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The Effect Of Fine Particle Migration On Void Ratio Of Gap Graded Soil

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Abstract: Soil is exposed to the migration of fine particles in some cases because of some conditions, including excavation and the presence of a level of groundwater, which is equal to the level of soil in this case and because of the existence of this water leakage, which would work on the migration of fine particles in the soil. This migration of fine particles will change the structure of the soil and change its properties. In this study, we will know the change in the properties of the fouling soil due to the migration of fine particles and four types of soil. The first type does not contain fine particles , and the second type, the third and the fourth contains 10, 20 , 30% granules respectively, and tests were carried out for these soils (Atterberg limits, sieve analysis, specific gravity , shear resistance, permeability, modified Procter, consolidation). A model was created to simulate the reality of soil exposed to excavations. Three levels were selected in the model to compare the results of each of the four soils under study. The total number of models (24) model, through laboratory work obtained the initial and final voids ratio before and after aft the initial and final voids ratio er the particles migration. After these tests, it was found that the migration of granules clearly affects the increase in the voids ratio.

Index Terms: Fine Particles , Void Ratio , Migration , Gap Graded Soil.

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1 INTRODUCTION

IN geotechnical engineering, groundwater movement plays a vital role in the analysis of soil degradation, volume change and stabilization. In this study the effects of leaks on soil behavior will be studied and usually ignored if the hydraulic gradient is generally low. Thus, flow conditions are usually described by Darcy's law on the assumption that the hydraulic conductivity of the soil is fixed. However, the leakage effects become significant when the hydraulic tilt is high. Leakage problems have been observed in some facilities, such as pipes in the underside of the paper buildup under the bridge finger, erosion of the tunnel surface and slope of the soil, and staining in the well pumping environment. The movement of water will induce the drag force to lose the fine particles, causing the migration of these fine particles from the soil. In the location where the particulate washed and increase the proportion of voids, on the contrary, will reduce the proportion of voids in the site, which will move him and the confined particles. This effect will affect the structure of the soil and the distribution ratio of the voids, that the change in the proportion of voids will affect the hydraulic conductivity. When we have a better understanding of the spill effects will help us more in the design of engineering structures..

Gap graded Soil

Gap grading is a type of grading which lacks one or more than intermediary size. By definition gap graded soils have a range of lost particles (usually fine to medium sand particles). Apparently, the hiatus in particle sizes is useful to clast-supported fabric which may respect the conditions of internal instability Fig.1,2. The size of voids build by a particular size of aggregate can hold the second or third lower size aggregates only i.e. voids created by (40) mm will be able to hold size equal to 10 mm or (4.75) mm but not (20) mm. This access is called Gap Grading.

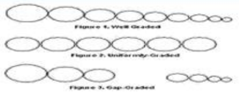

Fig. 1. Types of Soil Gradient

Fig. 2. Types of Soil Gradient With Voids

"Nathan (2010) [1]"studied "Geo- Mechanical Effect of Suffusion on Sand Kaolite Mixtures and he used gap graded soil in his research, he find :

(1) In the presence of suffusion, changes in permeability, properties of the force of pressure, and volume (any adjustment) can occur. The permeability decreases with the progression of suffusion, ranging from the reduction of permeability from about one to two orders of magnitude in the gradient, to almost any change in the gradient core soil. The degree of permeability reduction is highly dependent upon the internal clogging that happen, which is beyond the range of this study. The changes in compressive strength cannot be minutely explained in this thesis. The gap graded in soil show that compressive strength was greater after erosion, while basic soil showed that compressive strength was lower after erosion. The loss of saturation during erosion is supposed to take into account differences in force, but the opposite directions of varying strength can not be explained between graded gap and poor gradient soil, and changes in volume show approximately one third to three percent variation in the volume of different soil types that have been Tested. In terms of quality, reduce the volume consistent with the part of the soil solids eroded.

(2) Suffusion does not change the overall gradation of a soil, however, it can cause few localized changes. Gradation of eroded particles showed two approximately opposite

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directions, one is that the solids contained within the first few effluent samples had the coarsest 83gradations and the later effluent samples contained finer gradations. Another direction is that finer particles are removed first, then coarser particles. It was expected that in the presence of particle clogging, the gradations would become successively finer grained. The gradations that showed progression towards coarser gradations could be due to erosion of sand particles from the bottom of the specimen ,a phenomenon that differs than the suffusion and has a large effect on the gradation test results.

(3) Gap graded soils lead to produce more clear changes than poorly graded soils, at the time that recommended by the greater erosion rates, permeability reduction and volume reduction observed in the gap graded soils when compared with the mean soil.

