Evaluation of Seismic Mitigation of Embankment Model

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Abstract
Conducting experiment on embankment model by shaking table could be one of the accurate methods to evaluating behavior of embankment when it is under seismic loading. Dynamic force is responsible for nonlinear stress in the system. When the model is under dynamic loading, suitable arrangement of dense zone in the subsoil is the main factor at the play in embankment stability. In this paper for mitigate seismic force was applied up on the embankment model, the results of three experiments have been considered to assessment function of dense zone installed in different location of the subsoil. The stress in the system has been measured and photographs were taken for presenting reaction of the embankment model. At final the results of three experiments indicated possibility of understanding embankment behavior when it is under seismic force.

Keyword: Liquefaction, Stress, Dense Zone, and Pore Water Pressure

1. Introduction
Seismic liquefaction refers to a sudden loss in stiffness and strength of soil as a result of cyclic loading effects of an earthquake. This loss arises from a tendency for soil to contract under cyclic loading, and if such contraction is prevented or curtailed by the presence of water in the pores that cannot escape, it leads to a rise in pore water pressure and a resulting decrease in effective stress. If the effective stress drops to zero (100 per cent pore water pressure rise), the strength and stiffness also drop to zero and the soil behaves as a heavy liquid. [1] At the time of the earthquake, the embankment rested on saturated loose sandy subsoil faces high level of liquefaction risk and may bridge to failure of the embankment. Seismic force creates liquefaction due to nonlinear stress up on the model. Constructing dense zone in the subsoil is a method to reduction of stress in the embankment model. [2]. There is presented a research work on Dynamic properties and liquefaction potential of soils [3]. Jack W. Baker, M.ASCE and Michael H. Faber conducted research by using Random-field theory and geostatistics tools to model soil properties and earthquake shaking intensity for present of potential extent of liquefaction by accounting for spatial dependence of soil properties and potential future earthquake shaking [4]. Dash et al. investigated the use of reinforcement in increasing stability of soil foundation [5]. Schimizu and Inui carried out load tests on a single six-sided cell of geo-textile wall buried in the subsurface of the soft ground [6] and also Mandal and Manjunath used geo-grid and bamboo sticks as vertical reinforcement elements and studied their effect on the soil bearing capacity [7]. Rajagopal et al have studied the strength of confined sand and the influence of geo-cell confinement on the strength and stiffness behavior of granular soils [8]. Seismic motion could be responsible for instability of

embankment model. It is possible to controlling of seismic motion by provision of dense zone in the subsoil as a feasible method. Embankment with good enough foundation stability could more resistance against seismic force and increases factor of safety in the system.

2. Methodology and Experiments

The evaluation of embankment model behavior, when it is under seismic force by manual-shaking table provided insight in understanding seismic mitigation of embankment. Provision of dense zone consisted of composite material confined in geo-textile in loose saturated sandy subsoil was studied to assessment disability of liquefaction. The manual-shaking table has used to vibrate in one direction Fig (3.a-c). It consisted of two wooden panels with steel plates between them for producing harmonic vibration at frequency of 1 Hz to 3 Hz and approximately around 75Kg force is applied on model. One type of transducer (acceleration sensors (A1-A3)) was used to measure the acceleration and its results integrated to draw shear stress graph.
Test Procedure of Experimental Are following as

- The filter plates were fixed and sealed on top of baffle walls inside the acrylic box.
- The aluminum channels were fixed with gum tape inside the acrylic box.
- Signal conditioner of acceleration sensor was switched.
- The prepared sand was laid according to the requirement of density.
- Acceleration sensors were placed at required locations.
- The colored sand was laid at every 10 cm height horizontally and at 10 cm vertically in aluminum channels.
- The water was allowed through baffle walls at very slow rate for saturating the ground.
- The shaking was carried out uniformly.
- The results recorded in the computer and created in the form of the graphs.

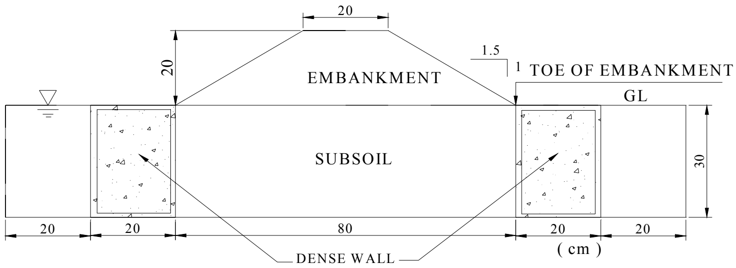

Fig 1.a Model of loose sandy embankment and loose sandy saturated subsoil consists of dense wall made up from composite material (60 % sand and 40 % gravel) confined in geo textile installed outside toe of embankment

