Performance of Reinforced Earth Retaining Wall with Fly Ash under Static and Dynamic Loading

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ABSTRACT: **Retaining walls shall be designed to withstand lateral earth and water pressures, the effects of surcharge loads, the self-weight of the wall and in special cases, earthquake loads. Retaining walls are used to prevent retained material from assuming its natural slope Estimation of the active earth pressure acting on a segmental retaining wall is very important in the design of many geotechnical engineering structures, particularly retaining walls. In this present study, a numerical simulation of a reinforced earth wall is described and a parametric study using a finite element method is conducted to investigate the performance of the wall under both static and seismic conditions. The damage of retaining wall under seismic forces has been due to the increase in the pressure resulting from the movement of the structure during earthquake. Wall movement and pressure depends on the response of the soil behind the wall, the response of the subsoil.**
In case of Fly ash it is observed that by replacing the Fly ash as a retained fill instead of soil, lateral earth pressure decreases about 75% in static condition and about 55% in dynamic condition. It is also observed that by replacing the Fly ash as a retained fill instead of soil, there is a sufficient decrease about 35% in the displacement of the wall in static condition and largely decrease about 75% in dynamic condition. The proposed numerical model intended to study the effect of Fly ash on the lateral earth pressure and displacement of the wall.

***Index Terms*— Static & Dynamic earth pressure, Wall displacement under Seismic forces**

I. INTRODUCTION

A soil mass is generally a discrete system consisting of soil grains and is unable to withstand tensile stresses and this is particularly true in the case of cohesion less soils, like sands such soils cannot be stable on steep slopes and relatively large strains will be caused when external loads are imposed on them. Reinforced earth is a composite material, a combination of soil and reinforcement suitably placed, to withstand the development of tensile stresses and also to improve the resistance of the soil in the direction of the greatest stress. Excessive dynamic earth pressure due to earthquakes has caused several instances of major damage to retaining structures. The increase in lateral earth pressure during earthquakes induced sliding and/or overturning of the retaining structures. The seismic behavior of retaining wall depends on the total lateral earth pressure that develops during the earth shaking. This total pressure includes both the static gravitational pressure that exist before earthquake occurs and the transient dynamic pressure induced by the earthquake. Therefore, the static pressure on the retaining wall is of significant in the seismic design of retaining wall. Dynamic wall pressures are influenced by the dynamic response of the wall and backfill and can increase significantly near the natural frequency of the wall-backfill system. Permanent wall displacements also increase at frequencies near the natural frequency of the wall-backfill system. Dynamic response effects can be particularly significant for walls that penetrate into the foundation soils when the backfill soils move out of phase with the foundation soils.

II. LITERATURE REVIEW

Faisal Ali & Lee Chee Hai (2011) [2] describes numerical simulation of a reinforced earth wall construction and a parametric study using a finite element method is conducted to investigate the performance of the wall during and after construction. The main objective of this study was to Investigate and determine the influence of the boundary Conditions on the behavior of the anchored reinforced Wall system. The boundary conditions investigated were the slope surcharge at the crest, the deformation at the Facing and the deformation at the base of the wall. The Mohr-Coulomb soil model was chosen to model the foundation soil. This was an elastic perfectly-plastic soil model. The results show that if the wall is allowed to move laterally, horizontal pressures at the connection increases with the depth of overburden until a depth of 0.6 H (height of wall) is reached. Beyond 0.6 H, the horizontal pressure starts to reduce with further depth. With the insertion of the geo inclusion at the wall facing, the horizontal pressure decreases as the geo inclusion becomes more compressible.

Bujang B. K. Huat et al(2011) [3] found that using drainage systems behind a retaining wall (RW) could control the excess pore water pressure during seismic loading, it has an essential effect on reducing the amount of water pressure adjacent to wall structures. Three different models were analyzed using 2D Plaxis, They found that using drainage system for both cases has an important effect in reducing the forces acting for overturning the structures. The reduction factors were 35% and 38% for bending moment and shear stress value respectively. The horizontal deformation reduction factor at the top of the wall observed as 43% in comparison with the non drainage used one.

III. MATERIALS USED AND ITS PROPERTIES

The properties of the foundation soil used for the analysis are listed as shown in Table No.1. As a backfill granular soil is having dry density 18 kN/m^3, cohesion 100kN/m^2 and friction angle 36° is used. Table No.2 represents the properties of wall.

