Behavior Of Foundation On Reinforced Clay Sandy Soil Adjacent To Slopes And Subjected To Earthquake Load

Mostafa Elswaf[1]; WaseimR.Azzam[2]; Maram Awad Awad[3]

***Abstract*—Structures are subjected to additional loads due to earthquakes may yeild failure in soil and superstructure. The dynamic response of a structure to an earthquake can significantly affected by the geotechnical properties of the bearing soil layers. So, in this thesis the dynamic analysis of structures resting on three types of reinforced and non-reinforced clay sandy soil were studied. Numerical study using PLAXIS 2D (Dynamic module) was carried out. Parametric study was conducted to investigate the effect of reinforcement layers such as number and length of layers as well as, the depth of the first reinforcement layer below foundation. The result of this parametric study was evaluated to show the effect of each parameter on the dynamic response and straining actions of the structure due to earthquake. The present thesis indicates that, it is important to take the effect of soil properties into consideration during the dynamic analysis of the superstructure. Also, the existence of geotextile in the sand is found to be an effective tool to increase the bearing capacity and improve the foundation subgrade response during seismic loading. It can be concluded that the lateral displacement at the foundation level decreased with a value of63% for all cases; while the vertical displacement decreased with a rate of about 70%. The structure response also improved with using geotextile layers. The lateral deformation and acceleration reduced by 73%, and 65%respectively. In addition, the induced bending moment and shear force reduced by 71% and 80% respectively.**

Keywords—Seismicloads, Geotextile, Foundation, Numericalanalysis.

1-Introduction:

2.1 Introduction:

A massive earthquake and its devastating aftershocks are one of nature's most terrifying and destructive events.An earthquake is a sudden movement of the Ground due to sudden release of long-term strain.Plate tectonic forces have formed the Earth for millions of years because the massive plates that make up the Earth's surface gently move over, beneath, and past each other.At other times, the plates are locked together, preventing the building energy from being released. The plates break free when the accumulated energy becomes strong enough. If the earthquake happens in a populous location, it might result in a large number of deaths and injuries, as well as substantial property damage.Today, we are debating whether earthquakes must be an uncontrollable and unpredictable threat to life and property. Moreover, Scientists have begun to predict the locations and probabilities of future destructive earthquakes

Soil reinforcementis considere done of the modern methods in the field of Foundation Engineering which aims to raise the soil resistance to excess loads. Themeaningofreinforcingthesoilisstrengthenthesoilby adding new materials Performed the same purpose,which Played by steel in concrete.Soil reinforcement performed by using different elements in the form of strips(Geosynthetic).These materials have high resistance to chemical and biological degradation and can be processed to meet the requirements of resistance, tensile deformation, providing good adherence with the reinforced soil. In this research, it has been used as a new tool to increase bearing capacity of the soil and decreasing the settlement of the foundation as stated by Arvind(2000), Puri(2010), Keshavarz(2011), and Agarwal(2012). The soil reinforcement technique was also used to improve the soil resistance against dynamicloads as reported by(Shin2009, Hajiani2010, Elsawwaf2011, Vinod2011, Asakereh2011, Moghaddas2012, Khalaj2012, and Gohil2013). The previous technique of using soil reinforcement was mainly focused only on studying the behavior of foundation without considering its effect on the performance of the both foundation and structure. Therefore,the present paper was aimedat studying the effectof increasing the subgrade stiffness using soil reinforcement on the deformation characteristics of foundation performance pluss uperstructure under earthquake loading. In order to avoid the scale effect and the problem of shaking table, full-scale testes were used to simulate the actual foundation building behavior.The finite element analysis using Plaxis dynamic version, was adopted to model the earthquake and thes tructure.

