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Soil Structure Interaction of Plan Irregular RC Structures in Seismic Zone-5

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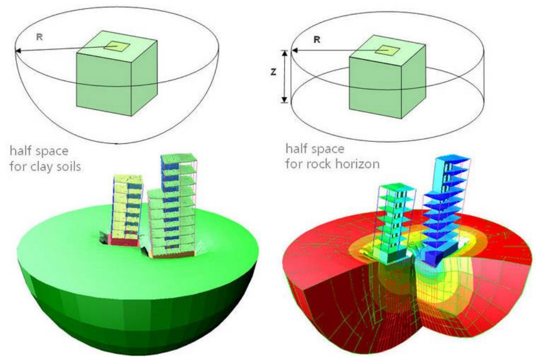
ABSTRACT

In the present study to account the effect of support settlement modulus of sub grade reaction(ks) is considered in modeling of buildings of height G+7 RCC structures having material properties M30 grade for concrete and Fe415 for reinforcing steel and structure dimensions height is 26m from the foundation or footing top, three different support conditions are considered having modulus of sub grade reaction value ks =10,000kN/m^3, ks =20,000kN/m^3, ks =40,000kN/m^3 and fixed base and foundation depth is considered as 2m below the ground level structures are modeled using STAAD.Pro in seismic zone V as per IS 1893-2002 and the plan irregular shapes considered are rectangular, L and T, It is observed that higher the modulus of sub grade reaction value (ks) lesser will be seismic effect on structures.

INTRODUCTION

The process in which the response of the soil influences the motion of the structure and motion structure influences the response of the soil is termed as soil structure interaction. Probably the most widely used value in a soil report is soil bearing capacity. The obvious reason is that basic examples given in most text books almost always use bearing capacity to calculate the plan dimension of a footing. Because of simplicity and ease of use, this method is still the fundamental soil parameter for foundation design.

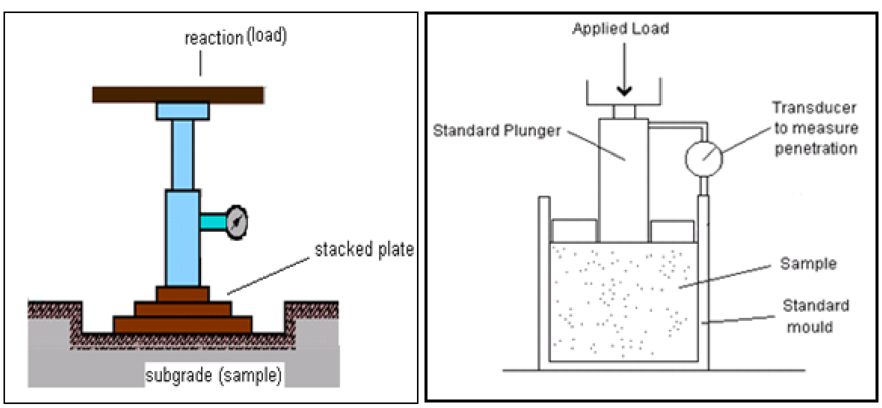


Calculation of Modulus of Sub grade Reaction as per IS 9214-1979

K-value - If the assumption that the reaction of the subgrade is proportional to the deflection is entirely correct, the curve should be straight line and the slope of this line should give the modulus of subgrade reaction measured in MPa/cm ($kgf/cm^2/cm$). The results, however, usually give a curve which is convex upwards and which has no straight portion even initially, value is, therefore, taken as the slope of the line passing through the origin and the point on the curve corresponding to 1.25 mm settlement.

K = 10p/0.125 ($kgf/cm^2/cm$)

Where; p = load intensity corresponding to settlement of plate of 1·25 mm



loads considering in analysis and design

- Dead loads

- Live loads
- Wind loads
- Earthquake loads
- Load combinations as per Indian code IS :875-5

types of irregular buildings

1. vertical irregularity
2. plan irregularity

Vertical irregularities
a. Stiffness Irregularity
b. Mass Irregularity
c. Vertical Geometric Irregularity
d. Discontinuity in capacity - Weak Storey
e. In-Plane Discontinuity

Plan irregularities:
a. Torsion Irregularity:

b. Re-entrant Corners:

c. Diaphragm Discontinuity

d. Out-of-Plane Offsets

e. Non-parallel Systems

LITERATURE SURVEY

K. S. Sai Kumar, Mr. M. K. M. V. Ratnam, Dr. U. Ranga Raju (2016)[3] made A Study on Soil Structural Interaction of MultiStoried Framed Structure with Different Support Conditions The response of a structure to earthquake shaking is affected by interactions between three linked systems: the structure, the foundation, and the soil underlying and surrounding the foundation. The terms Soil-Structure Interaction (SSI) and Soil-Foundation-Structure Interaction (SFSI) are both used to describe this effect in the literature. In this report, the foundation is considered part of the structure, and the term SSI has been adopted. The study is carried out by considering high raised building of about G+19 storied considering all the basic parameters like stiffness factors, base shear, wind forces etc. it is observed that displacements are increased with increase in floor heights.

Sachin Hosamani, R.J.Fernandes(2015)[6] made investigation of soil structure interaction of rc framed irregular building with shear walls in the present study, vertical irregular three dimensional building of varying storey and of plan size 31.5mx31.5m is considered with the beam size 0.25mx0.3m and column size varying from 0.3mx0.3m to 0.6mx0.6m. The buildings of various storey have been considered like 6,9 and 15 storey to compare the analysis results for fixed base and flexible base condition. Fundamental natural period of the flexible building system is more when compared to conventional fixed base. It also increases with the soft soil i.e with flexibility and increase in storeys and decreases with adding of shear walls. Fundamental natural period of shear walls placed at four corners is more compared to that when shear wall placed at the center along with corners. The adding of shear walls which is required for stiffness in lateral direction, increases the stiffness but also increases spectral acceleration coefficient value. Spectral acceleration coefficient is found lower in case of bare frames then that compared to shear wall buildings. It is maximum for shear walls placed at center along with four corners. Storey displacement and storey drifts are maximum in case of bare frame building with or without soil structure interaction.

