Unit Less Ratio on Design of Diaphragm Wall with near Surcharge Loading

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Abstract: *Establishing of limit states is very important on design of embedded retaining wall. There are Ultimate limit State and Serviceability limit state. In Ultimate limit state, shear strength parameters and soil stiffness are applied with reduction factor to cause safety of people and the safety of the structure. Moreover, the purpose of design calculation- is to ensure: Acceptable deformation and performance at the serviceability limit state. In this paper, design of diaphragm wall (distance from wall to surcharge is 0 to 1.2 m.) is solved using soil structure interaction analysis. Consider with natural soil condition and increasing of shear strength parameter with relative stiffness of natural soil to get dredged level reaches stiff soil condition. Then wall depth becomes more safe and economical condition. Natural soil is mostly cohesive soil. There are medium (low), stiff, medium, hard soil layers. Water level is average 2 m below the ground surface. BM and SF are described with unit less ratio. Moreover ground movements are described with relative depth ratio vs moduli of elasticity ratio.*

Key Words: *shear strength parameter, wall depth, deep excavation, horizontal and vertical movement, wall deflection, soil conditions.*

1. INTRODUCTION:

In this paper is emphasized on diaphragm wall. It is possible to make economies in embedded retaining walls by selecting an appropriate wall type and support system for the future possibility construction sequence and long –term use. Objectives of this paper are to find behavior of diaphragm wall based on influence of shear strength parameter with relative soil stiffness on design of diaphragm walls and to find unit less ratio on design of diaphragm wall for future application. Scopes of the this paper are (a)Sites are located in urban setting,(b) there are near building and separately from main structure.(c)This project involves the construction of 5 m depth cantilever retaining wall.(d) Selections of design parameters are considered according to the soil profile and laboratory results. (e) Determination of wall depth for overall lateral stability is determined using ultimate limit state.

2. METHODOLOGY:

A.Establishing of limit states

1. Ultimate limit states **-**with collapse or with other similar forms of structural failure. To cause safety of people and the safety of the structure. 2. Serviceability limit states correspond to specific service performance requirements. To use predefined limits on the wall deflection. 3. The purpose of design calculation- is to ensure: Satisfactory safety and overall stability of the wall at the ultimate limit state. Acceptable deformation and performance at the serviceability limit state. The purpose of the factors is to allow for uncertainty in material properties.

B. Selection of wall type

Case study (A) 1. Bo Ba Htoo Project, North Dagon Town Ship, Yangon 2. Soil is mostly cohesive soil. There are medium (low), stiff, medium, hard soil layers. 3. Water level is average 2 m below the ground surface 4. That place is Suitable for Diaphragm Wall.

C. Finding of loads

Firstly , to find concentrated load of surcharge building and then to change line load. After that to calculate pressure of the line load to the wall. Finally to add minimum surcharge load.

D. Determination of wall depth for overall lateral stabilitywith ultimate limit state

In case study (A) retained soils is soft, medium (low) clay, restrained soil medium (low), stiff, medium, hard soil layers. In case studies (B to H) with increasing shear strength parameters with relative stiffness of natural soil to get the level of the dredge line is stiff soil. In this study, soil structure interaction analysis is used for wall depth with overall lateral stability. FS=1.4 for c and FS=1.25 for ϕ.E_{ULS}=1/2E_{SLS}

E. Prediction of wall deflections and ground surface movements using serviceability limit states

In this study, soil structure interaction analysis is used with FS=1 for shear strength parameter.

3. RESULTS AND DISCUSSIONS:

For all cases ,distance from wall to Building =0 m, 0.2m, 0.4m, 0.6 m, 0.8m,1m,1.2m respectively.
Surcharge loads are 13, 13,13,13,13,12.5,12.5 kN/m^2 respectively.
Table 3 shows Summaries of Ground Parameters
A. Case study (A) **Natural Soil Condition:**

Table 1 **Summaries of Ground Parameters for Case Study I**

Soil layers								
Particular	I CL (1.5-3.0) m	II CH (3.0-15.0) m	III CL (15.0-20) m	IV CH,CL (20-26.0) m	V CH (26.0-35.0) m	VI CL,CH (36.0-39.0) m	VII SM (39.0-41.0) m	Unit
γ_{dry}	16	12	17	14	16.5	16.25	15	kN/m^3
γ_{sat}	19	18	20.4	19	19.5	20	19	kN/m^3
E_{SLS}	4	3	22	8	40	24	79	Mpa
ν	0.35	0.35	0.35	0.35	0.35	0.35	0.3	-
C_{ref}	40.89	12.1	36.55	22.68	45.76	28.77	19.4	kN/m^2
ϕ	4.65	3.2	7.73	5.74	10.5	15.4	28.15	°

B. CASE B 1.5% Increasing shear strength parameter
C. CASE C 2.0% Increasing shear strength parameter
D. CASE D 2.5% Increasing shear strength parameter
E. CASE E 3.0% Increasing shear strength parameter
F. CASE F 3.5% Increasing shear strength parameter
G. CASE G 4.0% Increasing shear strength parameter
H. CASE H 4.5% Increasing shear strength parameter

Figure 1 shows for all cases , wall depth with distance from wall to surcharge for ultimate limit state condition. Increasing shear strength parameters cause shorter wall depth.

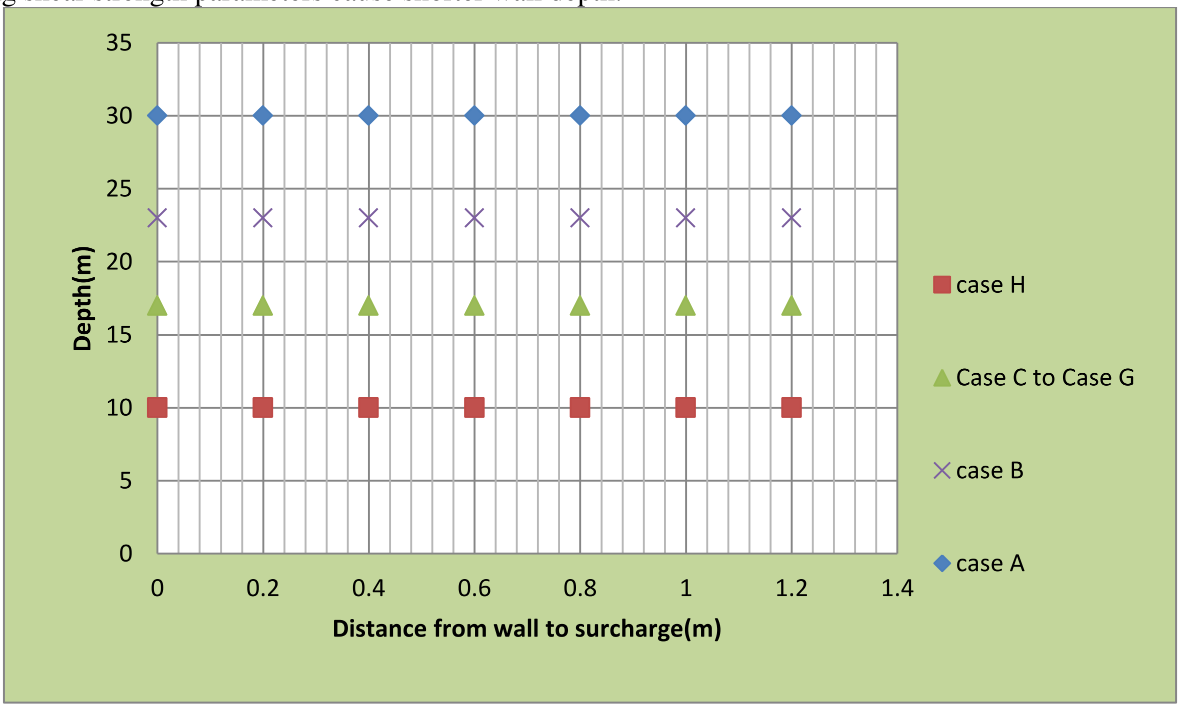

Figure 1.Wall depth with distance from wall to surcharge (ULS)

Figure 2 shows for all cases, SUM Msf for wall depth (ULS) with distance from wall to surcharge.
When shear strength parameters increase, SUM Msf become increase in same wall depth.
Figure 3 describes Modulus of Elasticity E_s vs soil layers. Correlative of C_u, $\sigma_{o'}$, OCR give normally consolidated soil or over consolidated soil. Standard penetration number and relative soil type correlate with Modulus of Elasticity.