(4) Eroded particles beyond the fine limit of the gap in gap graded soils are affected to being transferred by suffusion, because of the pores formed by the coarse particles larger than the coarse bound of the gap. ‘Mojtaba et al. (2013)[2]”studied the Stress transpration in internally unstable gap-graded particle soils using discrete element modeling ,Three dimensional discreted element modeling is occupied to explore micromechanical behavior of internally unstable/stable gap-graded particle soils under isotropic compression. There are two gap-graded soils, one of them is internally stable and the other one is unstable, are modeled by collecting of spherical particles and the micromechanical The parameters are searching in stress transmission.. The diffrence of coordination number and contacts per particle during isotropic squeezing submit higher coordination number for internally stable soil. Mechanical coordination number observation that floating particles with low number of contacts are more repeated in the internally unstable soil. Evolution of contact force networks during compression appearance that internal instability corresponds to a more heterogeneous contact force network, the results confirm the hypothesis that loose particles nest within pores of the primary fabric (coarser fraction) which is overpowering in transporting stresses and the tolerance Of the stress reduction factor (α) with the restriction pressure and the void ratio, confirms past experimental and numerical research that α is greater for internally stable soil. “Ndriamihaja et al. (2016)[3]” studied Influence of the percentage of sand on the behavior of gap graded cohesion -less soils ,The results presented in his work showed that the sand mixture deteriorated and gravel by the extraction of fines has large consequences on the mechanical behavior of the samples: The intact sample presents the lowest values of the standardized emin and emax void ratios. The degradation of the samples results in an increase of emin and emax. Absolutely , there are less and less fines to fill the voids between the coarse pieces when the soil is degraded. For a consistence volume of coarse grains, the cutback of the fine content results in an increase in the volume of voids and therefore, to an increase in void ratio; The intact sample Int30 presents the highest value of the monotonic un drained peak strength beneath both confining stresses The decrease in monotonic undrained summit strength is related to the destabilization of the force chains as the fine content is reduced, resulting in grain rearrangement and the formation of a new balance state, which is not compensated by the consolidation of the soil. In addition to the unit weight of the samples decrease as they are decadent; The intact sample Int30 presents a dilative behavior. The breadth of the contract phase is very small, as the sample porosity is low. The declination of the samples results in a decrease in their monotonic un drained peak strength. The results highlight a important increase in the contractive phase and a decrease in the dilative one. These changes are all the more significant as the fine content decreases; The internal friction angle of the soil increases when the fine content decreases. This part is related to the change in the texture of the material, allowing more direct contact between coarse grains, but also to the angle and surface characteristics of the different fractures of grain.

Fines Particles

Fines are similar small solid or solid particles sitting in the pore area. The fines that can be crowded by the permeating fluid are called the migratory fines. The shape and size as well as the surface charge of the fine paticles of soil influent the migration processes. In general, the fine particles are not of regular shape and described as platelets, blades, needles and flakes in the literatures .Due to the irregular shape of the fine particle, the description of the particle size would be complicated. Since the migrating particle usually steers the largest distance after it is in the parallel path to the flow direction, and the volume related to the fine-tuning processes, for instance plugging and bridging, the size will be in normal direction to the longest trend. generally, The larger dimension and other dimensions of migration fines differ from 0.1 to 10 microns “Keller and Vogler,(1998)[4]”.