2 Numerical modeling and selection of parameters

The plane strain model was used with the six node element.For the mesh generation, the global coarseness is set to ’coarse’ and the clusters inside the building are refined twice. This is because of the high concentration of stresses that canbe expected just in and under the building elements. The subsoil is consisted of a deposit of clay layer of 40 m thickness. It assumed to be Mohr-coulomb in dynamic analysis. The Rayleigh damping is considered at vertical boundaries with o, § = 0.01 in order to resist the Rayleigh waves.While the plastic propertiesof soil (viscous properties)are defined by using material damping,whichis defined in PlaxisbyRayleigh (o and b), where a damping term is assumed which is proportional to the mass and stiffness of the system (Rayleigh damping) such that: C = o M + §M, C damping coefficient, Mmass, K stiffness and. (o and b) Rayleigh coefficient. The Rayleigh damping is considered to be object-dependent in material data set to consider the plastic properties of soil during the dynamic analysis in Plaxis. The adopted building consists of basement and 10 floors with total height 33 meters; it has two bayswith total width 10 meters. The building and foundation are simulated as plate properties. Geosynthetic material as geotextile of polypropylene(PP) is used.For all the models analyzed,the values of (h/B), and (d/B) were taken as, 0.1 and 0.2 respectively, (L/B) was taken as (1, 2, and 3) and N was from (1 to 3).Where B is the foundationwidth, h is the vertical spacing of consecutive geotextile layers, L is the geotextile length and N is the number of geotextile layers.The geotextile properties are(EA= 15000 KN/m).The earthquake is modeled by imposing a prescribed horizontal displacement at the bottom of boundary in contrast to standard unit length(Ux=0.01mandUy=0) as used in manual default. The geometry of finite element model adopted for the analysis is shown in Figure 1.The selected monitored points along building and foundation was used to identify the performance of both foundation and building during earthquake. These points are selected on the top of the building,at foundation level and within and under the reinforced zone.

Properties of the soil

Parameter	clay	sand
Material type	Un- drained	Un- drained
Material model	Mohr coulomb	Mohr coulomb
Soil unit weight	16 KN/m2	18 KN/m2
Modulus of elasticity	2100 KN/m2	5000 KN/m2
Poisson’s ratio	0.32	0.3
Cu, (kpa)	70	.001
Angle of friction (φ)	0	38
Dilatancy angle (ψ) (φ-30)	0	8

properties of the beam

parameter	Name	value	unit
Type of behavior	**Material type**	**Elastic**	**------**
Normal stiffness	**EA**	**2.344E+07**	**KN/m**
Bending stiffness	**EI**	**3.126E+05**	**KN/m2/M**
Equivalent thickness	**d**	**0.4**	**M**
Weight	**W**	**17.5**	**KN/m2**
Poisson ratio	**υ**	**0.15**	**--------**

properties of the columns

parameter	Name	value	unit
Type of behavior	**Material type**	**Elastic**	**------**
Normal stiffness	**EA**	**2.200E+07**	**KN/m**
Bending stiffness	**EI**	**1.833E+05**	**KN/m2/M**
Equivalent thickness	**d**	**1**	**M**
weight	**W**	**25**	**KN/m2**
Poisson ratio	**υ**	**.15**	**--------**