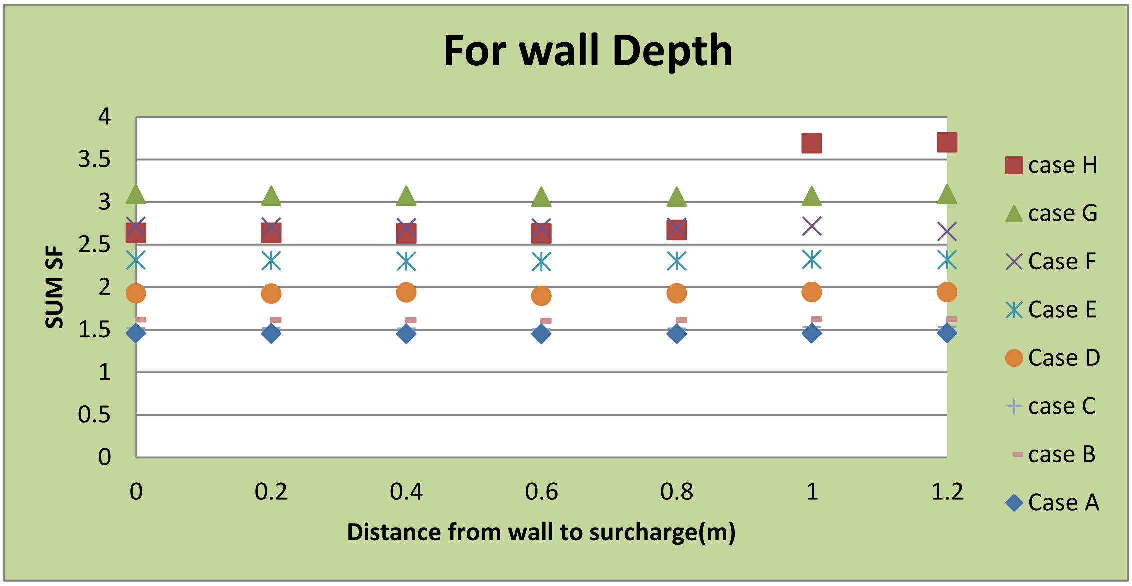

Figure 2.SUM Msf for wall depth (ULS) with distance from wall to surcharge

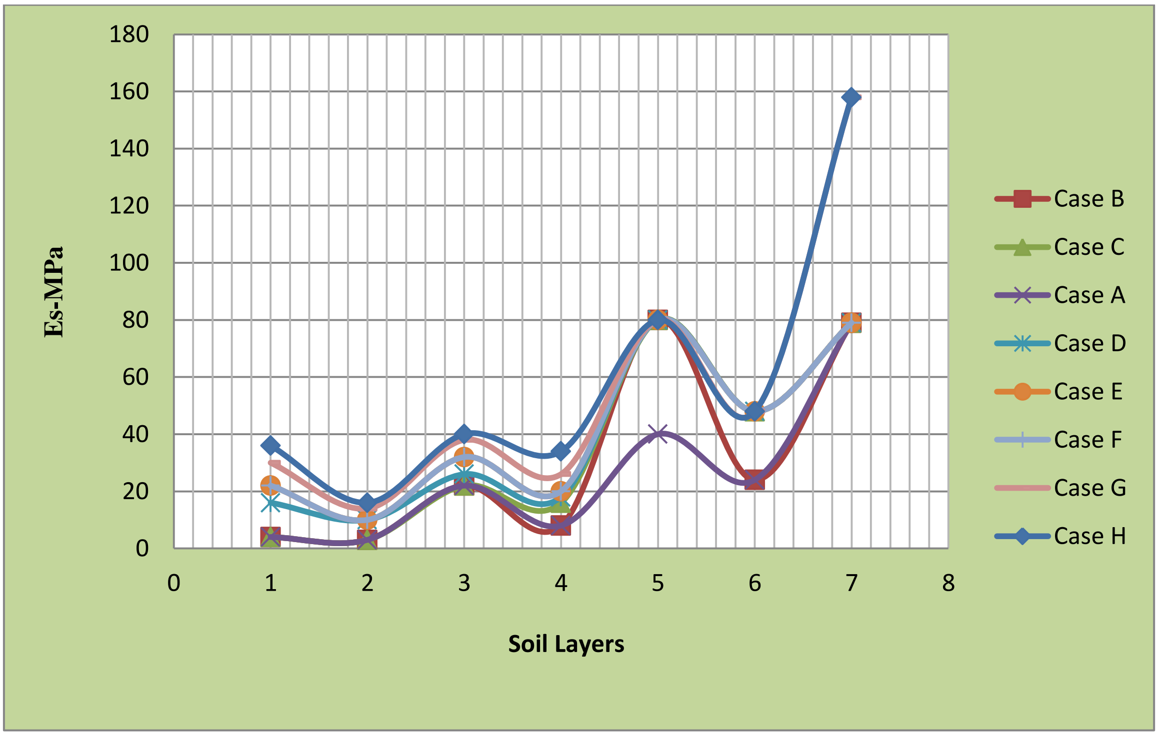

Figure 3 Modulus of Elasticity E_s vs soil layers

Figure 4 shows Depth Ratio Vs Modulus of Elasticity (Es) Ratio for Clay Soil. Depth ratio means ratio of wall depth to the excavation depth (retained high). Modulus of Elasticity (Es) Ratio means Ratio of average E_s for all soil layers to the dredged level of E_s for ULS condition.

Depth ratio 6 and modulus of elasticity ratio 7 with relative ground movements, bending movements and shear forces represent in Figure 5, 6, 7. Figure 8,9,10 show for depth ratio 4.6 and modulus of elasticity ratio 10.3 with relative ground movements, bending movements and shear forces. Figure 11,12 , 13 represent for depth ratio 3.4 and modulus of elasticity ratio 11.33 with relative ground movements, bending movements and shear forces. Figure 14,15,16 represent for depth ratio 3.4 and modulus of elasticity ratio 3.75 with relative ground movements, bending movements and shear forces. Figure 17,18,19 represent for depth ratio 3.4 and modulus of elasticity ratio 3.89 with relative ground movements, bending movements and shear forces.

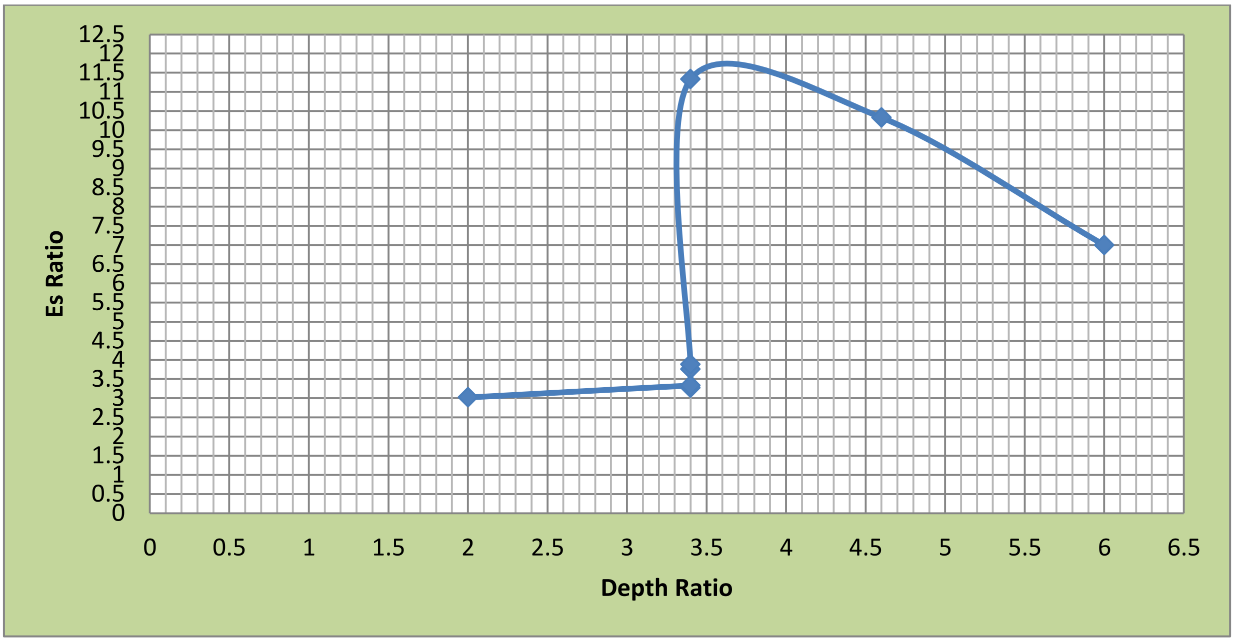

Figure (4) Depth Ratio Vs Modulus of Elasticity (Es)Ratio for Clay Soil

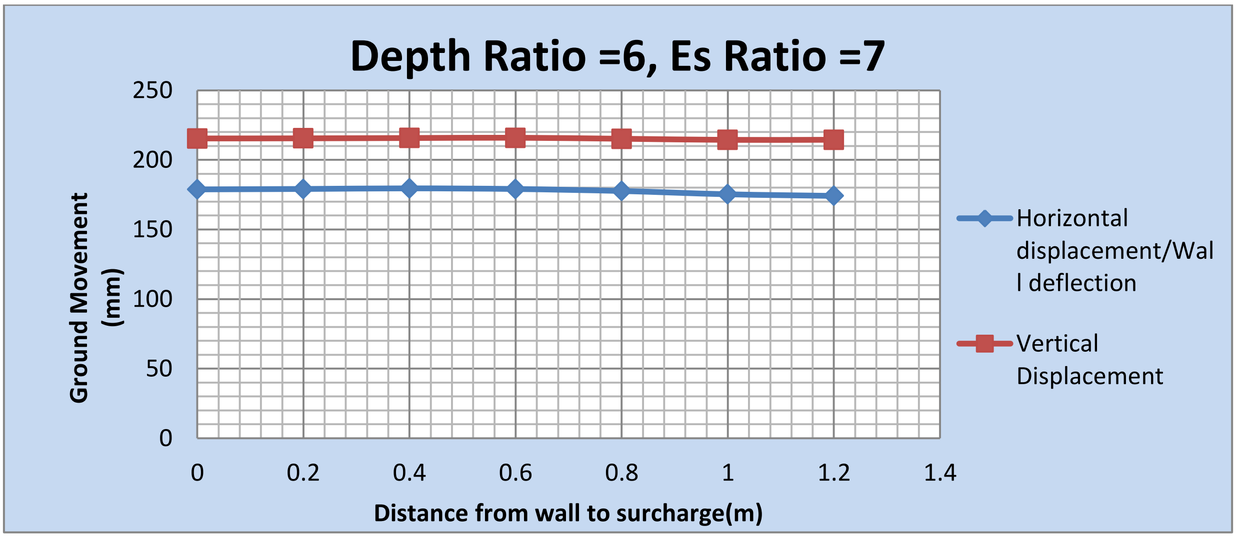

Figure5 .Ground Movement with Distance from Wall to Surcharge (Depth ratio =6, Es Ratio =7)

