Accumulative Stability Increment of Multi-Storey Building Rested over Soft, Medium and Hard Soil using Different Grades of Concrete in Beam

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Abstract

To ensure that the building faces, all loads affect the building, such as the structure's own weight, live loads, and lateral loads and its impact action on the structure such as earthquakes and wind force. The Grade of concrete used in the building is one of the main parameters to ensure strength & stability of the building. In this project the impact of Grade of concrete can be asset to ensure the stability of multi storey building. A G+16 Storey building having a plane area 576 m^2. The two types of grade of concrete i.e. M25 & M40 is used in the building. A concrete up gradation or concrete belt is used in the structure on the 8 th & 16 th floor of the building. The Impact of Concrete belt is analyzed in soft, Medium & Hard soil. The results are based on the max. Displacement, base shear, bending moments, Torsional moments & Stresses. The project concluded that The Structure Models ASI 3,6,9 (All 8^{th} floor beam M- 40 Grade of Beam) Show the optimum Strucure with All 8^{th} floor beam M- 40 Grade of Beam. The priorty basis structure conctruction is used as M-40 grade concrete belt with 8 th floor, at plinth, all structre with M25 grade of concrete and then at the top floor(18 th floor) in decrement order. If N no. of storey is there than the concrete belt with change in grade is best placed at the position of N/2 Storey. Soft Soil Exhibits less parameteric magnitute value and it goes in increment mode in the medium and hard soil.

Keywords – *Concrete Belt, M-25 & M-40, soft, Medium, Hard soil, Strength, Stability*

Introduction

Stability of a concrete structure described by authors and researchers in different ways. The Stability can be defined as the ability to restore balance or resist sudden changes, displacements, or overturns. In addition, the stable structure must remain stable with all conceivable load systems. For any structure, it is essential to have a path that passes through clearly defined structure members through which stabilizing forces and horizontal forces can be transmitted to the foundations & Sub soils exist below the structure. Soil condition is an essential area of analysis in earthquake engineering work; this soil condition (Dexter 1988) "Physical state and dynamic properties of soil that can be shared according to standards Indian code entered; hard soil (Rocky), medium soil, soft soil (loose). It is common practice in building analysis and design to assume the foundation of construction to restore the soil, whereas in reality, soil support influences the structural response as it allows some degree of movement due to its natural deformability. Lessons learned from previous earthquakes in neglecting soil effects have highlighted the importance of soil-structure interaction in seismic analysis of structures. The operation in which the reaction of the soil affects the movement of the structure and the movement of the structure influences the response of the soil.

Grades of concrete are defined the character tics strength of concrete in 28 days. The basis focus on the strength and composition of the concrete, and the minimum strength the concrete should have following 28 days of initial construction. The grade of concrete is understood in measurements of MPa, where M stands for mix and the MPa denotes the overall strength.

Table 1: Grade of Concrete

Grade of Concrete as per IS 456:2000		
Group	**Grade Designation**	**Specific Charactertics Compressive Strength (N/mm^2)**
Ordinary Concrete	M-10	10
	M-15	15
	M-20	20
Standard Concrete	M-25	25
	M-30	30
	M-35	35
	M-40	40
	M-45	45
	M-50	50
	M-55	55
High Strength Concrete	M-60	60
	M-65	65
	M-70	70
	M-75	75
	M-80	80

As per new amendments it goes up to M-100. In this the analysis is carried out to constructed a concrete belt at plinth beam, 8th floor & 16 floor (at the top). The aim is to find the stability assessment based on the change in concrete grade in the respective storey. There are 12 different cases are consider in to it from the ASI1A to ASI10.

Modeling and Analysis:

The Different models are modeled by using CSI- ETABS software. The Notations of models are such that:

Soft Soil Models

1. ASI 1A: Strucure with All Beam M- 25 Grade.
2. ASI 2: Strucure with All Plinth beam M- 40 Grade of Beam
3. ASI 3: Strucure with All 8^{th} floor beam M- 40 Grade of Beam
4. ASI 4: Strucure with All 16^{th} floor beam M- 40 Grade of Beam

Medium Soil Models

1. ASI 1B: Strucure with All Beam M- 25 Grade
2. ASI 5: Strucure with All Plinth beam M- 40 Grade of Beam
3. ASI 6: Strucure with All 8^{th} floor beam M- 40 Grade of Beam
4. ASI 7: Strucure with All 16^{th} floor beam M- 40 Grade of Beam

Hard Soil Models

1. ASI 1C: Strucure with All Beam M- 25 Grade.
2. ASI 8: Strucure with All Plinth beam M- 40 Grade of Beam
3. ASI 9: Strucure with All 8^{th} floor beam M- 40 Grade of Beam
4. ASI 10: Strucure with All Plinth beam M- 40 Grade of Beam