properties of the reinforcement

Geotextile		
EA	**1-500E+4**	**KN/m**

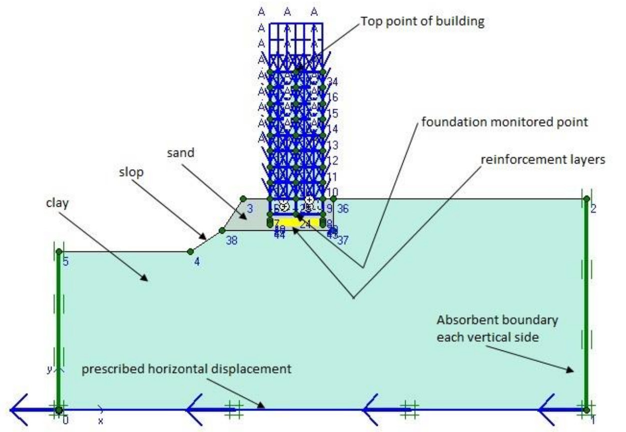


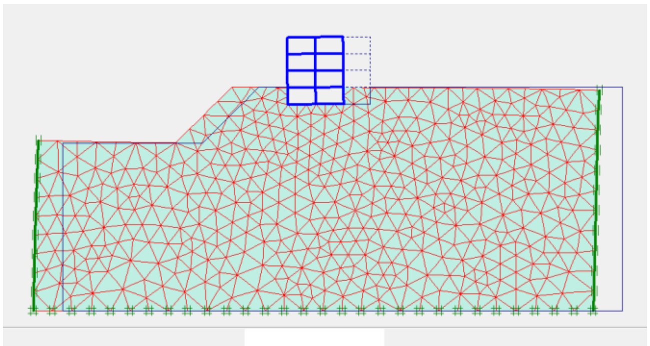
Figure1:Geometrymodelwithstandard earthquake boundaryconditions

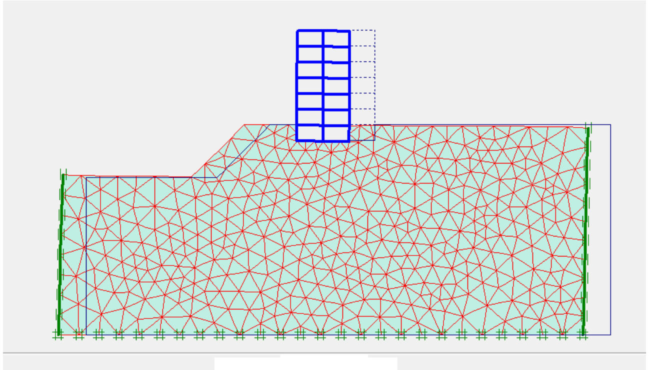
2.1 Analysisprocedures:

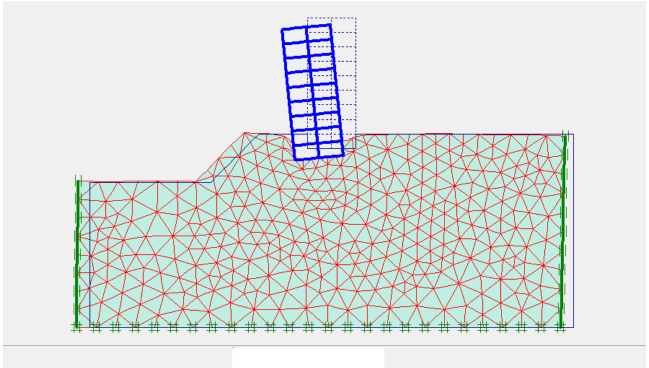
A series of dynamic numerical models were run for the problem investigation using under different numbers of floor ; different distances from slope ; different numbers of soil replacement and different numbers of geotextile layers. The calculation procedure involves two phase.The first one is a normal plastic calculation in which the building is constructed. The second is a dynamic analysis in which the earthquake is simulated. In this phase the displacement are reset to zero and the time interval 10 sec,the acceleration of the input earthquake is chosen from the default acceleration data file in program (225smc) (SMC, Strong Motion CD-ROM). The acceleration time history used as a default in program with maximum horizontal acceleration of 2.3 m/sec2 at time of 2.53. Before the mesh generation, the water pressure can be activated for considering the pore water pressure.