Bhojegowda V T, Mr. K GSubramanya(2015)[7] studied Soil Structure Interaction of Framed Structure Supported on Different Types of Foundation building models are analysed in ETABS Height of each floor: 3m Plan dimension: 12x9m. Base shear has reduced for flexible foundation in comparison with fixed base analysis since the natural period increases for flexible base condition. There is no much variation in time period for frame model with pile foundation of flexible base in comparison with the fixed base model. Framed structure with pile foundation modelled as flexible base shows no difference in Base shear value in comparison with fixed base analysis. Response of the structure increases with change in soil type from hard to medium and soft irrespective of height of structure and type of foundation. As the height of the structure increases, proportionally the base shear, time period and response also increases. Hence the tall structure supported on soft soil will have more displacement and it needs to be more flexible. Framed structure with Irregular and regular plan did not differ much in its response since the percentage of irregularity is less.

MODELLING & METHODOLOGY

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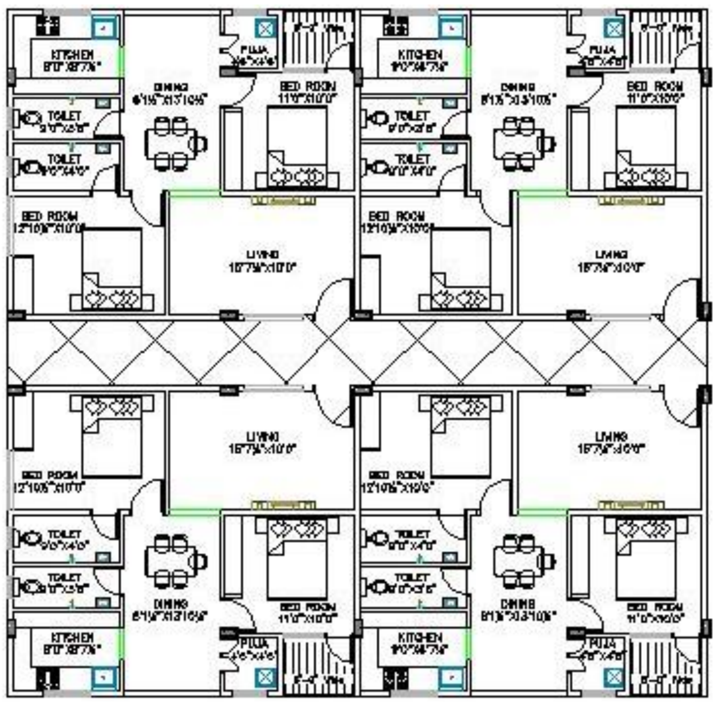

Fig: floor plan of G+7 rectangular building

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Fig: floor plan of G+7 Z shape building

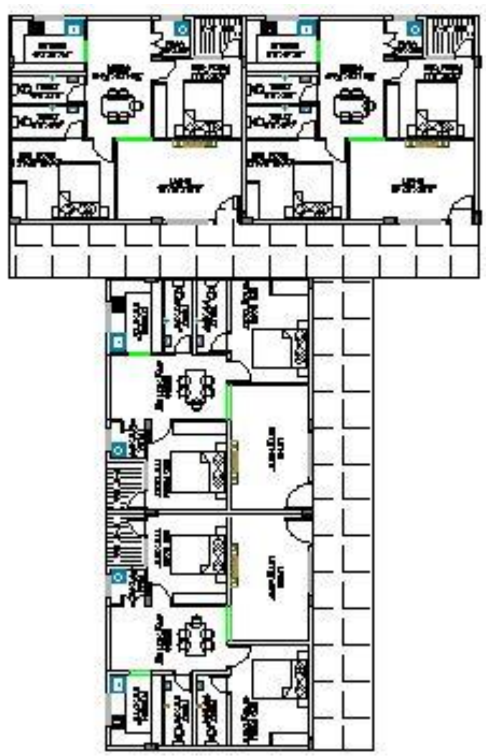

Fig: floor plan of G+7 T shape building

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Table : Design data of structures rectangular, Z and T shape plan irregular

Materials	M30, Fe415
Loadings	Dead, live, earthquake
Heights of building	G+7
Foundation depth	2.0m
Floor to floor height	3.0m
Zones	5
Software	STAAD.Pro
columns	230x450
Beam size	230x500
Geometry of Building	Rectangular, T, Z
Ks(modulus of subgrade reaction)	Fixed, 10,000,20,000, 40,000

.

Table : lateral displacement of rectangular shape structure with different supports in mm

HEIGHT m	FIXED	Ks = 10,000kN/m^3	Ks = 20,000 kN/m^3	Ks = 40,000 kN/m^3
26	174.53	252.61	230.86	215.83
23	160.23	233.46	213.61	199.82
20	143.41	210.79	193.16	180.87
17	123.18	184.44	169.12	158.41
14	100.38	155.30	142.37	133.29
11	76.06	124.34	113.90	106.54
8	51.11	92.31	84.51	78.99
5	26.61	59.58	54.56	50.99

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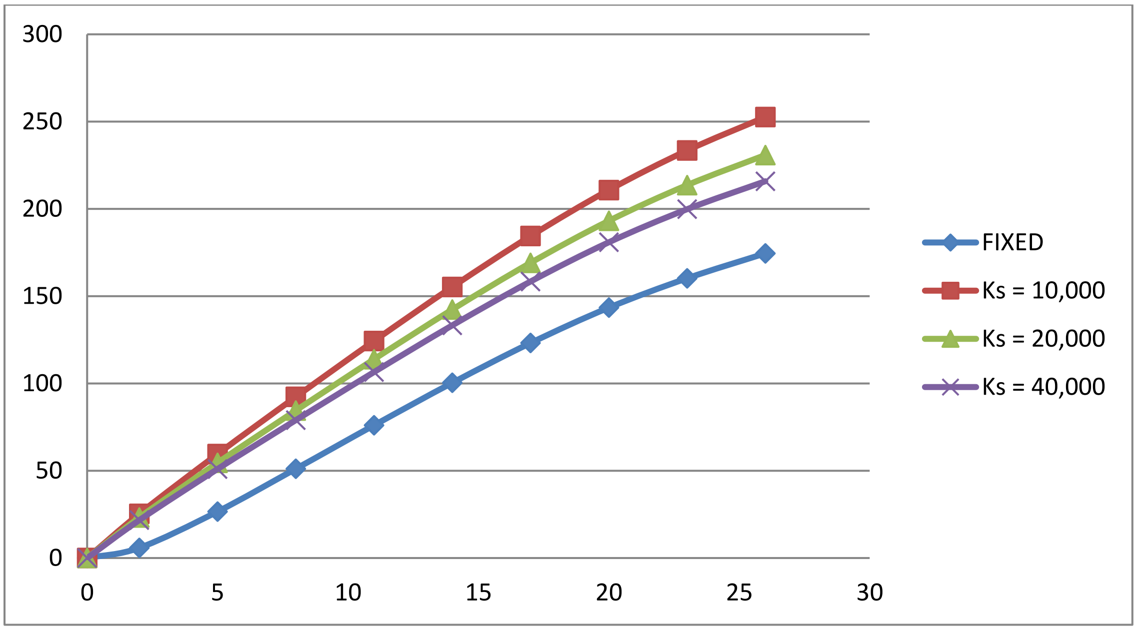
2	5.83	25.34	23.22	21.71
0	0	0	0	0

