The phenomenon of liquefaction in the foundation of the Persian Gulf dams using numerical modeling

H. Khademi – V. Tayari
civil engineering graduate student at Hormozgan University

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Name of the Presenter: Hosein khademi

Abstract

The phenomenon of liquefaction in the fondation of the persian gulf dams using numericol modeling.
Liquefaction is an important geotechnical phenomenon that causes severe structural damages during earthquake. This phenomenon usually takes place in saturated loose sandy soils under static/dynamic conditions. Interaction of solid and fluid phases during cyclic loading causes the pore water pressure builds up thus the effective stresses in the solid phases decrease. This leads to the reduction of the shear strength of the soil.
The dams founded on loose sand deposits, are susceptible for liquefaction and damage. Liquefaction
occurrence in the dam foundation causes failure of dam or large permanent deformation in dam body.
In this research, static and cyclic behavior of soils is analyzed by modeling of a two-phase medium considering interaction between its phases. Biot's modified theory is employed for modeling saturated soil behavior. Analysis is carried out by applying dynamic loading of recorded earthquakes. Densification model is used for modeling liquefaction.
In this research, PISA finite element software is modified and its capabilities are increased to do dynamic analysis as well as liquefaction modeling.
Several static and dynamic problems are analyzed in order to verify the program's formulation. Program's results are compared with analytical solutions and/or other software's results.
In order to demonstrate the capability of the modified PISA for liquefaction modeling, results of a centrifuge experiment of VELACS project is used; and the obtained results from the program are compared with the experimental results and other numerical simulations' output.

Another centrifuge test was analyzed for demonstrating the modified PISA capability in the modeling of liquefaction occurrence in dam foundation. Numerical modeling results were compared with experimental and another numerical modeling results. Comparison showed that the PISA can capture the main features of liquefaction in dam foundation.

Key words: ravangraei , pisa,

Introduction

ravangraei Is one of the main Geotechnical phenomenon that occurs in Persian gulf margin due to the type of solid that is in this region and it cause destruction of structure such as building and dams in the time of earthquake. the solid of margin of Persian gulf is usually in sandy type and is saturated and windy sand phenomenon often occurs in this kind of solid. The interaction of flow and solid phases in this phenomenon, increases the pro pressure due to the alternative movement of earth and as a result effective stress of soil decrease and shear strength of solid goes from. Buildings and dams which are on saturated sedimentary basin such as sandy layer in the event of earthquake are prone to ravangraei and failure. ravangraei Which often occurs on sandy solid of sea margin, specially Persian gulf margin ,cause the total destruction of building and dams and cause great transformation in their body.

In this article it is tried that saturated soil be modeling like two phase environment that its solid and liquid phase have interaction with each other. And for modeling the saturated environment action , the generalized theory of biot was used. Saturated solid is analyzed in the effect of dynamic load of earthquake . for modeling , densification model is used. at this article the limited element program of pisa is used and has given the necessary capability in order to dynamic analyze and ravangraei modeling of windy sand .in order to analyze accuracy of formula after analyze , the obtain result is compared by computer program also for indicating program capability in order to modeling of windy sand ravangraei .is used of the santryfus laboratory model and the result is compared with each other in order to survey the program capability in ravangraei modeling in foundation of adjacent building of sea and dams ,numerical modeling of a sentryfus experiment that a weir operation of one layer windy sand which is saturated, is placed and the finding of numerical modeling is compared whit the other.. the comparison showed that the software that anticipated the main characteristic of ravangray well and is in accordance whit laboratory result.

Data and Material

Numerical modeling of number 1 experiment :welace

1 layer, 3 relative Nevada dr=40 in a layer box (laminar box) include of 40 aluminum circle. The solid which is in box can move in lateral direction by contriving a roller between the circle. The most movement of circle is limited to 1.27 cm in any direction the sandy layer become thoroughly saturated and is circle by accelerate santyfuse of 50 gr . and then the box is placed under the horizontal displacement in the experiment time. The additional pro water pressure , vertical displacement and vertical soil meeting is measured in different place .for the numerical modeling , the parameter of chart 1 is used. The change of pro water pressure in place of p1 and p 2 is also determined.

