***Corresponding author:** Emmanuel EJ, Addis Ababa University, School of Technology, China State Construction Engineering Co Ltd, Ethiopia, Tel: +251 92 262 7694; E-mail: emuriat25@yahoo.co.uk

Received December 20, 2016;

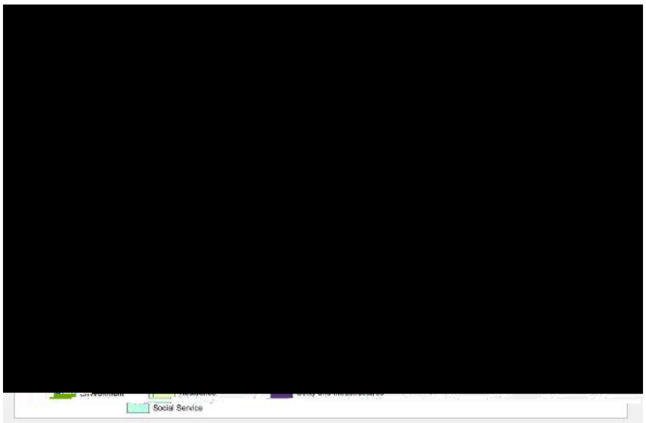

Figure 1: Site location plan.

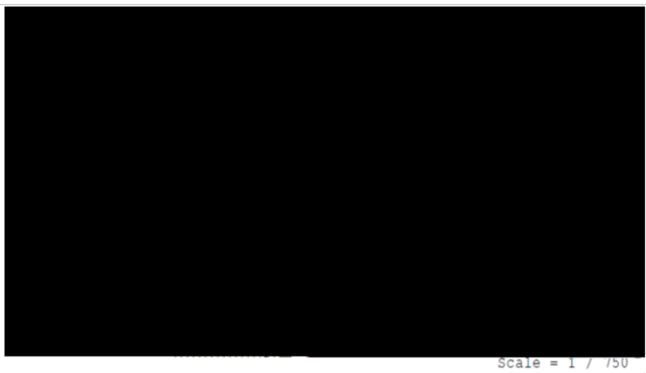

Figure 2:

ere are many internationally recognized codes of practice related to the design and construction of the excavation and lateral support works. Stability of excavation is the major criterion in order to avoid collapse of the excavation. Stability analysis involves the distribution of the earth pressure.

is section presents the Finite Element Method (FEM) analyses with PLAXIS3D so ware.

PLAXIS” is a three-dimensional element computer program used to perform deformation and stability analysis for various types of geotechnical applications.

is program allows di erent soil types to be modelled along with structural and interface elements for realistic representation of soil structure interaction e ects.

The numerical modelling was performed by "PLAXIS" 3D Finite Element Method in order to carry out parametric studies, since it allows for modelling complicated nonlinear soil behaviour and various interface conditions with different geometries and soil properties.

Other material parameters required for modelling were determined as per the material used and the modelling was according to the site dimensions.

Model geometry is shown in Figures 3-5.

Model Parameters are given in Figures 4-7.

Due to the existence of several buildings around the excavation and the associated traffic. The large surcharge load is expected to take care of the adjoining structures and the traffic loading. The applied overload of 150 kPa 36 was used in the modelling. This load was used in 3D finite element analysis of a deep excavation for the Odeon project in Monaco. The project consisted of the construction of a high-rise building (160 m), the tallest building in Monaco with approximately 10 basement levels, located on a steep slope hillside. TERRASOL was the geotechnical consultant to carry out soil testing, foundation and 3D finite element model to analyze the influence of excavations on surrounding buildings.