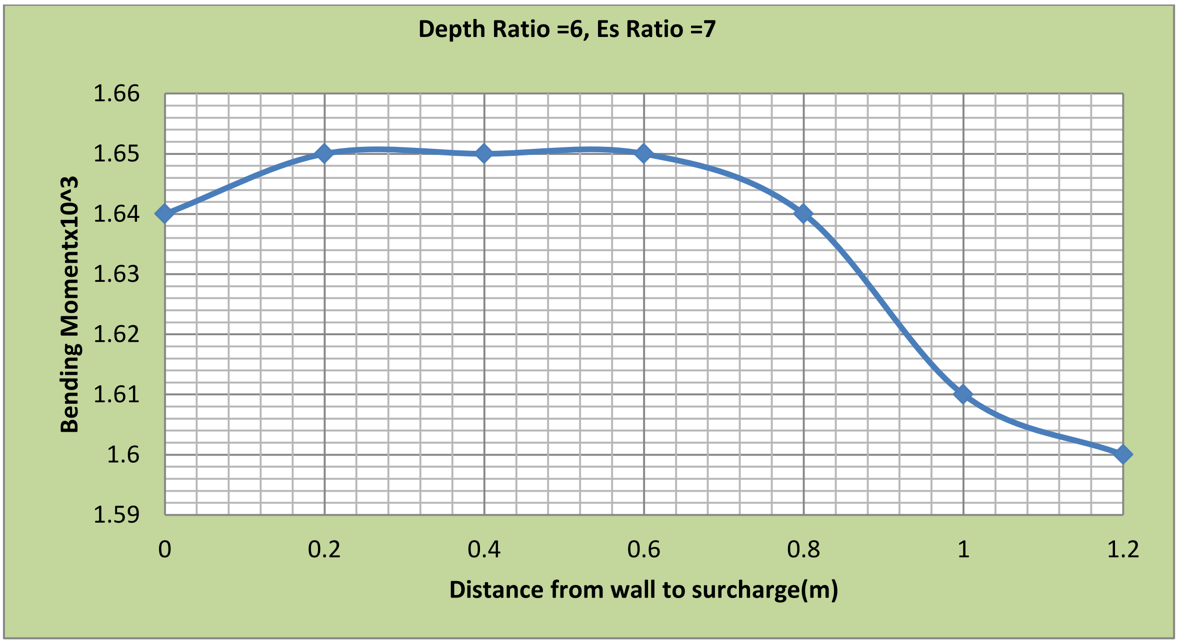

Figure 6 .BM with Distance from Wall to Surcharge (Depth ratio =6, Es Ratio =7)

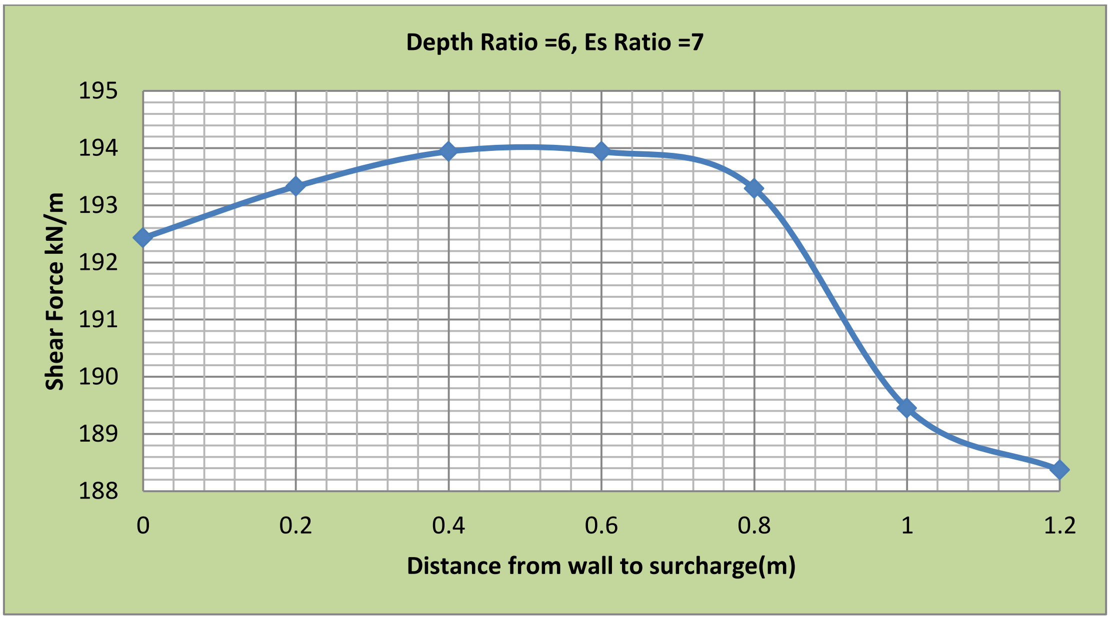

Figure 7 . SF with Distance from Wall to Surcharge (Depth ratio =6, Es Ratio =7)

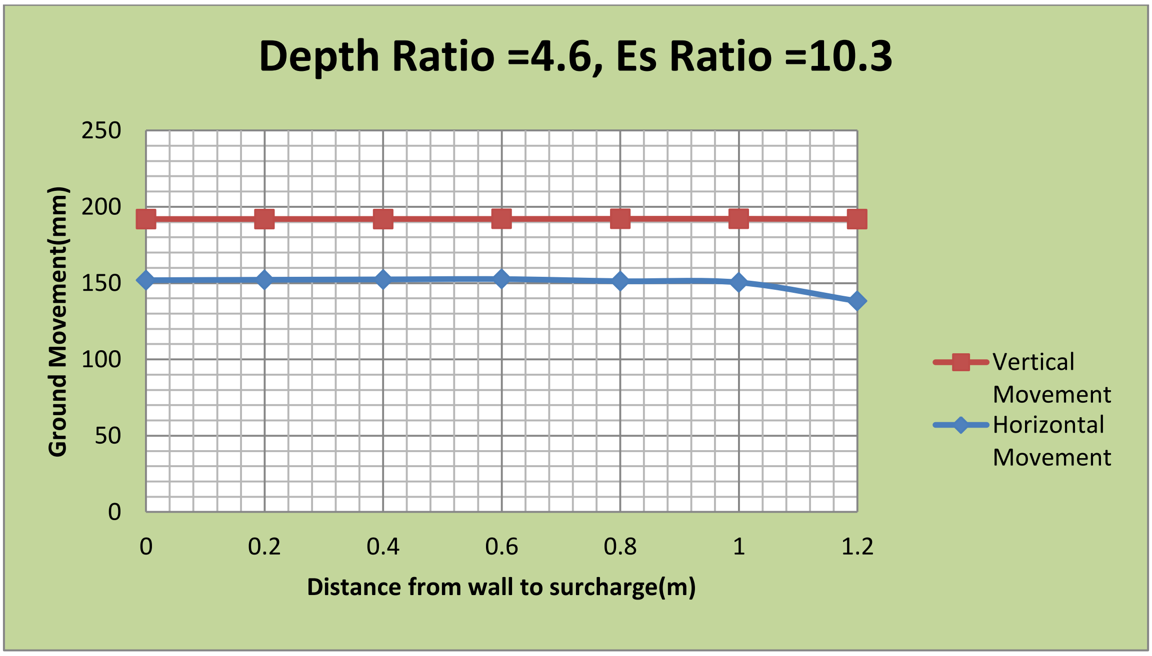

Figure 8.Ground Movement with Distance from Wall to Surcharge (Depth ratio =4.6, Es Ratio =10.33)

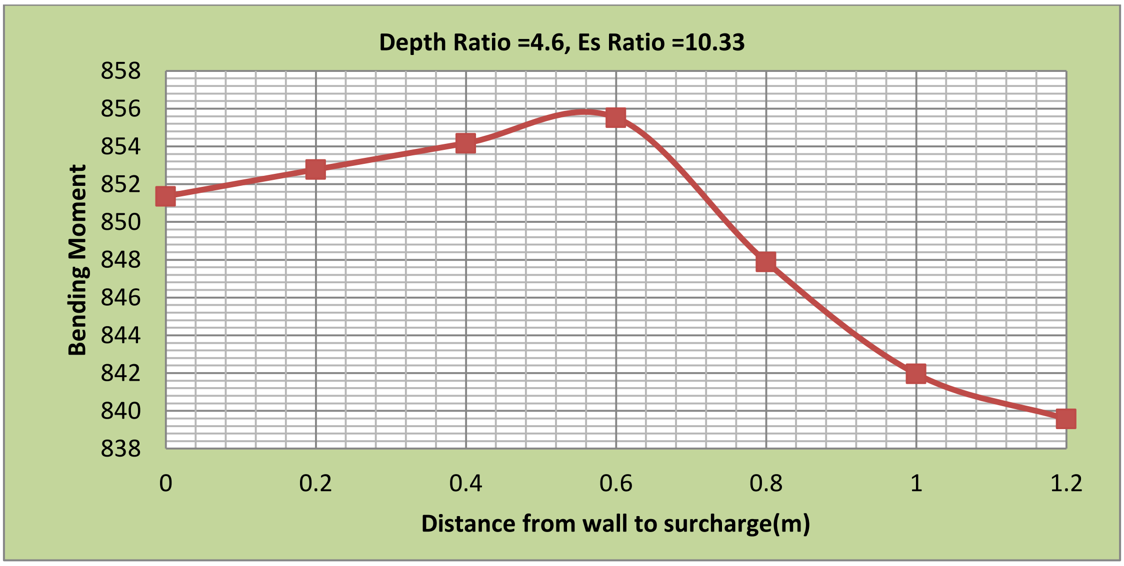

Figure 9 . SF with Distance from Wall to Surcharge (Depth ratio =4.6, Es Ratio =10.33)