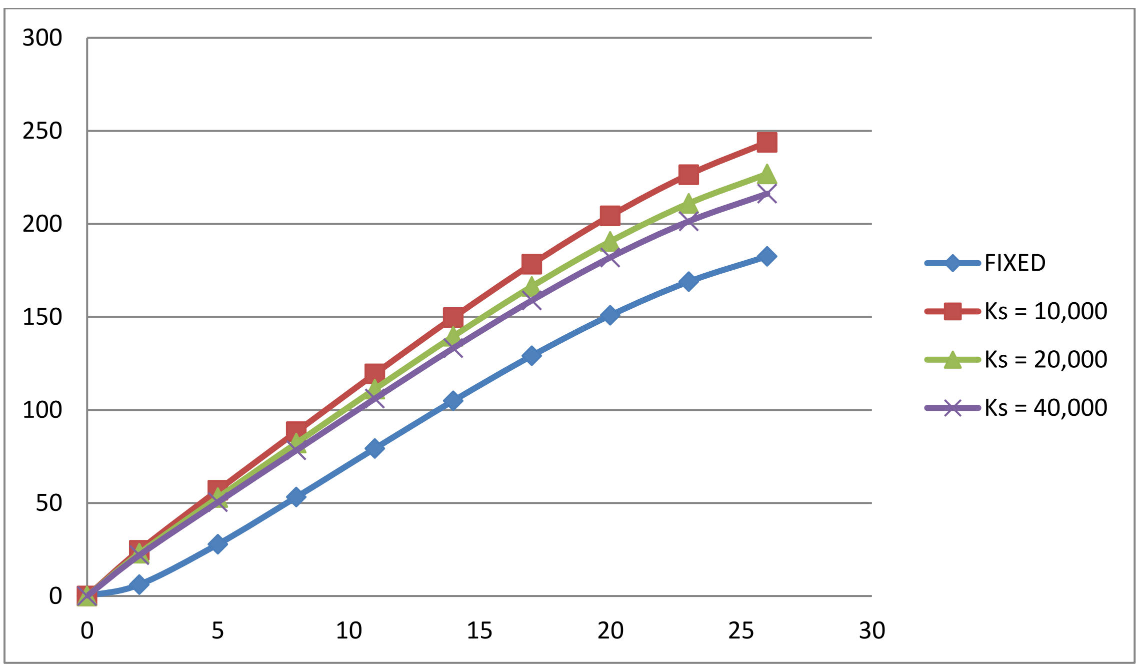


Graph : lateral displacement of rectangular shape structure with different supports in mm

Table : lateral displacement of Z shape structure with different supports in mm

HEIGHT m	FIXED	Ks = 10,000kN/m^3	Ks = 20,000 kN/m^3	Ks = 40,000 kN/m^3
26	182.58	243.87	226.86	216.25
23	168.95	226.49	211.03	201.38
20	150.85	204.35	190.58	181.96
17	129.13	178.37	166.39	158.86
14	104.92	149.71	139.60	133.22

11	79.29	119.41	111.25	106.09
8	53.20	88.29	82.19	78.31
5	27.82	56.84	52.92	50.42
2	6.15	24.58	22.97	21.95
0	0	0	0	0