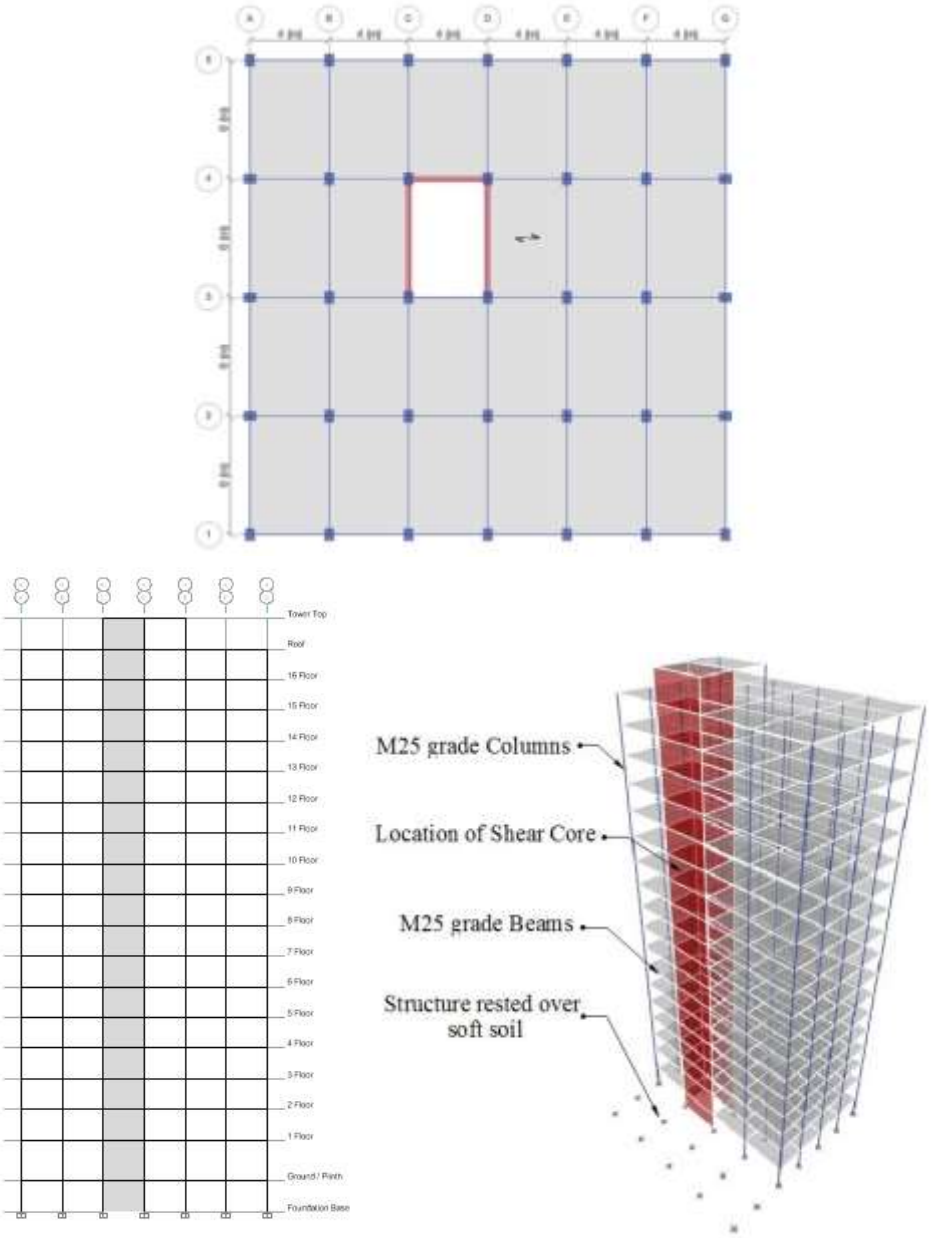


Figure 1: Plane, elevation & section of G+16 storey Building

Parameters Used in the Structure: Table 2 & Table 3 shows the basic parameters used in the analysis of building.

Table 2. Structural Parameters

S. No.	Element Name	Description
1	Building Types	Residential
2	No. of Storey	G+16
3	Plinth Area	576 m^2
4	Floor Height	4 m(Ground Storey) & 3m.(1-16 floor)
5	Dimensions of Beam	0.55 m. x 0.30 m
6	Dimensions of Column	0.50 m. x 0.55 m
7	Slab Thickness	0.130 m.

8	Shear wall	0.180 m.
10	Grade of Concrete	M-25 & M-40
11	Steel Used	Fe-415
12	Concrete Belt used at	8^{th} & 16^{th} floor
13	Grid Spacing in X- Direction	4m. each in 6 bay
14	Grid Spacing in Y- Direction	4m. each in 6 bay
15	Analysis Software used	CSI-etabs

Earthquake Analysis Parameters:

Table 3. Earthquake Parameters

S. No.	Parameters	Description
1	Earthquake Code	IS 1893(Part 1):2016
2	Earthquake Zone	III
3	Response Factor(RF)	4
4	Importance Factor(IF)	1.2
5	Soil Types	Soft, Medium & Hard
6	Damping	0.05
7	Structural Type	RCC Framed Building

Result & Discussions

The Following results are to be obtained from the modeling and analysis of Multi storey building Under the influence of soft, medium & hard soil. The results are as follows:

Maximum Displacement: It is defined as the maximum displacement or distance moved by a point on a vibrating body or wave measured from its equilibrium position. Table 4 Shows that max. value of displacement in G+16 Storey Building in soft, medium & Hard Soils.

Table 4. Maximum Displacement Results

Maximum Displacement Results (mm)		
Soft Soil		
Beam Stability Case	**For X Direction**	**For Z Direction**
Case ASI 1A	245.756	170.053
Case ASI 2	245.038	169.809
Case ASI 3	243.46	169.033
Case ASI 4	244.911	169.323
Medium Soil		
Beam Stability Case	**For X Direction**	**For Z Direction**
Case ASI 1B	333.108	225.018
Case ASI 5	325.915	224.687
Case ASI 6	324.987	223.647
Case ASI 7	325.808	224.051
Hard Soil		
Beam Stability Case	**For X Direction**	**For Z Direction**
Case ASI 1C	408.328	238.517
Case ASI 8	407.129	238.145
Case ASI 9	404.497	270.676
Case ASI 10	406.936	271.177

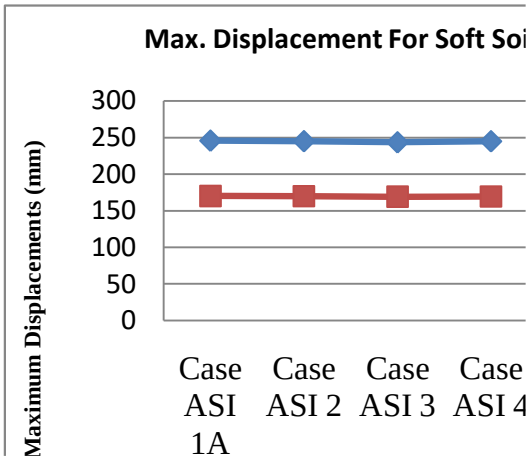


Figure 2: Max. Displacement for Soft Soil

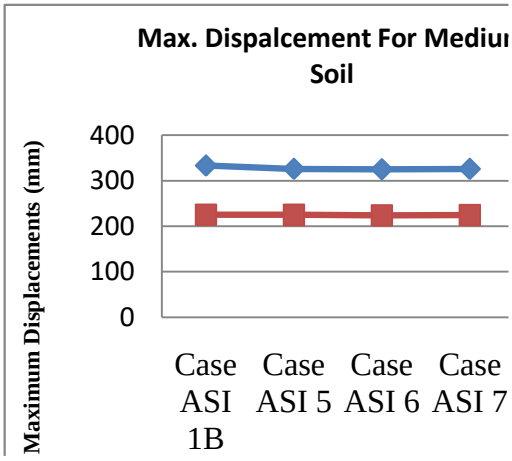


Figure 3: Max. Displacement for Medium Soil

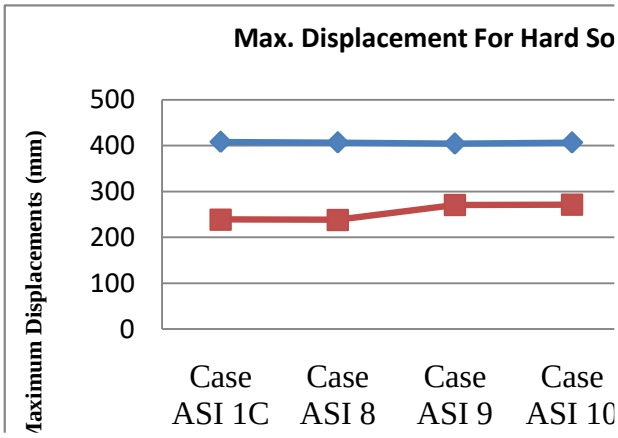


Figure 4: Max. Displacement for Hard Soil

Figure 2 to 4 shows that Graphical Represented for displacement value of structure in soft, medium & hard soil respectively. The maximum value is obtained under soft soil is in model ASI 1A are 245.756mm &170.053mm. The minimum value is obtained under soft soil model in ASI 3 are 243.46 mm & 169.033 mm in both major direction i.e. X&Y Direction respectively. In Medium soil building Max. value in ASI 5 i.e. 325.915mm & 224.687 mm in X & Y direction respectively. The minimum value obtained in the ASI 7 is 325.808mm & 224.051mm. Similarly hard soil obtained max. Displacement in ASI 1B is 408.328 mm &238.517 mm. and the minimal value in ASI 6 404.497 mm &270.676 mm in x & y direction respectively.

