"Parametric Study of Different Types of Diaphragm Wall Using Soil –Structure Interaction For Section Optimization"

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Abstract: *Control of soil deformation is crucial for deep excavation in congested urban areas to minimize its effect on adjacent structures. Therefore, an analysis and parametric study is important to realistically represent the response of the soil to excavation and to predict the wall deformation and steel consumption. This paper present a study of the effects of deep excavations with diaphragm wall in loose sandy soil, medium sandy soil and clay soil. The objectives of this study are to investigate the effect of different parameters on the prediction of wall deformation by using staad pro software. Study aims to find an optimal section for a different diaphragm wall considering variations in many of its design parameters to suit the soil conditions and depth of excavation. Extensive review of relevant literature published in the past four decades was conducted in order to understand the trends and the key developments in this area. Parametric studies were carried out to identify important variables controlling the mechanisms of soil-structure interaction. The principal parameters considered in the study include soil type, depth of excavation, wall embedment depth, wall stiffness, and strut spacing. These variables were used to conduct a series of finite element analyses using simplified geometry and ground conditions for the purpose of achieving the objective of this thesis. Results of these analyses were recorded in terms horizontal displacement of the diaphragm wall, steel consumption at the depth of 3m ,8m, 12m at Strutted Diaphragm Wall, Cantilevered Diaphragm Wall , Anchored Diaphragm Wall behind the diaphragm wall, and deflection induced in the diaphragm wall due to an adjacent deep excavation Using Staad Pro Software.*

Keywords: Soil Deformation, Soil-Structure Interaction, Soil Type, Staad Pro, Diaphragm Wall

1. INTRODUCTION

Diaphragm wall is a very a very common type of earth retention system in deep excavation/foundation, weak/poor soil condition or congested site condition. They are generally used in deep basement of building, congested urban spaces, underground structures of metro trains, riverfront structures and marine structures. The stability of diaphragm wall is provided through an embedment of the wall on the ground working as a cantilever structure and a system of anchors. It is generally a reinforced concrete wall which can be used to transfer lateral loads like earth pressure, hydrostatic pressure, etc. Diaphragm wall provide structural support and water tightness. These reinforced concrete diaphragm walls are also called Slurry trench walls due to the construction technique where excavation is made possible by filling and keeping the wall cavity full with bentonite-water mixture during excavation to prevent collapse of vertical excavated surfaces. These are also used as a permanent basement wall. Typical wall thickness varies between 0.6 to 1.1m. The wall is constructed panel by panel in full depth. Panel width varies from 2.5m to about 6m. For the Study is focus on the optimization of design of diaphragm wall system. For that comparison is done for the value of steel Consumption and structural displacements for different wall heights, different soil condition and different types of diaphragm wall the analysis of a diaphragm wall is a classic example of interaction soil structure. The interaction between the soil and the structure depends on the applied load of the soil and the reaction of the structure. Design of diaphragm walls requires experience and understanding of the principles of both soil mechanics and structural engineering. A proper design must allow for the knowledge of the properties of the soil (geologic profile, groundwater, geotechnical parameters) and for the presence of whatever boundary conditions exist: neighboring buildings, facilities and surcharge loads. Objective of the study is to find the optimized section of the diaphragm wall for a particular soil condition and for a particular depth.

2. METHODOLOGY

The analysis of a diaphragm wall is a classic example of interaction soil-structure. The interaction between the soil and the structure depends on the applied load of the soil and the reaction of the structure. Lateral pressure acting behind the sheeting wall is contributed majorly by soil mass and ground water pressure. Their distribution has been recommended by many investigators and verified by field studies, but actual pattern somewhat varies widely with the retaining system adopted and deflection of sheeting occurred. However, for a very rigid wall with a condition that only a little deflection is allowed to occur, the K0 condition may be the most critical state.Underground structures require a quantitative estimate of the lateral pressure on a structural member for the either a design or stability analysis. The lateral earth pressure is of three types at rest, active and passive. The lateral earth pressure acting on the either side of the wall is computed using Rankin's analysis.

a) Parameter consider for Study
Type of diaphragm wall used for study
1- Cantilever Diaphragm wall
2- Anchored Diaphragm wall
3- Strutted Diaphragm Wall