Characteristics of Pores and Fines

Knowing the natures of pores and fines would help to understand the various phenomena related to movement of fines in porous media. Details of 25 pores and fines characteristics have been concise by “Khilar and Fogler (1998)[5]”. The porous medium or Porous material containing dispersed spaces in a solid matrix. Fluid can flow through the void spaces form one side of the medium to the other. Porous media can be review as systems in Which are separated by a solid matrix and void space at random in such a way that both phases form interpenetrating continua. The Pores are the void randomly distributed with different shapes and sizes “Dolaine, (1979)[6]” Some Pores are interrelated and constitute a uninterrupted phase while others are not connected It takes a dead end or a blind pore, Pore area is called interconnected Pores are effective space, in which case migration of fine particles can occur. Effective pore space can be modeled as a network of pore chamber connected by the pore throat or pore constriction “Lymberopoulos and Payatakew (1992)[7]”. The pore constrictions are the more tight segment of the interconnect pore space while the pore chambers are the famous segment, The pore size of the sandstone constriction is a few microns and the size of the pore size is greater than the size of the constriction “Dullien and Dhawan, 1974; Lymberopoulos and Payatakew, (1992)[7]. Generally, the fine particles of soil are not of regular shape, they are described as platelets, blades, needles, and flakes shapes in the literatures “Grim, 1968; Khilar and Fogler, 1983)[8]”.In the network of pore space, Pore chambers are generally associated with pore contraction in more than one effective direction. The network connection can be described by the number of format 26. The format coordination number represents the number for a pores constriction associated with the pore chamber. In general, the average number of sandstone coordination figures ranges from 4 to 8 “Lynn & Slatery, 1982; Yanuka et al., (1984)[8]. The charge intensity and the mineralogical composition of pore surface affect the electric forces between the attached fine particles and the pore surface. Surface loading is influenced by chemical properties of fluid permeability (Hiemenz, 1986). It is believed that the magnitude of the adhesion forces would affect the fine particles separation process (Sharma et al., 1992; Das et al., 1994). have shown that a resisting torque force is induced by the surface roughness when a fine particle is detaching by hydrodynamic forces. The greater the number of coordination, the less the likelihood of plugging occurs in all the pore constrictions, The migratory fine particles of soil are attached To the surface of the pores. The release and capture of fines is hardly influenced by the characteristics of the surface of the pores. The main characteristics that affect the fine particles migration processes are roughness of surface , charge intensity of surface and the mineralogical formation of the surface grains. The surface roughness influences the interaction energy and the adhesion forces between the fine particles and pore surface (Swantons, 1995).. The fines that can be mobilized by the penetrate fluid are named the migratory fines. The shape and size as well as the surface charge of the fine particles soil effect the migration processes. Due to irregular shape of the fine particle, The particle size description would be complex. As mobilized migratory particles usually orient to have a larger dimension in the parallel path to the flow direction, the size pertinent to the fine entrapment processes, for instance plugging and dare, would be the size in the direction normal to the longest direction. In general, The larger dimension and other dimensions of the migration fine particles differ from 0.1 to 10 The surface charge of the migrating fine particles affects the strength of the electrical forces between the fine particles and the surface of the pores. The charge hold by fine particles depends on the metal structure of the fine particles. The formation of fines, and the physicochemical interactions between the fine particles and the permeating fluid (Grim, 1968; Khilar and Fogler, 1998).

Fine Particles Migration

Internal erosion refers to the redistribution of fines on soil. In some cases, so far, fines can be washed Internal corrosion refers to the redistribution of fines on soil. In some cases, so far, fines can be washed from the soil, and washing fines will increase hydraulic conductivity, and sometimes pipes (Mitchell, etc.) may be confined to the downstream, 1967.The fine particles can cause internal erosion or wash fines .These types of soils are known as serious problems in geotechnical engineering because they are the major causes of dam failure in dams, roads and soil slopes (Parker and Jane, 1967; Sherard et al., 1972; Pearson, 1983). (23)). The volume of particle transfer depends on soil properties. If the fines are closed or washed in the case of the swarm depends on the texture and size of the soil particles, soil skeletal structure, permeability and the content of organic matter ‘Goldman et al., (1986)”. Fines are believed to be more likely than fines. Laboratory experiments have shown that measuring hydraulic conductivity here is a reduction in measurement when increasing hydraulic gradient. For example, Dunn and Mitchell (1984) found that clay mud pressure was reduced by a factor of 2.5 when the hydraulic gradient increased from 20 to 200.

Lawet al.(2001)think obout the effects of seepage on soil behavior, he present a practical case of fines migration in a re compacted fill slope at Tai Au Mun Bus Terminus, he studied there compacted fill material of the slope is a completely decomposed volcanic that can be classified as a clayey salty sand with some gravel. Based on the site investigation, the mean fine content of the slope was measured to be about 50%. Vegetation was also covered on the slope surface for protection. Several months after completing the upgrading of the fill slope, a typhoon struck Hong Kong and brought the huge downpour. Part of the slope subject to prescriptive measures at the Bus Terminus was damaged in the rainstorm. The mean fine content of the slope was measured to be below 40%, significantly lower than the fine content before the rainfall. Au et al.(2007) investigated and investigated the migration of particulate matter in completely decomposed volcanic. Based on the experimental results, the researchers concluded that the content of the fines of the test samples under the leakage will decrease over time and the particle migration rate will decrease over time.