Baser Shear*:* Base shear is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity. Table 5 tabulated the obtained base shear under soft, medium & hard soil.

Table 5. Base Shear Results

Base Shear Results (KN)		
Soft Soil		
Beam Stability Case	**For X Direction**	**For Z Direction**
Case ASI 1A	2338.6068	2338.6073
Case ASI 2	2338.6068	2338.6073
Case ASI 3	2338.6068	2338.6073
Case ASI 4	2338.6067	2338.6072
Medium Soil		
Beam Stability Case	**For X Direction**	**For Z Direction**
Case ASI 1B	3180.5052	3180.5058
Case ASI 5	3180.5052	3180.5058

Case ASI 6	3180.5052	3180.5058
Case ASI 7	3180.5051	3180.5057
Hard Soil		
Beam Stability Case	**For X Direction**	**For Z Direction**
Case ASI 1C	3905.4733	3905.4741
Case ASI 8	3905.4733	3905.4741
Case ASI 9	3905.4731	3905.414
Case ASI 10	3905.4734	3905.474

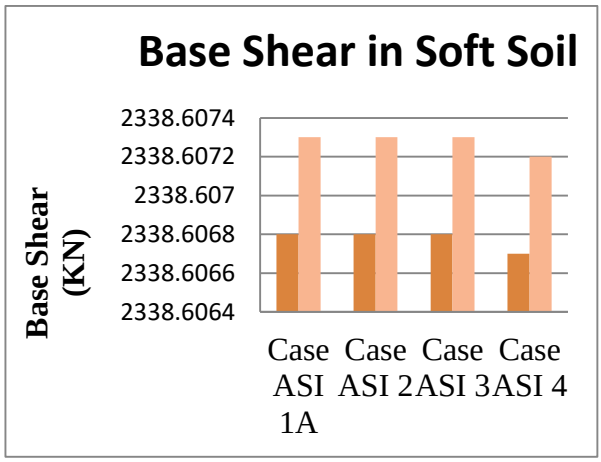


Figure 5: Base shear for soft Soil

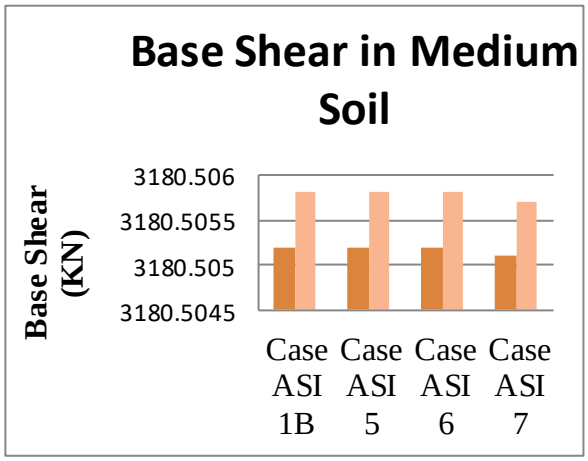


Figure 6: Base shear for Medium Soil

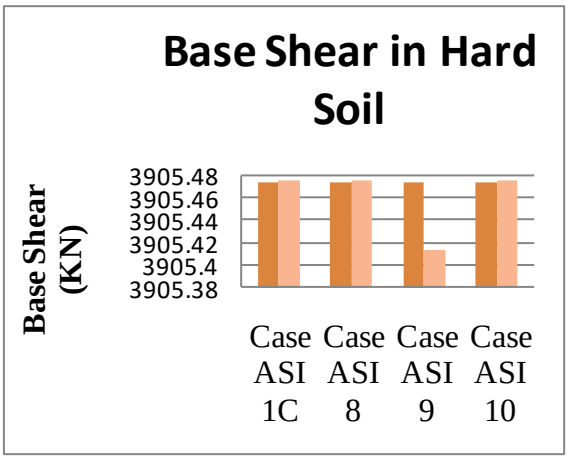


Figure 7: Base shear for Hard Soil

The figure 5 to 7 the bar chart of base shears value which maximum value obtained in the Hard soil all cases. The value is almost similar in all case of hard soil . the minimum value obtained in the soft soil all cases. Means there is no effect occurs due to concrete belt in same type of soil case.

Maximum Axial Forces: If the load on a column is applied through the center of gravity of its cross section, it is called an axial load. Axial force is the compression or tension force acting in a member. The table 6 is shown the result of maximum axial force in the three subcategory division of soil is soft, medium & hard.

Table 6: Maximum Axial Forces Results

Maximum Axial Forces Results (KN)					
Soft Soil		**Medium Soil**		**Hard Soil**	
Beam Stability Case	**Axial Force in column**	**Beam Stability Case**	**Axial Force in column**	**Beam Stability Case**	**Axial Force in column**
Case ASI 1A	7522.5248	**Case ASI 1B**	7602.4352	**Case ASI 1C**	8593.0856
Case ASI 2	7522.6233	**Case ASI 5**	7602.3504	**Case ASI 8**	8588.556
Case ASI 3	7521.697	**Case ASI 6**	7599.7855	**Case ASI 9**	8576.5481
Case ASI 4	7521.2332	**Case ASI 7**	7597.9567	**Case ASI 10**	8579.1484

