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Static and Dynamic Analysis of Soil Nail Wall and Retaining Wall for Vertical Cut

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***Abstract*—In recent years, due to the advantages of soil nail which can be constructed in areas with difficult access and minimizes earthwork, soil nail system has also demonstrated its applicability for deep excavation works. The use of soil nail system has resulted in cost saving to deep excavation project and also enables basement construction to be carried out in a relatively unobstructed work space. Therefore it becomes necessary to study the applications of soil nail wall in excavation since it provides straight forward construction method and is relatively maintenance free. Comparisons of RCC Retaining Wall with soil nail wall gives a clear idea about the performance of both when used to retain the vertical cut.**

A static and dynamic analysis is carried out for 6m and 8m height retaining wall and soil nail wall which is numerically simulated in plaxis 8.2 then its global factor of safety, horizontal displacement, base heave comparison is carried out in this study.

***Index Terms*— Soil Nail Wall (SNW), Retaining Wall (RW), Global Factor of Safety (FS_G), Horizontal Wall Displacement, Base Heave.**

I. INTRODUCTION

Retaining walls and Soil nailing wall are usually built to hold back soil mass. Retaining walls are structures that are constructed to retain soil or any such materials which are unable to stand vertically by themselves. They are also provided to maintain the grounds at two different levels. Retaining structures hold back soil or other loose material where an abrupt change in ground elevation occurs. The retained material or backfill exerts a push on the structure and thus tends to overturn or slide it, or both. The analysis is carried out for 6m and 8m height of vertical cut. Retaining wall is designed manually and then modelled in the software plaxis 8.2 whereas the soil nail wall is directly modelled in plaxis by fixing the nail length with trial and error method to obtain the global factor of safety above 1.5.

II. MATERIAL PROPERTIES

The properties of soil taken is given in table I , concrete and steel combined values taken as plate element is given in table III, IV & V which has been calculated using the formulas given in table II.

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TABLE I : PARAMETERS ADOPTED FOR NUMERICAL SIMULATION USING PLAXIS 2D [1]

Soil properties	
Material model	Mohr-coulomb
Cohesion c(Kpa)	4
Internal friction angle Ø{deg}	31.5^0
Unit weight γ[KN/m^3]	17
Elastic modulus E_s[Mpa]	20
Poison's ratio of soil ν_s	0.3

III. MODELING AND ANALYSIS

Plaxis version 8.2 is used for the simulation of models. Numerical modeling is carried out taking the plane strain state of stresses. The 15-node triangular element with finer mesh density is used for the finite element discretization. The in-situ soil is simulated as Mohr-coulomb (MC) material. A plate element is used to model the nail and facing in case of soil nail wall the same plate element is used for the stem, heel and toe in case of retaining wall. The generated soil models are as shown in Fig. 1 and Fig. 2. For boundary condition the bottom of the soil is given total fixity and horizontal fixity is provided in vertical sides since soil continues on either sides.

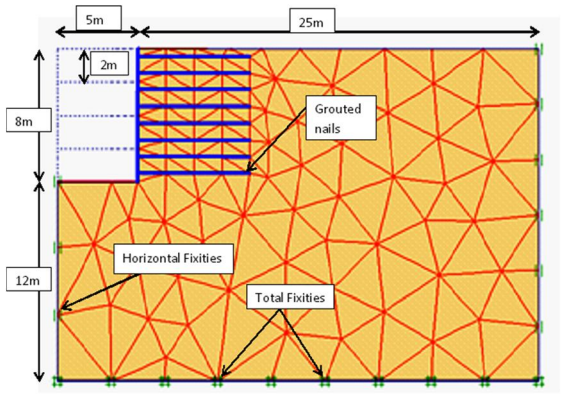

Figure 1: Numerically Simulated Soil Nail Wall

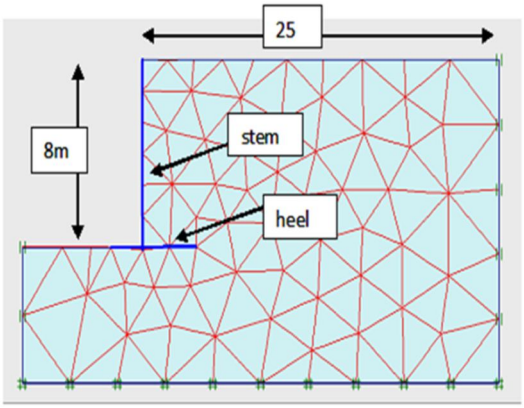

Figure.2: Numerically Simulated Retaining Wall

TABLE II: CALCULATION OF AXIAL STIFFNESS (EA) AND BENDING STIFFNESS (EI)