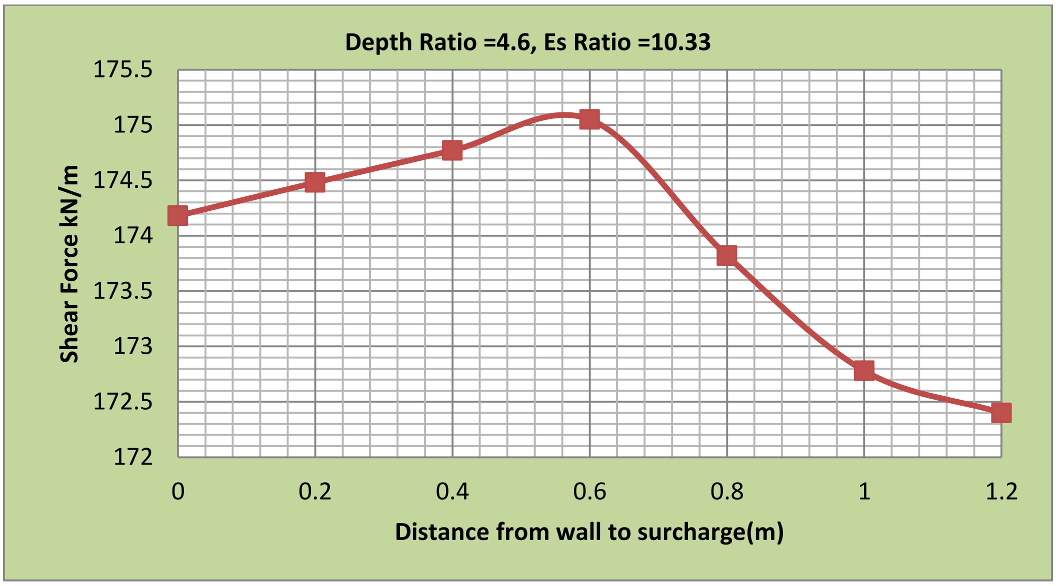

Figure 10 . SF with Distance from Wall to Surcharge (Depth ratio =4.6, Es Ratio =10.33)

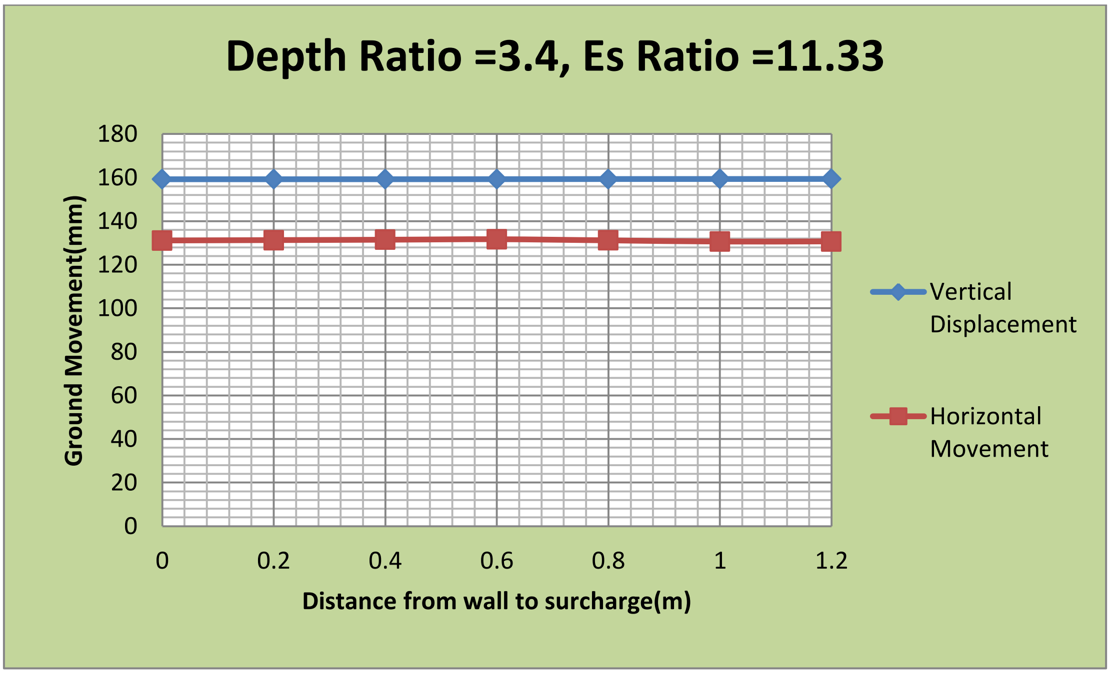

Figure 11 .Ground Movement with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =11.33)

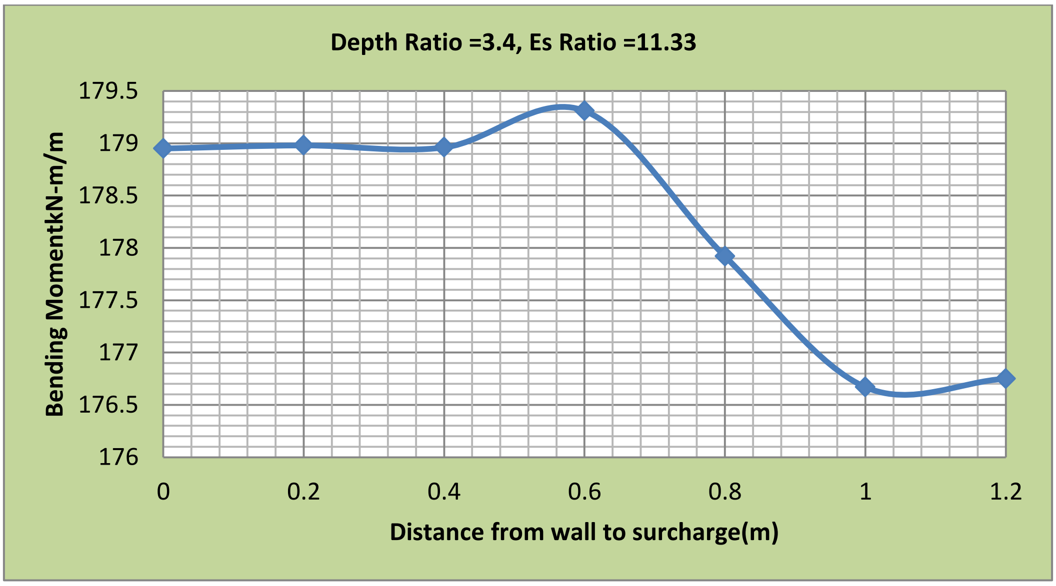

Figure 12 .BM with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =11.33)

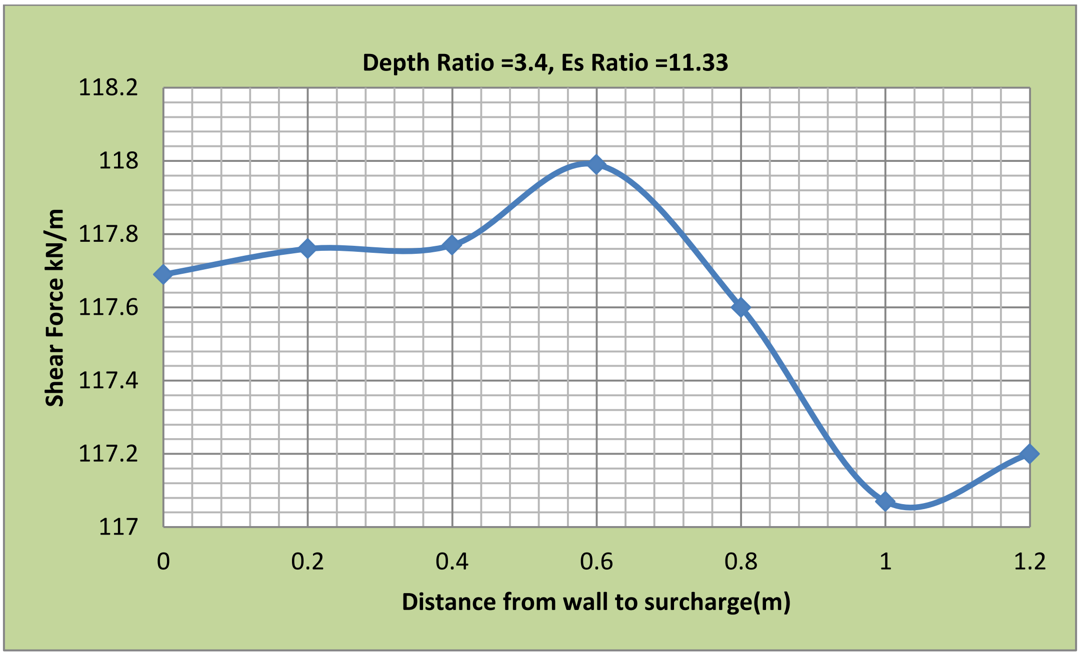

Figure 13 .SF with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =11.33)