3 Resultsandanalysis:

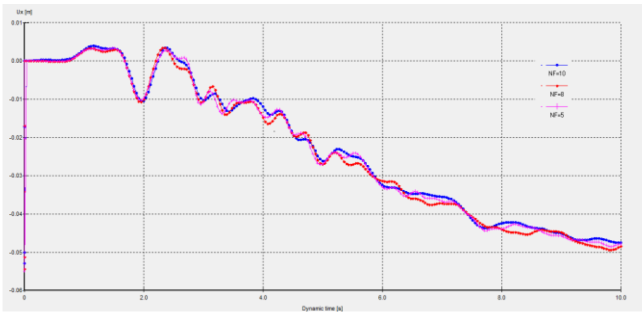
3.1 Effectofnumbers of floors:





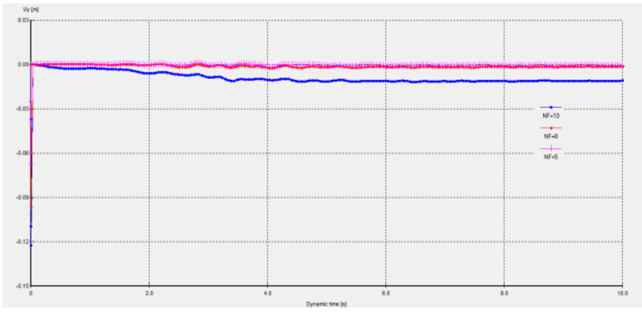


Horizontal displacement



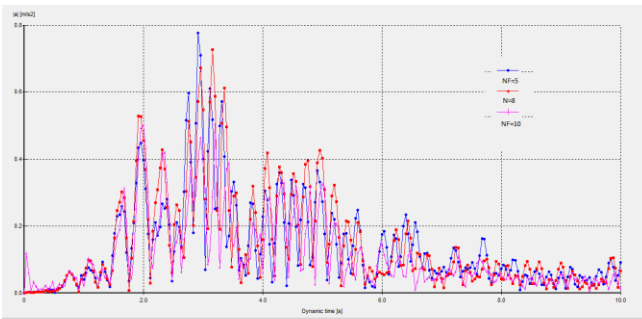
Dynamic time

vertical displacement

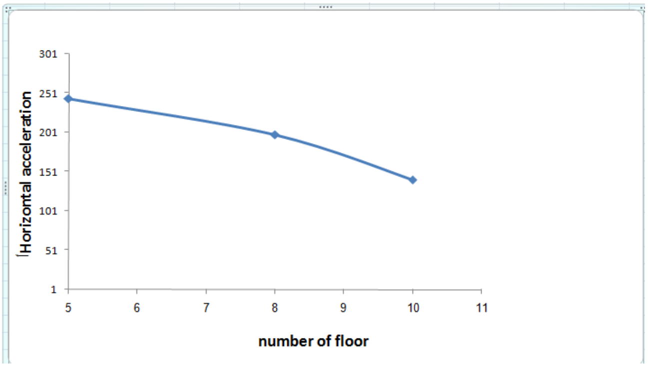


Dynamic time