Figure 2..1: Soil type for model

Description	type
Soil 1	Loose Sand
Soil 2	Medium and
Soil 3	Clay

Table 2.2 Depth of wall for the model

Parameters	Unit	Dex1	Dex2	Dex3
Depth of wall.	M	3	8	12

Table 2.3 Soil parameters for base model

Various Representative Soil Parameters		riction Angle	y Unit Wt.	Sat. Wt.
Soil Type		f	gs	g(sat)
Sand	**Loose**	**28-30**	**14-18**	**18-20**
	Medium	31-36	18-20	19-20
Clay		10-15	15-18	18-21

b) Soil in Passive Side
The soil in the passive side is assumed to behave as a series of springs. So the diaphragm wall behaves as a beam resting on elastic foundation. The spring constants of these soils springs can be computed by various methods. Here, IS 2911 method has been considered for the calculation of the soil subgrade modulus and spring constants can be calculated from these subgrade reaction coefficients. The smaller the discrete elements used during the analysis of the wall below the excavation the more refined the analysis will be. So 1m long elements can be considered for the modelling of the wall below the excavation. We must note that IS 2911 Part I Sec. 3 makes the following assumptions. (As given in IS 2911, we will use the symbol *K* for the modulus of subgrade reaction for Wall and k1 for modulus got for a 30 cm square plate.)

a) Modulus of vertical subgrade reaction, Kv : the modulus of subgrade reaction Ks is a function of the contact pressure and allowable settlement on an area of soil it is also known as pressure per unit settlement. Modulus of subgrade reaction taken from Joseph E Bowles' Foundation analysis and design book's table 9-1 Range of modulus of subgrade Reaction Ks

Table 2.4 Vertical Modulus of Subgrade Reaction

Soil	Ks,KN/m3
Loose Sand	4800-16000
Medium Soil	9600-80000
Clayey Soil	12000-24000

b) Modulus of horizontal subgrade reaction, Kh : We assume the following values of K For sands and normally consolidated clays, modulus varies with depth (type 2 soils)
K = (hh)(z/B), p = hh (z/B)
Where,
hh = coefficient of horizontal modulus variation (kN/m3)
z = depth below G.L.
B = width of shaft in metres.
The range of values of hh are given in Tables 13.3 and 13.4.

Table 2.5 Horizontal Modulus of Subgrade Reaction

		hh (MN/m3)
Description of soil Submerged	Dry	submerged
Loose sand	2.5	1.4
Medium sand	7.5	5
Consolidated Clay		0.4

c) Modeling : For analyzing diaphragm wall, modeling has been done for different sections, such as cantilever, anchored and struttrd section in STAAD PRO software. For a particular depth of wall and for different models were made by changing soil condition such as loose sand, medium sand and clay soil.

3) RESULTS AND DISCUSSION

In this section, the details and results of a total 27 parametric studies are presented. The parametric study conducted included a number of alternative arrangements of variables under consideration. Accordingly, the effect of varying a parameter is manifested by obtaining the variation in the following three quantities:

1. Maximum displacement of diaphragm wall
2. Steel consumption

3.1) Effect of change on the type of soil

In this part of analysis, the dissertation concentrates on how change in soil type affects the performance of deep excavations supported by diaphragm wall for each of 3m, 8m and 12m depth of excavation. The output of this analysis is presented for each soil for varying type of diaphragm wall as follows.

Case 1- Wall Height D= 3m

In this section, the effect of change in soil type on the performance of deep excavations supported by different diaphragm wall for 3 m depth of wall is presented