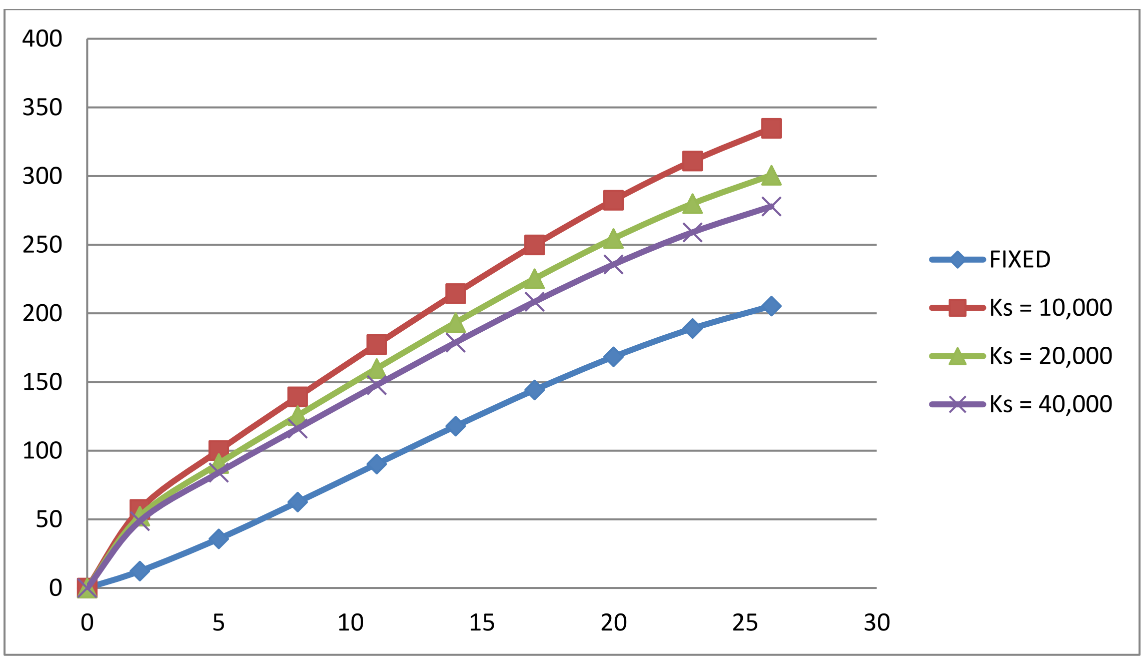


Graph: lateral displacement of Z shape structure with different supports in mm

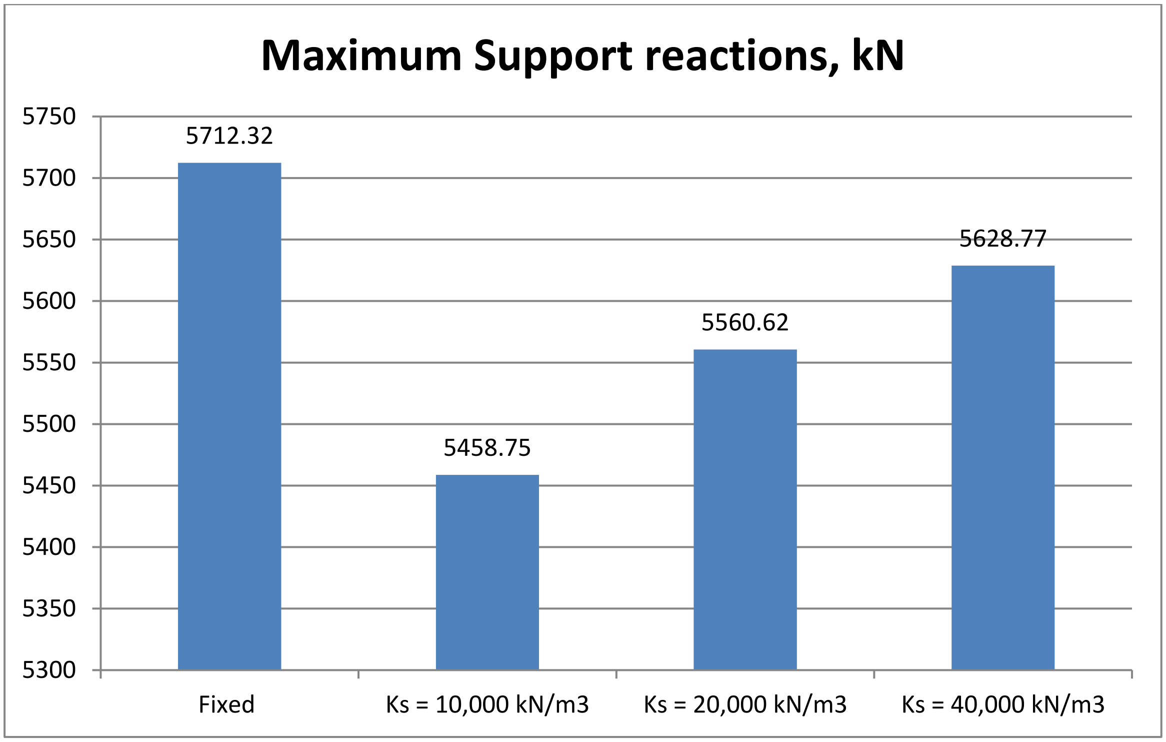
Table : lateral displacement of T shape structure with different supports in mm

HEIGHT m	FIXED	Ks = 10,000 kN/m^3	Ks = 20,000 kN/m^3	Ks = 40,000 kN/m^3
26	205.38	334.78	300.66	277.91
23	188.98	310.98	279.93	259.04

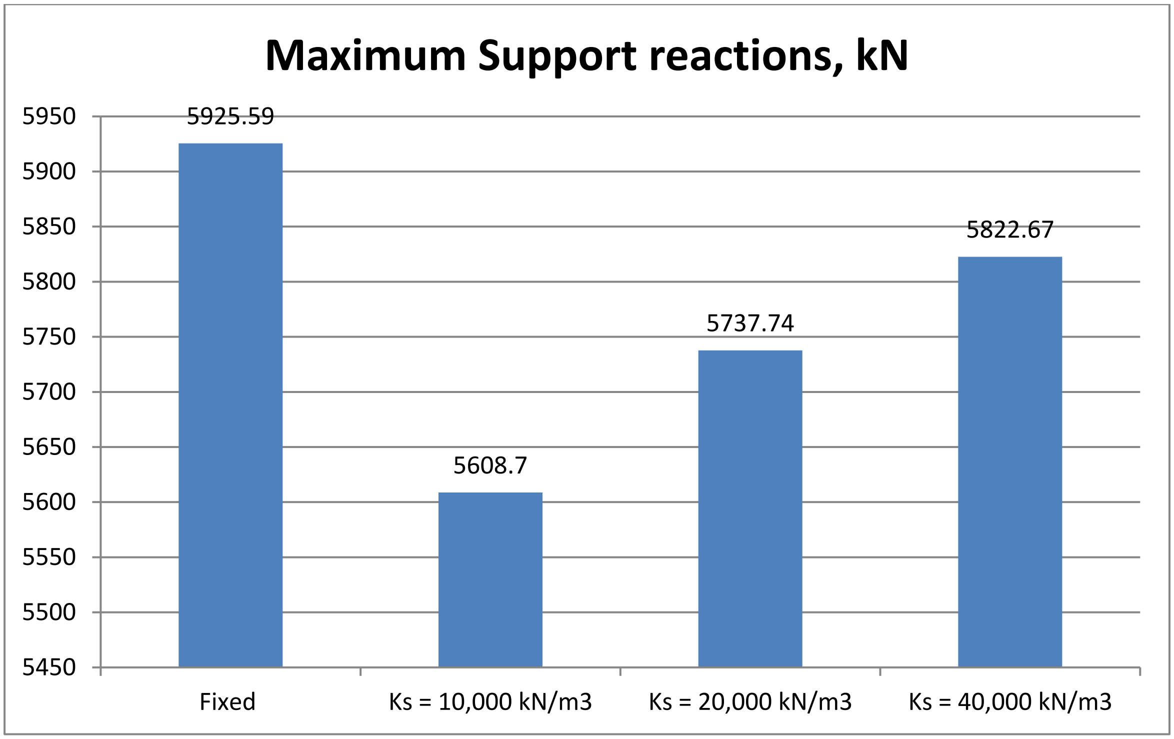
20	168.38	282.42	254.54	235.63
17	144.25	249.85	225.26	208.46
14	117.86	214.48	193.34	178.81
11	90.30	177.34	159.86	147.75
8	62.58	139.20	125.62	116.15
5	35.83	100.10	90.68	84.04
2	12.30	57.27	52.29	48.71
0	0	0	0	0