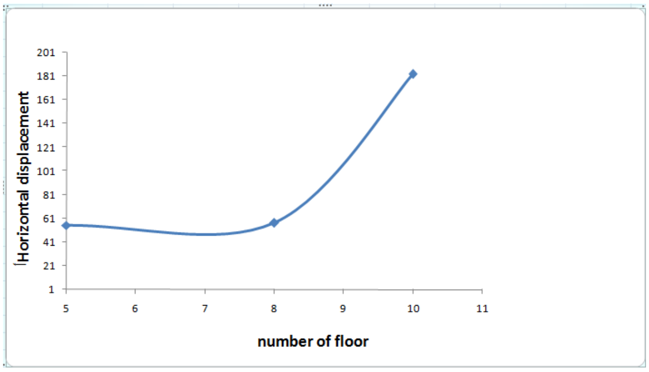
Acceleration



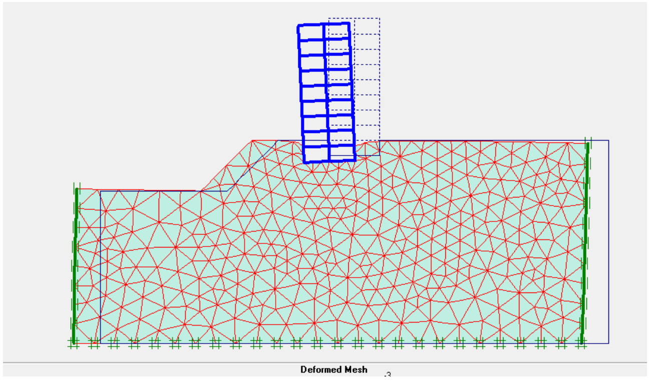
Dynamic time



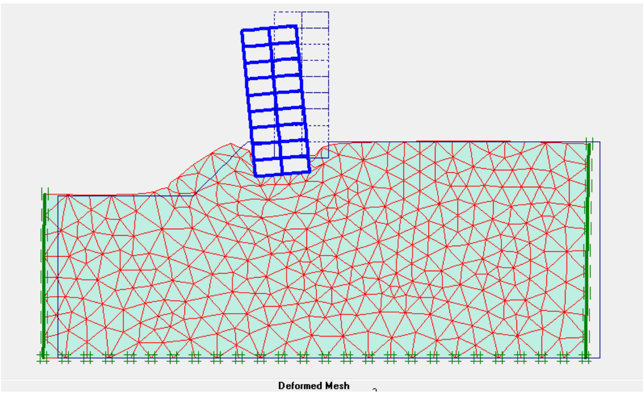
Horizontal displacement

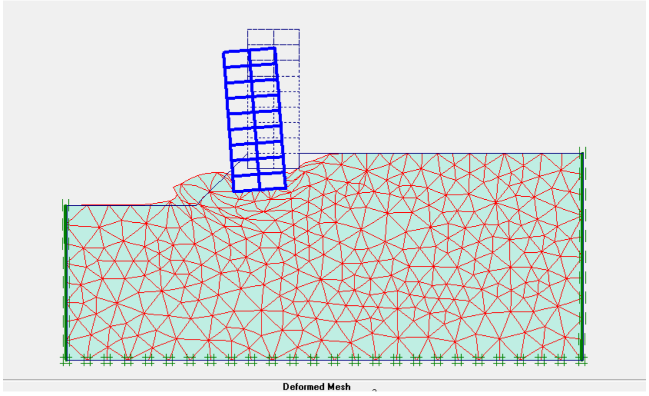


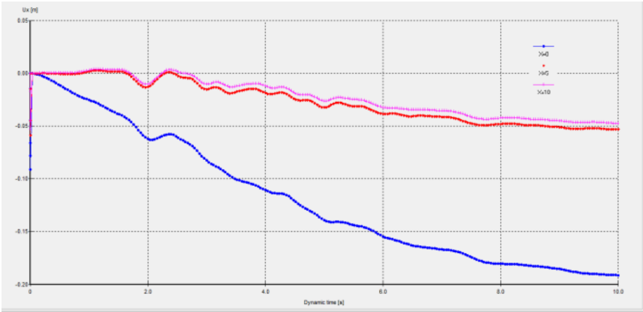
3.2 Effectofdifferent distances from slope :