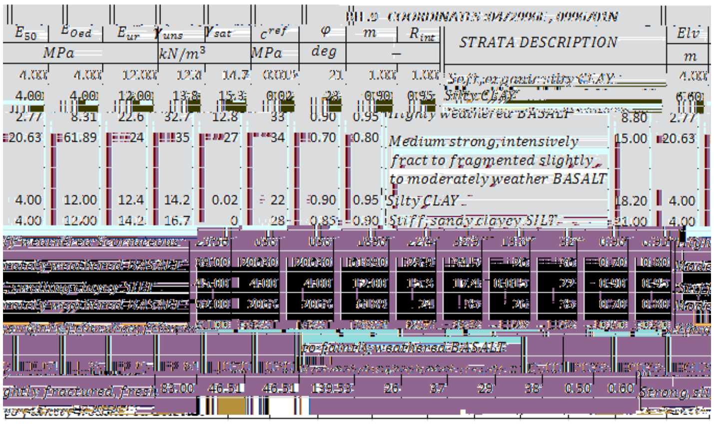

Figure 4: Summary of ground conditions encountered in borehole(BH9).

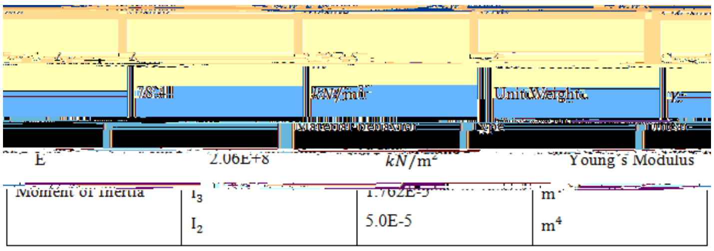

Figure 5: Material properties of beam(C-Plain purlins).

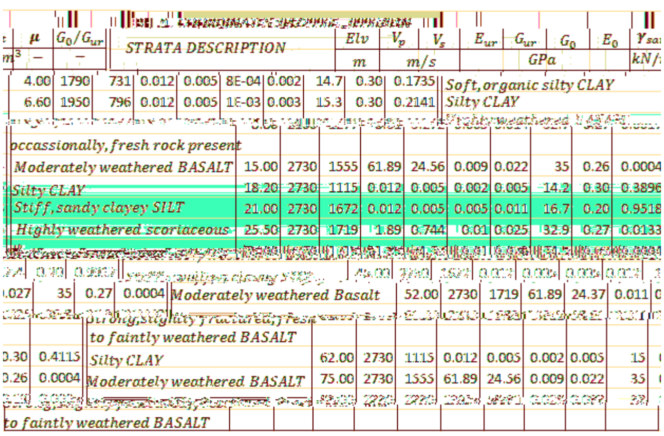

Figure 6: Summary of Seismic properties encountered in borehole(BH9).

In 3D plaxis non option is selected, it is assumed that the base of the model is rigid and the seismic signal is trapped within the soil deposit and cannot escape through the bottom boundary (Figures 8-10).

e comparison was made between the secant and the shotcrete model. e soil material parameters and the loading conditions are the same in both models. e basic di erence between the two models is the sti ness parameter which in uences the results of the modeling. At the maximum excavation depth of 20 m the two models were subjected to deformation analysis and conclusions were drawn (Figure 11).

Comparing the maximum results of the displacements, contact stresses and other important parameters between shotcrete and secant pile model the following can be concluded:

e displacements in both models are acceptable and must apparently be regarded as unavoidable, even if a typical shotcrete shoring and shear wall system are currently used as the retaining structure in the New Commercial Bank building. Secant pile wall or a sheet pile might fare just well if it were correctly braced or anchored.

e unloading and reloading modulus is larger, thus sti ness is built up in the foundation. e sti er the foundation the larger structural sti ness and hence the smaller the displacement and the more the time

Figure 7: Material Properties for node to node Anchors.