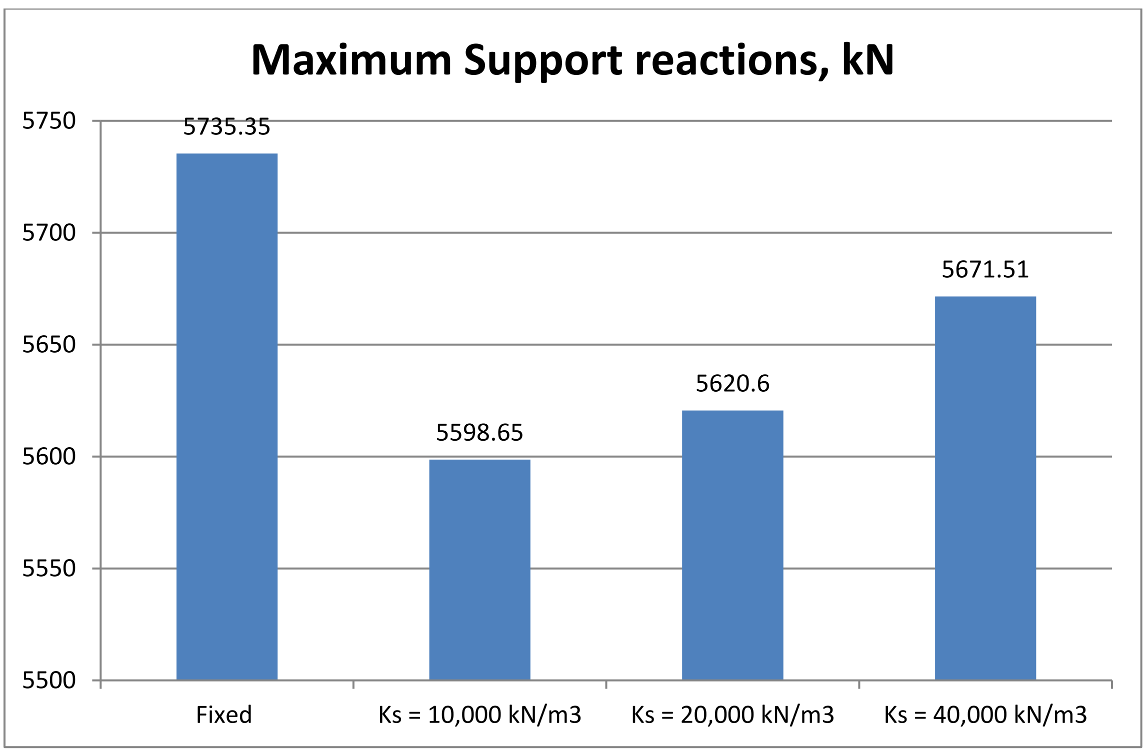
Graph : lateral displacement of T shape structure with different supports in mm



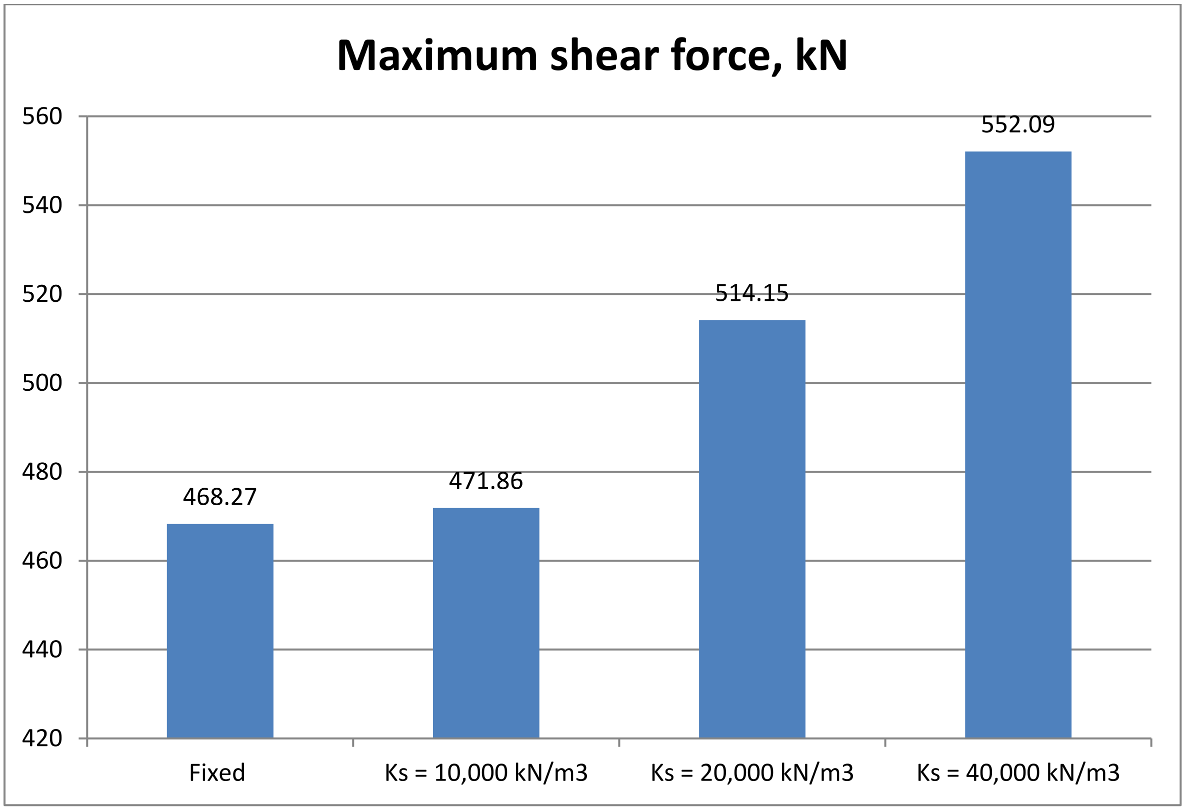
Graph : maximum support reactions for rectangular shape structure