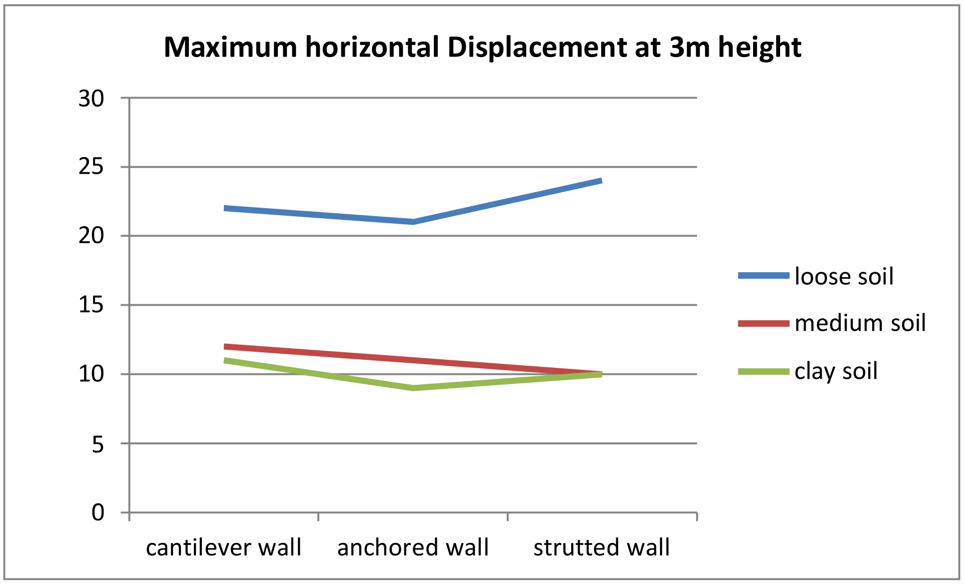

Figure 3.1 Maximum horizontal displacement of the diaphragm wall with different diaphragm wall (Case 1)

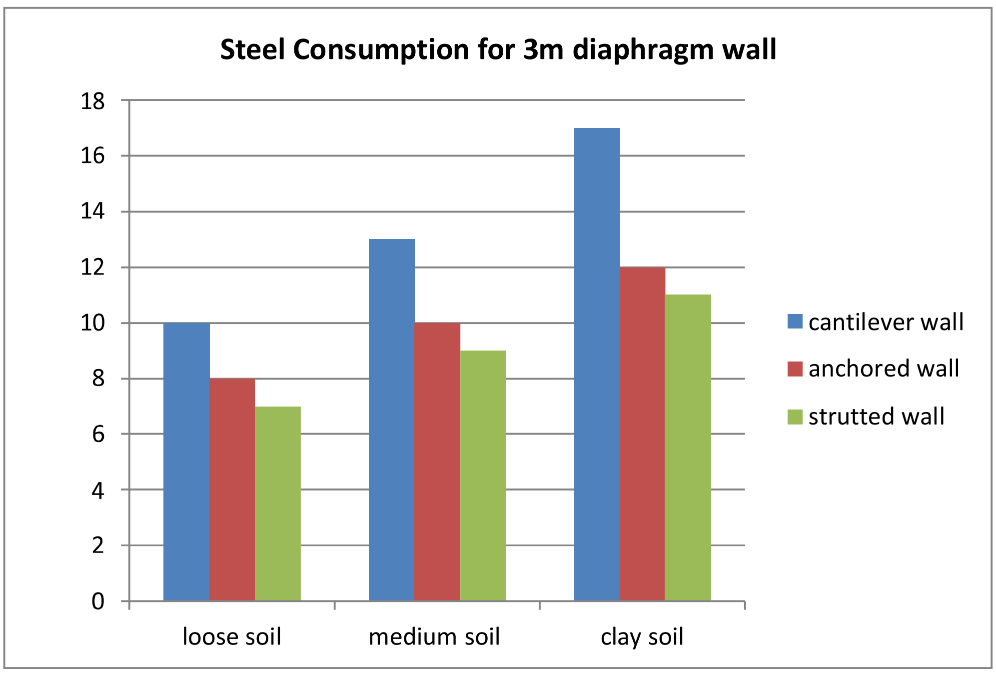

figure 3. 2 Steel Consumption of different diaphragm wall (Case 1)

Case 2- Wall Height D= 8 m

In this section, the effect of change in soil type on the performance of deep excavations supported by different diaphragm wall for 8 m depth of wall is presented