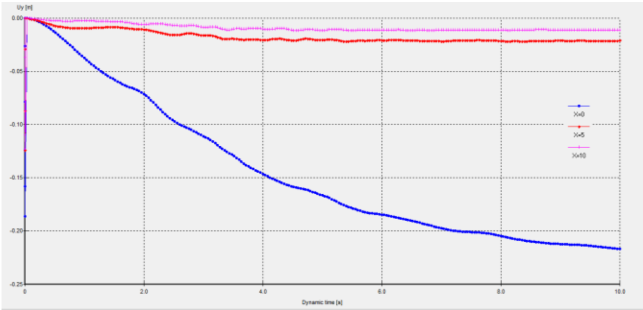
acceleration







Dynamic time



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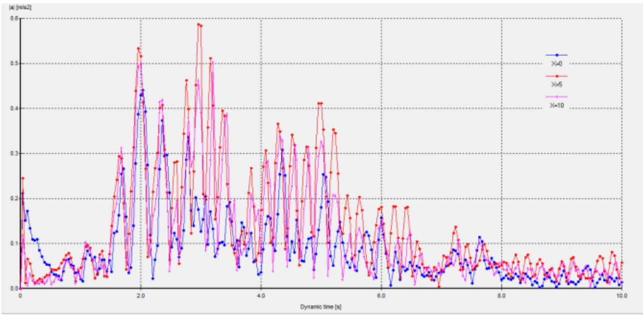
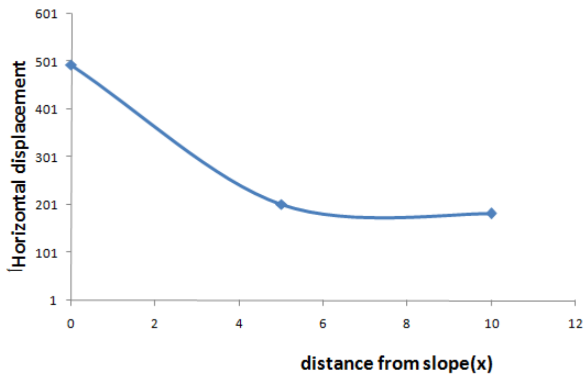
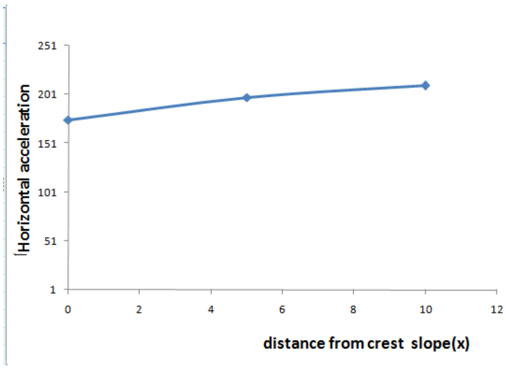
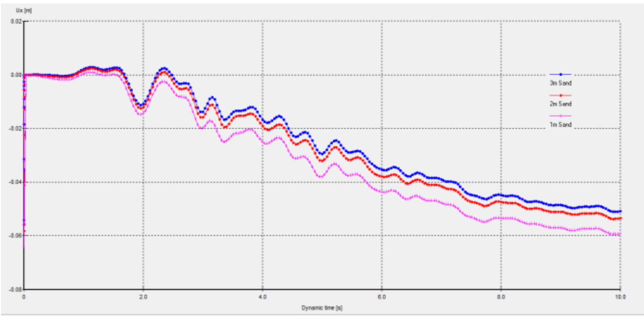


Dynamic time

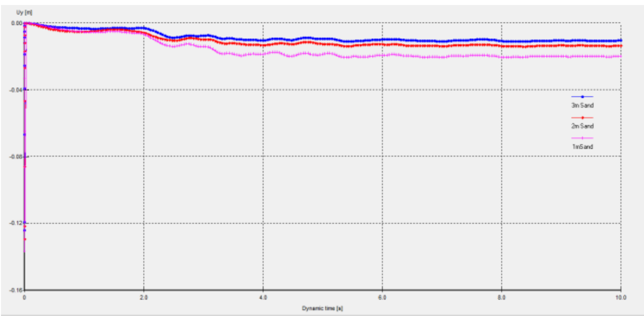




3.3 Effectofdifferent number of soil replacement :



Dynamic time



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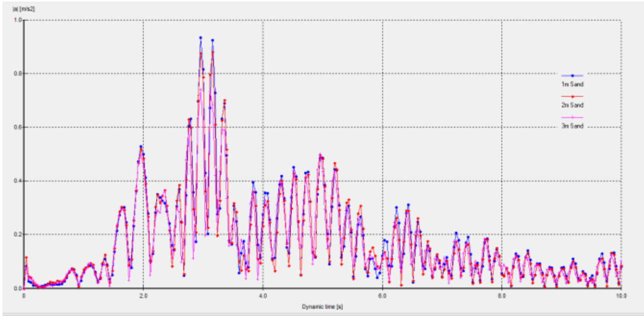