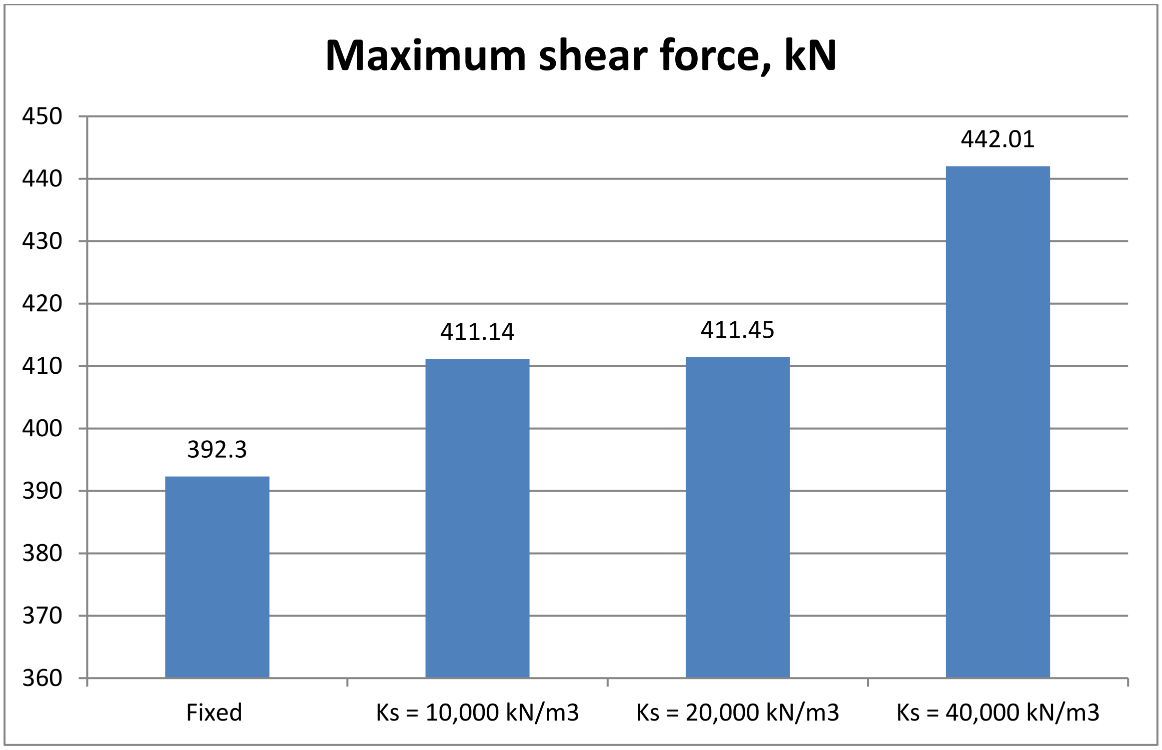
Graph 4.20: maximum support reactions for Z shape structure



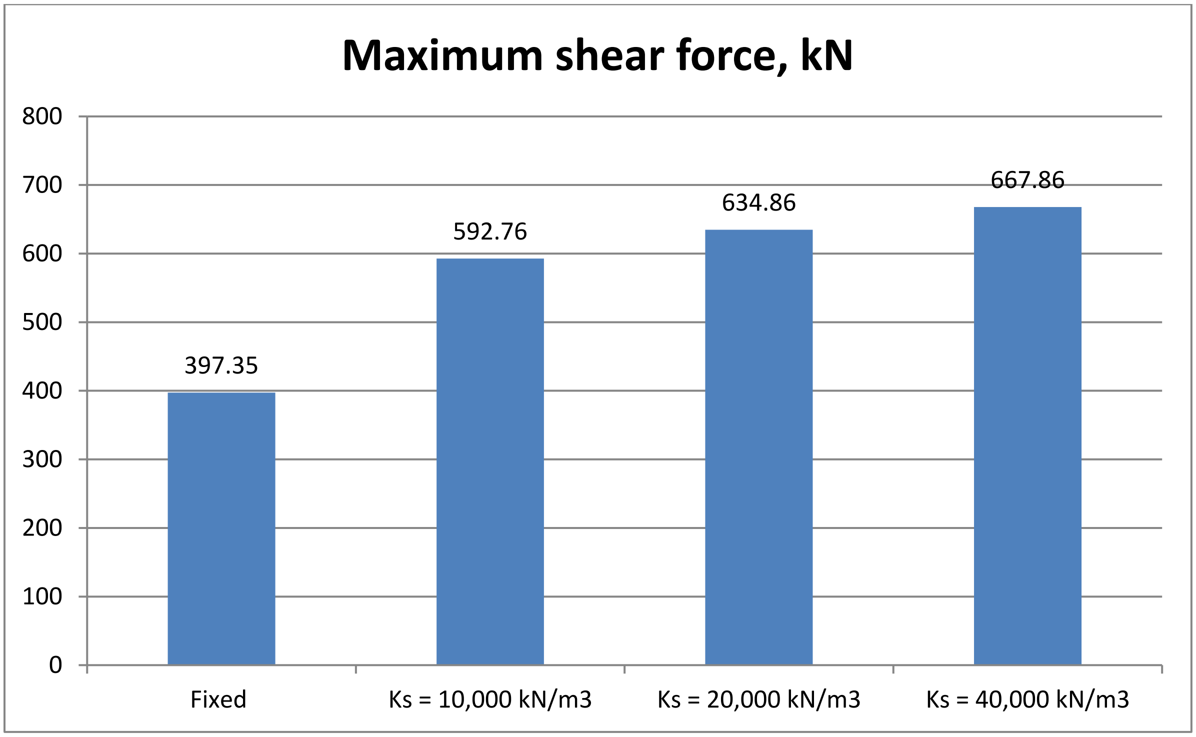
Graph : maximum support reactions for T shape structure