Fine Particles Migration Process

The migration of fine particles includes several stages. Valdes (2002) examines the whole migration process from phase one to final stage 28. The sequence of the migration process is briefly outlined in the following paragraph. The migration process begins with the emission or separation of the fine particles of soil present in the porous pores of the soil porous matrix, the migratory fine particles are kept in place by the electrical adhesion forces and self-weight. The mobilization of fine particles takes place When the electro dynamic and hydrodynamic forces caused by fluid permeability overcome the strength resistance. When particles are filled fine. The fluid is suspended in and move along the flow direction of the fluid. Their movement with the flow depends on the pore channel geometry, the fluid flow conditions, and the inertial force due to the gravity. When considering further movement, the fine particles are finaly catch in some pore constriction or are washed from the porous medium. The migration of the fines would cause the structural redistribution of the solid grains. The flow conditions in the porous medium would be altered. The porosity and hence the conductivity would decrease in the zone of fine particles accumulation. otherwise, the aforementioned parameters would increase in the zone of fines removal. entrapment of fines are the most important phenomena during the fine particles migration process. Hence, they are studies extensively in the past literatures (Kovács, 1981; Khilar and Fogler, 1998; Valdés, 2002). When this force is the greatest influence on fine grains in the soil layer, these grains migrate along the length determined by the structure of the soil. When this force is the largest impact on the fine grains in the soil layer, these grains migrate along the length determined by the soil. Lam et al (2010) studied Effects of seepage on soil behavior recommended that the effects of seepage on soil behavior have been investigated in this study, they studied phenomena include the seepage-induced consolidation caused by the seepage force; the influence of seepage conditions on the laboratory hydraulic conductivity measurement; the changes in hydraulic conditions caused by fine particles migration; and the effects of particles migration on the shear strength of soil. The phenomena have been studied using diverse analytical models. Besides, a new laboratory-scale experimental apparatus has been designed to study these seepage-induced phenomena in sandy soil. Completely decomposed granite with different percentage of fine particles were used as the testing samples in the experiments. The main conclusions of this study are summarized below. The stress state of a soil specimen would change under a downward seepage. The change in effective stress state induced by seepage would result in consolidation of the specimen causing a variation in the void ratio distribution and hence the hydraulic conductivity. 223 .The range of seepage-induced consolidation rely on the seepage conditions, the confining stress, and the soil properties. Seepage-induced consolidation is manifest in soil specimen with high compression index, consolidated with a low confining pressure and experiencing seepage under a high hydraulic gradient. Analytical formulations and finite element model have been proposed to simulate the phenomena of seepage-induce consolidation. Under a given seepage environment, the models only required the compressibility property and the permeability property of the soil for a valid prediction. Laboratory-scale experiments have been carried out to verify the proposed simulation models for seepage-induced consolidation. The experimental data basically match with simulation results. In the seepage-induced consolidation experiments, void ratio – hydraulic conductivity relations of the test samples have been found. The results found in the experiments confirmed that the Kozeny-Carman equation predicts the relations well for the sandy soil. The influences of seepage-induced consolidation on the experimenter hydraulic conductivity measurement have been investigated. The account of the measurement depends on the approach used in setting up the seepage environment. On the based of proposed seepage-induced consolidation model, parametric 224 analyses have been executed to investigate the effect of experiential parameters on the value of hydraulic conductivity measurement. The following recommendations are made for producing an accurate laboratory hydraulic conductivity measurement: (1) seepage pressure should not be greater than fusion pressure to prevent excessive sample unification that would cause a significant reduction in hydraulic conductivity measurement. (2) Application of back pressure during measurement can reduce the degree of uniformity, application of high back pressure leads to swollen sample, But swelling will not cause a considerable alteration in hydraulic conductivity. (3) After sample saturation, the seepage should be facilitated by increasing the pore pressure at the end of the effect. This approach is recommended because it can provide an overestimate value with less error. Moreover, the sample tested by this approach can obtain the most uniform distributions of void ratio and hydraulic conductivity at the end of the test. The changes in hydraulic conditions caused by fine particles migration have been investigated. Microscopic model based on trajectory analysis and macroscopic model based on filter criteria (geometry constrains) Which describe the physics of particle migration. 