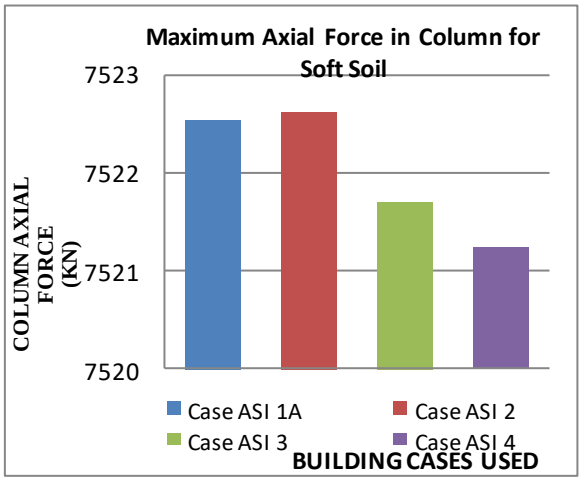


Figure 8: Axial Force in column in soft soil

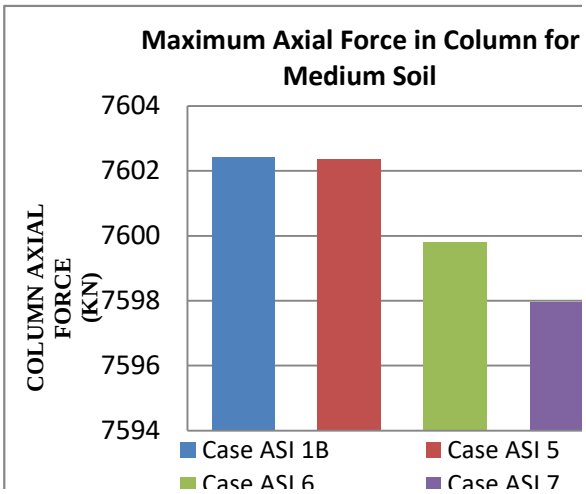


Figure 9: Axial Force in column in medium soil

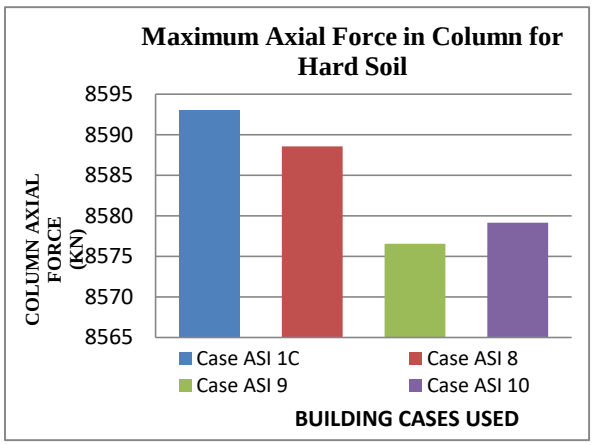


Figure 10: Axial Force in column in Hard soil

Maximum Shear Force in Column: Shearing forces are unaligned forces pushing one part of a body in one specific direction, and another part of the body in the opposite direction. When the forces are aligned into each other, they are called compression forces. Table 7 shown the result of shear force of column in tabulated form.

Table 7: Maximum shear Forces Results

Maximum Shear Force in Column Results (KN)		
Soft Soil		
Beam Stability Case	**Shear along Y Dir.**	**Shear along Z Dir.**
Case ASI 1A	77.7055	81.7365
Case ASI 2	77.7009	81.7353
Case ASI 3	77.4961	81.6722
Case ASI 4	81.4685	82.9122
Medium Soil		
Beam Stability Case	**Shear along Y Dir.**	**Shear along Z Dir.**
Case ASI 1B	93.406	86.4493
Case ASI 5	93.6556	86.4478
Case ASI 6	93.5695	86.3669
Case ASI 7	96.9363	87.8697
Hard Soil		
Beam Stability Case	**Shear along Y Dir.**	**Shear along Z Dir.**
Case ASI 1C	113.6555	90.5126
Case ASI 8	113.5936	90.5108
Case ASI 9	113.4987	90.415
Case ASI 10	113.6332	92.144

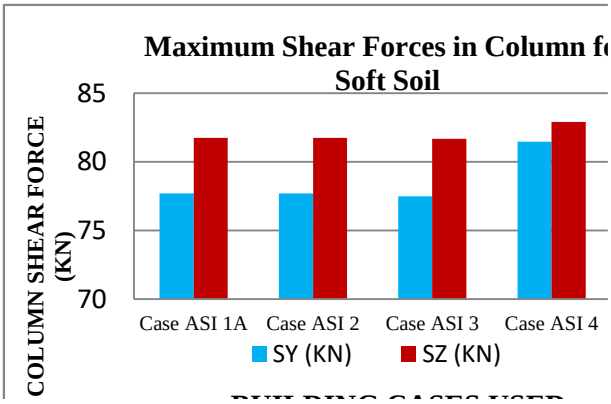


Figure 11: Shear Force in column in soft soil

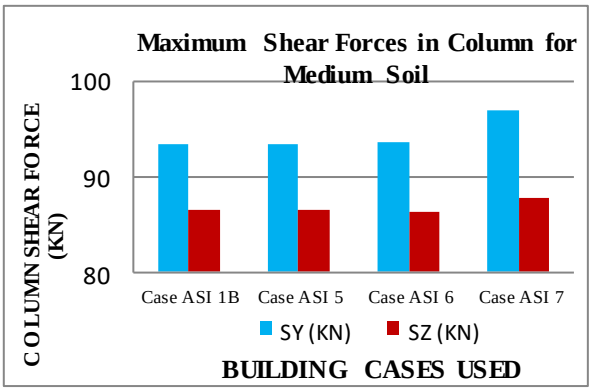


Figure 12: Shear Force in column in medium soil

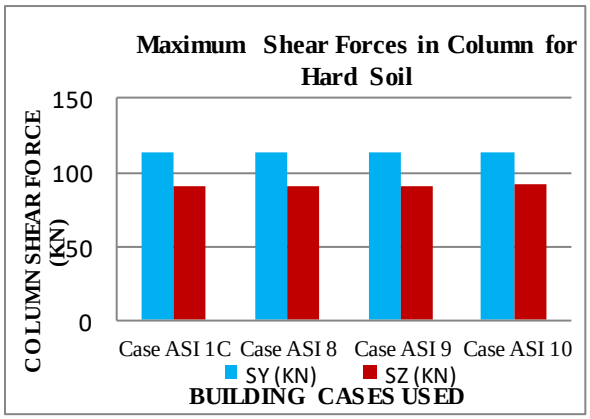


Figure 13: Shear Force in column in hard soil

Fig no 11 to 13 shown the bar indices of the maximum value obtained of shear force in column. The maximum value is gets in the case of Case of hard soil ASI 1B model is 113.6555 KN & 90.5126 KN in X, Y direction respectively. The minimum value obtained in the case of soft soil in the Case ASI 3 77.4961 KN & 81.6722 KN

respectively in x and y direction. In similar soil the value are most near bu to each other there no so much effect in the concrete belt. In all types of soil the concrete m+40 belt show reduction in shear force in the 8 th floor.

Maximum Bending Moment in Column: A bending moment is the reaction induced in a structural element when an external force or moment is applied to the element causing the element to bend. The most common or simplest structural element subjected to bending moments is the beam. The diagram shows a beam which is simply supported at both ends.

Table 8. Maximum Bending Moment Results

Maximum Bending Moment in Column Results (KN.m)		
Soft Soil		
Beam Stability Case	**Moment along Y Dir.**	**Moment along Z Dir.**
Case ASI 1A	128.6673	133.7962
Case ASI 2	126.2219	130.3159
Case ASI 3	128.6256	133.744
Case ASI 4	128.9122	133.7929
Medium Soil		
Beam Stability Case	**Moment along Y Dir.**	**Moment along Z Dir.**
Case ASI 1B	158.5402	176.3657
Case ASI 5	154.928	173.6389
Case ASI 6	158.4681	176.2951
Case ASI 7	158.5282	176.3617
Hard Soil		
Beam Stability Case	**Moment along Y Dir.**	**Moment along Z Dir.**
Case ASI 1C	191.9236	215.6227
Case ASI 8	187.0645	213.1548
Case ASI 9	191.4018	215.527
Case ASI 10	191.4757	215.6185

