Study on behavior of vertical settlement of two different structures resting on clay soil

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***Abstract*— Foundation is the lowest and supporting member of structure carrying loads from structure to soil influencing the structural design. Soil properties also have great influence on the structure, so as to enhance the elastic behavior the soil is supported by springs known as modulus of subgrade reaction in order to study the elastic settlement behavior; and primary consolidation settlement behavior by varying thickness and liquid limit of the clay layer on which the structure foundation rests. So in this paper, the structure is analyzed to discriminate the vertical settlement i.e., δ_y for two different structures differentiated by long span and short span to study the effect of soil structure interaction under the impact of size of footing on the buildings.**

***Index Terms*—Elastic settlement, Liquid limit, Modulus of subgrade reaction, Primary consolidation.**

I. INTRODUCTION

Foundation is a supporting layer through which the load transfers from structure to the soil. Most of the foundation failures are due to excessive deformation of the soil. The design of a foundation is influenced by the settlement behavior of soils. Settlement is the vertically downward movement of structure due to the compression of underlying soil because of increased load. The estimation of settlement of shallow foundation is an important topic in the design and construction of buildings and other related structures. In general, foundation supported by clay soil undergo two major settlements—elastic settlement and consolidation settlement. In turn, the consolidation settlement of a submerged clay layer has two stages; that is, the contribution of primary consolidation settlement and that due to secondary consolidation. As per IS 1904-1986, a maximum settlement of 75 mm, differential settlement of 0.0015L and angular distortion of 1 in 666 is permitted for clay soil bearing R.C.C structures on isolated footings.

Therefore, effect of load on the structure resting on fixed support under subgrade reaction is studied by considering two geometrically symmetric structures. The structures are differentiated as long span and short span building i.e., column to column spacing of 6m and 3m on both x and y axis with constant plinth area (24m X 24m). The values of subgrade reaction, K_s are increased monolithically i.e., 12000, 24000, 36000, 48000 and 60000KN/m^3 for a footing with provided width and calculated width. The structure is then subjected to gravity loads to obtain results of vertical settlements which are used for the study.

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II. MODELING AND ANALYSIS OF THE STRUCTURES

Two geometrically symmetric buildings, G+2 differentiated as long span and short span (column to column spacing 6m X 6m and 3m X 3m along x and y direction) supported by square isolated footing of depth 2m is analysed using STAAD.Pro V8i for gravity loads which results in vertical settlement, δ_y. The structures have a plinth area of 24m X 24m with a total height of 9m (each story is of 3m). The size of beam, column and footing is considered in such a way that the contact area for both the buildings remains constant and satisfies the design parameters. Two different sizes of footings are provided to the structure, one as per the requirement of the design and another as per the assumed set of modulus of subgrade reaction (12000KN/m^3, 24000KN/m^3, 36000KN/m^3, 48000KN/m^3 and 60000KN/m^3) calculated using Vesic's equation. The clay soil on which the structure rests is assumed to be free from organic matter with soil properties as void ratio 0.8, dispersion angle of the load 1V:1H, liquid limit of 30% and 50% and a varying thickness ranging from 8m to 20m with a uniform increment of 2m. Later for assumed set of properties and ranges maximum values of vertical settlement δy are observed and compared for long span and short span buildings. Graphs are plotted for the comparison carried out and conclusions are made.

III. RESULTS AND DISCUSSIONDS

The study shows two structures of same plinth area but different column to column spacing categorized as long and short span buildings. The vertical settlements are analyzed for different modulus of subgrade reaction values with provided and calculated widths under gravity loads.

The elastic settlement for assumed set of K_s values, primary consolidation calculated observed from the analysis is more in case of long span building than in case of short span building. The elastic settlement in case of provided sizes of footing decreases from 28mm to 11mm for long span building and 25mm to 8mm for short span building as shown in fig1, whereas in case of calculated size of footings the elastic settlement increases from 50mm to 218mm for long span building and 18mm to 71mm for short span building as shown in table 1.