225 Long-term seepage experiments have been carried out to study the phenomena of particles migration, 20% and 30% samples of fines were used in the tests, temporal variations of the hydraulic gradients and conductivities were observed at different positions of the test specimens. The changes of the flow conditions along the test samples indicated the occurrence of particles migration. Depending on the content of the fines, the specimen behaved differently under particles migration. For 20% fines sample, the hydraulic conductivity measurement reduced at the beginning of the seepage test and recovered at the later stage of the test. For the sample of fines of 30%, the hydraulic conductivity measurement continued to decline within the test duration. In the particles migration experiments, the temporal variations of the hydraulic gradients and conductivities at different positions of the test specimens can be dissect by the microscope model. Furthermore, the maximum size of migratory particles of the soil samples can be predicted by the macroscopic model. Multistage merged undrained triaxial compression tests were used to decide the impacts of particles migration on the shear strength of the soil, the examinations demonstrated that the seepage did not affect the viable shear strength parameters of the test examples, The absence of seepage is accepted to be insensitivity because of soil grain gradients. The self-filtering mechanism of the well-graded samples prevents 226 large-scaleparticles migration, the results of the triaxial tests showed that the particles movement strengthens the test specimens for samples with low fines content instead of lowering the effective shear strength parameters. It is believed that the rearrange of the particles improve the particle interlocking and hence the friction capability of the specimens. 8.2 Practical Applications The seepage phenomena discussed in this study are generally observed during underground constructions, Particularly in the construction of profound cellars and underground railway structures. The seepage effects are significant during dewatering process for the excavation prior the constructions of the permanent underground structures. When designing lateral support system for deep excavation, ground settlement is a general interest as the settlement would cause disturbance to the nearby structures. Soil properties would be another important component in the design process, Changes in soil characteristics will affect the implementation of temporary retention structures within the drilling areas, engineer should consider the effect of seepage-induced consolidation and the changes in soil properties caused by fine particles migration during the design process for underground construction. Raul et al. (2011) search in the Internal corrosion caused by the flow of water through earth dams and earth structures, the main conclusions and recommendations of this study are: If internal erosion caused by water flow or leakage is not detected through ground dams, dams, and other terrestrial structures containing water in a timely manner, and if corrective action is not taken to stop or control this erosion, the consequences may be a complete failure of this structure .Soil erosion may take place through the mass of the earth's structure or through its formation. The initiation of this process usually sets at the exit point of leakage and results in corrosion erosion in the formation of the "pipe". The prime factors that Influential the phenomenon of erosion are: a) Soil sensitivity to erosion . B) The velocity of the water within the soil mass. C) Earth structure engineering, soil permeability and ardibility depends on several factors, such as plasticity index, and water content. Un drained shear resistance, average grain size, # 200 scroll ratio, clay soil metal, soil dispersion ratio, salinity water, soil pH and pH in water and inter alia other factors. The seepage forces that impact the erosion problem are affined to the hydraulic gradient in the soil mass. Several practical measures and Recommendations were made to prevent damage from soil erosion. These include: a) Getting the best selection of building materials available. B) Control the homogeneity of materials through the construction process. C) the use of transmission areas between coarse and fine materials; and d) the use of properly designed filters and drains for all terrestrial installations exposed to harmful water actions in their foundations or around an impenetrable substance. A study has been hook up by Lin Ke et al.(2011) received in revised form 2 May 2012 One of the methods of internal erosion, , has been widely detected in both natural deposits and filled structures. It is the phenomenon that the fine particles in soil piecemeal migrate through the voids between coarse particles, Leaving behind a skeleton soil. The master focus is on changes in soil strength because of internal erosion. A series of single-dimensional ascending leak tests are performed at a fixed water head to cause internal erosion in the soil sample by controlling the three variable parameters, namely (a) The fine particles content, (b) The relative density of the soil and (c) The maximum decreed hydraulic gradient on the specimen. The mechanical result of the internal erosion are tested through cone penetration tests. The internal erosion of loss of fine particles of soil results in changes in the vacuum ratio and a significant increase in hydraulic conductivity, resulting in a lowering in soil strength of its elementary value. Experimental tests and tests also show in literature that this value is suitable for use to distinguish stable and unstable soils. The test results also show that in a transition zone the hydraulic gradients leading to erosion are depend heavily on the relative density of the soil. The tests reported here show that for clearly unstable soil, i.e. with values (d15f/d85b)mod>4, the critical hydraulic gradient for vertical upward flow around 0.20 with only the slight effect of initial relativity density. The tests notify here show that for clearly unstable soil, i.e. together with values (d15f/d85b)mod>4, the critical hydraulic gradient for vertical upward flow around 0.20 with only the slight effect of initial relativity density. Horizontal critical gradient is also about 60% up to 90% of the vertical one at the same initial relative density. The new design charts, which combine geometric and hydraulic criteria, are derived from the experimental results. By these charts, an assessment whether a soil is potentially unstable and an estimation of the critical hydraulic gradient for the onset of erosion is obtained.

