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Numerical Study to Evaluate Soil Strength due to Seismic Loading

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***Abstract*— Earthquake is one of the natural disaster which is unpredictable before it occurs. But after and during the earthquake, the damages are very high. Due to earthquake there will be changes in soil present nearer to the ground surface, which may results liquefaction and reduces inter granular stress (effective stress). The structure build on those soils automatically disturbed, there by building on that soil collapsed. So the human life also loosed. Hence understanding of soil behavior during and after seismic loading is necessary.**

In this project two dimensional soil column model imposed to seismic loading and soil column has been analyzed with the help of Open System for Earthquake Engineering Simulation (Open SEES). The Open SEES is developed by PEER (Pacific Earthquake Engineering Research). Open SEES has a facility to simulate dynamic soil response such as nonlinear behavior of soil, elasto-plastic behavior, etc.,

***Keywords*—Open SEES, Liquefaction, PEER.**

I . INTRODUCTION

Earthquake caused by many reasons; some of the reasons are volcanic eruption and the movement of the plate boundaries. During earthquake liquefaction takes place, due to liquefaction settlement of soil will occur , so due to the settlement of foundation of the structure gets failed and the building losses its stability. Earthquakes (Nigata 1964, Imperial Valley 1979, Haiti earthquake, Tabas 1978) often shows extensive damage to engineering structure such as buildings, highways, bridges, etc., Liquefaction occurs in loose to medium dense saturated sandy soil deposit due to earthquake (shear) loading, the effective stress of soil reduces to nearly zero with the corresponding increase in pore water pressure. It is quiet equivalent to tea leaves floating in a cup of tea.

II. GEOTECHNICAL EARTHQUAKE ENGINEERING SOFTWARE

Open SEES is an object oriented software framework for simulation applications in earthquake engineering using finite element methods. Open SEES is not a code, it is used to analyze the soil model by applying earthquake loading. The Pacific Earthquake Engineering Research (PEER) center is committed to the development of methods and produces for performance – based earthquake engineering. Open SEES and it has the facility to simulate dynamic soil interaction during earthquake excitation using object oriented framework of finite element analysis. The PEER Open SEES computational platform is available in Open SEES to capture the response of saturated soils in two phases such as soil skeleton and pore water. Soil displacement, pore water pressure and pore water displacement can be monitored during the simulation using this element formulation.

The material model is based on multi yield plasticity. Pressure dependent multi yield is an elastic – plastic material for simulating the essential response characteristics of pressure sensitive soil materials under general loading conditions. Such characteristics include dilatancy (shear – included volume contraction or dilation) and non – flow liquefaction (cyclic mobility), typically exhibited in sands during cyclic loading. In dynamic loading phase, the stress – strain response is elastic – plastic. Plasticity is formulated based on the multi surface concept, with a non – associative flow rule to reproduce dilatancy effect.

III. VALIDATION OF NUMERICAL SOIL COLUMN MODEL

The two dimensional soil column model consists of five numbers of 4-noded quadrilateral elements, which is shown in fig 1. These elements have the 4 corner nodes of 3 degrees – of – freedom (2 for displacements, 1 for pore water pressure). In the method we consider both single and double drainage conditions. Single drainage has zero pore pressure at the top of the soil layer. Double drainage has zero pore pressure at the top and bottom of the soil layer.

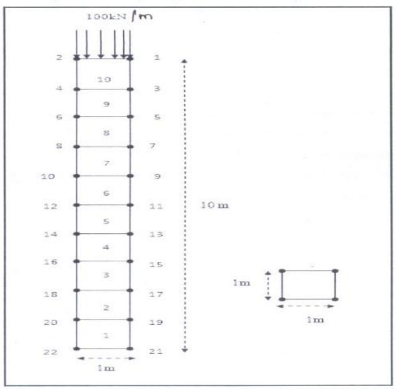

Fig 1. Schematic representation of 2D soil column model

The depth and width of the soil column model are assumed as 10m and 1m respectively. There are 10 elements of having 1m height each in the vertical direction and hence the elements represents square shape to increase the accuracy of finite element computations. The corner nodes of the elements have two degree of freedoms to capture the

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displacements in horizontal and vertical direction. And also, the third degree of freedom is to observe pore water pressure. All the corner nodes are fixed against horizontal translation. The nodes on the lower boundary are fixed against both horizontal and vertical translations.