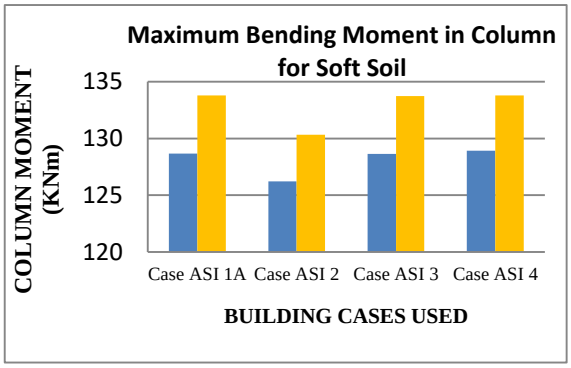


Figure 14: Bending Moment in column in soft soil

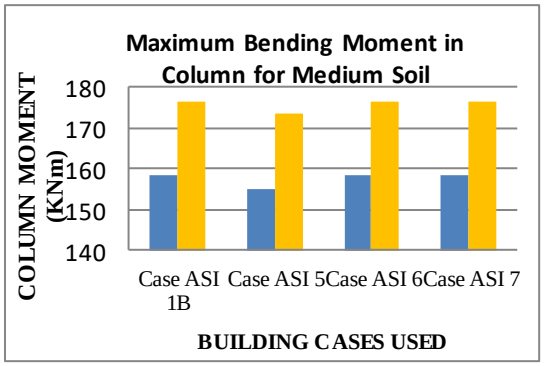


Figure 15: Bending Moment in column in medium soil

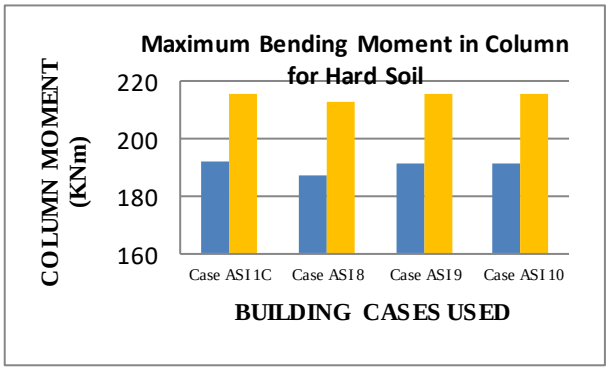


Figure 16: Bending Moment in column in hard soil

Table 8 gives the result of bending moment on column in soft, medium & hard soil. Along with the Bar chart figure 14 to 16 shown the bending moment in the structure. The maximum value is obtained in the Case ASI 1B is 191.9236 KN.m & 215.6227 KN.m in hard soil. The minimum value is gets in the category of soft soil Case ASI 2 is 126.2219 KN.m &130.3159 KN.m.

Maximum Shear Force in Beam*:* Table 9 shows the tabulated results of Maximum Bending Moment in beams and its bar chart is represented by the fig. 17-19.

Table 9: Maximum Shear Force in Beam

Maximum Shear Force in Beam Results (KN)		
Soft Soil		
Beam Stability Case	**Shear along Y Dir.**	**Shear along Z Dir.**
Case ASI 1A	153.8544	0.1019
Case ASI 2	154.277	0.1019
Case ASI 3	153.5395	0.1016
Case ASI 4	154.2806	0.1058
Medium Soil		
Beam Stability Case	**Shear along Y - Dir.**	**Shear along Z-Dir.**
Case ASI 1B	155.0707	0.1279
Case ASI 5	155.6376	0.1279
Case ASI 6	155.0672	0.1274
Case ASI 7	155.4948	0.1332
Hard Soil		
Beam Stability Case	**Shear along Y - Dir.**	**Shear along Z-Dir.**
Case ASI 1C	165.0523	0.1502
Case ASI 8	165.0453	0.1502
Case ASI 9	174.1496	0.1496
Case ASI 10	177.0127	0.1569

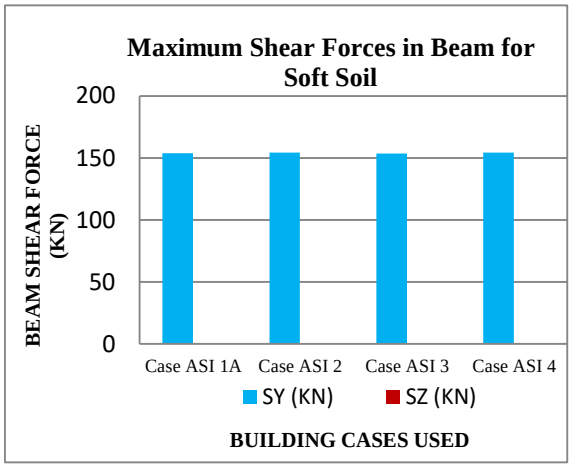


Figure 17: Shear Force in beam for soft soil

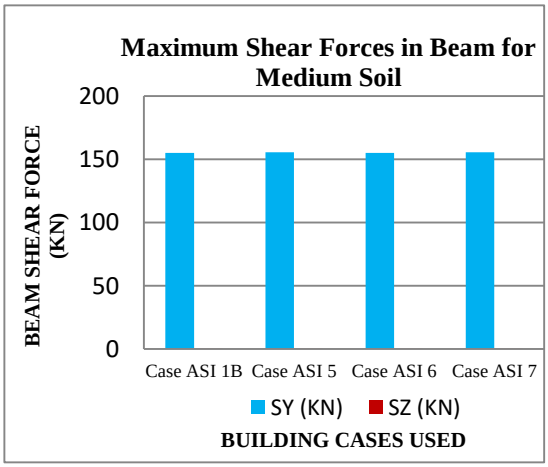


Figure 18: Shear Force in beam for medium soil

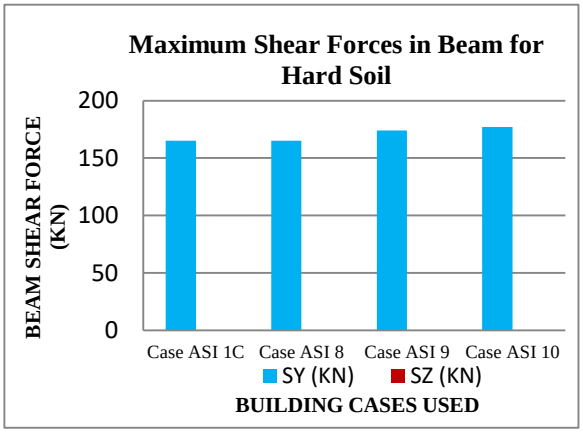


Figure 19: Shear Force in beam for Hard soil

Maximum Bending Moment in Beam:

Table 10: Maximum Bending Moment in beam

Maximum Bending Moment in Beam Results (KN.m)		
Soft Soil		
Beam Stability Case	**Moment along Y- Dir.**	**Moment along Z - Dir.**
Case ASI 1A	0.1829	190.1929
Case ASI 2	0.1829	190.1855
Case ASI 3	0.1822	200.6577
Case ASI 4	0.1893	210.7368
Medium Soil		
Beam Stability Case	**Moment along Y- Dir.**	**Moment along Z - Dir.**
Case ASI 1B	0.2282	213.4461
Case ASI 5	0.2282	213.4357
Case ASI 6	0.2273	228.9225
Case ASI 7	0.2293	234.0277
Hard Soil		
Beam Stability Case	**Moment along Y- Dir.**	**Moment along Z - Dir.**
Case ASI 1C	0.2671	233.6645
Case ASI 8	0.2671	233.6521
Case ASI 9	0.2576	253.2616
Case ASI 10	0.2709	254.0837

