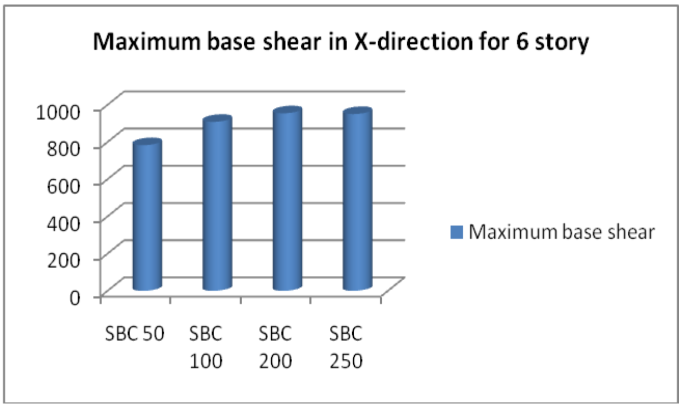

Chart 18: Comparison of Maximum Base Shear for 6 story in X-direction

Table 18: comparison of Maximum Base Shear for 6 story with different SBC

Base shear response in KN in Y-direction for different SBC					
Story	Elevation(m)	SBC 50	SBC 100	SBC 200	SBC 250
story6	21.9	167.9982	194.1918	203.2199	202.5116
stort5	18.25	356.3538	414.3452	436.057	434.6979
story4	14.6	505.0341	589.7942	623.2639	621.5729
story3	10.95	619.835	725.724	768.6667	766.7037
story2	7.3	709.0315	829.2687	877.5204	875.0356
story1	3.65	783.0357	908.4396	954.5909	950.5973
Base	0	0	0	0	0

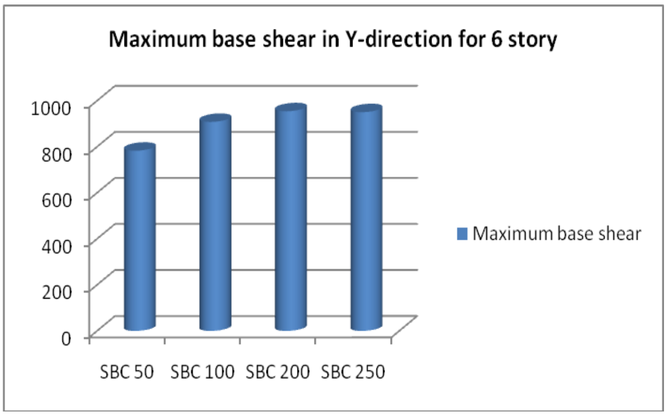

Chart 19: Comparison of Maximum Base Shear for 6 story in Y-direction

4. CONCLUSIONS

1. The present study was designed to study the earthquake response of tunnel form buildings. The results obtained in terms of time period, displacement, drifts and base shear shows the real behaviour of structures.

2. Comparison of results for RC wall and RC frames buildings revealed that the time period for RC frames are significantly higher compared to RC wall indicating the decrease in stiffness. Hence RC walls are much stiffer horizontally then the frames.

3. As a consequence, RC wall shows higher base shear and lesser lateral drifts and displacements compared to bare frames.

4. An attempt is also made to study the effect of openings in the seismic behaviour of RC wall buildings. It is found that increase in the percentage of opening significantly lengthens the time period and thus affects the overall seismic behaviour of RC structure.

5. As a consequence of increased flexibility because of openings, the structures with openings in the RC walls tend to undergo higher drifts and displacements compared to RC walls without opening. However, the total base shear decreases with increase in the percentage of opening.

6. An attempt is also made to study the effect of local soil conditions in the seismic behaviour of RC wall buildings. It is found that lower the safe bearing capacity of soil, time period will be significantly higher and thus affects the overall seismic behaviour of RC structure.

7. As a consequence, RC walls with high safe bearing capacity of soil experiences larger base shear but undergoes lower drifts and displacements compared to the subsequent lesser safe bearing capacities.

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