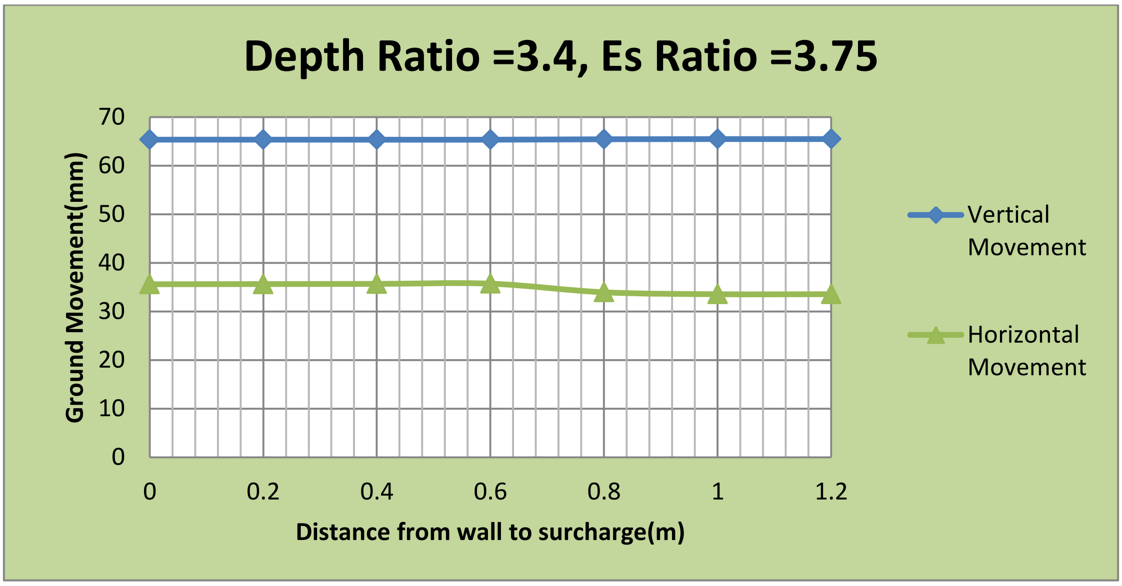

Figure 14 .Ground Movement with Distance from Wall to Surcharge (Depth Ratio =3.4., Es Ratio =3.75)

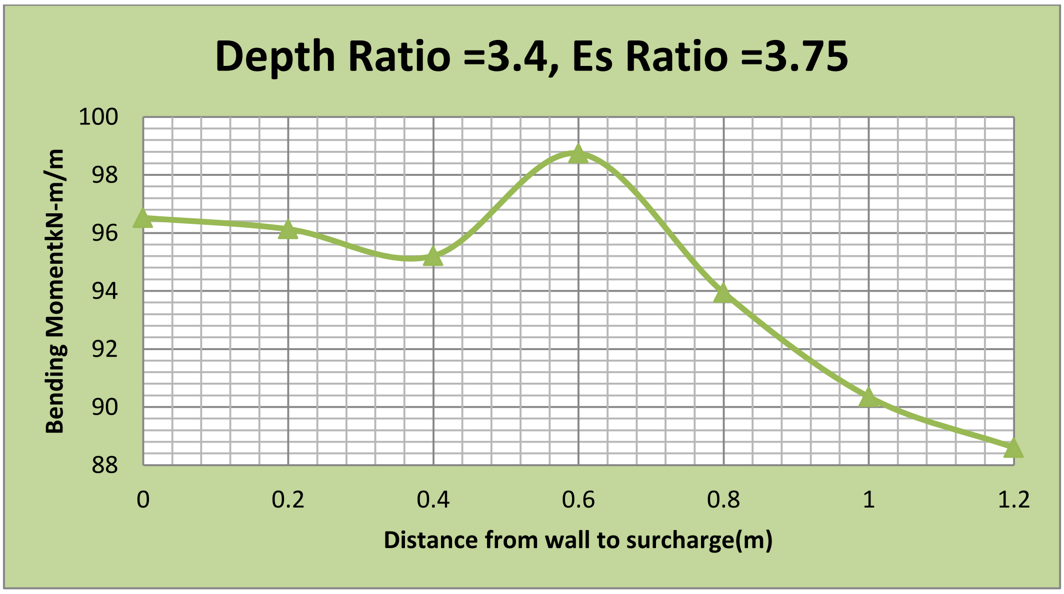

Figure 15.BM with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =3.75)

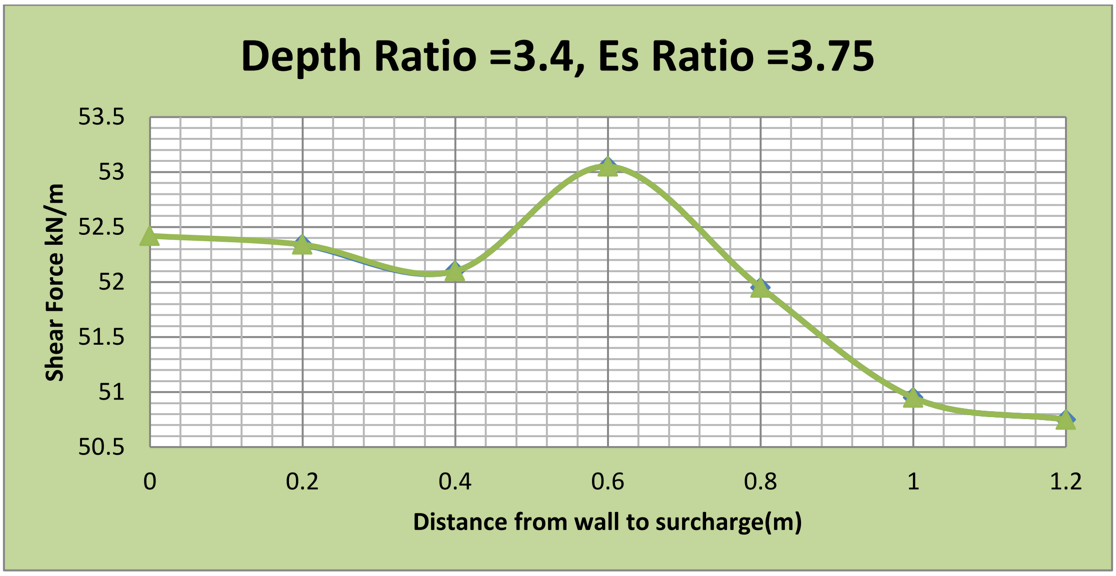

Figure 16 .SF with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =3.75)

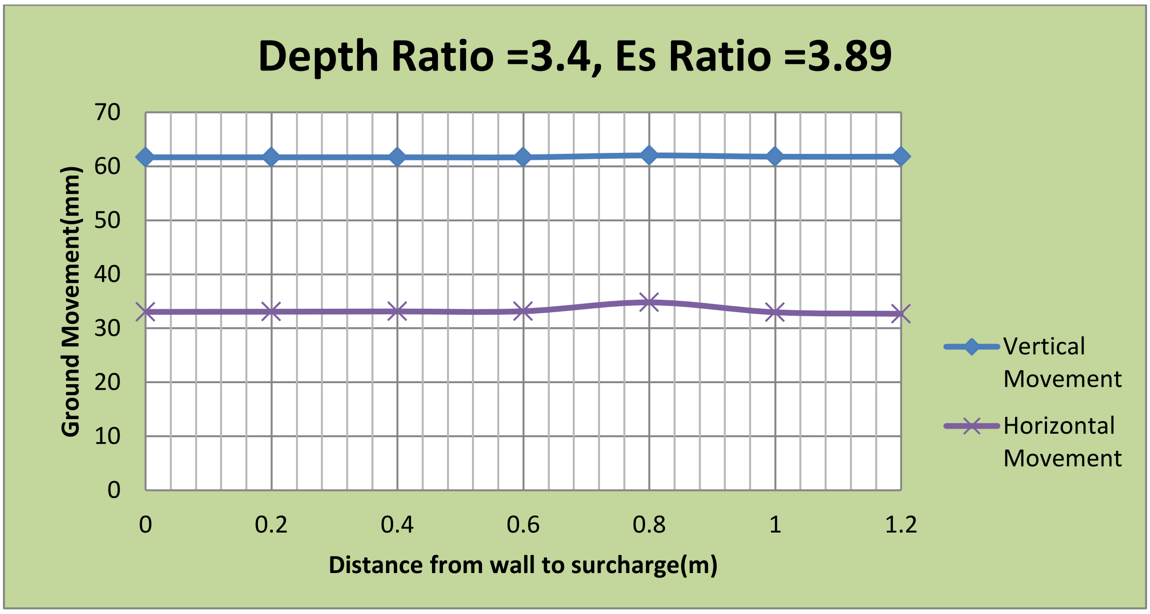

Figure 17 .Ground Movement with Distance from Wall to Surcharge (Depth ratio =3.4., Es Ratio =3.89)