$\mathbf{E_{eq}= E_n(\frac{An}{A}) + E_g(\frac{Ag}{A})}$	Where: **E_g :** modulus of elasticity of grout **E_n:** modulus of elasticity of nail **E_{eq}:** equivalent modulus of elasticity of grouted soil nail
$A = 0.25\ \pi\ D^2$ $A_n = 0.25\ \pi d^2$ $A_g = A - A_n$	**A_n:** Cross-section area of reinforcement bar **A_g:** Cross-section area of grout cover **A:** Cross-section area of grouted soil nail
Axial stiffness EA [kN/m] = $\frac{Eeq}{Sh}(\frac{\pi D^2}{4})$ **Bending stiffness EI [kNm²/m]** = $\frac{Eeq}{Sh}(\frac{\pi D^4}{64})$ $\mathbf{d_{eq}} = \sqrt{\mathbf{12}(\frac{EI}{EA})}$	D: Diameter of drill hole d: Diameter of nail

TABLE III: MATERIAL PROPERTIES INPUT FOR 6M AND 8M SOIL NAIL WALL

Parameters	Name	Value		Unit
		Grouted nail	Facing	
Axial stiffness	EA	228.707e3	4.4e6	KN/m
Bending stiffness	EI	142.9419	1466.74	KNm^2/m

TABLE IV: MATERIAL PROPERTIES INPUT FOR 6M HEIGHT RETAINING WALL

Parameters	Name	Value			Unit
		Stem	Heel	Toe	
Axial stiffness	EA	60.73e6	44.33e6	26.125e6	KN/m
Bending stiffness	EI	207.17e6	2.545e6	566.56e3	KNm^2/m

TABLE V: MATERIAL PROPERTIES INPUT FOR 8M HEIGHT RETAINING WALL

Parameters	Name	Value			Unit
		Stem	Heel	Toe	
Axial stiffness	EA	111.65e6	87.45e6	52.499e6	KN/m
Bending stiffness	EI	633.277e6	12.31e6	7.4e6	KNm^2/m

IV. RESULTS AND DISCUSSION

Global factor of safety

The first task is to verify the stability of the soil nail wall and retaining wall. This task is similar to a conventional slope stability analysis, in which the most critical failure surface and thus the lowest factor of safety are identified. This is the most common practice for computer analysis. The FS_G values for all the case are maintained above 1.5 in case of soil nail wall and since retaining wall is manually designed and then modelled the stability against different failures will be checked.

TABLE VI: GLOBAL FACTOR OF SAFETY FOR SOIL NAIL WALL AND RETAINING WALL

Depth in m	Global factor of safety	
	Soil nail wall	Retaining wall
6	1.912	1.343
8	1.63	1.27

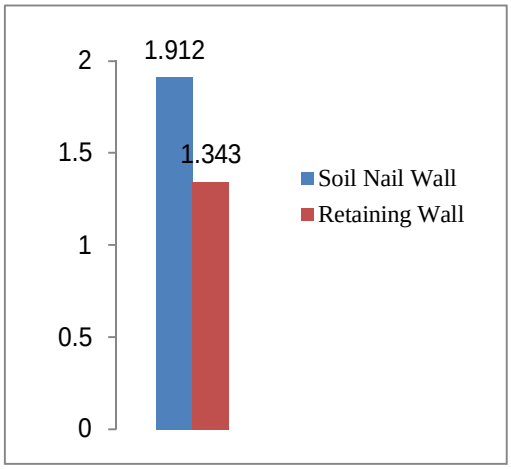

Figure 3: FS_G for 6m height of SNW & RW

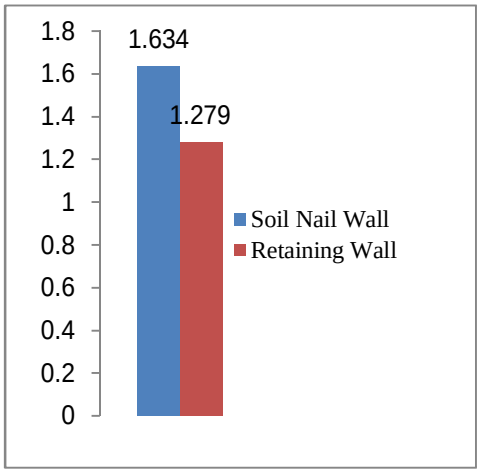

Figure 4: FS_G for 8m height of SNW & RW

From the results it gives that the Global factor of safety is more in case of Soil Nail Wall. Hence soil nail wall is more stable than Retaining Wall.