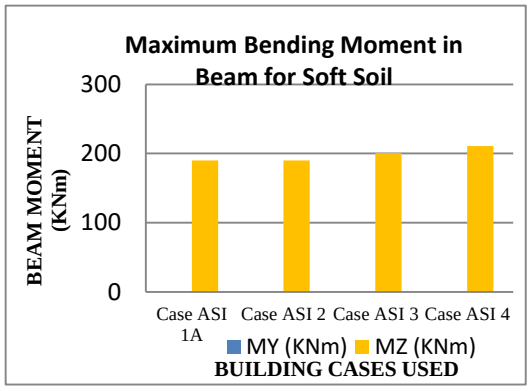


Figure 20: Bending moment in beam for soft soil

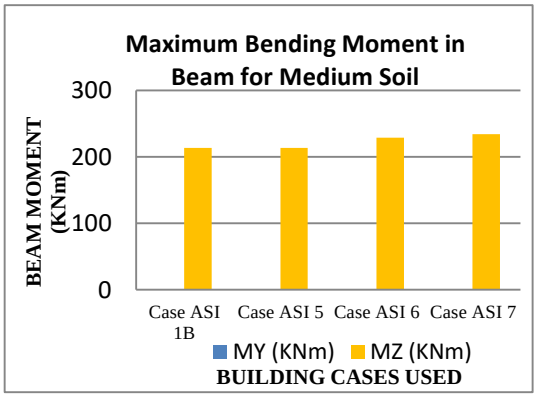


Figure 21: Bending moment in beam for medium soil

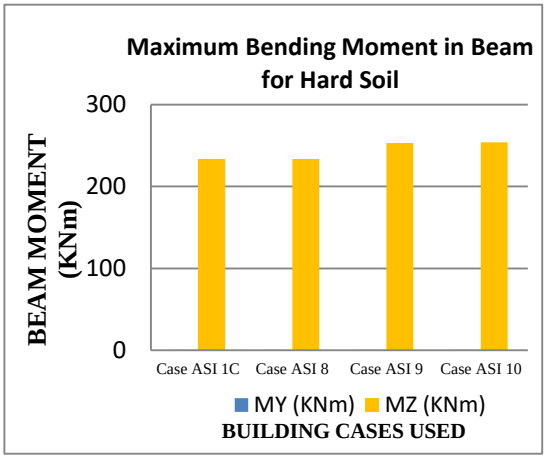


Figure 23: Bending moment in beam for Hard soil

Maximum Torsional Moments in Beam & Column: Torsion, also known as torque, describes a moment that is acting upon an object around the same axis in which the object lies.

Table 11: Torsional Moment in Beam & Column

Maximum Torsional Moment in Beam & Column (KN.m)		
Soft Soil		
Beam Stability Case	**Torsional Moment in Beam**	**Torsional Moment in Column**
Case ASI 1A	7.2581	22.1754
Case ASI 2	7.2301	22.1329
Case ASI 3	7.7	22.1154
Case ASI 4	7.2642	22.1922
Medium Soil		
Beam Stability Case	**Torsional Moment in Beam**	**Torsional Moment in Column**
Case ASI 1B	9.8535	30.1215
Case ASI 5	9.8352	30.0637
Case ASI 6	9.7748	30.039
Case ASI 7	9.8618	30.1443
Hard Soil		
Beam Stability Case	**Torsional Moment in Beam**	**Torsional Moment in Column**
Case ASI 1C	12.0885	36.9639
Case ASI 8	12.066	36.893
Case ASI 9	12.0328	36.8638
Case ASI 10	12.0986	36.9919

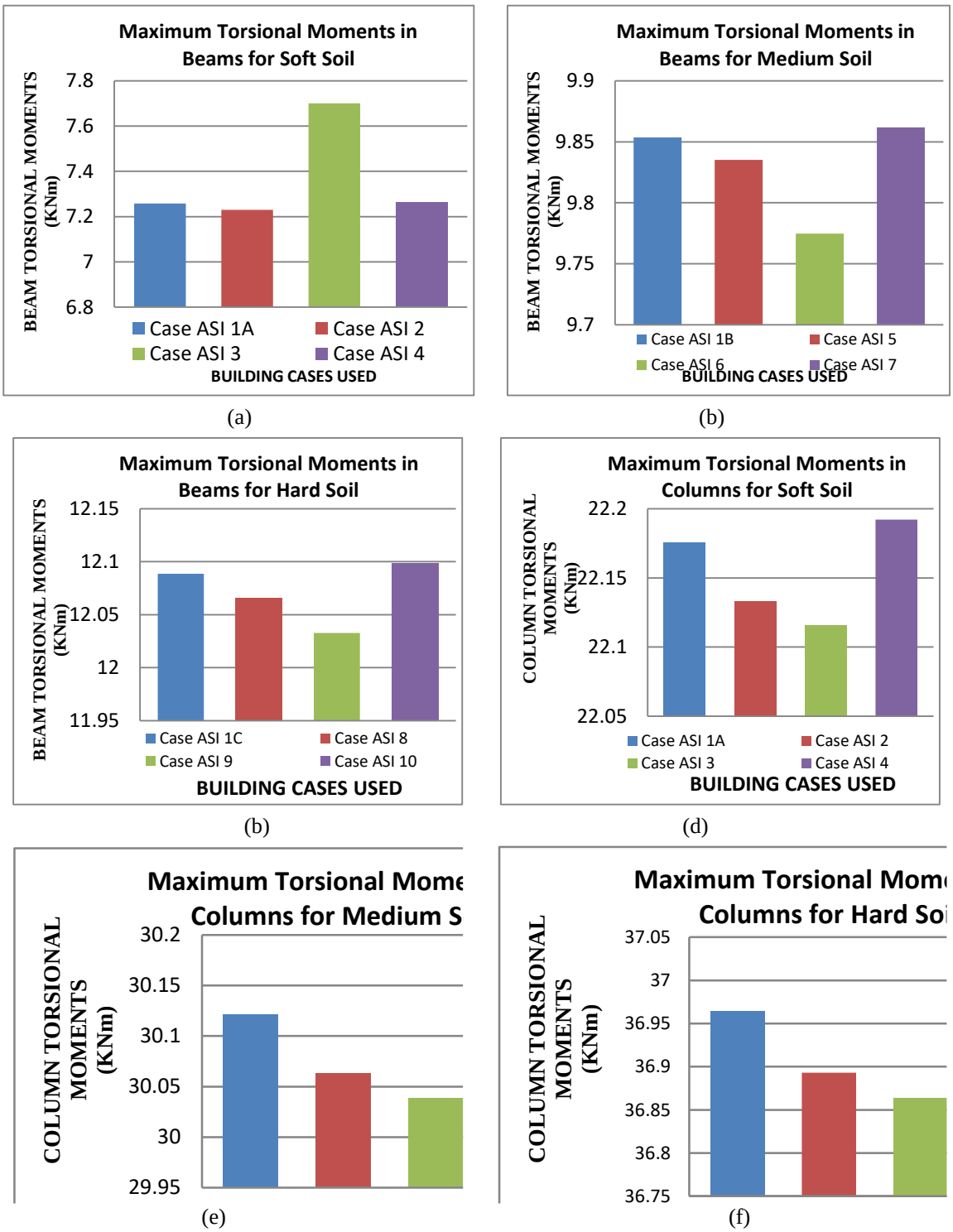
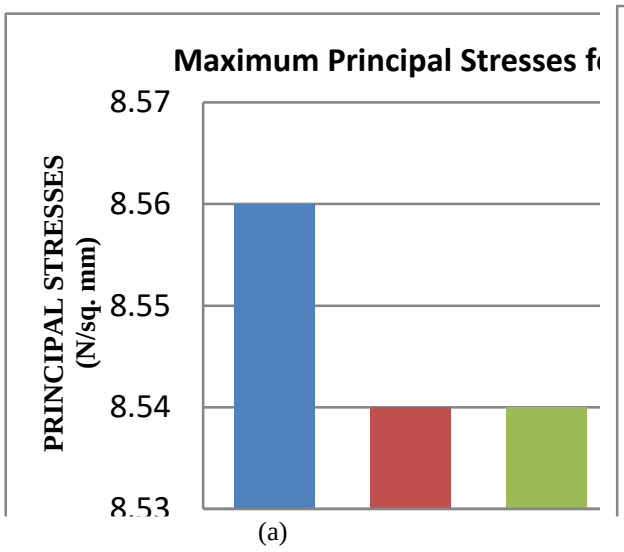