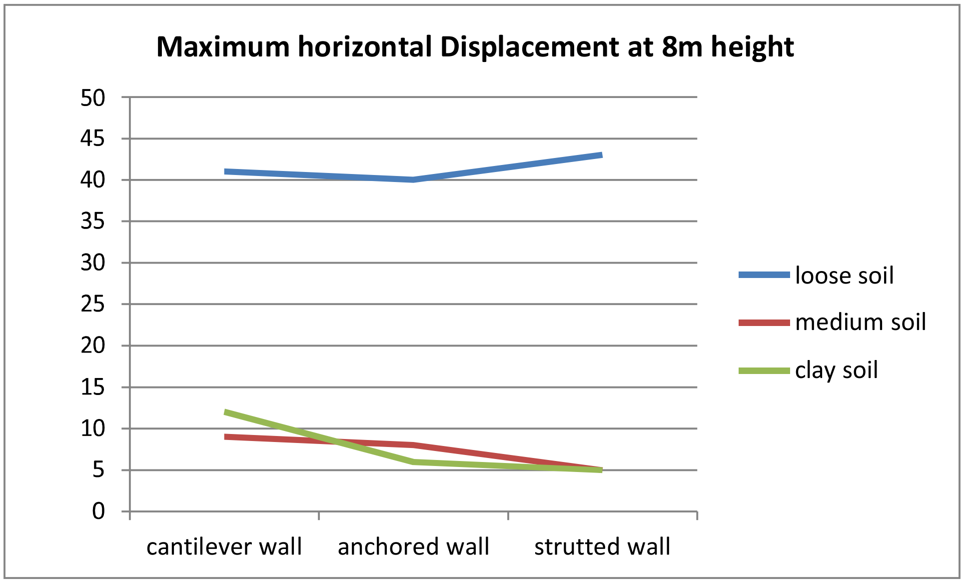

Figure 3.3 Maximum horizontal displacement of th.e diaphragm wall with different diaphragm wall (Case 2)

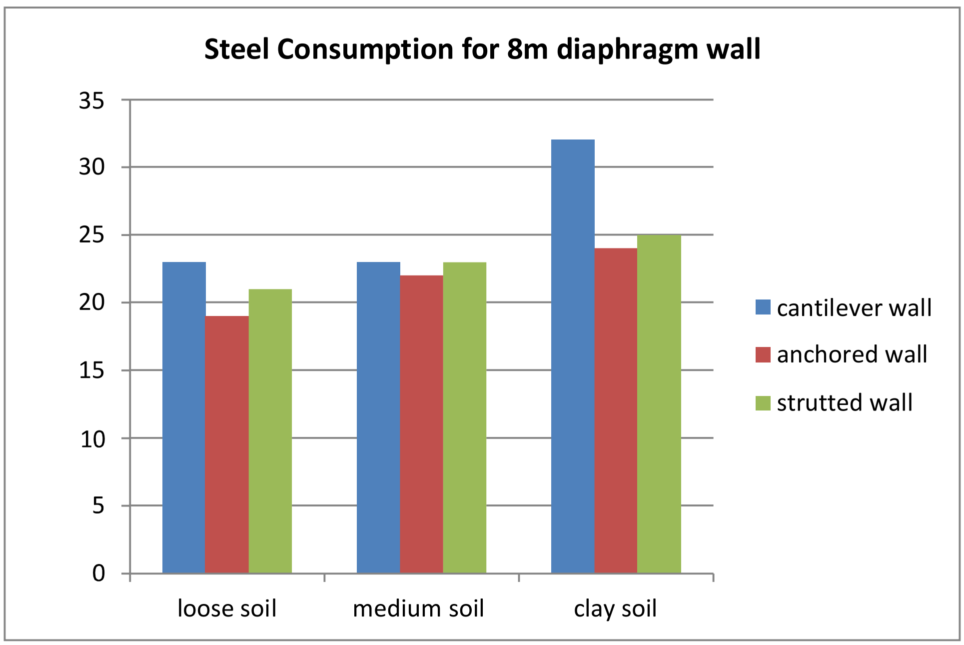

Figure 4. 4 Steel Consumption of different diaphragm wall (Case 2

Case 3- Wall Height D= 12m

In this section, the effect of change in soil type on the performance of deep excavations supported by different diaphragm wall for 12 m depth of wall is presented.