K_s(KN/m^3)	Long span building	Short span building
12000	50.229	17.519
24000	94.478	31.426
36000	135.228	44.296
48000	180.065	58.802
60000	217.757	71.236

Table 1: Elastic settlement in long span and short span buildings for calculated widths

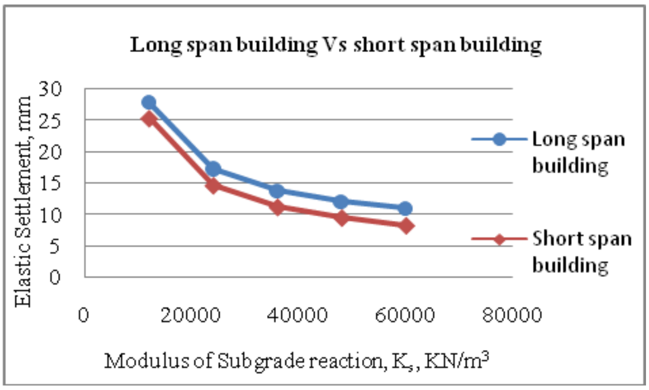

Fig 1: Modulus of subgrade reaction Vs elastic settlement for provided widths

Primary consolidation in case of provided size of footing remains constant as it is independent of modulus of subgrade reaction i.e., 238mm for long span building and 117mm for short span building whereas in case of calculated sizes of footing the settlement increases from 290mm to 425mm for long span building and 103mm to 176mm for short span building as shown in fig 2.

K_s(KN/m^3)	Long span building	Short span building
12000	289.7	103.41
24000	368.89	142.34
36000	399.67	159.48
48000	416.11	169.75
60000	424.9	175.82

Table 2: Primary consolidation in long span and short span building for calculated widths

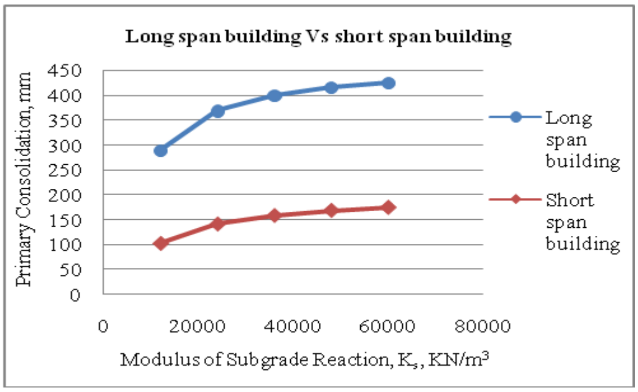

Fig 2: Modulus of subgrade reaction Vs Primary Consolidation for calculated width

The final settlement depends on the properties of the clay layer; the settlement linearly decreases with increase in the thickness of clay layer. This is because as the thickness of the clay layer increases the stresses produced due to the construction decreases on individual particle of the soil which results in reduction of the settlement.

For a increase in thickness of clay layer from 8m to 20m uniformly the value of primary consolidation decreases from 238mm to 116mm for long span building and 117mm to 40mm for short span building in case of provided width as shown in fig 3.

Thickness, H (m)	Long span building	Short span building
8	238.08	116.91
10	216.41	96.13
12	192.41	79.12
14	169.51	65.67
16	149	55.1
18	131.17	46.74
20	115.86	40.07

Table 3: Primary consolidation in long span and short span building for varying thickness and provided width

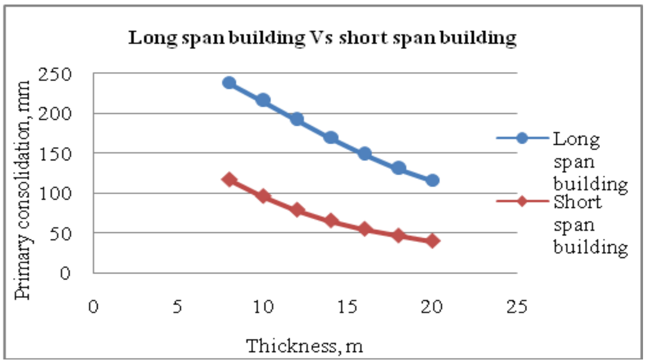

Fig 3: Thickness Vs Primary consolidation for provided widths

For increase in liquid limit of the clay soil from 30% to 50% the primary consolidation settlement in case of provided width i.e., 3m increases from 238mm to 476mm for long span building as shown in table 4.