Table.1 Properties of Foundation soil

Dry soil weight (γ_{dry})	18 kN/m^3
Wet soil weight (γ_{wet})	20 kN/m^3
Permeability in hor. direction (k_x)	1 m/day
Permeability in vert. direction (k_y)	1 m/day
Young's modulus (E_{ref})	20000 kN/m^2
Poisson's ratio, μ	0.3
Cohesion (C_{ref})	100 kN/m^2
Friction angle (φ^0)	34
Dilatancy angle, (ψ^0)	0
Interface strength reduction factor	1
Interface permeability	Neutral

Table.2 Properties of Wall

Axial stiffness (EA)	6.9X10^7 kN/m
Flexural rigidity (EI)	5.175X10^7 kN-m^2/ m
Equivalent thickness (d_{eq})	3.0 m
Weight (w)	5 kN/m/m
Poisson's ratio (μ)	0.30
Rayleigh α	0.01
Rayleigh β	0.01

IV. NUMERICAL MODELLING

In the present numerical analysis the soil has been modeled using the Mohr coulomb model and hardening soil model, incorporated into the Plaxis program, considered in drained conditions. The numerical analysis was carried out in plane strain as presented in Figure 1. The layout of the numerical model extends 30m horizontally and 25.75m vertically to the model, these boundary limits were assumed to be sufficient to avoid border disturbances. Conditions of plane strain were assumed throughout; the vertical boundaries of the model were pinned in the horizontal direction but free to move vertically and the horizontal boundary at the base of the model was assumed to be pinned in both vertical and the horizontal directions. Additionally earthquake loads are taken for dynamic analysis.

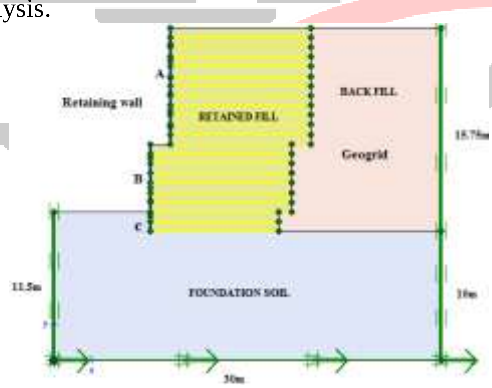

Fig.1 Geometry and Boundary Conditions

The analysis showed that horizontal stress varies from zero to maximum value of 146 kN/m^2. In this work an attempt has been made to study the dynamic behavior of Reinforced Earth Wall. From the numerical analysis, the results obtained mainly in terms of wall displacements at point A,B,C,D,E and F and earth pressure computation from different points shown in the fig 2

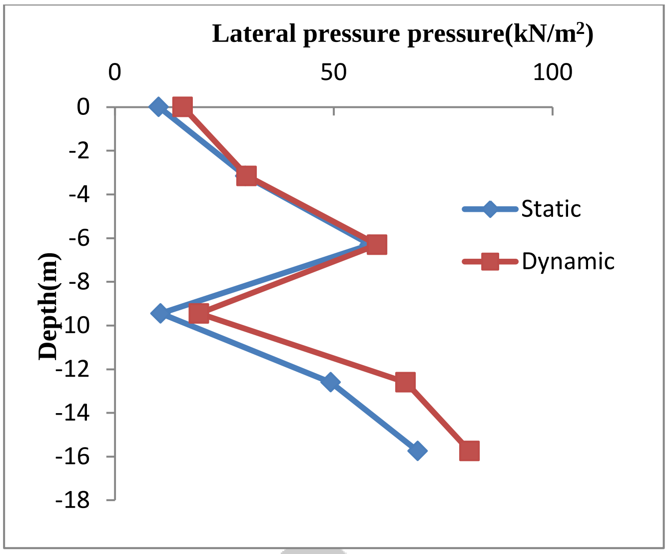

Fig.2 Lateral Earth Pressure v/s Depth

Fig.2 represents the variation of lateral earth pressure v/s depth, it shows that Dynamic earth pressures are more than the static earth pressures due to the movement of the structure during earthquake. Dynamic analysis is carried out by considering earthquake boundary conditions.

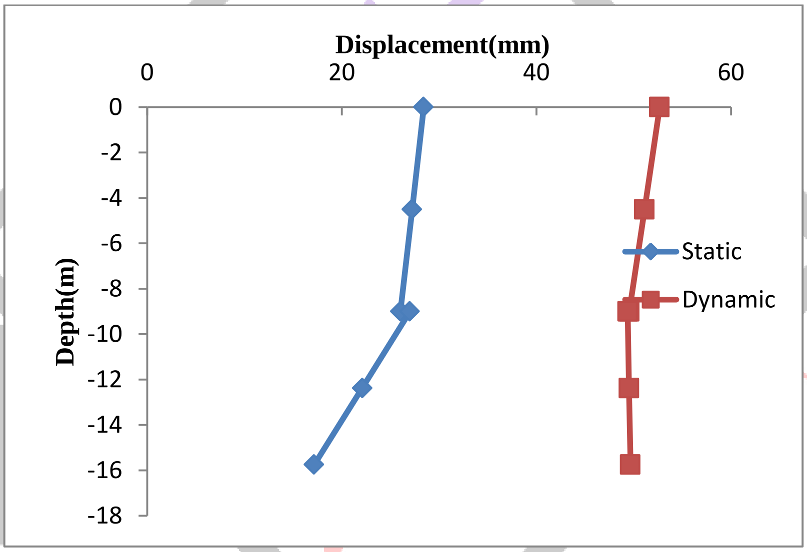

Fig.3 Wall Displacement v/s Depth

Fig.3 shows the variation of Horizontal displacement of the wall v/s depth for both static and dynamic analysis from that it clearly shows that dynamic displacements are more compared to static displacement due to earthquake.