Testing Program

Twenty-four samples of soil were divided into four groups, each containing a certain percentage of fine particles of 0.10,20 and 30%. Each group is placed in the model that was manufactured. The water is poured through a plastic pipe connected to a water basin Three water taps are opened at 10,20 and 30 cm height from the top of the model. The flow period was 3 hours, during which the outflow water was collected to determine the discharge and the quantity of the fine particles migratory. Change in unit weight , void ratio, internal friction angle and coefficient of permeability, change in effective stresses.

Materials Used

The Soil used

The soil used in this study was brought from Al-Musayb Governorate at distance about (70) km south of Baghdad as shown in Plate (3-1), approximately (150 kg) of sandy soil and (50 kg) of clayey soil. Standard tests are performed to determine the physical and mechanical properties of the soil.

One Dimensional Consolidation test

This test is performed to determine the mount and rate of volume decrease that a laterally confined soil specimen undergoes when subjected to different vertical pressures. From the measured data, the consolidation curve (pressure-void ratio relationship) can be plotted. This data is beneficial in determining the compression index, the recompression index and the pre consolidation pressure (or maximum past pressure) of the soil. In addition, the results obtained can also be used to determine the coefficient of consolidation and the coefficient of secondary compression of the soil. The tests were performed according to ***ASTM D 2435 - Standard Test Method for One-Dimensional Consolidation Properties of Soils*** More than 24 tests were carried out into two parts before and after the migration of the fine particles with 6 tests for each type of soil, three tests before migration and three after, with one test per depth as shown in Plates No. (3-5)

Model Design and Devise

Model Design

To study the effect of fine particles migration on the soil and to know the changes in soil properties we will need to make laboratory conditions similar to field conditions so that we can approach real results. In order to arrive at the results of an approach to reality it was necessary to manufacture a model that simulates the reality to some extent with many auxiliary tools A model made of steel was made in the form of a cube with dimensions (400 * 400 * 400) cm, nine valves were installed on three levels on one side of the steel container, the heights are (0, 10 ,20) cm from the base of the box. The model was supplied with water by connecting it to a water tank with a plastic tube ,Provide the vents with a flow valve to discharge the water from the saturated sample. The model was also supplied with a valve to enter the water into the sample and at a height of 30 cm. This valve was supplied with a 2-m long plastic tube, which was connected to the vent sample to provide water to simulate the presence of groundwater in fact. Each side of the model is equipped with a valve located at a height of 30 cm from the model base discharges excess water from the model as shown in Plate No.(3-15).

Devises

The apparatus consists of the following parts:-

1. Steel Container.
2. Loading steel frame.
3. Model footing.
4. Dial Gauge.
5. Plastic Tubes.
6. Accessories (water tank, plastic tubes, filter ,filter paper)

Model Preparation

For sandy sample

1. **T**he sample was prepared by extracting the desired soil weight by the pre-defined size of the sample and the dry density calculated by laboratory. The field density was extracted. The calculated soil volume was mixed with the optimum moisture content as shown Plate No. (3-16).

2. The sample is made saturated by calculating the saturated density and then extracting the water content to make the model saturated.
3. The soil was divided into five sections, the first layer was laid with 25 strokes and the second, third, fourth and fifth layers were placed in the same way as the first layer.
4. The prepared soil was then divided into (5-layers each 60 mm thick) compacted uniformly to achieve the required density. The compaction of each layer was carried out by a steel crucial hammer with (70) mm in diameter and about kg in mass.
5. Three openings were made for the three valves (10, 20 and 30 cm) to simulate the water permeability of the soil and then to withdraw the collected water from these openings through the valves and by the water withdrawal pump.
6. After completion of the five layers in the container, the bed of soil was covered with nylon sheets and allowed to cure for two days to give enough time for water to migrate and reached its equilibrium state.

For sandy soil with (10% , 20% , 30%) fine particles

The fine particles are milled to be mixed with the original model .The fine particles are mixed with the sandy soil and the mixing should be homogenous and then continue to return points (2-6) in a paragraph 1.