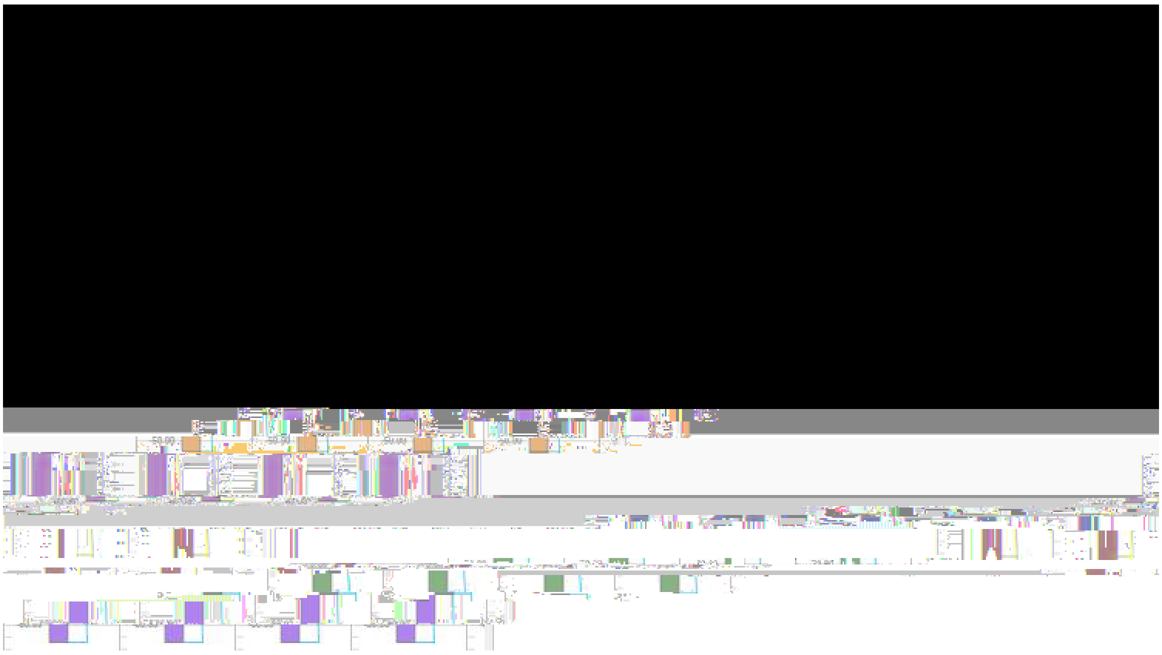

Figure 8: Soil proýle in Plaxis 3D Model.

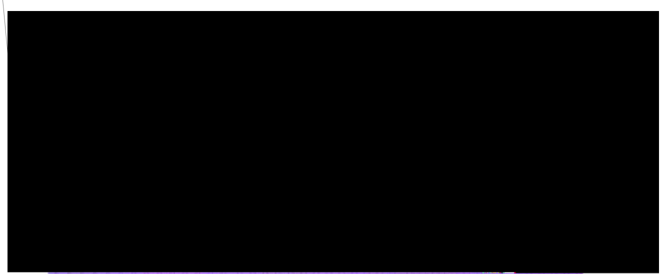

Figure 9: Overview of mesh set up for model B in Plaxis 3D model.

Figure 10: Overview of model B and ground Anchors in Plaxis 3D model.

required for the analysis in plaxis due to the larger matrix generated. This was also observed in the result.

The secant pile model is the preferred model to increase the wall stiffness compared to the equivalent stiffness of the shotcrete model.

The new Commercial Bank building site is filled with cobbles/ boulders and the water table is relatively high 5.0 m (field investigation

Citation: Emmanuel EJ

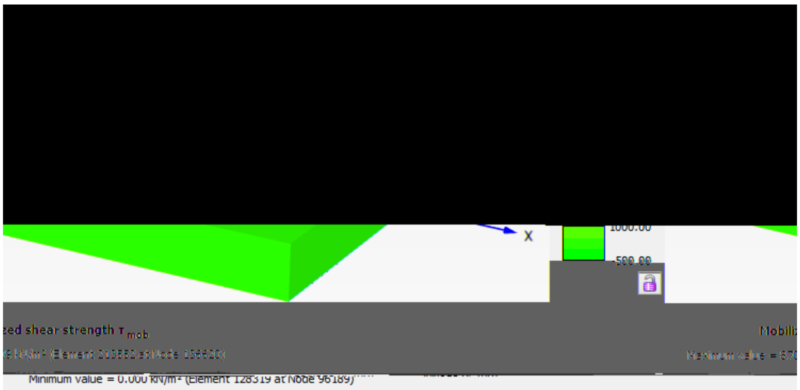

Figure 21: Mobilized shear strength at 10m excavation.