The boundaries at the bottom and along the sides are considered as impermeable and the top side is permeable, where drainage is permitted in case of single drainage. The boundaries along the sides are considered as impermeable but the top and bottom sides are permeable where drainage is allowed, in case of double drainage. The cohesive soil is assumed to be homogeneous throughout the soil column model.

IV. NUMERICAL ANALYSIS

The analysis is conducted as a transient analysis for 50 steps with a time step of 1. Material is entirely elasto – plastic constructive behavior. The self-weight of the soil column is acting downward direction, which is acting as a load for gravity analysis. The analysis is conducted using the New mark integrator such as gamma and beta co efficient are 1.5 & 1 respectively. The consolidation analysis is also conducted as a transient analysis, and is analyzed for 500 steps with a time step of 0.1. . The analysis is conducted using the New mark integrator using the same gamma and beta co efficient defined in the gravity analysis.

V. RESULTS & DISCUSSION

The results are recorded for gravity & consolidation analysis. The results are recorded the nodal displacements in the displacement degree of freedom, the nodal velocities in the pore pressures degree of freedom, and the stress and strain response at the four Gauss point in each element. The results of numerical analysis such as pore water pressure, settlement, effective stress for both single and double drainage are described in graph format. Initial time step of the analysis has been indicated in green colour, and then advancing steps of the analysis are has been indicated in red colour. The hydrostatic analysis results are has been indicated in black colour line for entire analysis results.

Single drainage

The pore pressure distribution and effective vertical stress for single drainage is shown in Fig 2 & Fig 3 respectively. Due to the sudden application of consolidation load the pore pressure is increased to 185.3 Kpa at the time period of 0.1 sec. As this time increases the pore pressure is gradually decreased as shown in Fig 2. Because the water is dissipated from the voids and pore pressure comes to the hydrostatic pressure (initial stage) at the time period of 15.2 sec. In single drainage condition top side is permeable. So only we can get the zero pore pressure at the ground level.

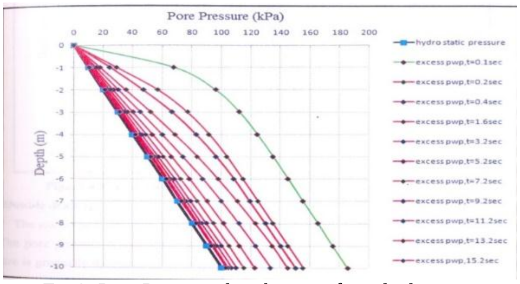

Fig 2. Pore Pressure distribution of single drainage

Effective stress of single Drainage

The Effective vertical stress of a single drainage is as shown in Fig 3. The effective vertical stress is decreased during the application of load. The effective stress is comes to 206.5 Kpa at the time period of 0.1 sec. then the effective pressure is increased as increase in time. During the application of load the effective stress is decreased and then increased with respect to increase in time. The effective vertical stress is increased to 295 Kpa at a time period of 15.2 sec.

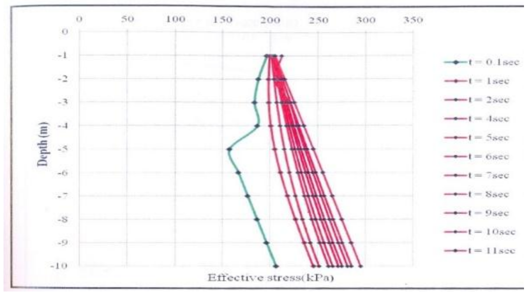

Fig 3. Effective vertical stress distribution for single drainage

Double Drainage

The excess pore pressure distribution for double drainage condition is shown in Fig 4. The pore pressure is increased up to 85 Kpa at the time period of 0.1 sec. then the pore pressure is gradually decreases as increase in time. The pore pressure is reached the hydrostatic pressure at the time period of 7.4 sec. The pore pressure is zero at top and bottom surface. Because the boundary condition for double drainage is allow the water to permeate in both top and bottom layer.

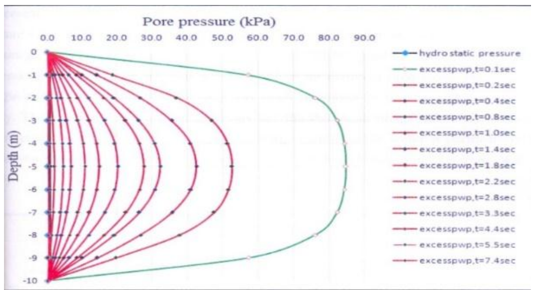

Fig 4. Pore Pressure distribution for Double drainage

The effective vertical stress for double drainage is shown in Fig 5. At a 10m depth, the effective vertical stress is comes to 356 Kpa at a time period of 0.1 sec. then the vertical stress is gradually increased to 390 Kpa at a time period of 11 sec. The Fig 5. Shows the gradual increase in effective vertical stress. As increase in time the pore pressure is reduced and the effective stress is increased.