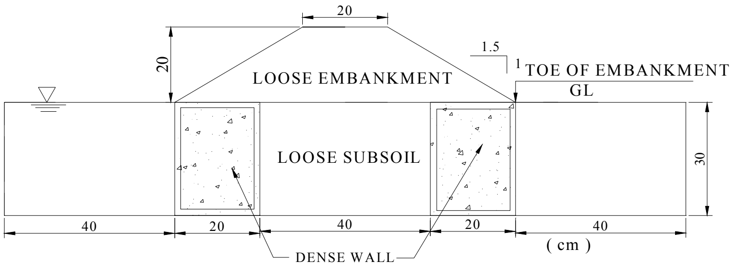

Fig 1.b. Model of loose sandy embankment and loose sandy saturated subsoil consists of dense wall made up from composite material (60 % sand and 40 % gravel) confined in geo textile installed inside toe of embankment

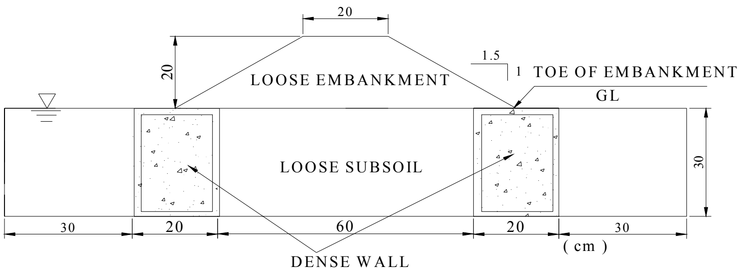

Fig 1.c. Model loose sandy embankment and loose sandy saturated subsoil made up from composite material (60 % sand and 40 % gravel) confined in geo textile centrally installed on the toe of embankment.

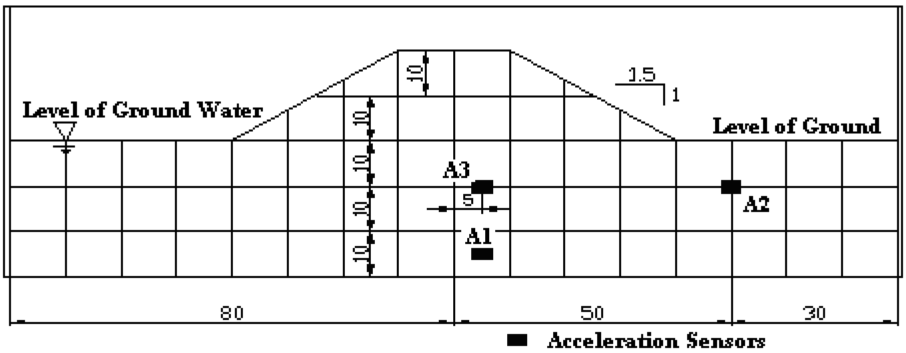

Fig. 2.1. Position of Transducer

Three different types of models have been developed. The first model is loose sandy embankment and loose sandy saturated subsoil consists of dense wall made up from composite material (60 % sand and 40 % gravel) confined in geo textile installed outside toe of embankment and the second model is loose sandy embankment and loose sandy saturated subsoil consists of dense wall made up from composite material (60 % sand and 40 % gravel) confined in geo textile installed inside toe of embankment and the third model is loose sandy embankment and loose sandy saturated subsoil made up from composite material (60 % sand and 40 % gravel) confined in geo textile centrally installed on the toe of embankment. (Fig.1.a-c). Figure .2.1shown the cross section of ground and water level with positions of acceleration transducers in the model. The horizontal shear strain γ is obtained from the differential displacement between two adjacent accelerometers as illustrated in Fig. 2.2 and is given by

$$\gamma = \Delta d / \Delta h$$

Where, Δd = differential horizontal displacement between two adjacent points

Δh = Distance between the two acceleration points

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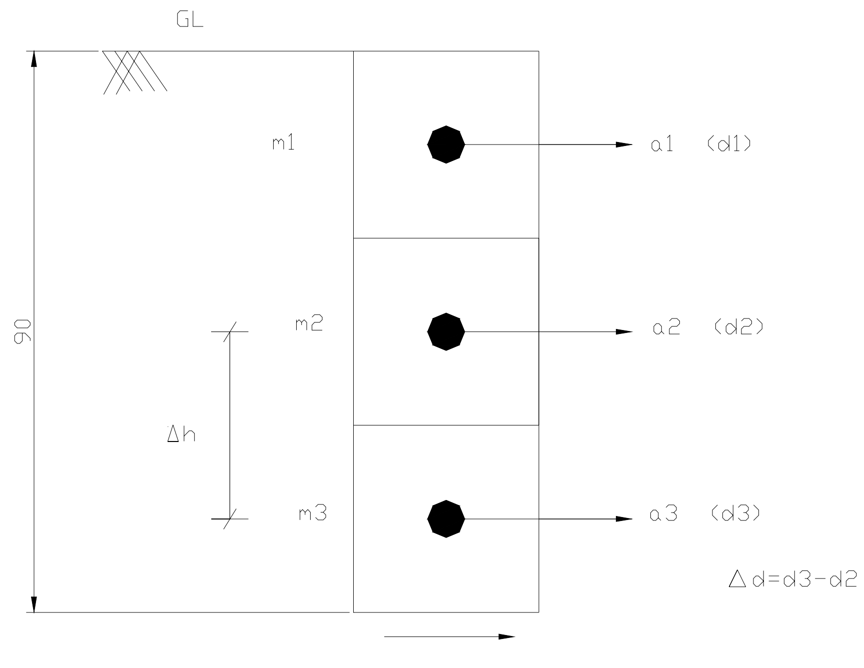