2 numerical modeling of ravangraei phenomenon was foundation .the is model is done by kosel and his colleague. And includes a one layer of sand and saturation of toyoro in(1,x) by diameter of 200 milititer in a box that in which there is a weir by height of 70 mililitre on it .weir building is a mixture of sand and gravel by per step of 1 to 4 and the humidity is 150. The sandy layer is saturated by con oil which its dysykvzyth ia 3 time more than that water. a synovial horizontal acceleration under the santryfus acceleration is of 30 gr is applied to the model. The inter accelerate includes 20 cycle of sinusoidal wave by the frequency of 100 hertz and range of 5/4g.the numerical modeling is done in real scale and in two dimension in the condition of level interaction displacement of lower point of windy layer is done in horizontal and vertical direction and the displacement of lateral point is done in the horizontal rang .the material of parameter of numerical modeling is shown in chart 21. For the assurance of response stability in dynamic analyze ,the time step of t=10 3anf the new mark parameter of θ=0/6,$\propto$=0/30, δ=6 id used .result of numerical and laboratory modeling is shown in figure 7,6.in the point by free level , despite the result vibration , medium quantity of ad pro pressure of water is approximately equal.

Primary vertical effective stress is solved in this point. the zero effective stress that is indication of in its point. The experimental seeing also acknowledges this subject. the medium quantity of add pro pressure of water in point of weir p4, p6 has nit reach to vertical effective stress and zero effective stress is not made. So ravangraei is not occur. in this point

time history of crowns summit of weir has shown iv figure 8 that is the indication of good modeling of ravangraei .

Results and Analysis

Differential equation in the action of saturation environment are : balance equation, for total part of element , balance equation for flow phase and and equation of balance crime .by combining the two above equation to eleman balance of equation (1) and continuity of phase fluid below equation . equation and unknowns 1,2 including urf ,p, us that obtain from inside of equation and obtain the building for on the above equation in the name of us-p by use of procedure content of finites element and inter prolation on result(n)and comparison derivative (b) and total some of equation 1, 2 the embedded procedure of new mark is used for time. some of nonlinear system of equation is solved by newton –rophson. The authentic of formulation and result of computer program is acknowledged.The solidarity subject By elastic and plastic treat of (lewis and schrefler 1988) and dynamical analyze of an elastic solid column under effect of horizontal accelerate of earthquake and comparison of the result of numerical model by analytical and laboratory .

In this article the model of densification is used for modeling ravangraei . .

At this model,(zlnl :ewicz, otal1978) the elasto plastic treat of soil and increment of pressure of pro water is taken in to account by tw0 mechanism. The equation(4)pep tensor is the action elastic 6, tensor effective stress ,tensor 40 is the total obeisance. At this model , the treat of mohr- culomb by the zyro saturated for imager of action of elastic plastic was used that obeisance)4) out genous for formula 5 is calculated , which in this relation hip , the volume of obeisnce is k , destruction quantity out genuose b ,a are the static number the quantity of k is defined from (formula 6) at this relation ship , is the that is ragard as the thirf parameter of the mifel desification.(formula 7which in this formula is 20 is the econd UNVARIABLE of DEVIATION stress and 6 IS THE MEDIUM OF EFFECTIVE TRESS IN THE BEGINNING OF that CUMULATIVE shear strain is IACOUNTED FROM THE RELATIONSHIP OF (formula 7)(DF) QUANTITY OF E:J SHOWS that is tenesor of the DEVIATOR stress.

Numerical dangray modeling.

2 example is provided about the capability of program in order to numerical modeling of ravangraei that the example one is the numerical model of experiment number 1 the project

of velace (arulauxqn &sch 1993) and the second example is the numerical modeling of ravangraei phenomenon according to suntryfuse experiment by kosek.

Conclusions

In this article a software by limited element which is able to do dynamic analyze and anticipate the ravangraei of windy sand and decy layer, is done . doing of analyze showed that the provided software by formula of u-p and model of densification has a good capability for the modeling of ravangraei . The result of analyze shows that for obtaining appropriate result about quantity of pro pressur should the quantity of in time of and ravangraei , amount of primary measuring in laboratory shod be selected .

In order to showing the capability of program in ravangraei modeling in base on dams ,numerical modeling of a santrifus experiment which in it a weir is placed on the weak windy sand layer. Ant the result of numerical modeling has compared by the quantity which is registed in laboratory and the result of other modeling.

The comparison of result shows that the program is able to anticipate the main characteristic and incident of ravangraei phenomenon and its result is in accordance whit laboratory result. Using other model for modeling saturated windy sand under the effect of interning load is taken into mind.