Figure 24: Torsional Moment in Beam(a,b,c) & column(d,e,f)

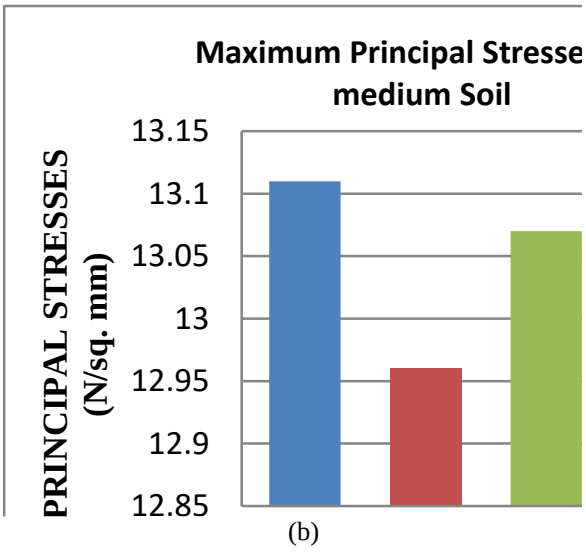
Maximum Stresses developed: Stress is a physical quantity that expresses the internal forces that neighboring particles of a continuous material exert on each other. In this project three types stresses are to be analyzed i.e principal stresses, Von Mises Stresses, Shearing Stresses with their maximum magnitude.

Table 12: Maximum Stresses developed

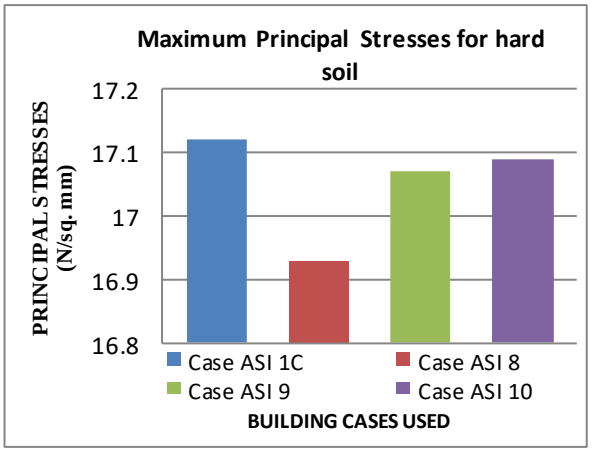
Maximum Stresses developed (N/sq. mm)			
Soft Soil			
Beam Stability Case	**Maximum Principal Stresses (N/sq. mm)**	**Maximum Von Mises Stresses (N/sq. mm)**	**Maximum Shearing Stresses (N/sq. mm)**
Case ASI 1A	8.56	22	2.53
Case ASI 2	8.54	21.99	2.49
Case ASI 3	8.53	21.97	2.53
Case ASI 4	8.54	21.98	2.53
Medium Soil			
Beam Stability Case	**Maximum Principal Stresses (N/sq. mm)**	**Maximum Von Mises Stresses (N/sq. mm)**	**Maximum Shearing Stresses (N/sq. mm)**
Case ASI 1B	13.11	26.32	3.43
Case ASI 5	12.96	26.31	3.37
Case ASI 6	13.07	26.28	3.43
Case ASI 7	13.09	26.29	3.43
Hard Soil			
Beam Stability Case	**Maximum Principal Stresses (N/sq. mm)**	**Maximum Von Mises Stresses (N/sq. mm)**	**Maximum Shearing Stresses (N/sq. mm)**
Case ASI 1C	17.12	30.04	4.21
Case ASI 8	16.93	30.02	4.21
Case ASI 9	17.07	29.99	4.2
Case ASI 10	17.09	30	4.21



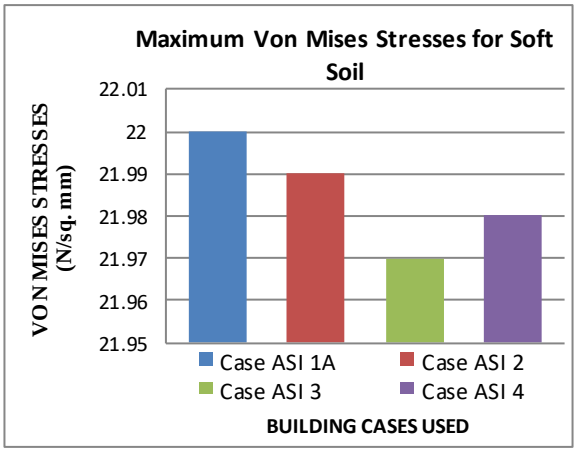
(a)



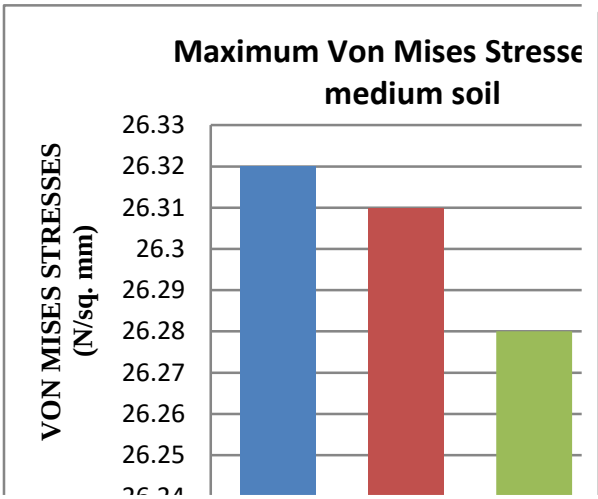
(b)


Maximum Principal Stresses for hard soil
PRINCIPAL STRESSES (N/sq. mm)
17.2
17.1
17
16.9
16.8
Case ASI 1C
Case ASI 8
Case ASI 9
Case ASI 10
BUILDING CASES USED

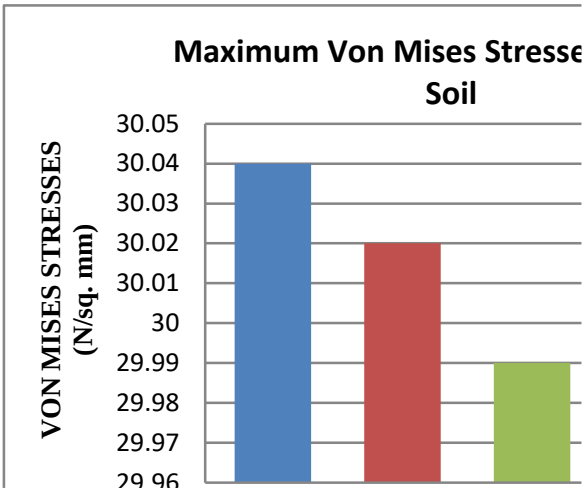
(c)