Note: a = Acceleration, d = Corresponding displacement

Fig.2.2 Key sketch for the computation of shear stress and shear strain in the embankment.

Displacement can be obtained by double integration of the acceleration records.

In a sand deposit, consider a column of soil of height 'h' and unit area of cross section subjected to maximum ground acceleration a_{max}. Assuming a soil column to behave as a rigid body, the maximum shear stress τ_{max} at a depth 'h' is given by,

$$\tau_{max} = \Sigma \{\gamma_s h / g\} * a_{max}$$

Where, g = Acceleration due to gravity

γ_s= Unit weight of soil

3. Results and Discussion

To mitigation of an embankment, when it is under dynamic force, installing of dense zone in the subsoil is the easiest method to make an embankment stable enough.

Purpose of this investigation is to find right location of the subsoil for installation of dense zone. The results of experiments recorded in the form of tables, graphs and photos. Stress characteristic is responsible for controlling liquefaction at the time of the system is under shaking. From the results of all experiments could be mention main reason of increasing embankment instability are weakness of dense zone in controlling lateral force due to bad placement of that, in the test C (Fig 3.a-c) due to suitable placement of dense zone could observe low level liquefaction and more stability, also in this test even more stress was applied. Placement of dense wall in suitable location of subsoil is like constructing strong sufficient column in the right place of structure. Photographs A, B and C (Fig3, a-c) providing sufficient evidence at the time of the collapsing of embankment at any second, by the referring to the Figs (4,a1- c2) and table 1 the level of stress on the all models, could be observed maximum stress in the model C. and also in the all models, maximum level of stress could be observed at the below of the embankment and minimum level of stress occurred at the away of embankment in the subsoil, this phenomenon is due to pressurizing of the subsoil by the weight of the embankment.
In the model C due to suitable installation of dense zone could be observe significantly controlled lateral force, deformation and creep deformation in the subsoil and increased time stability of dense zone and embankment. Easy collapsing of embankment during earthquake due to any reason could accelerate excess pore water pressure and placing system in the great danger, and also Immediately collapsing of embankment and pressurizing more subsoil due to dynamic falling weight of embankment on subsoil could increases seismic force. The ability of seismic forces upon model is results of a model characteristic. Arranging dense zone with proper material reduces speeds of collapsing of embankment as well as creep deformation and settlement of whole model. Intensity of dynamic force due to result of collapsing embankment directly depending on weight and speed of collapse of embankment in the model. Here could be observing vertical dynamic force created in the model. Embankment satiability is depending on the subsoil strength and deformation during vibrating model by seismic force. Displacement, deformation, stress, pore water pressure and intensity of liquefaction in the embankment models are results of selecting accurate place of dense wall. Performance of dense wall could restrict of seismic force as well as mitigate of liquefaction.
Liquefied soil exerts higher pressure on retaining walls, which can cause them to tilt or slide. This movement can cause settlement of the retained soil and destruction of structures on the ground surface. Increased water pressure can also trigger landslides and cause the collapse of dams [9]. The lateral shear forces developed under the embankment should be compared with the shear strength of the subsoil [10]. The improvement of soil strength with geotextile material depends on the soil grading. The effect is significant for soil with more fine percent [11]. The liquefaction potential of a soil mass during an earthquake is dependent on both seismic and soil parameters [12].