Figure 22: Mobilization of undrained shear strength.

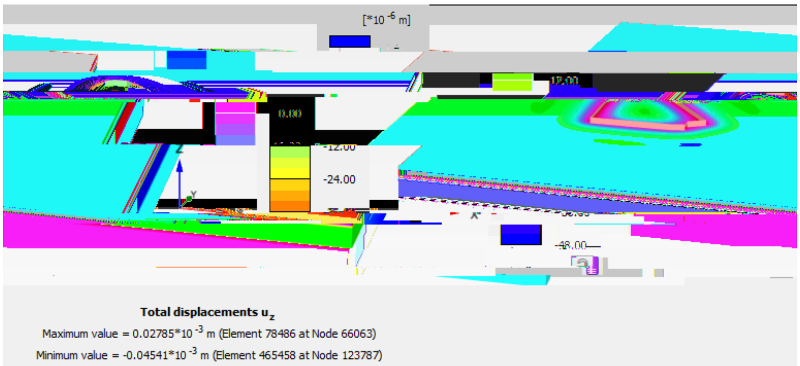

Figure 23: Total displacement U_z at 5m excavation.

varies with building period; as the period lengthens (moving towards the right of the horizontal axis of the spectrum), accelerations decrease and displacements increases (Figure 27).

e velocity of motion on the ground caused by seismic wave is quite slow. is is because large quantities of earth and the rock are moved. As a result the motion of the structure is slow and the displacements are very low (Figure 28).

Earthquake shaking is initiated by a fault slippage in the underlying rock. As the shaking propagates to the surface, it may be ampli ed depending on the intensity of shaking, the surface soil and depth of the layers and the nature of the rock.

Weaker layers of so soil may results in to higher ampli cation factor over the rock shaking. e ampli cation factor 1.0 indicates the soils are rm. e ampli cation also tends to decrease as the level of shaking is increased. e earthquake damage tends to be more severe in areas of so soils (Figure 29).

In order to stimulate eld conditions in the numerical modelling the initial stresses were calculated before loading. e k_0 pressure remained the same throughout the calculation.