V. REINFORCED EARTH WALL WITH FLY ASH AS A RETAINED FILL

In this analysis fly ash material has been provided as a retained fill instead of soil using the Mohr's Coulomb model, incorporated into the Plaxis program, considered in drained conditions. Table 3 gives the properties of Fly ash Material used. Figure 5 represents the model with fly as retained fill of wall.

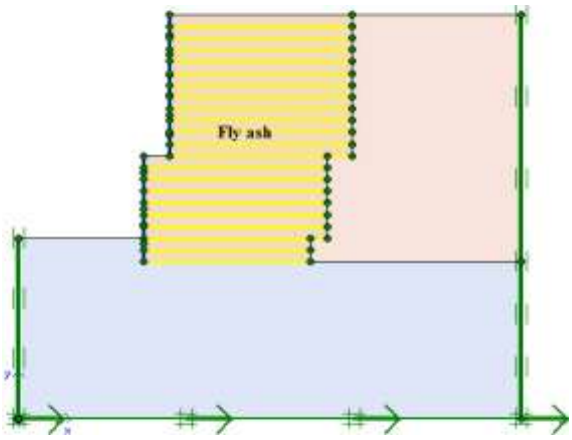

Fig.4 Geometry and Boundary Conditions

Table 3.Properties of Fly ash

Wet soil weight (γ_{Sat})	13.82 kN/m^3
Permeability in hor. direction (k_x)	1 m/day
Permeability in vert. direction (k_y)	1 m/day
Young's modulus (constant) (E_{ref})	8000 kN/m^2
Poisson's ratio, μ	0.38
Cohesion (constant) (C_{ref})	20 kN/m^2
Friction angle (φ^0)	14
Dilatancy angle, (ψ^0)	0

VI. RESULTS AND DISCUSSION

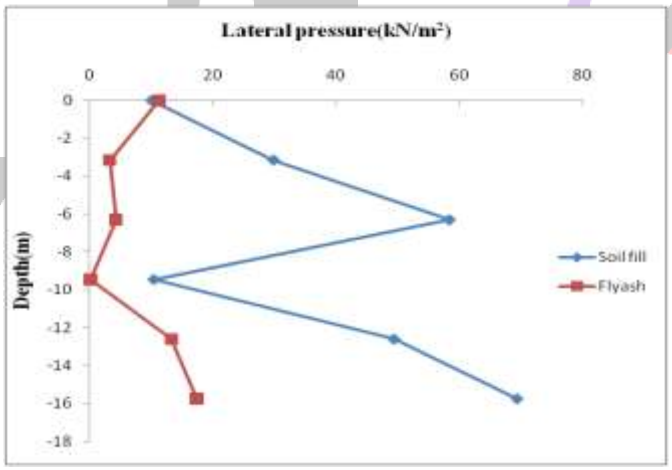

Fig.5 Static Earth Pressure v/s Depth

Fig.5 represents the variation of Static earth pressure with the depth with Fly ash as a retained fill. It clearly shows that Fly ash reduces the lateral earth pressure about 75% as compared to the case 1. Result obtained in dynamic case is same as static case. It shows that Fly ash reduces the lateral earth pressure about 55%.

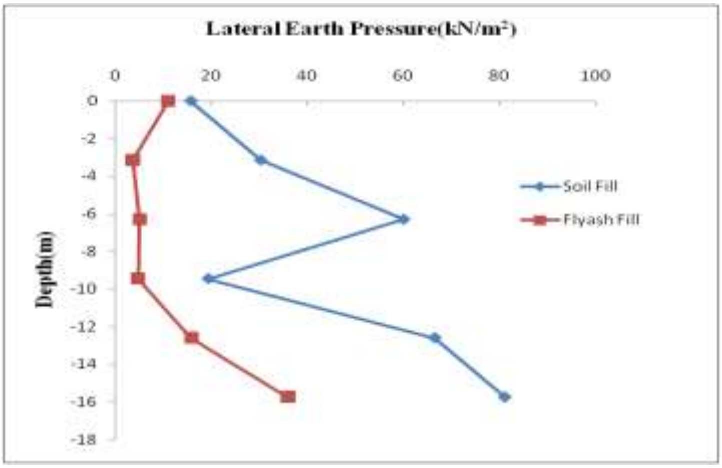

Fig.6 Dynamic Earth Pressure v/s Depth

From the above result it can be seen that, by replacing the Fly ash instead of soil is very effective in reducing the lateral earth pressure both in Static case and Dynamic case.