Maximum horizontal displacement of wall

The outward movement is initiated by incremental rotation about the toe of the wall, similar to the movement of a cantilever retaining wall. Maximum horizontal displacements occur at the top of the wall and decrease progressively toward the toe of the wall in both Soil nail wall and Retaining wall. Table VII shows the maximum horizontal displacement for both cases. In both 6m and 8m height the Soil Nail Wall gives less maximum horizontal displacemnt when compared to Retaining Wall. hence it can be said the soil nail performes better and also it is cost effective and easy to install when compared to RCC Retaining Wall.

TABLE VII: MAXIMUM HORIZONTAL WALL DISPLACEMENT

Depth in m	Max. horizontal Wall displacement in mm	
	Soil nail wall	Retaining wall
6	5.15	33.40
8	10.47	55.42

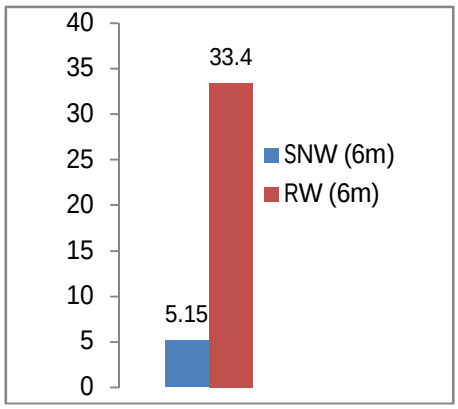

Figure 5: Max. Horizontal Displacement for RW 6m Height SNW &

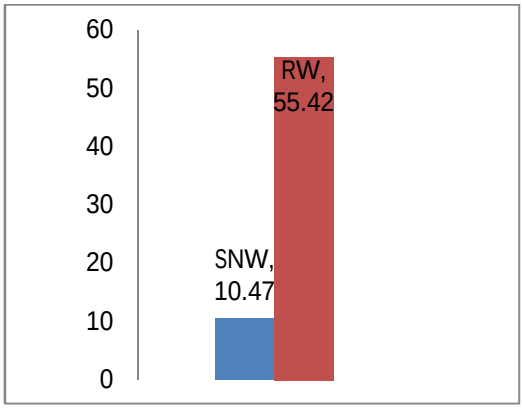

Figure 6: Max. Horizontal Displacement for 8m Height SNW & RW

Base heave

Basal heave or the baring capacity failure as one of the external failure modes for Soil nails walls and Retaining wall. Because the wall facing does not extend below the bottom of excavation, the unbalance load due to the excavation may cause the bottom the excavation to heave and stimulate a bearing capacity failure of foundation. Fig.7 & Fig.8 shows upward heave or the displacement of the excavated soil in front of the wall face. Here it can be seen that the base heave is more in case of Soil Nail Wall and less in case of Retaining wall as given in table VIII. This is because in retaining wall the part of toe avoids the vertical movement of soil whereas in case of soil nail there is no such thing. Hence the base heave is more in Soil Nail Wall

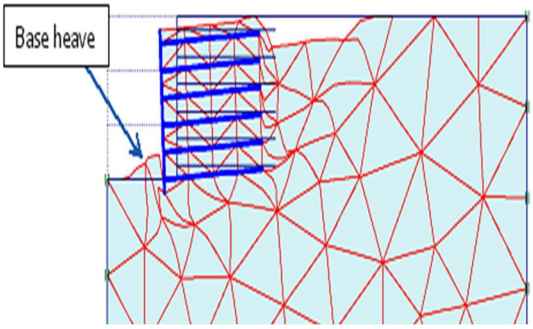

Figure 7: Base heave for SNW

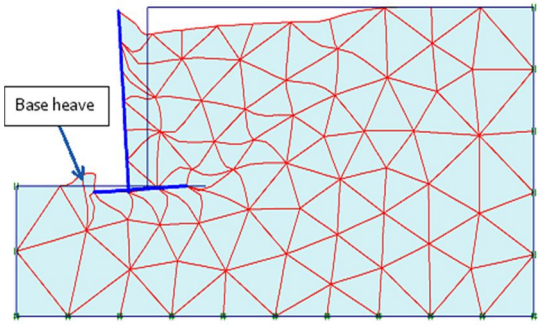

Figure.8: Base heave for RW

TABLEVIII: BASE HEAVE IN MM

Depth in m	Base heave in mm	
	Soil nail wall	Retaining wall
6	43.40	1.536
8	51.03	2.129