e analysis also indicated that the maximum total displacement

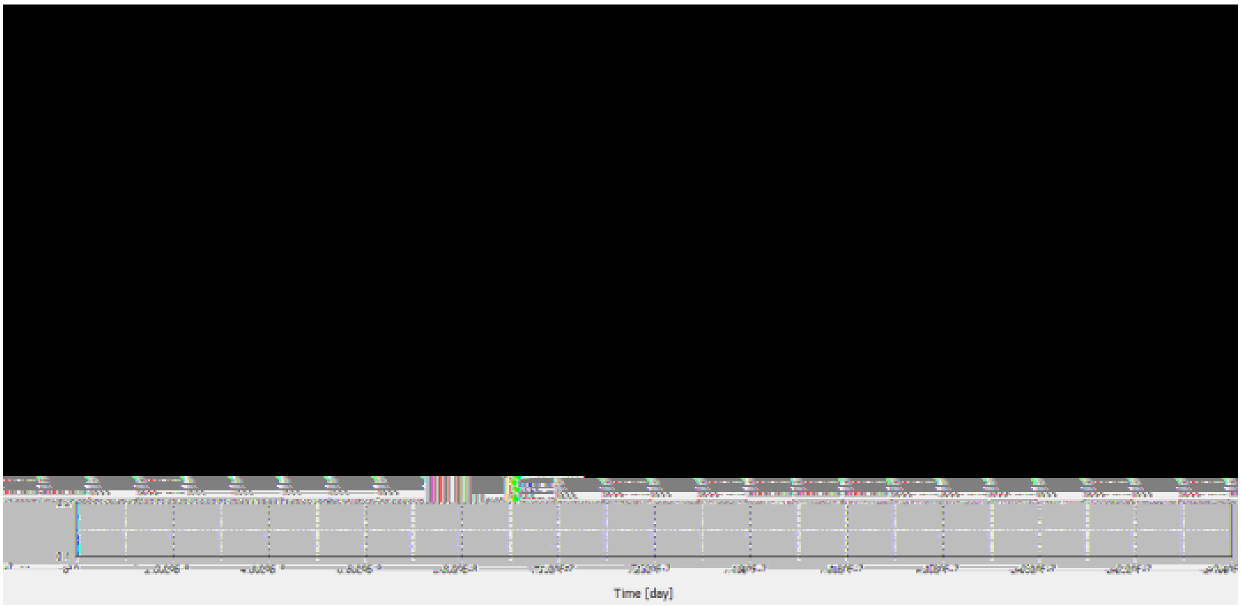

Figure 27: Site Response Spectrum.

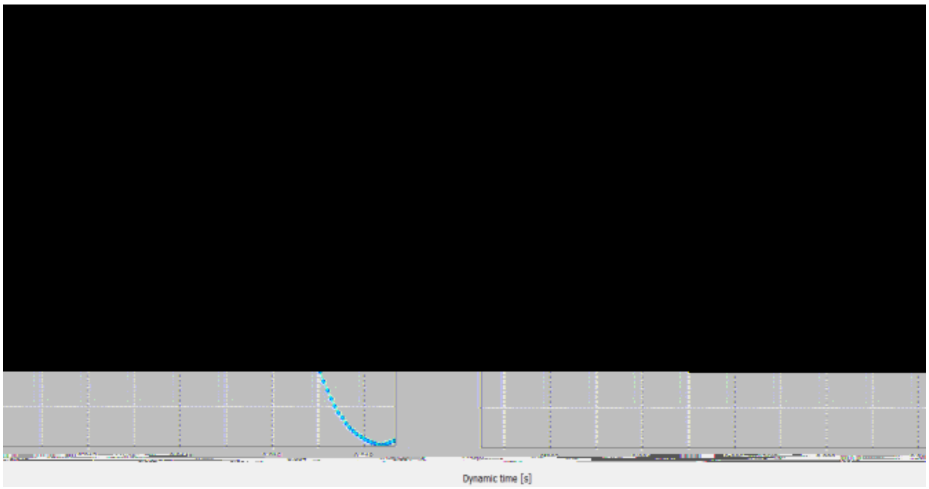

Figure 28: Velocity in horizontal direction.

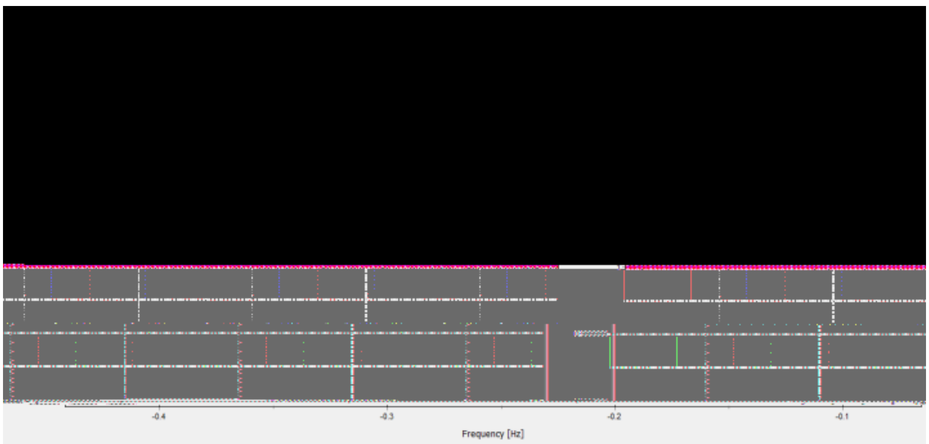

Figure 29: Ground Ampliýcation.

reduced. Further increase in height to 30, 33 and 36 m resulted to signi cant decrease in total and horizontal displacements.

e distinct failure plane of the system can be achieved by reducing the mesh size. e incremental shear strains were observed by re ning the mesh size. e coarser mesh take short time to calculate with higher values of deformations and the smaller mesh takes long calculation time with small deformations.

e stress distribution in the soil plays a role when determining the settlement of foundation. e stresses in the soil closely beneath the foundation slab will almost be the same as the stress acting on the foundation. is stresses will however decrease in large depth of the soil Figures 4 and 8-20. It is clearly seen that the depth increases with reduction in shear strength in the mobilization of undrained shear strength.

e nite element program Plaxis 3D was used to model the secant pile wall. Two di erent constitutive models in plaxis (Hardening soil model and Hardening small strain model) were used to stimulate the structure and soil behavior.