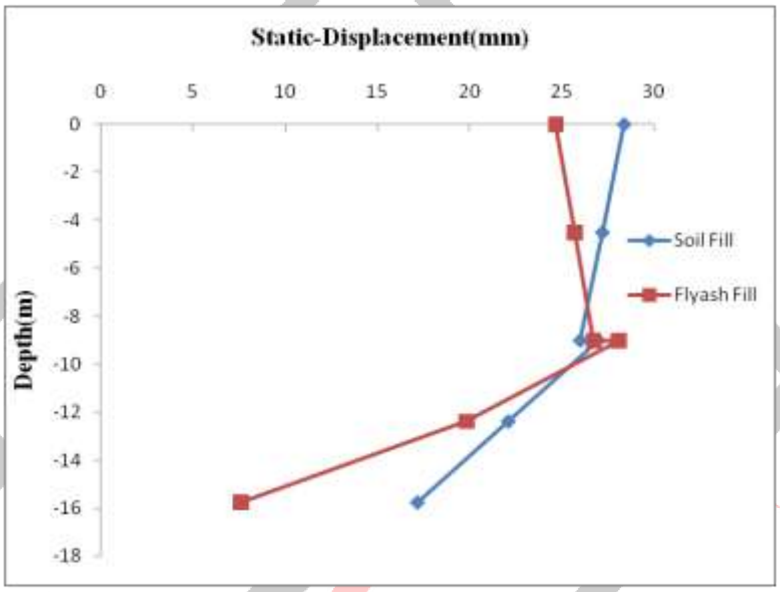

Fig.7 Wall displacement v/s Depth

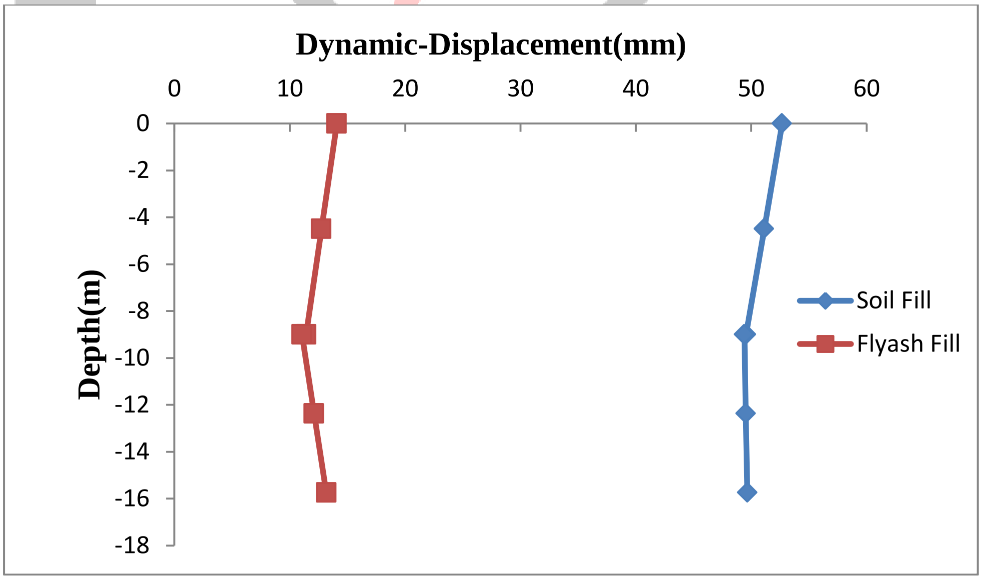

Fig.8 Wall displacement v/s Depth

Fig.7 shows the Horizontal displacement of the wall with the depth in Static case. It represents that by replacing the Fly ash instead of soil, there is a greater decrease in the displacement at top and bottom of the wall but at the depth 0.6H it is increased compared to Soil fill. But in the Dynamic case there is a greater decreasing in the displacement of the wall compared to Soil fill as shown in the Fig.8. From the above result it can be seen that, By replacing the Fly ash instead of soil it highly effects the displacement of the wall in both static and dynamic case.

CONCLUSIONS

1. Analysis shows that the fly as can be used as backfill material as it is effective in reducing the displacement of retaining wall. It also solves the problem of disposal of fly as by making best utilization of it as backfill material.
2. By replacing the Fly ash as a retained fill instead of soil, lateral earth pressure decreases about 75% in static condition and about 55% in dynamic condition.
3. By replacing the Fly ash as a retained fill instead of soil, there is a sufficient decrease about 35% in the displacement of the wall in static condition and largely decrease about 75% in dynamic condition.

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