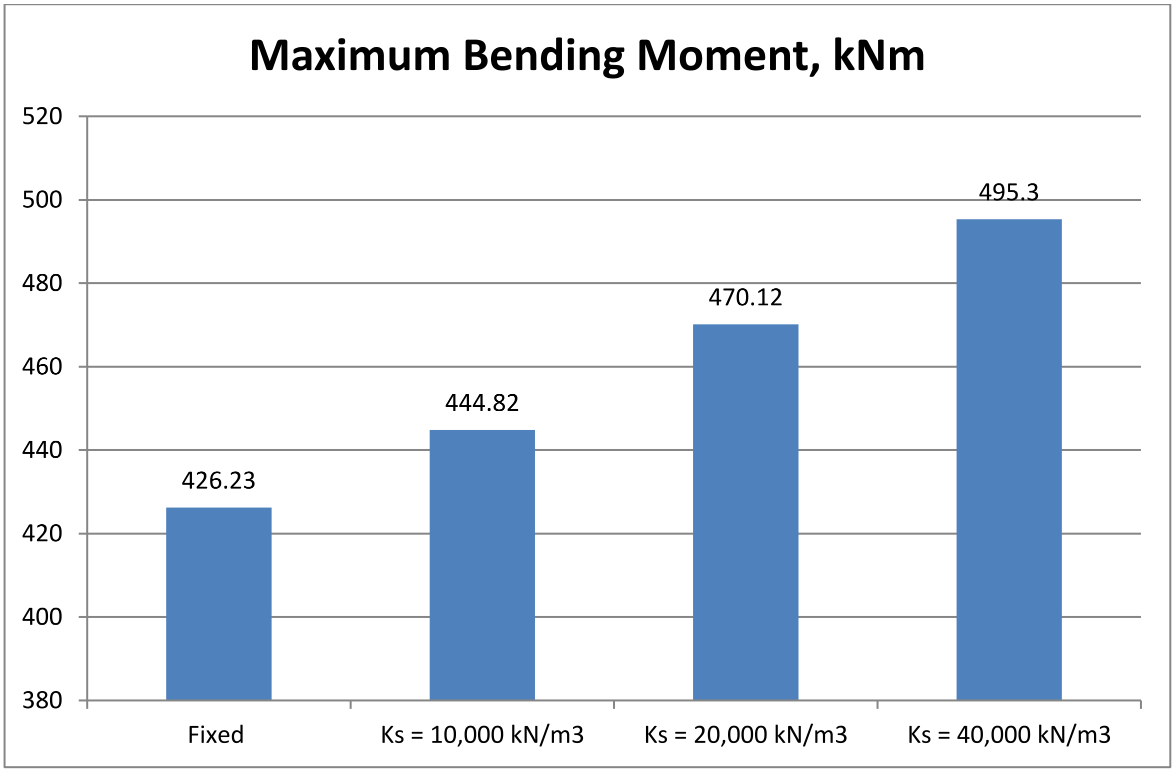
Graph : maximum shear force for rectangular shape structure



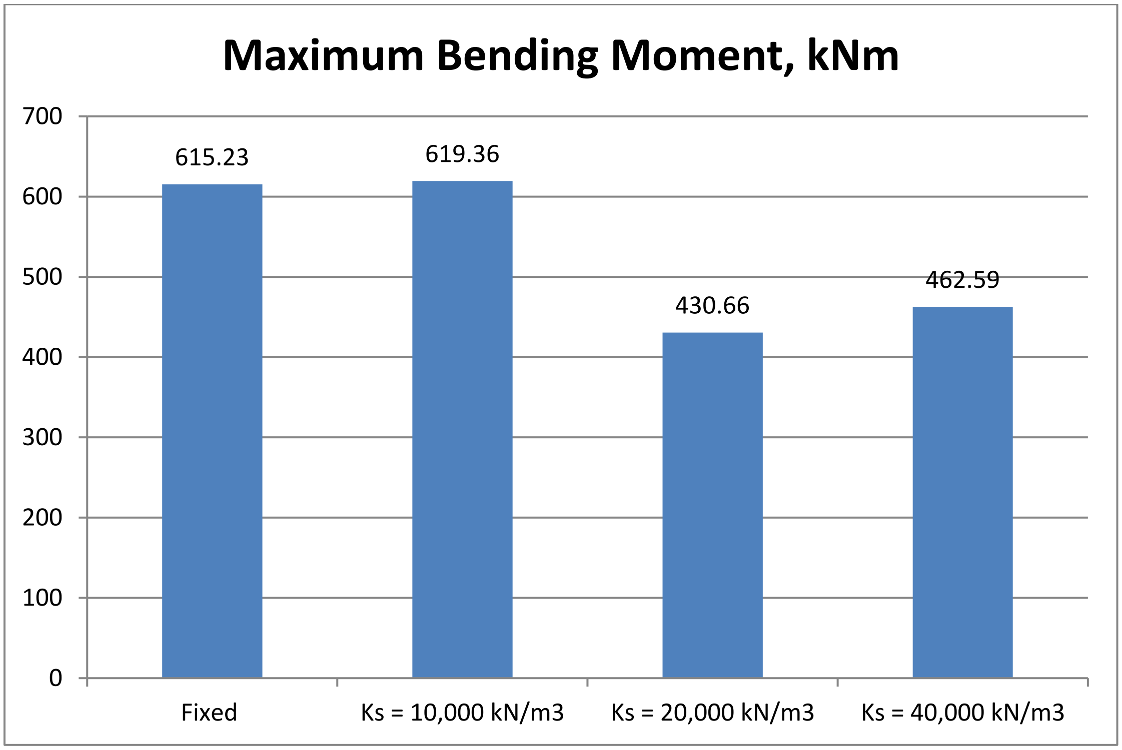
Graph: maximum shear force for Z shape structure