Table 1 Maximum Stresses at Each Test

Test name	At the below of embankment (Kpa)	At the away from the embankment (kpa)
A	1.22	1.1
B	1.622	0.47
C	3.13	1.95

TEST A

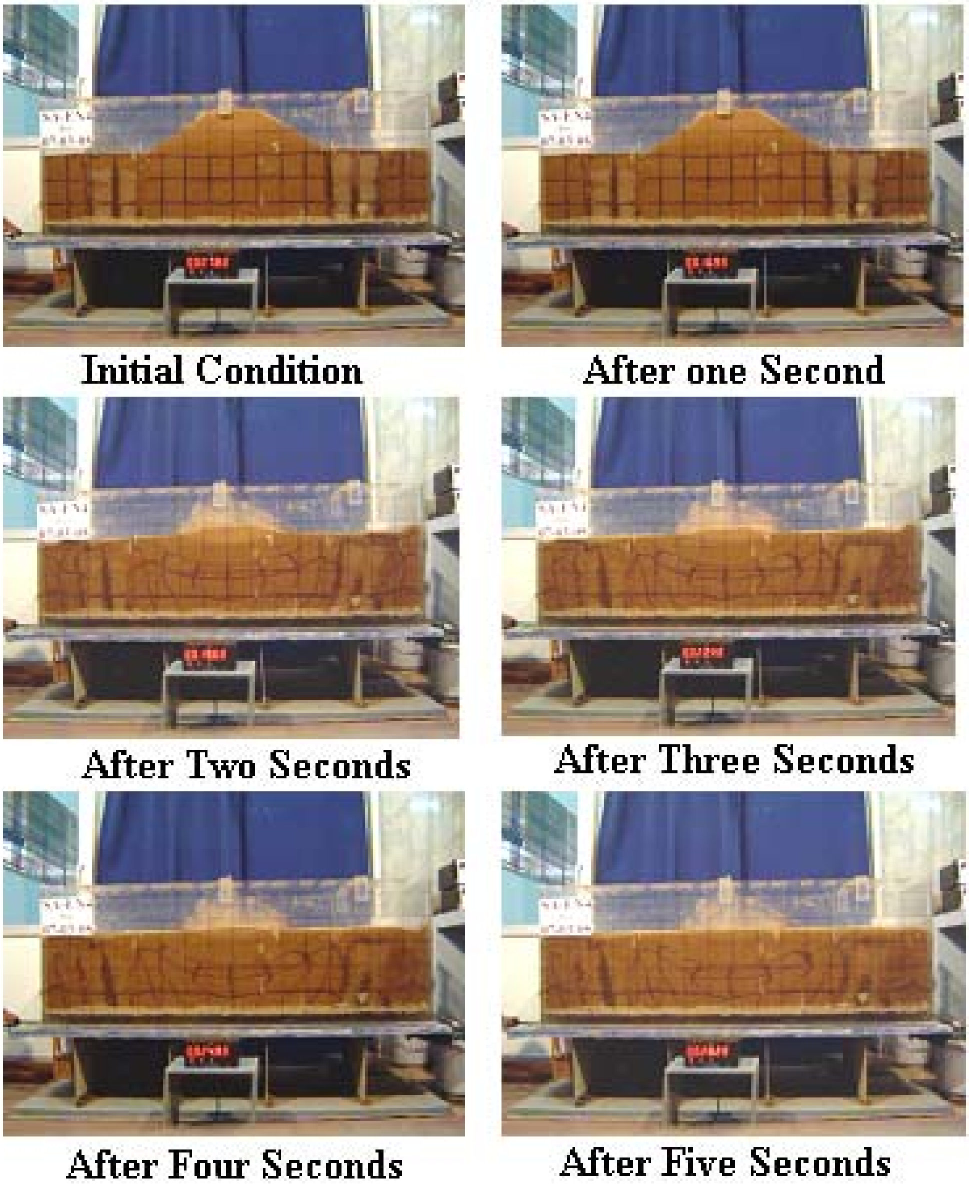
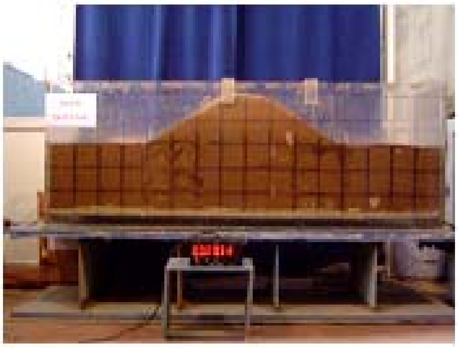
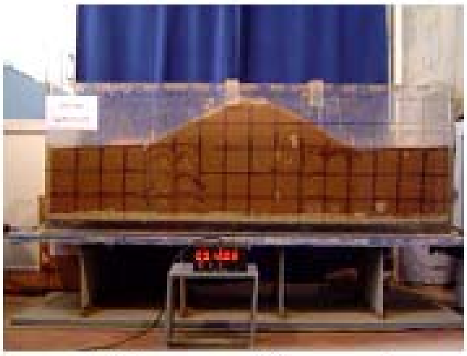


Fig 3.a. Deformation shape of embankment subsoil system at different instants of time

TEST B



Initial Condition



After one Second

After Two Seconds

After Three Seconds

After Four Seconds

After Five Seconds

Fig 3.b. Deformation shape of embankment subsoil system at different instants of time