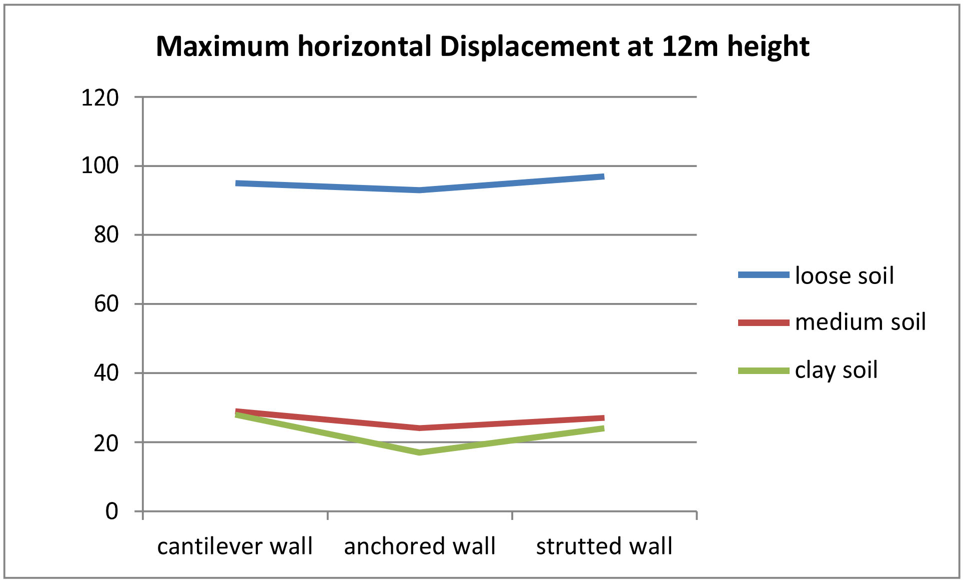

Figure 4.5 Maximum horizontal displacement of the diaphragm wall with different diaphragm wall (Case 3)

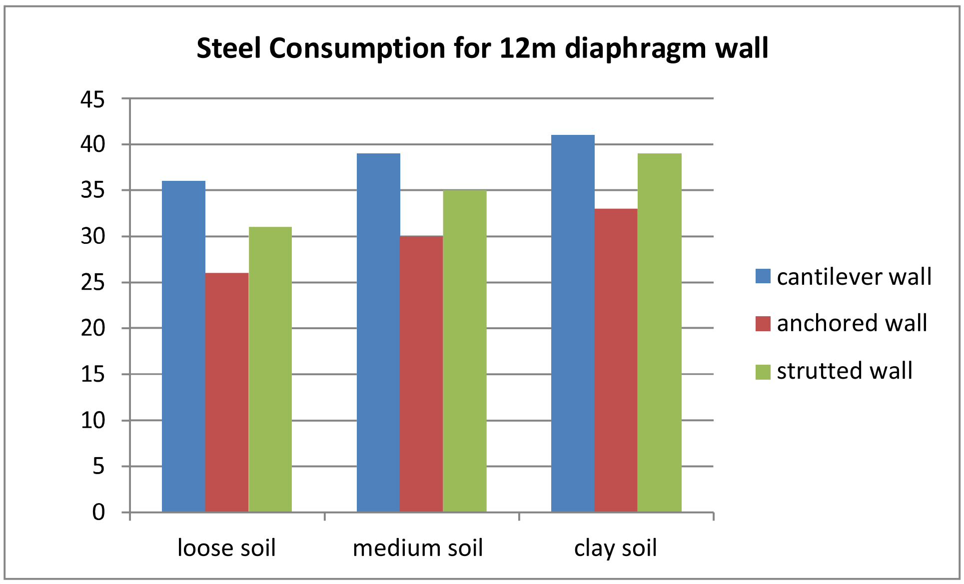

Figure 4. 6 Steel Consumption of different diaphragm wall (Case 3)

3.2 Discussion:

- Maximum horizontal Displacement is little higher in loose soil compare to medium and clay soil. By providing the different type of wall it is found that cantilever wall has maximum horizontal displacement
- At the height of 12m it is found that compare to all the cases of 3m and 8m ,12m wall height has maximum horizontal displacement .
- Maximum Steel Consumption of different diaphragm wall It is found that cantilever wall has little higher consumption of steel compare to the other wall and at the height of 12m steel consumption is maximum for different type of wall.

4) CONCLUSION

Based on the study, the following conclusions are made

1) From the Literature review carried out by stages study of design parameters, effects on adjacent buildings, effects of earth and water pressure, seismic effects and study of Indian standards. Through the study of design parameter study we can understand the suitable parameters, optimum dimensions, grade of concrete, soil conditions and position of anchor rod which can be used for the design.

2) Also these study deals with the effective bending moment displacement and shear force. There is particular amount of settlement when the load are exposed near to diaphragm wall. Water pressure and earth pressure have great importance in diaphragm wall design.

3) Stability of structure based on these factors, Diaphragm walls are considered as deep ground structures, hence it should exposed to seismic effect. From the study of Indian standards, there are some uncertainties in the field of analysis.

4) Maximum horizontal Displacement is little higher in loose soil compare to medium and clay soil. By providing the different type of wall it is found that cantilever wall has maximum horizontal displacement.

5) At the height of 12m it is found that compare to all the cases of 3m and 8m ,12m wall height has maximum horizontal displacement .

6) Maximum Steel Consumption of different diaphragm wall It is found that cantilever wall has little higher consumption of steel compare to the other wall and at the height of 12m stell consumption is maximum for different type of wall.

5) REFERENCE

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