For increase in liquid limit of the clay soil from 30% to 50% the primary consolidation settlement in case of calculated width increases from 290mm to 580mm for a width of 2.09m, 369mm to 738mm for a width of 1.04m, 400mm to 800mm for a width of 0.7m, 416mm to 832mm for a width of 0.52 and 425mm to 850mm for a width of 0.42mm for long span building as shown in table 4.

For increase in liquid limit of the clay soil from 30% to 50% the primary consolidation settlement in case of provided width i.e., 1.67m increases from 117mm to 234mm for short span building as shown in fig 4.

For increase in liquid limit of the clay soil from 30% to 50% the primary consolidation settlement in case of calculated width increases from 103mm to 207mm for a width of 2.09m, 142mm to 285mm for a width of 1.04m, 160mm to 319mm for a width of 0.7m, 170mm to 340mm for a width of 0.52 and 176mm to 352mm for a width of 0.42mm for short span building as shown in fig 4.

The primary consolidation settlement in case of clay having liquid limit of 50% give twice the settlement values when compared to the clay having liquid limit of 30%. This is because; the soils with 50% have high compressibility when compared to 30%. Therefore, for soils having high compressibility special foundation cases are to be considered rather than isolated footing.

B (m)	ω_l = 30%	ω_l = 50%
3	238.08	476.17
2.09	289.7	579.39
1.04	368.89	737.79
0.7	399.67	799.33
0.52	416.11	832.21
0.42	424.9	849.81

Table 4: Primary consolidation for varying liquid limits for calculated and provided width in case of long span building

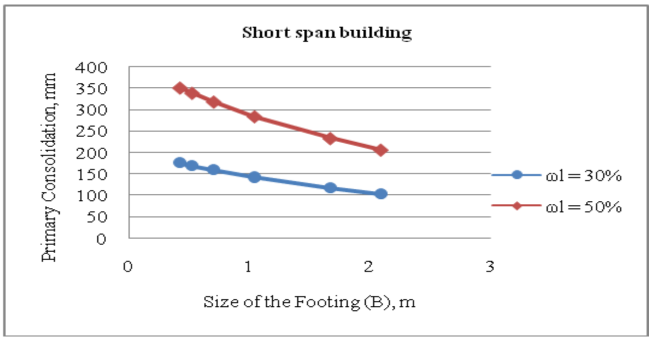

Fig 4: Size of the footing Vs Primary consolidation for varying liquid limits in case of short span building

IV. CONCLUSION

The following conclusions are made after the analysis of the structures:

- The vertical settlements observed from the analysis is more in case of long span building than in case of short span building. There is a need to analyse long span buildings more carefully compared to short span buildings.
- The settlement is more critical at the centre of the structure whereas the primary consolidation settlement is more critical at the medial portion of the structure for both long span and short span buildings.
- For the increase of K_s value from 12000KN/m^3 to 60000KN/m^3, in case of calculated width of the footing the elastic and primary consolidation settlement increases where as in case of provided width of the footing the elastic settlement decreases and primary consolidation remains constant.
- As the size of the footing increases both elastic and consolidation settlement decreases. But the final settlement depends on the properties of the clay layer; the settlement linearly decreases with increase in the thickness of clay layer and increases with the increase in liquid limit.
- The values of the settlement indicate that foundation treatments should be applied to control the settlement in shallow foundations.
- If in case of excessive settlements ground improvement techniques or replacement of shallow foundation by pile foundation should be adopted to reduce the settlement up to permissible limits.

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