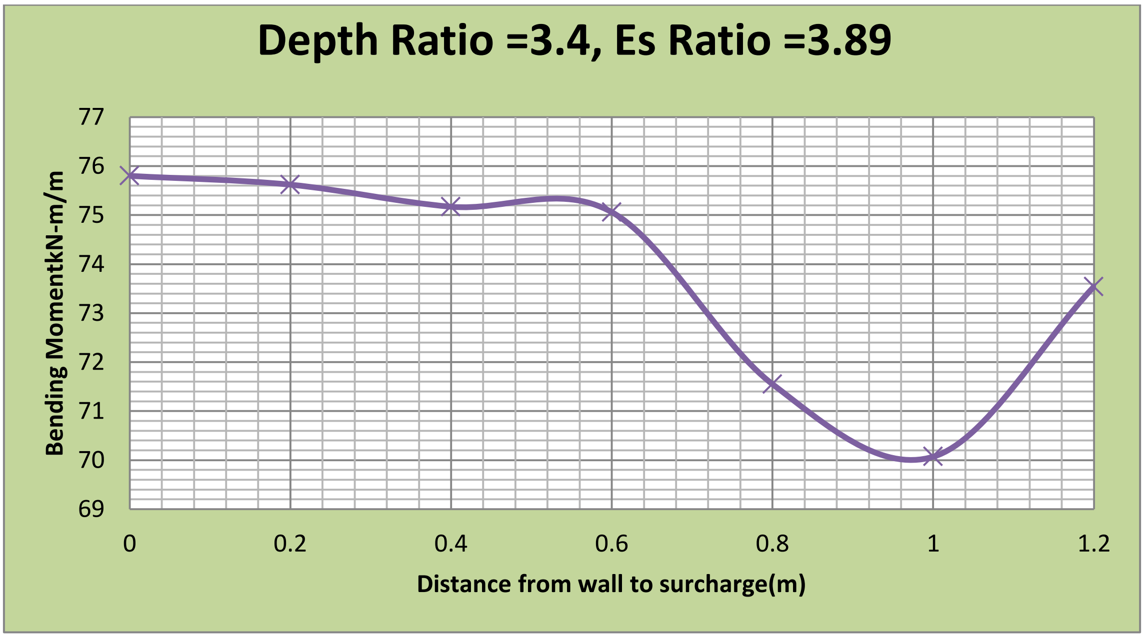

Figure 18.BM with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =3.89)

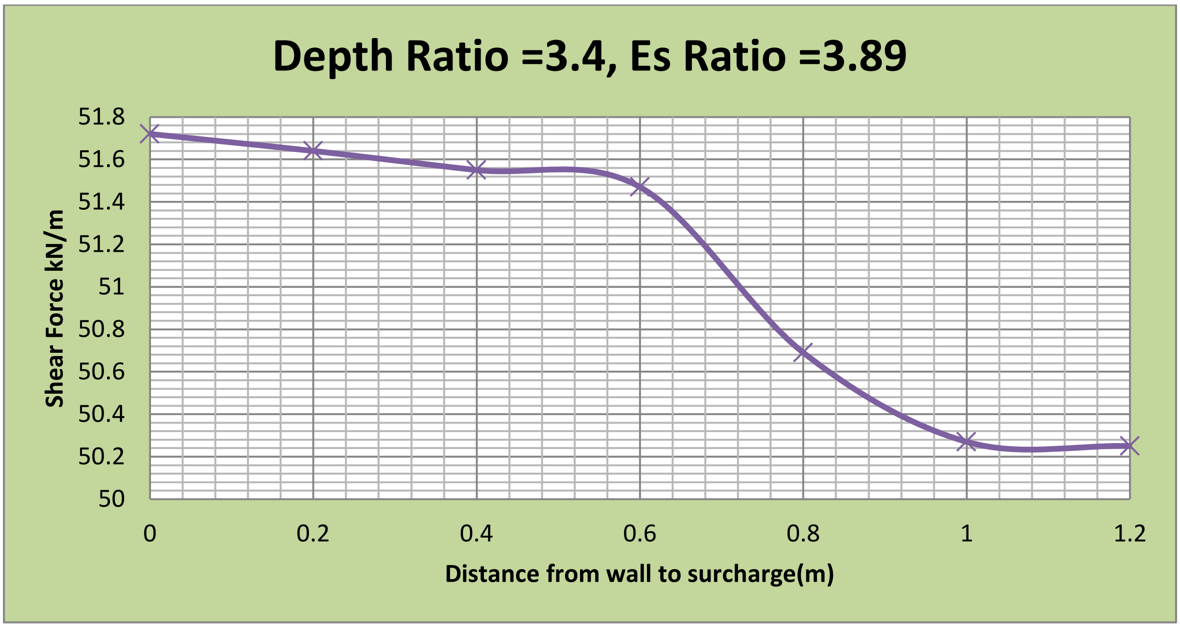

Figure 19 .SF with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =3.89)

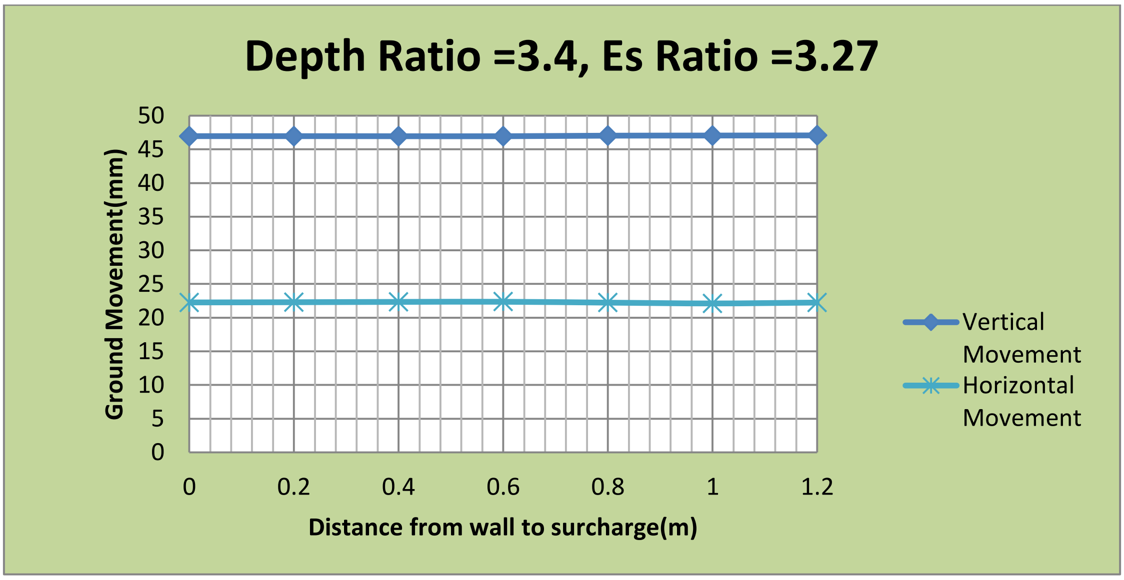

Figure 20 .Ground Movement with Distance from Wall to Surcharge (Depth ratio =3.4., Es Ratio =3.27)

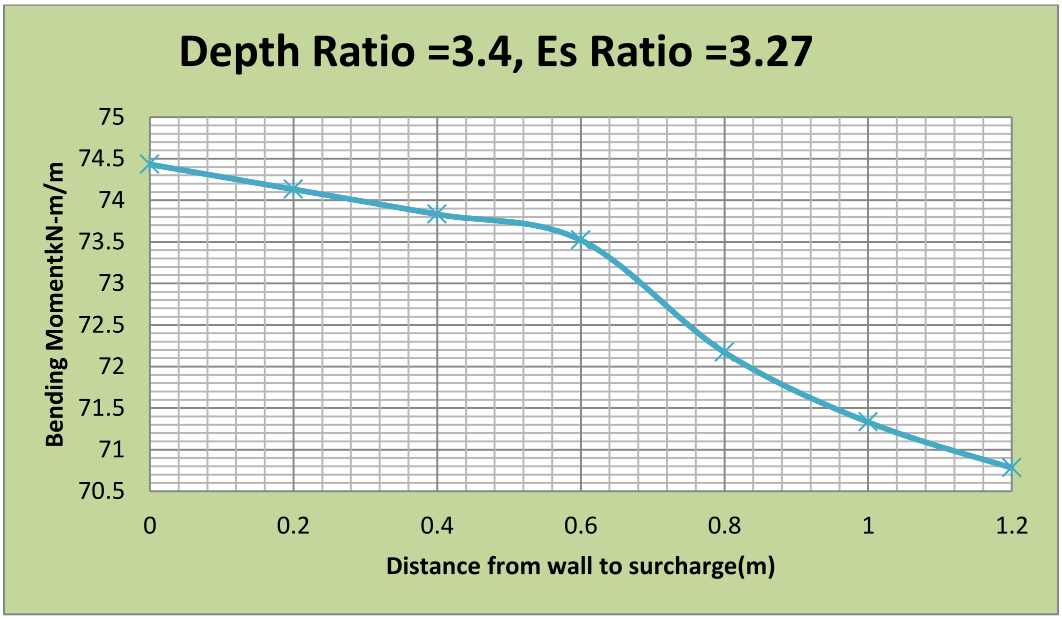

Figure 21.BM with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =3.27)