Dynamic Analysis

For dynamic analysis Upland earthquake (occurred during 20th Feb 1990 at 3:44 pm in South California) of peak acceleration of 0.245g was used. The Maximum Horizontal Displacement due to upland earthquake is

given in below table IX.

TABLE IX: MAX. HORIZONTAL DISPLACEMENT IN MM

Depth in m	Max. Horizontal Displacement in mm (for Dynamic Analysis)	
	Soil nail wall	Retaining wall
6	55.13	91.23
8	64.10	95.47

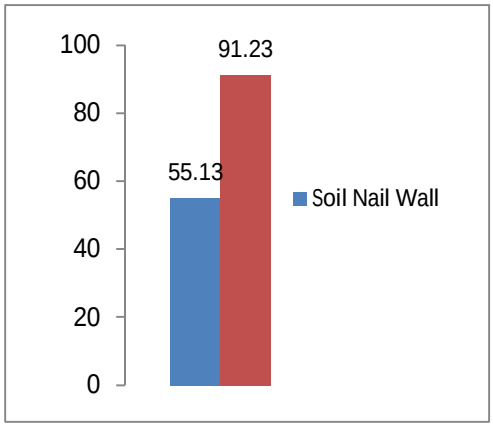

Fig.9: Max. Horizontal Displacement For 6m SNW& RW

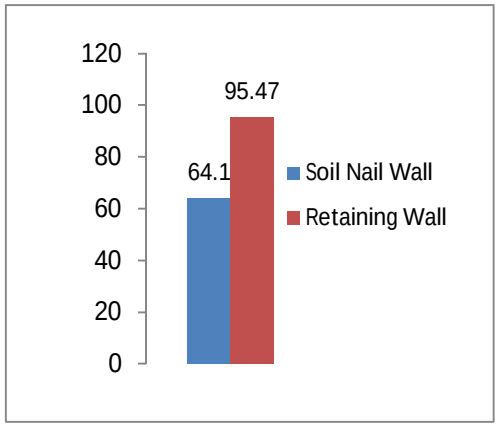

Fig.10: Max. Horizontal Displacement For 6m SNW&RW

From the results it can be seen that the maximum horizontal displacement is more for both 6m and 8m height Retaining Wall when compared Soil Nail Wall. Hence Soil Nail Wall performes well during seismic condition.

V. CONCLUSIONS

- The Global factor of safety for Soil nail wall in both 6m and 8m is higher than that of Retaining wall. If the Global factor of safety then the displacement will be less.
- Soil nail wall gives very less maximum horizontal displacement when compared to retaining wall.
- In dynamic condition also Soil nail wall performs well then Retaining wall by giving lesser horizontal displacement.
- During construction, it causes less environmental impact than that of retaining wall construction as no major earthworks and tree felling are needed.
- Soil nailing could be time and cost savings compared to conventional techniques retaining.

REFERENCE

[1] Shiva Kumar Babu G.L, et al. (2008) “Numerical analysis of performance of soil nail walls in seismic conditions”, ISET journal of earthquake technology, vol 45, pp 31-40.

[2] A. J. Khana and M. Sikderb (2004) “Design basis and economic aspects of Different types of retaining walls”, Journal of Civil Engineering (IEB), pp 17-34.

[3] Siva Kumar Babu G. L, (2009) “Simulation of soil nail structures using PLAXIS 2D”, plaxis bulletin, pp 16-21.

[4] Siva Kumar Babu G. L, (2010) “ 2D numerical simulation of soil nail walls”, geotech geological engineering, pp 299-309.

[5] Arindam DEY, et al. (2011) “A full scale instrumented retaining wall: interpretation of the measurements using numerical tools”, 5th International Conference on Earthquake Geotechnical Engineering , Santiago, chile