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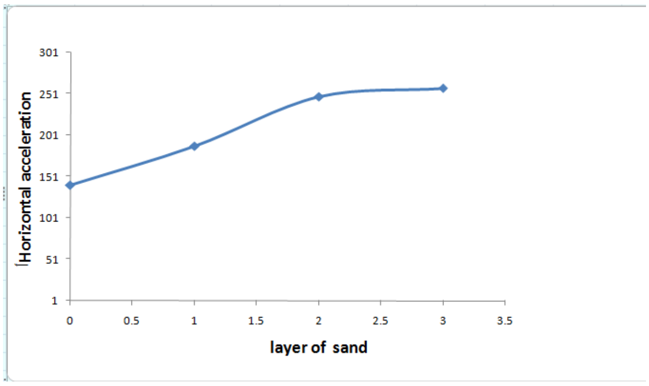
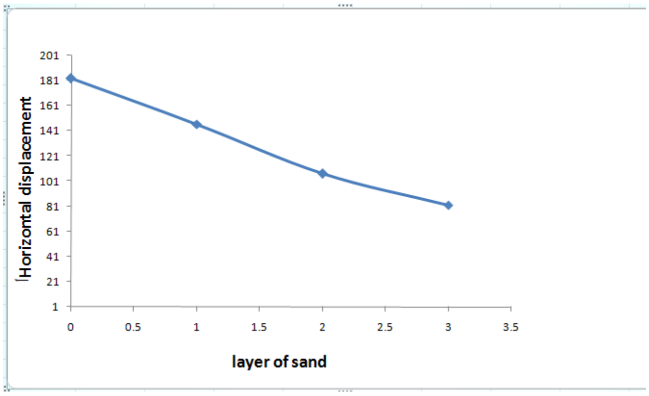
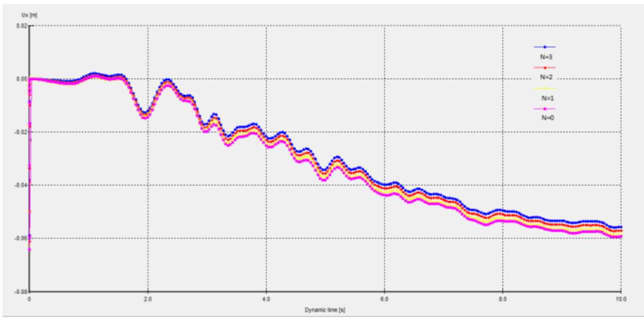