The Model Testing Procedure

After the completion of the curing time, the test was carried out as follows:

1. The loading frame was placed in position so that the center of footing in the same position of the center of soil bed as shown in Plate No. (3)
2. Loads were applied through the upper loading plate.
3. The model is supplied with water from the water tank by a plastic tube and the water level must be level with the level of soil surface.
4. Loads are left on the model for two days so as to simulate the reality to some extent and to make the soil stable .
5. The water exit valves are opened to the first level (30 cm) above the model base and the water outside is collected in cylinders for 3 hours.
6. Precipitation is calculated at certain time intervals and over a period of 3 hours.
7. The amount of water collected in the cylinder is calculated to calculate the discharge and the amount of fine particles.
8. The collected water is filtered on filter paper and the filter paper containing the fine granules is placed in the oven for the purpose of weighing .
9. The water supply valve and water exit valves are closed.
10. Loads, footing and loading frame are removed.
11. The model is drilled at a depth of 5 cm and is mid-rise to the first level for sampling for direct shear testing, consolidation, density and moisture content.
12. The points are returned from (1-10) to the second level and the reality is 20 cm above the model base, but the samples are taken at a distance of (10) cm from the soil level
13. The points are returned from (1-10) to the second level and the reality is 10 cm above the model base, but the samples are taken at a distance of (15) cm from the soil level .
14. Points (1-12) are returned to the second soil model, which contains 10% fine particles.
15. Points (1-12) are returned to the third soil model, which contains 20% fine particles.
16. Points (1-12) are returned to the fourth soil model, which contains 30% fine particles.
17. Points (1-12) are returned to the second soil model, which contains 10% fine particles.
18. Points (1-12) are returned to the third soil model, which contains 20% fine particles.
19. Points (1-12) are returned to the fourth soil model, which contains 30% fine particles.

Effect of Fine Particle Migration on Initial and Final Void Ratio

Fine particle migration had an effect on the void ratio, where the migration of fine particles led to an increase in the void ratio due to leaving the fine grains of the areas occupied by.

1. The initial and final void ratio of the soil without fine particles were 0.537,0.562, respectively, after flow were 0.562 and 0.449 at a depth of 10 cm from the soil surface. And 0.477, 0.438 before flow and then0.438 ,0.383 after flow at a depth of 20 cm from the soil surface. And 0.438,0.427 before flow and then 0.427 , 0.385 after flow at a depth of 30 cm from the soil surface. The initial and final void ratio of the soil with10% fine particles were 0.468 ,0.361 respectively, after flow were 0.527, 0.415,at a depth of 10 cm from the soil surface. And 0.418,0.320 before flow and then 0.418 ,0.320 after flow at a depth of 20 cm from the soil surface. And 0.418,0.314before flow and then 0.418, 0.314 after flow at a depth of 30 cm from the soil surface.
2. The initial and final void ratio of the soil with20% fine particles were0.476 ,0.368, respectively, after flow were 0.401,0.311 at a depth of 10 cm from the soil surface. And then 0.399,0.297 before flow and 0.399,0.297 after flow at a depth of 20 cm from the soil surface. And 0.364, 0.264 before flow and then0.364, 0.264 after flow at a depth of 30 cm from the soil surface.
3. The initial and final void ratio of the soil with30% fine particles were0.387, 0.259, respectively, after flow were 0.479, 0.364 at a depth of 10 cm from the soil surface. And 0.370,0.255 before flow and then0.370,0.255 after flow at a depth of 20 cm from the soil surface. And0.36,0.232 before flow and then 0.360, 0.232 after flow at a depth of 30 cm from the soil surface.

The values of the initial and final void ratio of the four models of soil were shown in the tables and shapes below:

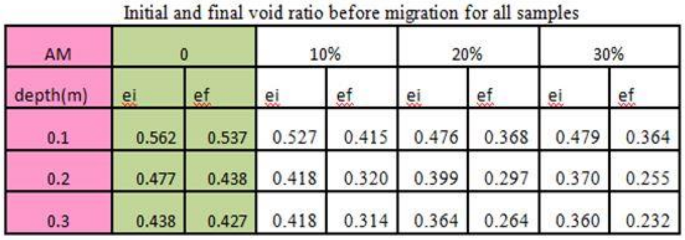

TABLE 1
Initial and final void ratio before migration for all samples

AM	0		10%		20%		30%	
depth(m)	ei	ef	ei	ef	ei	ef	ei	ef
0.1	0.562	0.537	0.527	0.415	0.476	0.368	0.479	0.364
0.2	0.477	0.438	0.418	0.320	0.399	0.297	0.370	0.255
0.3	0.438	0.427	0.418	0.314	0.364	0.264	0.360	0.232

TABLE 2
Initial and final void ratio after migration for all samples

BM	0%		10%		20%		30%	
depth(m)	ei	ef	ei	ef	ei	ef	ei	ef
0.1	0.537	0.449	0.468	0.361	0.401	0.311	0.387	0.259
0.2	0.438	0.383	0.418	0.320	0.399	0.297	0.370	0.255
0.3	0.427	0.385	0.418	0.314	0.364	0.264	0.36	0.232