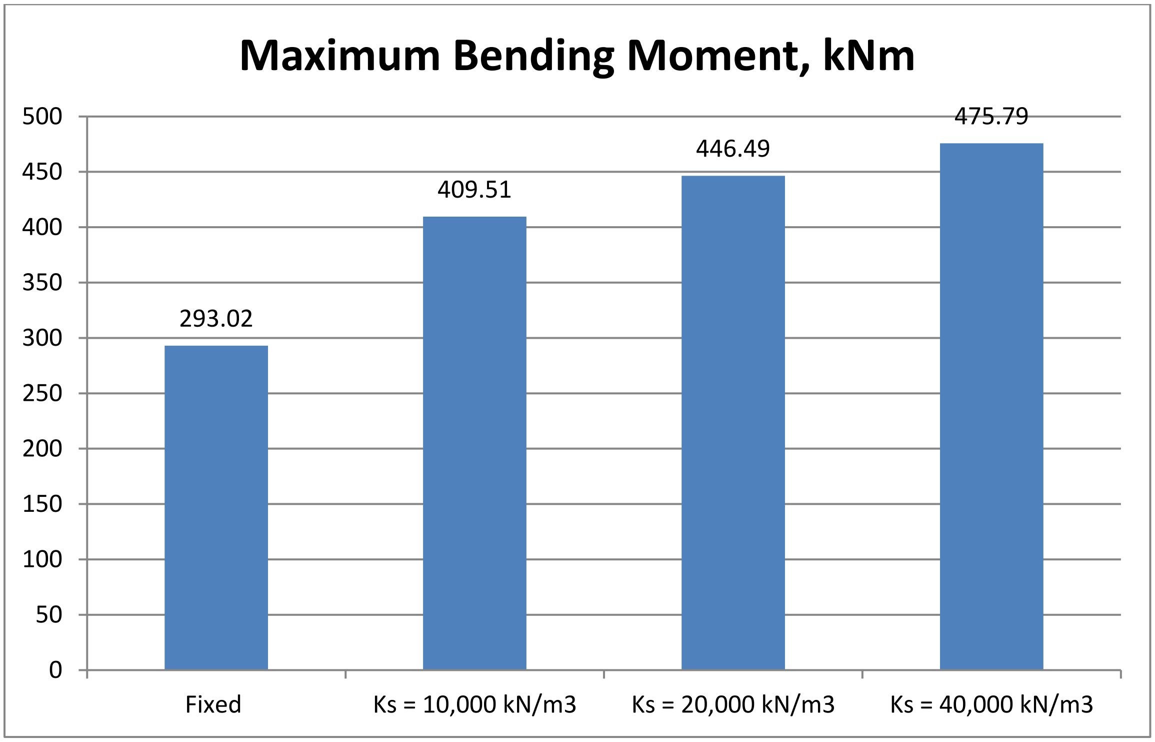
Graph : maximum shear force for T shape structure



Graph : maximum bending moment for rectangle shape structure



Graph : maximum bending moment for Z shape structure



Graph: maximum bending moment for T shape structure

RESULTS AND DISCUSSIONS

1. It is observed that support settlements are decreased with the increase of modulus of sub grade reaction values.
2. T shape plan irregular buildings shown lesser support settlements when compared with Rectangular and Z shape plan irregular structures.
3. The support displacements for T shape irregular structures are decreased by 0.89%, 0.67% and 0.51%, when compared with rectangular section for ks =10,000kN/$m^{3,}$ ks =20,000kN/m^3 and ks =40,000kN/$m^{3.}$
4. The support displacements for Z shape irregular structures are increased by 3.2%, 2.62% and 2.22%, when compared with rectangular section for ks =10,000kN/$m^{3,}$ ks =20,000kN/m^3 and ks =40,000kN/$m^{3.}$

5. The Maximum lateral displacements for T shape irregular structures are increased by 17.67%, 32.52%, 30.23% and 28.76% when compared with rectangular section for fixed, ks =10,000kN/$m^{3,}$ ks =20,000kN/m^3 and ks =40,000kN/$m^{3.}$
6. The Maximum lateral displacements for Z shape irregular structures are decreased by 4.61%, 3.45%, 1.73% and 0.19% when compared with rectangular section for fixed, ks =10,000kN/$m^{3,}$ ks =20,000kN/m^3 and ks =40,000kN/m^3
7. The Maximum support reactions for T shape irregular structures are increased by 0.4%, 2.56%, 1.08% and 0.76% when compared with rectangular section for fixed, ks =10,000kN/$m^{3,}$ ks =20,000kN/m^3 and ks =40,000kN/$m^{3.}$
8. The Maximum support reactions for Z shape irregular structures are increased by 3.73%, 2.67%, 3.18% and 3.44% when compared with rectangular section for fixed, ks =10,000kN/$m^{3,}$ ks =20,000kN/m^3 and ks =40,000kN/$m^{3.}$
9. The Maximum bending moments for T shape irregular structures are decreased by 36.58%, 7.88%, 5.10% and 4.04% when compared with rectangular section for fixed, ks =10,000kN/$m^{3,}$ ks =20,000kN/m^3 and ks =40,000kN/$m^{3.}$
10. The Maximum bending moments for Z shape irregular structures are increased by 33.11%, 39.41%, 8.51% and 6.66% when compared with rectangular section for fixed, ks =10,000kN/$m^{3,}$ ks =20,000kN/m^3 and ks =40,000kN/m^3

CONCLUSIONS

The following are the results drawn from the analysis effect of support settlement modulus of sub grade reaction (ks) is considered in modeling of building of height G+7 RCC structures with plan irregularity as considered such as Rectangular, T, Z support conditions are considered having modulus of sub grade reaction value ks =10,000kN/m^3, ks =20,000kN/m^3, ks =40,000kN/m^3 and fixed base and foundation depth is considered as 2m below the ground level structures are modeled using STAAD.Pro.

1. It is observed that the displacements, bending moments and support reactions are increased with the increase of modulus of sub grade reaction.

2. When compared with rectangular shape structures T shape plan irregular structures showed higher displacements, Support reactions and bending moments.
3. When compared with rectangular shape structures Z shape plan irregular structures showed lesser displacements, support reactions and bending moments.
4. T shape plan irregular structures are more affected when compared with Z shape plan irregular structures.

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