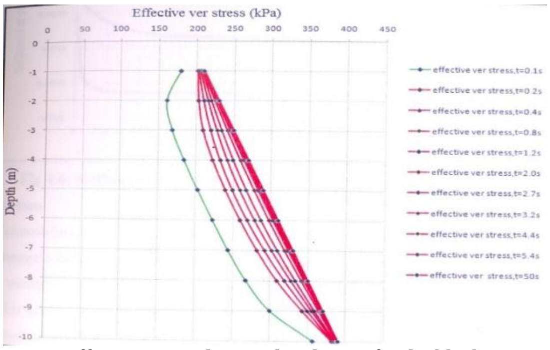

Fig 5. Effective vertical stress distribution for double drainage

Settlement

Fig 6. Shows the evolution of the settlement at the ground surface for single and double drainage conditions. The settlement occurs more rapidly for the double drainage case as compared to single drainage conditions. Because, in double drainage condition the water is permeate in both top and bottom side.

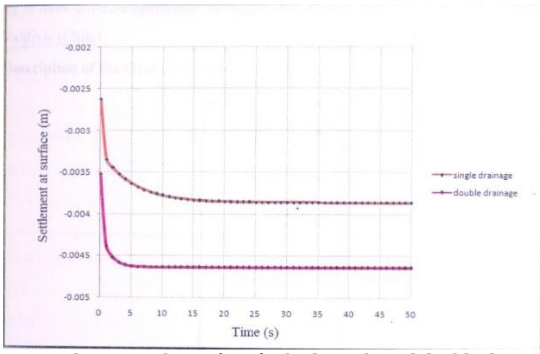

Fig 6. Settlement at the surface for both single and double drainage

VI. CONCLUSION

After the consolidation analysis the soil undergoes settlement. The settlement for single and double drainage condition is 3.8mm and 4.6mm respectively. From this analysis the created numerical model is observed as excellent model.

REFERENCES

[1] Duggal S.K, “Earthquake Resistant Design of Structures”, Oxford University, pg: 1-29

[2] Idriss I.M., Boulanger R.W., “Semi-Empirical Procedures for evaluating liquefaction potential during earthquakes”, University of California, USA, Soil dynamics and Earthquake Engineering 2006, vol 26, issue 2-4, pg 115-130

[3] Liyanapathiranaa D.S., Poulosb H.G., “A Numerical model for dynamic soil liquefaction analysis, soil dynamics and earthquake engineering 2002, vol 22, issue 9-12, pg 1007 – 1015

[4] Mahdi Taiebat, Hadi shahir, Ali pak, “Study of pore pressure variation during liquefaction using two constitutive models for sand”, soil dynamics and earthquake engineering 2007, vol 27, issue 1, pg 60-72

[5] Nadarajah Ravichandran, “Fully coupled finite element model for dynamics of partially saturated soils”, Soil Dynamics and Earthquake Engineering 2009, vol 29, issue 9, pg 1294 – 1304

[6] Radu Popescua, Jean H. Prevost, George Deodatisc, Pradipt Chakraborttya, “Dynamics of nonlinear porous media with applications to soil liquefaction”, Soil dynamics and Earthquake Engineering 2006, vol 26, issue 6-7, pg 648-665

[7] Reyes D.K., Rodriguez- Mareb A., Lizcano A., “A hypo plastic model for site response analysis”, Soil dynamics and Earthquake engineering 2009, vol 29, issue 1, pg 173 – 184

[8] Steven L. Kramer (2007), “Geotechnical Earthquake Engineering”, University of Washington, pg 348 – 408

[9] Yijun Liu, “Introduction to finite element method”, CAE Research laboratory, University of Cincinnati, USA.

[10] Zhaohui Yang, Jinchi Lu, and Ahmed Elgamal, “Open SEES Soil models and Solid-fluid fully coupled elements”, University of California, San Diego Department of Structural engineering, Oct 2010.

[11] Zhao Cheng, Boris Jeremic, “Numerical modelling and simulation of pile in liquefiable soil”, Soil dynamics and Earthquake Engineering 2009, vol 29, issue 11 -12, pg 1405 - 1416