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Tables:

Kind of parameter	elastic parameter	plastic parameter,	Desification parameter	the relation of vertical lateral pressure	a solid phase	flow phase	the content chart of flow phase	time step	Newmark parameter
Indication	G_0, ν, n	C, $\emptyset, \psi$	γ, A, B	K_O	ρ_S	ρ_F	K_F	Δ_t	α, δ, D
Value	73000,0.31,0,5	0.01,34,0.0	0.5,0.05,12	0.4	26.7	9.81	2000000	0.008	0.3025,0.6,0.6

Table 1

Indication	ρ	N	K	σ_o/σ_m	ν	C	$\emptyset$	ψ	A	B Densifi	γ Densifi	K_F Dausf
Sand layer	19.26	0.43	0.000005	2340	0.35	0.0	34.0	0		200.0	1.50	0.000002
Levee	19.54	0.38	-----	638	0.30	20.0	330.0	0		200.0	1.50	-------

Table 2

Equation:

$$\text{div}\sigma + \rho b = \rho u_s^{\&\&} + \rho_f u_{ij}^{\&\&} \quad (1)$$

$$\frac{I^{\&}}{Q} + \alpha \text{div} u_s^{\&} \left(k\left[-\text{grad}P + \rho_F\left(b - u_s^{\&\&} - \frac{u_{ij}^{\&\&}}{n}\right)\right]\right) = o \quad (2)$$

$$\begin{bmatrix} M & O \\ O & O \end{bmatrix}\begin{Bmatrix} u^{\&\&} \\ p^{\&} \end{Bmatrix} + \begin{bmatrix} O & O \\ Q^T & S \end{bmatrix}\begin{Bmatrix} u^{\&} \\ p^{\&} \end{Bmatrix} + \begin{bmatrix} K & -Q \\ O & H \end{bmatrix}\begin{Bmatrix} U \\ P \end{Bmatrix} = \begin{Bmatrix} f^{(1)} \\ f^{(2)} \end{Bmatrix} \quad (3)$$

$$d\delta = D_{ep}(d\varepsilon - d\varepsilon_o) \quad (4)$$

$$d\varepsilon_v^o = \frac{-A}{1+BK} dk \qquad (5)$$

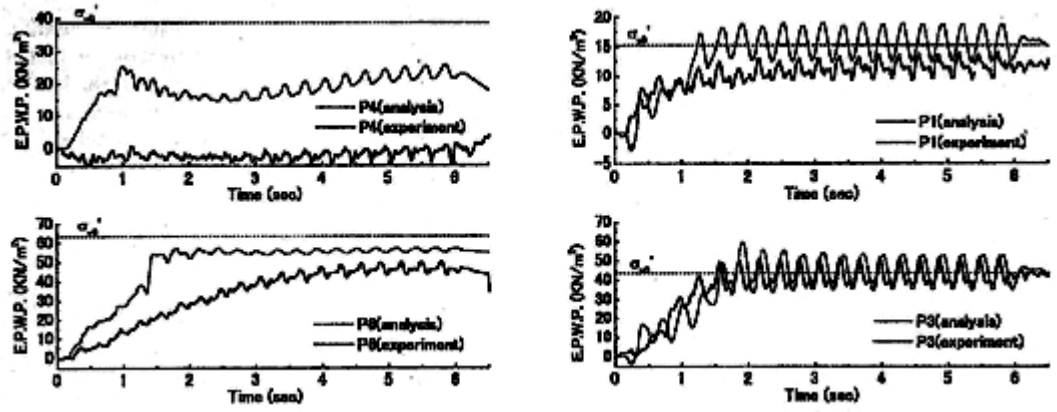
dk=exp(γ^{θ})d ξ (6)

$$\theta = \frac{\sqrt{J_{2D}}}{\sigma_{mo}} \qquad (7)$$

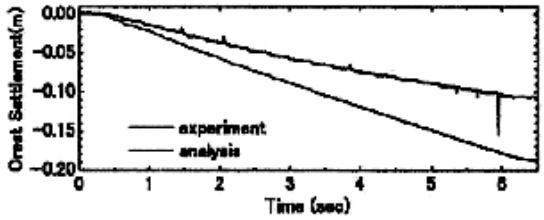
$$\xi = (de_{ij} de_{ij})^{\frac{1}{2}} \qquad (8)$$

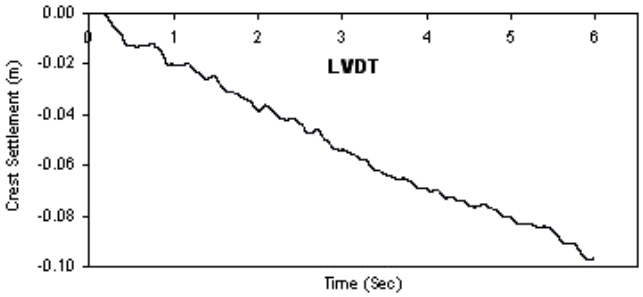
d

Figures:



(7)


Crest Settlement(m)
0.00
-0.05
-0.10
-0.15
-0.20
0
1
2
3
4
5
6
Time (sec)
experiment
analysis


Crest Settlement (m)
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
0
1
2
3
4
5
6
LVDT
Time (Sec)

(8)