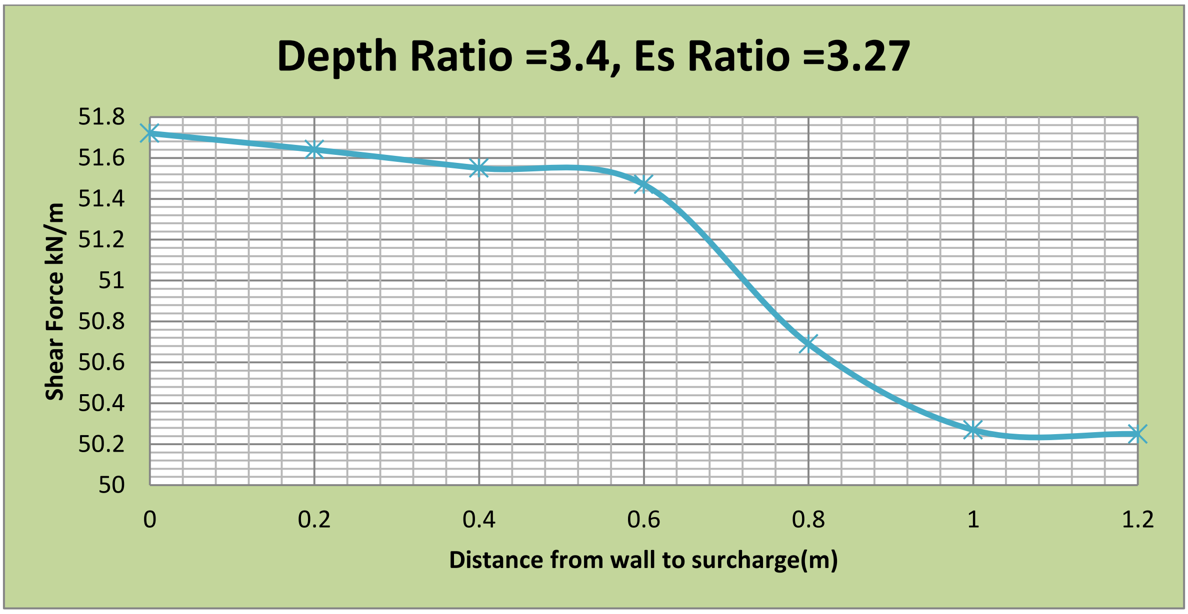

Figure 22.SF with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =3.27)

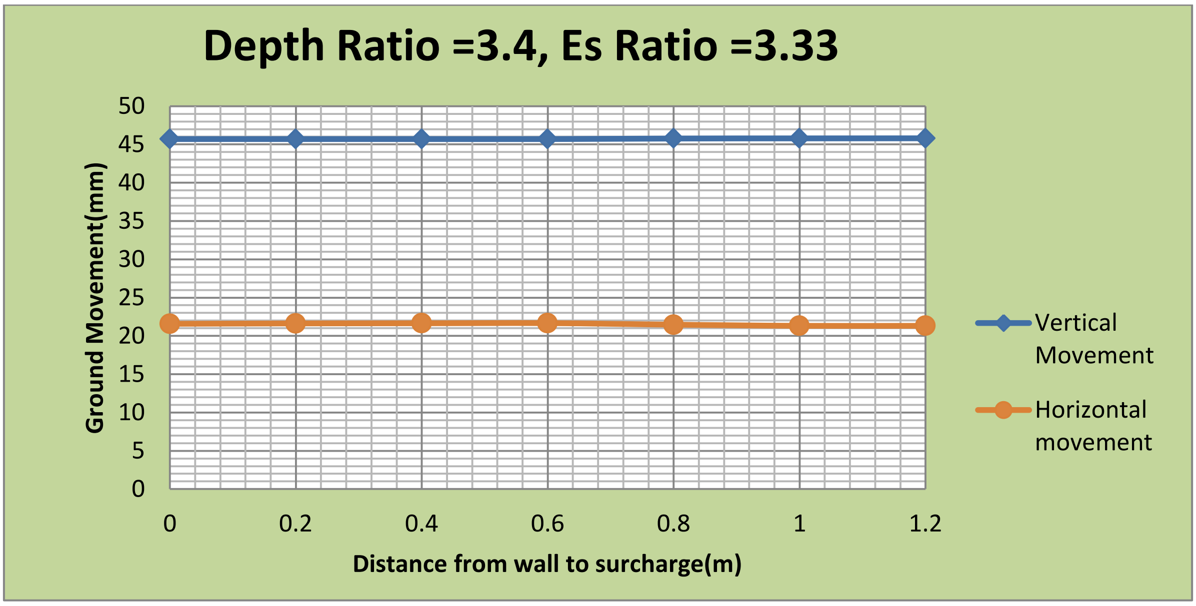

Figure 23 .Ground Movement with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =3.33)

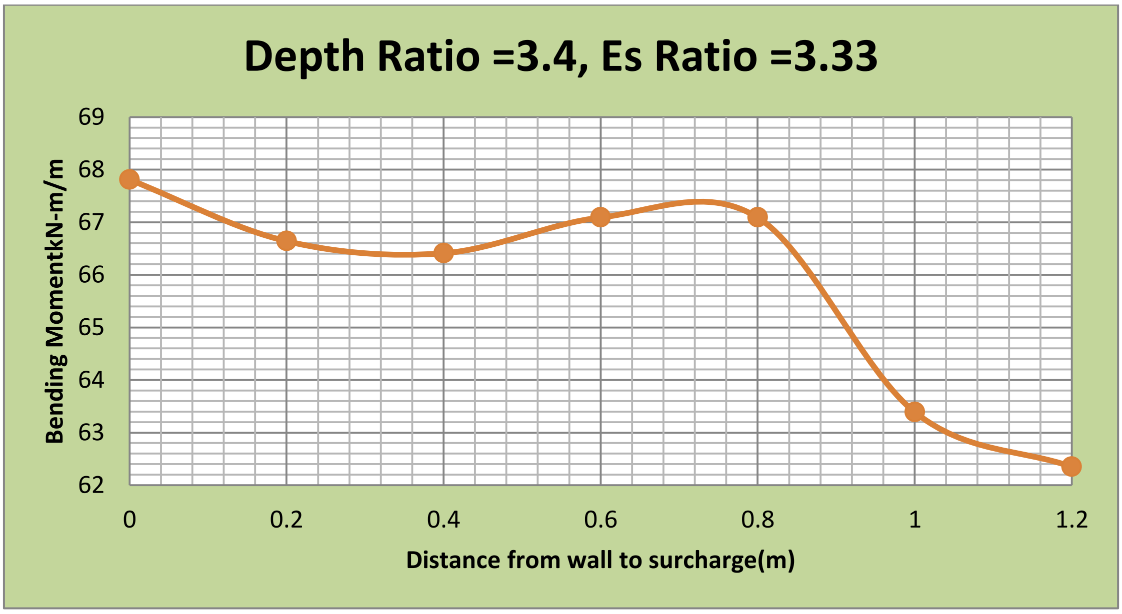

Figure 24 .BM with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =3.33)

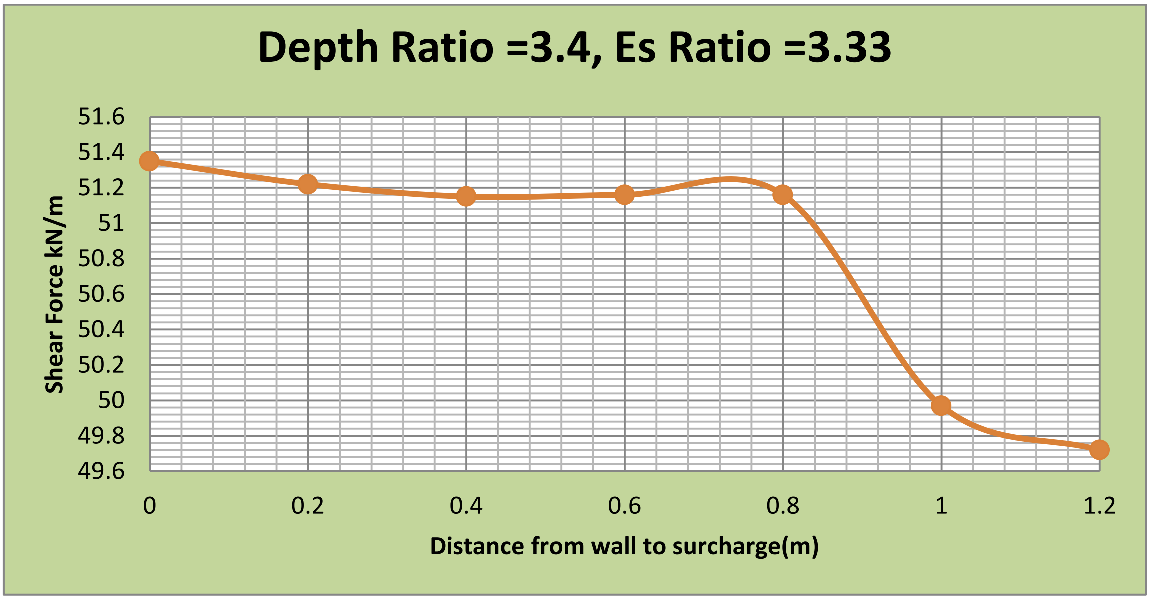

Figure 25 .SF with Distance from Wall to Surcharge (Depth ratio =3.4, Es Ratio =3.33)