TEST C

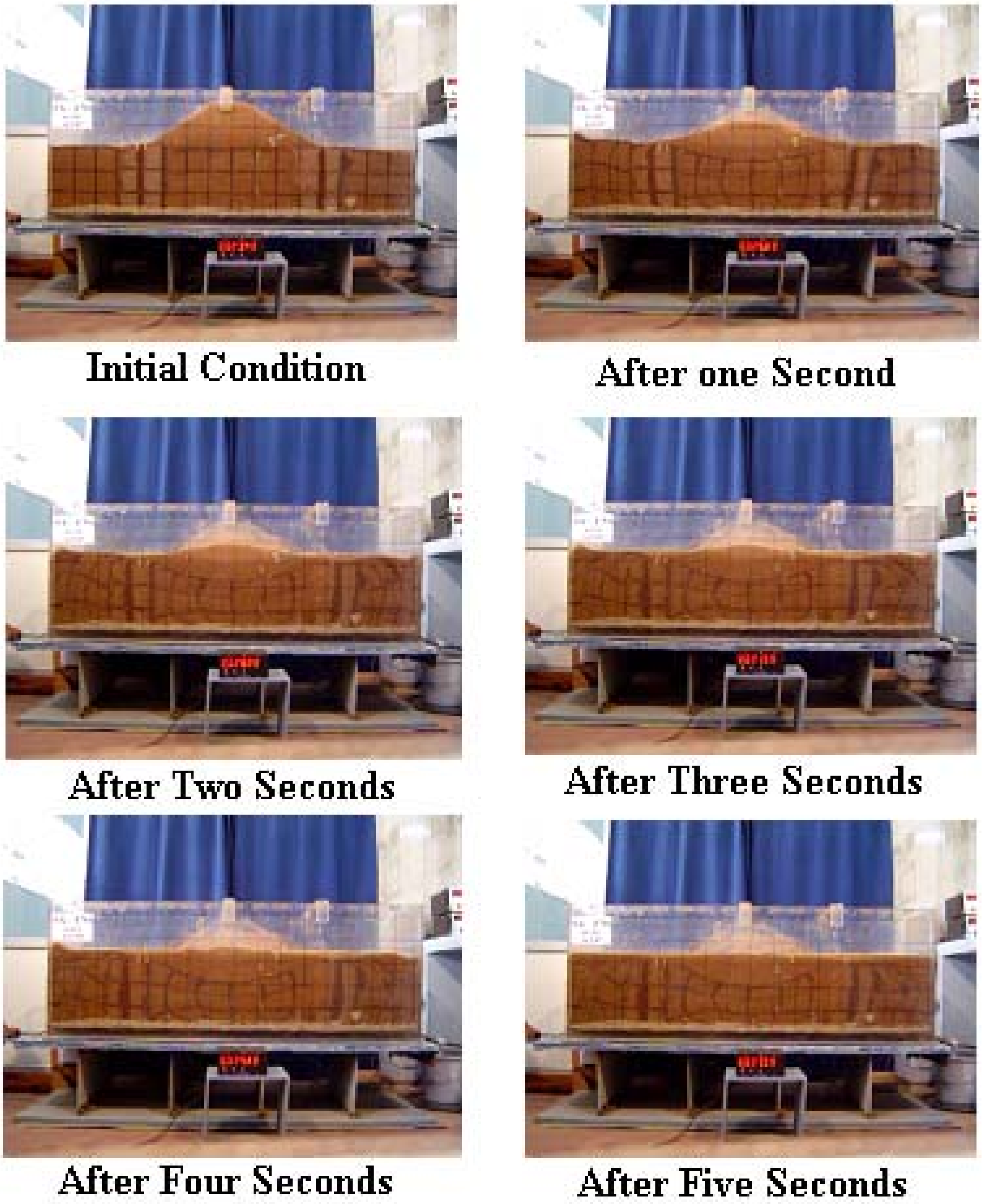


Fig 3. c. Deformation shape of embankment subsoil system at different instants of time