3.4 Effectofdifferent number of geotextile layers :

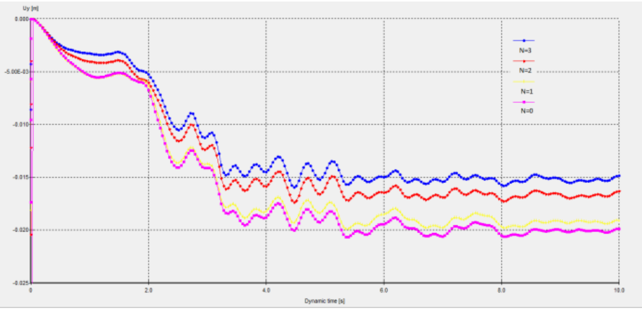


Dynamic time

horizontal displacement

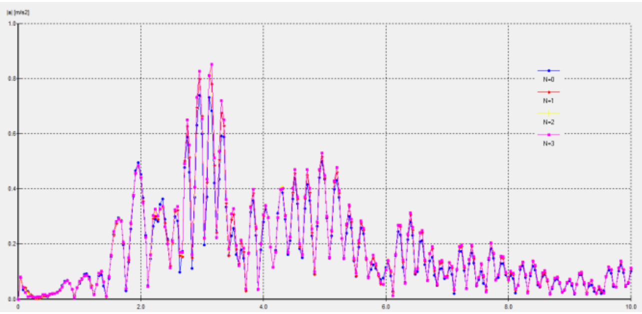
acceleratiohorizontal displacement

vertical displacement



Dynamic time

Acceleration



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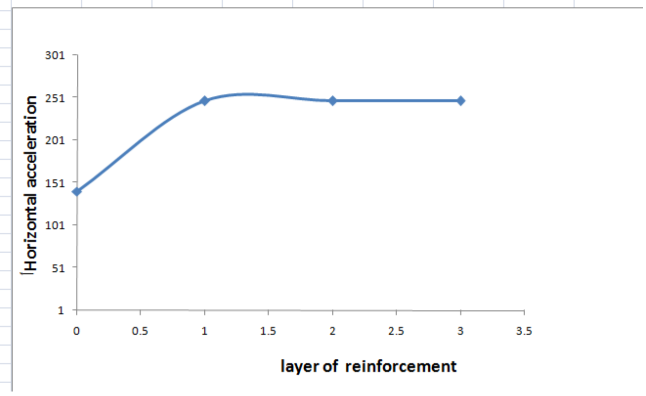

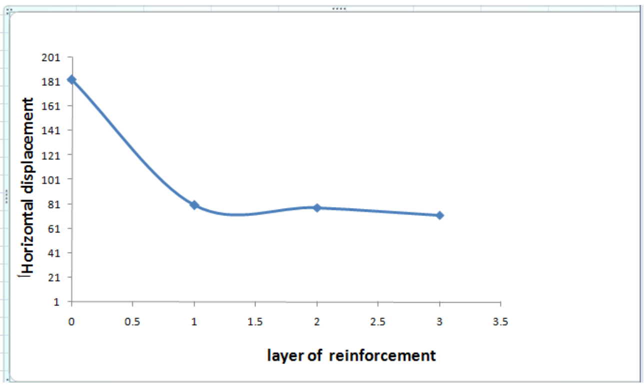

Conclusions:

Based on the finite element analysis for reinforced foundation soil system subjected to anearthquake, the benefits of using geosynthetic-reinforced sand foundations were demonstrated inthispaperthroughincreasingthesoil'sbearingcapacityand reducingthefootingsettlement.

The following conclusions can be drawn:

1) The finite element analysis of the problem under investigation is helped in betterunderstandingthedeformationbehavior,failurepatternandinducedbuildingdeformationundertheeffectofearthquake.

2) Thereductionofextremehorizontaldisplacement,andbendingmomentforfoundationreachedto63%,and78% respectivelyat3reinforcedlayer=3.

3) Thereinforcementreducethefoundationaccelerationby63%ofitsinitialvaluethisleadtoconsiderableeffectofincreasingthefoundationstability.

4) Thesoilwithinthereinforcedzonewasactedasacoherentmasswhichincreasethebuildingstability and absorb the ground excitation. This coherent mass prevents the accelerationamplification from occurrenceand the soil shear strains associatedwith earthquakeloading istakenplaceunderthereinforcedzone.

5) Thereductioninexcessporepressurewasfoundtobe70%atN=3.Thereinforcedlayersareconsidereda goodmethodtopreventandcontroltheexcessofporewaterpressurebelowthefoundationduringearthquakes.

6) There is considerablereductionin the lateral deformation, acceleration and bending momentofthesuperstructure,thesereductionswere63%,65%and75%respectivelyin additiontoincrease the building stiffnessdue to inclusion of the reinforcement. Therefore,it considered aneconomicinsuperstructuresdesign.

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