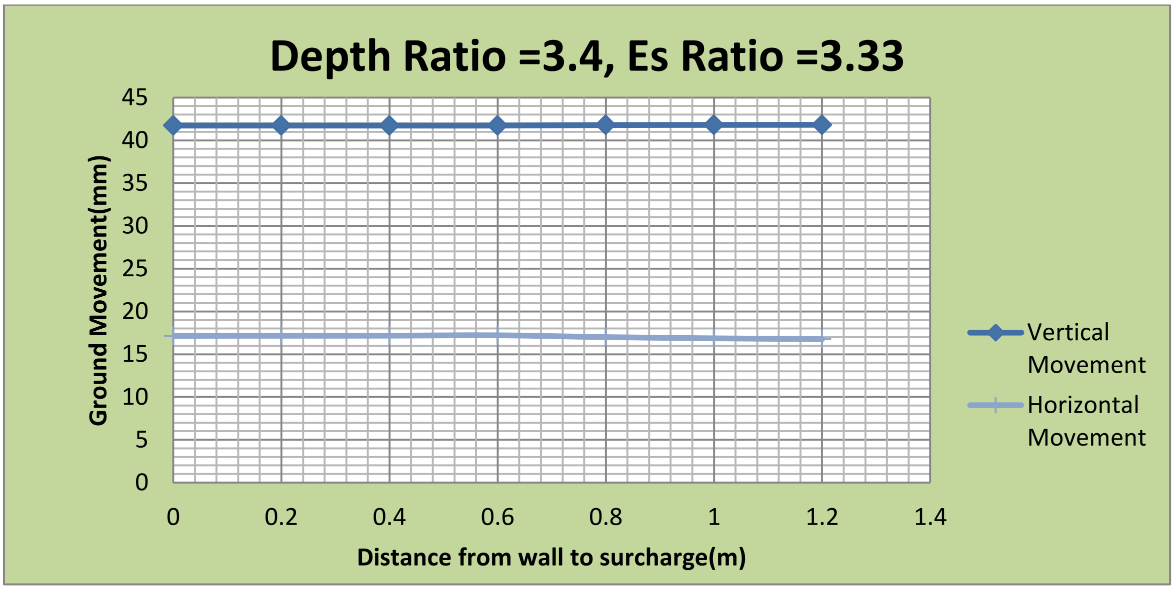

Figure 26 .Ground Movement with Distance from Wall to Surcharge (Depth ratio =2.0, Es Ratio =3.02)

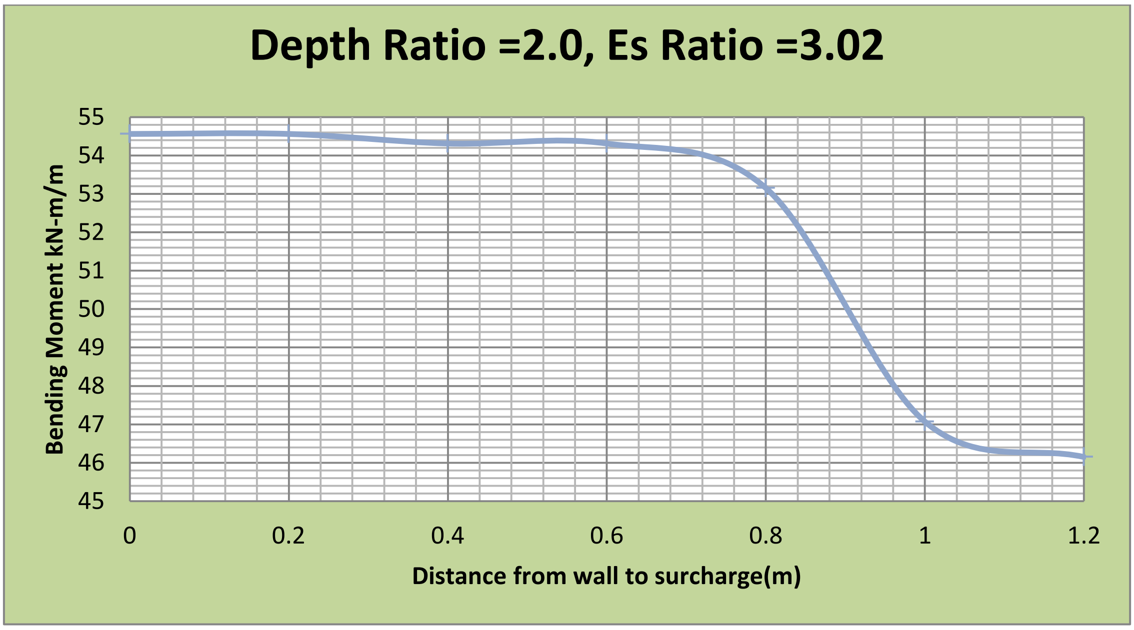

Figure 27 .BM with Distance from Wall to Surcharge (Depth ratio =2.0, Es Ratio =3.02)

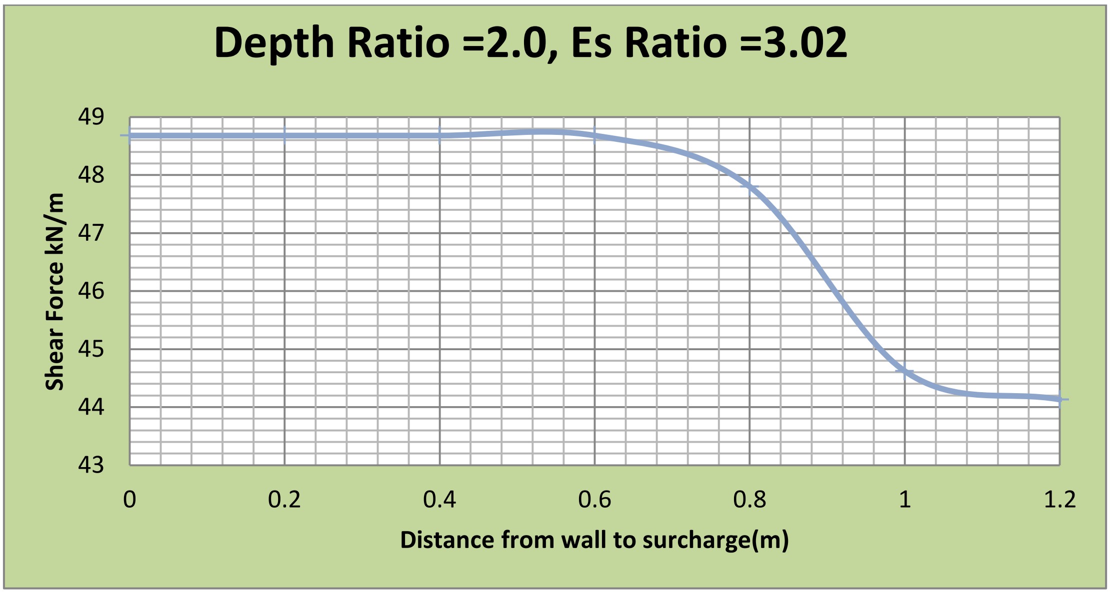

Figure 28 .SF with Distance from Wall to Surcharge (Depth ratio =2.0, Es Ratio =3.02)

Depth ratio 3.4 and modulus of elasticity ratio 3.27 with relative ground movements, bending movements and shear forces represent Figure 20, 21, 22. Figure 23, 24 ,25 represent for depth ratio 3.4 and modulus of elasticity ratio 3.33 with relative ground movements, bending movements and shear forces. Figure 26, 27 ,28 represent for depth ratio 2 and modulus of elasticity ratio 3.02 with relative ground movements, bending movements and shear forces.

4. CONCLUSION:

- From the results, Surcharge load should be placed at zero distance from the wall or distance from wall to surcharge is more than 1.2m.
- **In Natural soil condition,** ground movements are more than limitation amount because layer 1 is soft clay and layer 2 is medium (low) until 15m depth from ground surface. Wall depth is not change from all distances from wall to surcharge.
- **In Increasing of shear strength parameter condition (case C to G):** Wall depth is not change for all cases**.** Moreover, when different distance from wall to surcharge ,wall depth is not change because below the dredged level is medium (low) clay.
- **In Increasing of shear strength parameter condition (case D to G):** Decreasing of Horizontal ground movements and Vertical ground movements are dominantly because changing of normally consolidated clay to over consolidated clay in layer 2.
- **CASE H 4.5% Increasing shear strength Parameter**: Soil condition of Layer 2 starts to change stiff state. Therefore below dredged level become stiff condition. Although it is not strong stiff, horizontal ground movements reach acceptable limit (0.5% of H). Wall depth becomes more economical and good working condition. Vertical movement is less than limit value of 1% of H. But to be more satisfied limit 0.5% of H, It is need to compact the dredged level with granular soil.
- 5m depth cantilever retaining wall is supported by embedment stiff clay to reach overall economy.
- In case C and D, there are same depth ratio but ground movements are different because modulus of elasticity (Es) ratio . (Figure 11 and 14)
- In same depth ratio, Grater Es ratio gives greater ground movement and smaller Es ratio gives smaller ground movement.
- In case H, depth ratio =2, Es ratio = 3.Then Ground movements become in acceptable limit.

In this study, boring depth which must be greater than 50 of SPT number in site investigation. Diaphragm wall properties are EA=7.5x10^6kN/m. EI=1.0x 10^6 kNm^2/m and equivalent thickness d= 1.265 m

5. ACKNOWLEDGEMENTS:

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