Parametric studies for the geometry were evaluated based on the deformation analysis that was conducted. e test results showed that the dimensions of the excavation may have great in uence over the response of the secant pile wall.

e parametric study on the mesh set up indicate the results especially the distribution of forces varied due to di erent mesh set up. Precisely, coarse mesh leads to forces distributed to limited number of nodes and some nodes receive extra force than the actual condition. In plaxis 3D model the degree of re nement of mesh is essential. e use of coarse mesh discretization was due to expectation of high gradients of stresses near corners or sharply curved edges. e time required for the calculation is long and depends on the matrices size generated. e larger the matrice the more the time required for the calculation.

e excavation step used in the excavation model range from 5 m to 20 m. e result from normal stage excavation model and sequential model with 5 m excavation set the boundaries for all results. In general, longer excavation step results in less calculation time and higher de ection. e whole soil model was stimulated and the stage construction was conducted by deactivated the soil layers in the phase.

With increase in height of pile wall from 24 m to 27 m, there is decrease in deformation of pile wall. Further increase in the wall height to 30, 33 and 36 m resulted to signi cant decrease in total and horizontal wall displacements.

During progress in excavation on stage construction, the ground deformations increase and the settlement value increases as the excavation depth is increased.

e e ect of mesh size was studied by generating a ner mesh and re-running the analysis. A more distinct failure plane of the system was observed by reducing the mesh size.

A sample earthquake recorded by the USGS is used for the analysis. Water pressure is neglected. e total displacement a er the seismic event resulted to less displacements.

e nal results were totally satisfying and for complexity excavation projects of this nature plaxis3D gives stimulations close to reality.

e deformation analysis due to excavation was performed through the plaxis simulations. It was complex to model the real behavior of the soil due to unloading in the plaxis simulations. erefore, increasing the accuracy of the investigation of important soil parameters and other conditions will make plaxis simulations simple and accurate results would be obtained.

Usually the unloading modulus is determined by performing unloading and reloading test in the Oedometer laboratory test. For this simulations the results used were not obtained from the Ondometer test but default value as suggested by plaxis of thrice the tangent modulus.

Further investigations on parameters and other conditions that a ect the deformation analysis like liquid limit, density and swelling parameters of clay, the eld deformation measurements and in uence of structural elements on the deformation near the excavation area shall be carried out in order to increase the accuracy of the deformation analysis and decrease the possible error.

Further investigations on parameters and other conditions that a ect seismic analysis like density and shear modulus and p-waves and S-waves are calculated from those parameters soil.

Using di erent earthquake input in order to investigate the e ect of seismic characteristics such as magnitude, frequency etc. and performing the analysis with the use of structures with di erent geometries.

Acknowledgment

The author wishes to extend his gratitude to the project owner, Commercial Bank of Ethiopia for allowing to use the ýeld investigation data. Many thanks to Dr. Ing. Henok Fikre of the Geotechnical Department at Addis Ababa University, School of Technology for the helpful advice and support. The support provided by China State Construction Engineering Co Ltd is appreciated.

Author Emuriat Julius Emmanuel received the BEng. Degree in Civil and Building Engineering a receiw φ'

9. Jen LC (1998) The design and performance of deep Excavation in clay. PhD Thesis MIT.

10. Atalay A (2016) Unpublished Seismic Investigation Report for the CBE, new building site.

Citation: Emmanuel EJ (2016) Parametric Study on Analysis and Design of Permanently Anchored Secant Pile Wall for Earth Quake Loading. J Archit Eng Tech 5: 181. doi: 10.4172/2168-9717.1000181