Maximum Von Mises Stresses for Soft Soil
VON MISES STRESSES (N/sq. mm)
22.01
22
21.99
21.98
21.97
21.96
21.95
Case ASI 1A
Case ASI 2
Case ASI 3
Case ASI 4
BUILDING CASES USED

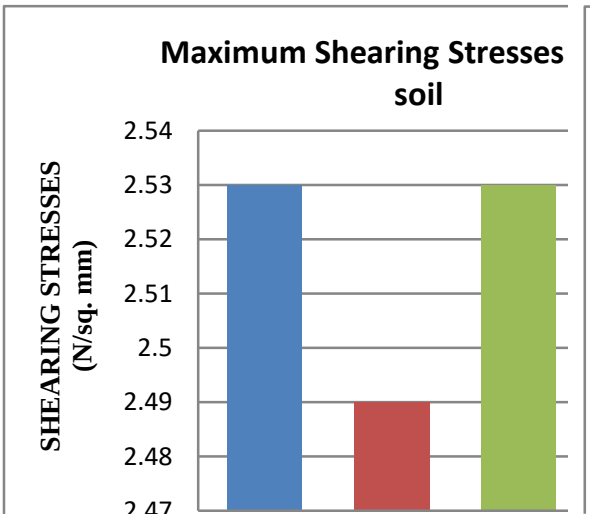
(d)


Maximum Von Mises Stresse medium soil
VON MISES STRESSES (N/sq. mm)
26.33
26.32
26.31
26.3
26.29
26.28
26.27
26.26
26.25

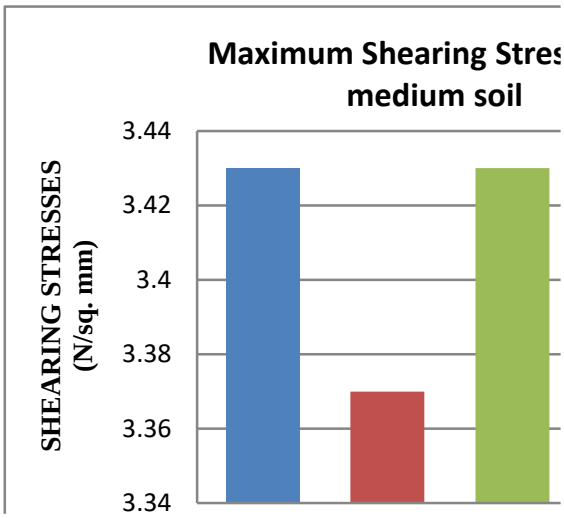
(e)


Maximum Von Mises Stresse Soil
VON MISES STRESSES (N/sq. mm)
30.05
30.04
30.03
30.02
30.01
30
29.99
29.98
29.97

(f)


Maximum Shearing Stresses soil
SHEARING STRESSES (N/sq. mm)
2.54
2.53
2.52
2.51
2.5
2.49
2.48

(g)


Maximum Shearing Stres medium soil
SHEARING STRESSES (N/sq. mm)
3.44
3.42
3.4
3.38
3.36
3.34

(h)

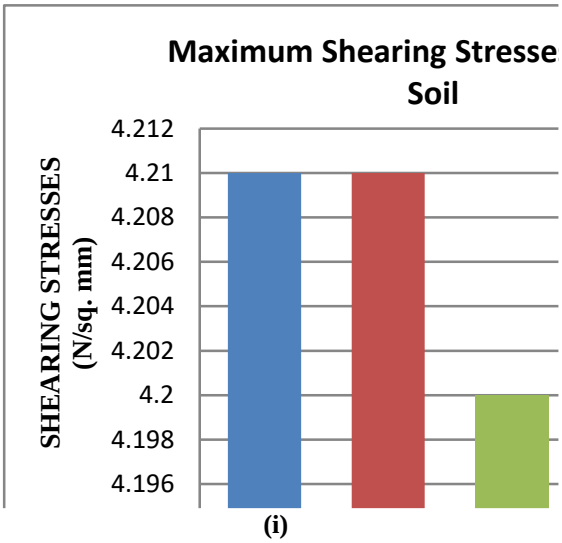


Figure 25: Maximum Stresses developed- Principal Stresses (a,b,c) ,Maximum Von Mises Stresses (d,e,f) Maximum Shearing Stresses (g, h,i)

Conclusions

The following conclusions are obtained based the different results obtained of model ASI 1A to model ASI 7.
The entire conclusion are valid only and only for this project. The conclusions are as follows:

1. The increment in maximum displacement value is 33.76% & 32.31 % in Medium soil, 66.15% & 50.17% in hard soil in X, Y direction respectively with respect to soft soil.
2. The lowest value of displacement gets under the ASI 3 Model and maximum value is obtained in ASI 1B in both directions.
3. The increment in base shear value is 36% & 67% in Medium soil and hard soil respectively with respect to soft soil. There is no effect generated in direction change in base shear.
4. There is slight increment in Maximum Axial Forces in medium soil which is 1.045% and 14.12% in hard soil with reference to soft soil base axial forces.
5. There is a increment Maximum Shear Force in Column 20.10% & 5.81% in medium soil, 44.53% & 10.82% in hard soil in Y, Z direction with reference to soft soil.
6. The increment in Maximum Bending Moment in Column is 23.03% & 32.16% in medium soil, 48.67% & 61.74% in hard soil in Y. Z direction with reference to soft soil
7. Maximum Shear Force in Beam Results is shows the increment of 0.86 % & 25.58% in medium soil, 10.60% & 47.59% in hard soil in Y. Z direction with reference to soft soil.
8. Maximum Bending Moment in Beam Results is shows the increment of 23.83% &12.38% in medium soil, 44.13% & 23.09% in hard soil in Y. Z direction with respect to soft soil.
9. Increment in Maximum Torsional Moment in Beam & Column is 33.52% &35.83% in medium soil and 63.94% & 66.68% in hard soil with respect to soft soil.
10. The value obtained of Principal**,** Von Mises ,Shearing Stresses show the huge incremental variation of 52.85%, 19.62% & 35.51% in medium soil and 99.62%,36.51% & 66.96% in hard soil with refrence to soft soil magnitude of stresses
11. All stresses developed in all cases of stability are satisfied the permissible limit of stress as per IS 456: 2000.
12. The Structure Models ASI 3,6,9 (All 8^{th} floor beam M- 40 Grade of Beam) Show the optimum Strucure with All 8^{th} floor beam M- 40 Grade of Beam.
13. The priorty basis structure conctruction is used as M-40 grade concrete belt with 8 th floor, at plinth, all structre with M25 grade of concrete and then at the top floor(18 th floor) in decrement order.
14. If N no. of storey is there than the concrete belt with change in grade is best placed at the position of N/2 Storey.
15. Soft Soil Exhibits less parameteric magnitute value and it goes in increment mode in the medium and hard soil.

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