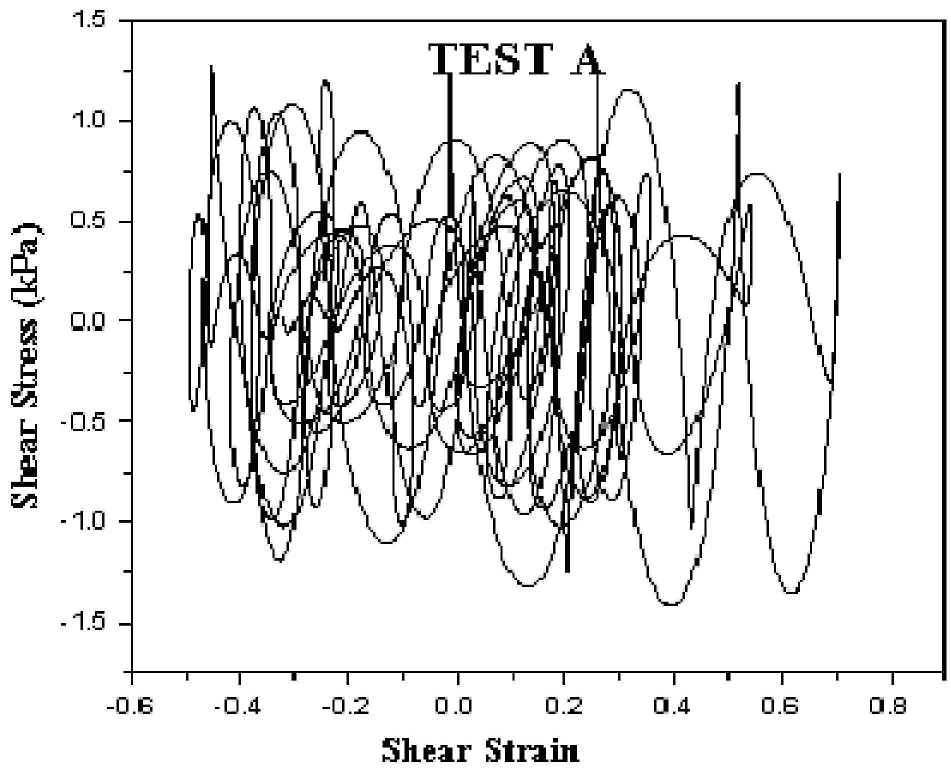


Fig.4.a.1 Stress strain history in the subsoil away from embankment

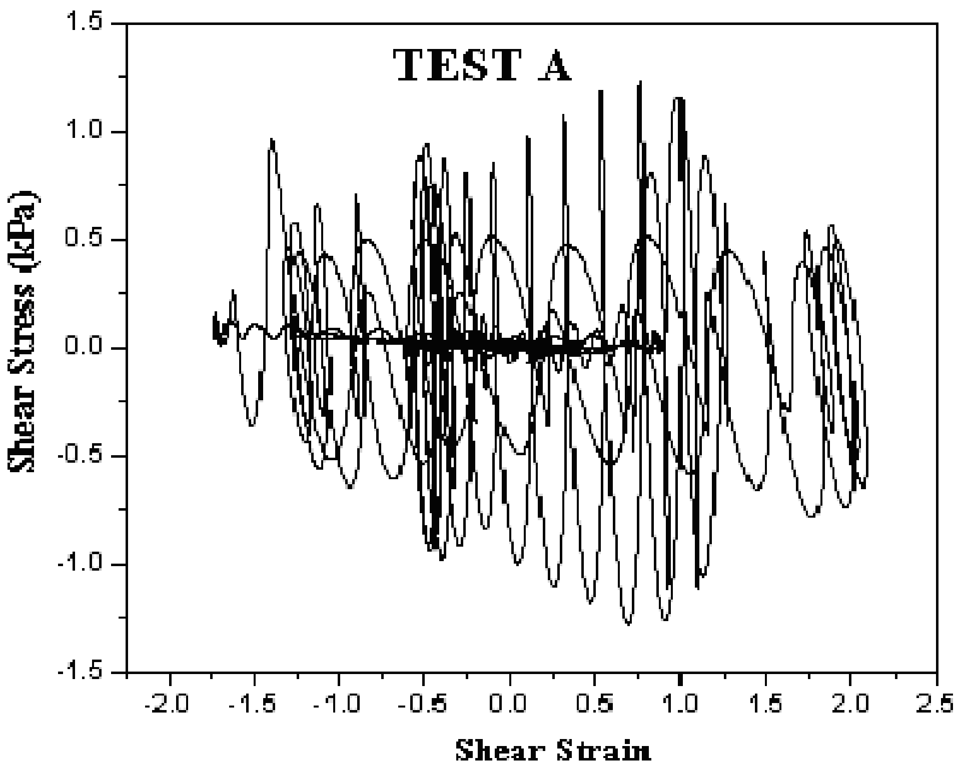


Fig.4 .a.2 Stress strain history in the subsoil below embankment

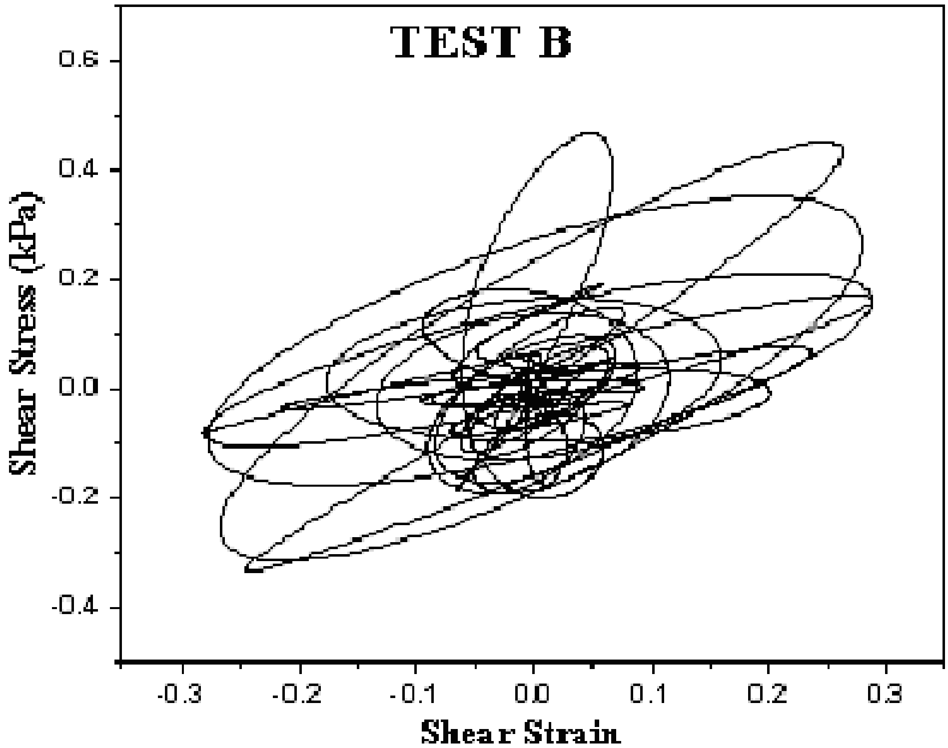


Fig.4.b.1 Stress strain history in the sub soil away from embankment

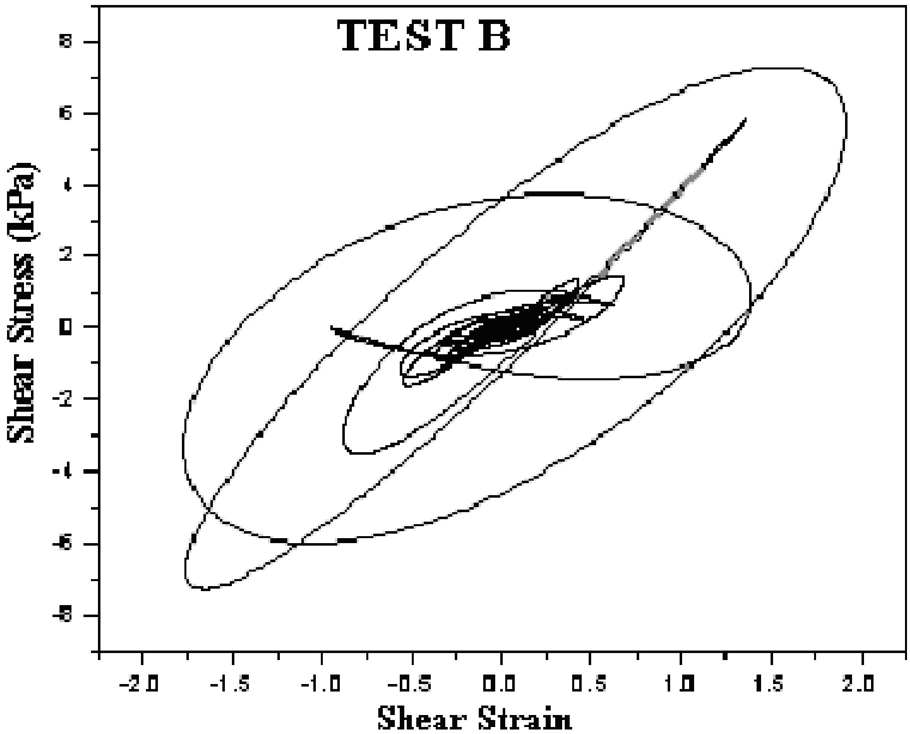


Fig.4.b.2 Stress strain history in the sub soil below embankment

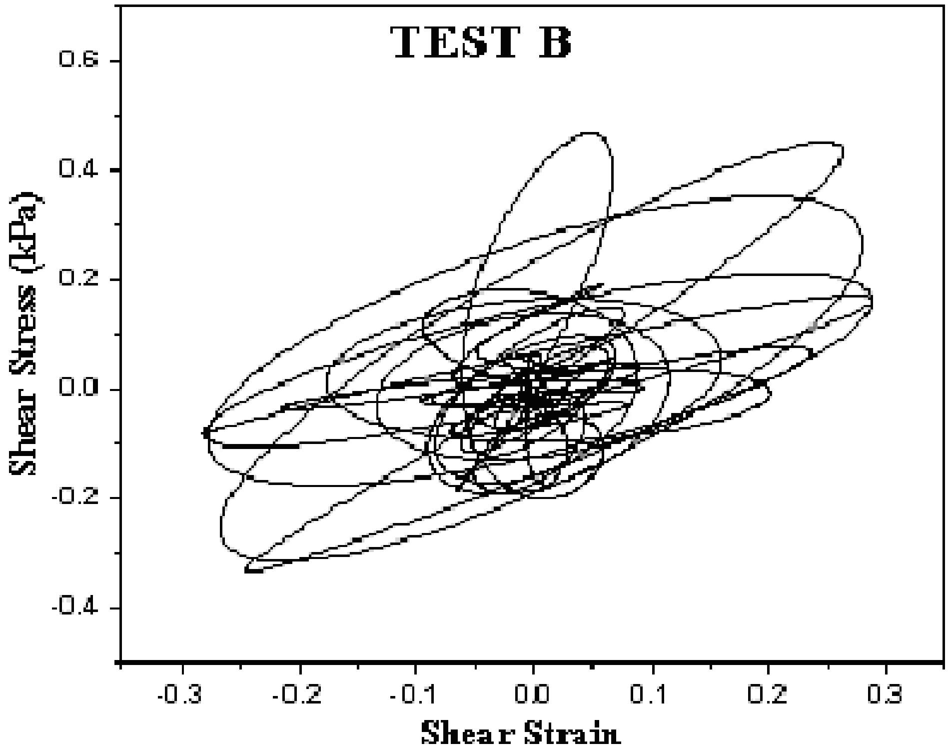


Fig.4 .b.1 Stress strain history in the sub soil away from embankment

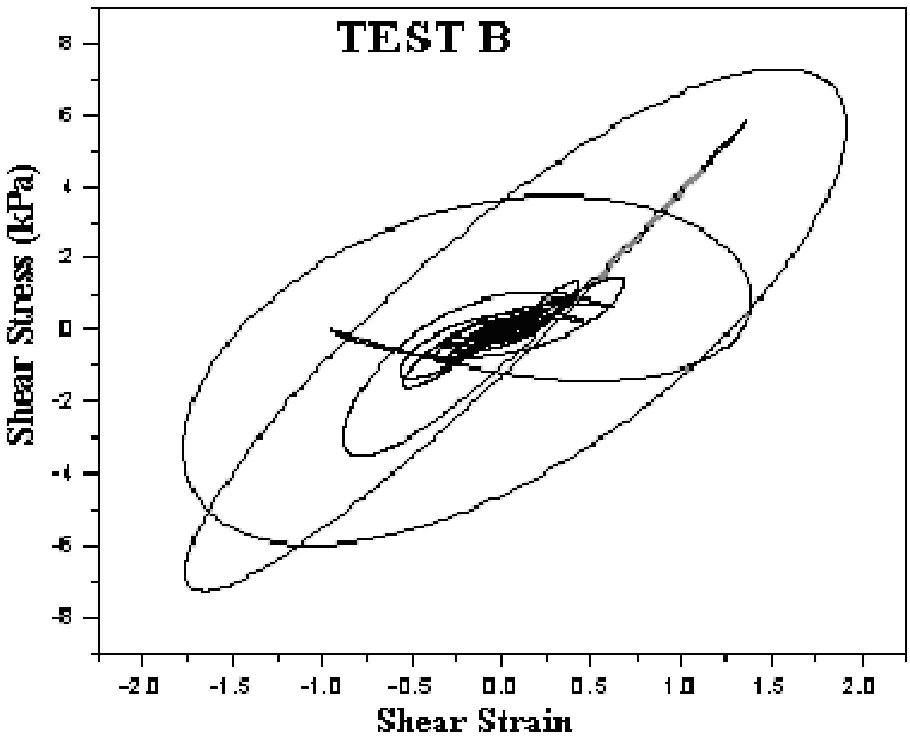


Fig.4.b.2 Stress strain history in the sub soil below embankment

4. Conclusion

- In construction of any embankment needs consideration of soil foundation behavior with accurate interpretation of the results.
- The results of three experiments have been carried out indicated possibility of understanding behavior of embankment when it is under dynamic loading.
- Placement of dense wall in suitable location of subsoil is like constructing strong sufficient column in the right place of structure.
- Suitable placement of dense zone can more control pore water pressure and lateral force in the system and reducing of settlement and creep deformation of the subsoil and embankment as well as increases time stability of embankment during the earthquake.
- Easy collapsing of embankment during earthquake could accelerate excess pore water pressure.
- Collapsing of embankment has effect on neighboring area of the subsoil of embankment in term of increasing deformation, stress and excess pore water pressure.
- All ability of seismic force activity in the system is result of model characteristics.

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