TABLE 3
Initial and final void ratio before and after migration for all samples

Depth (m)	10%				10%				20%				30%			
	ei BM	ei AM	ef BM	ef AM	ei BM	ei AM	ef BM	ef AM	ei BM	ei AM	ef BM	ef AM	ei BM	ei AM	ef BM	ef AM
0.1	0.537	0.562	0.416	0.449	0.447	0.468	0.334	0.361	0.383	0.401	0.288	0.311	0.369	0.387	0.240	0.259
0.2	0.438	0.477	0.306	0.383	0.384	0.418	0.256	0.320	0.367	0.399	0.238	0.297	0.340	0.370	0.204	0.255
0.3	0.427	0.438	0.356	0.385	0.407	0.418	0.291	0.314	0.355	0.364	0.244	0.264	0.351	0.360	0.215	0.232

Void Ratio Distributions of the Specimens Before Migration

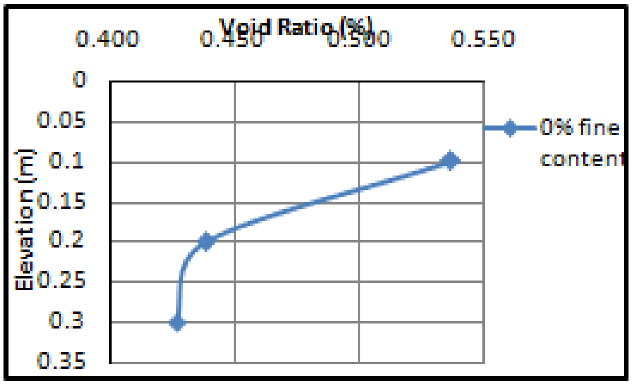

Fig. 3. Void Ratio Distribution With Elevation for Sandy Sample Before Migration

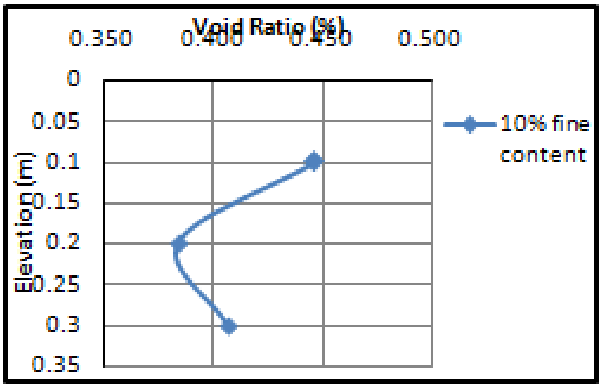

Fig. 4. Void Ratio Distribution With Elevation for 10% Fine Content Sample Before Migration

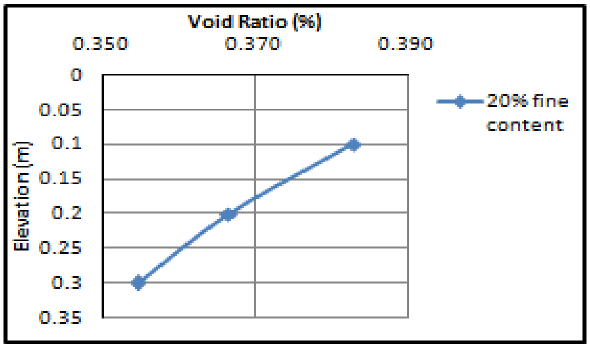

Fig. 5. Void Ratio Distribution With Elevation for 20% Fine Content Sample Before Migration

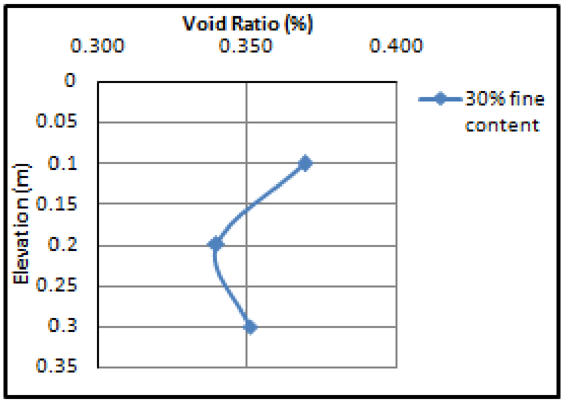

Fig. 6. Void Ratio Distribution With Elevation for 30% Fine Content Sample Before Migration

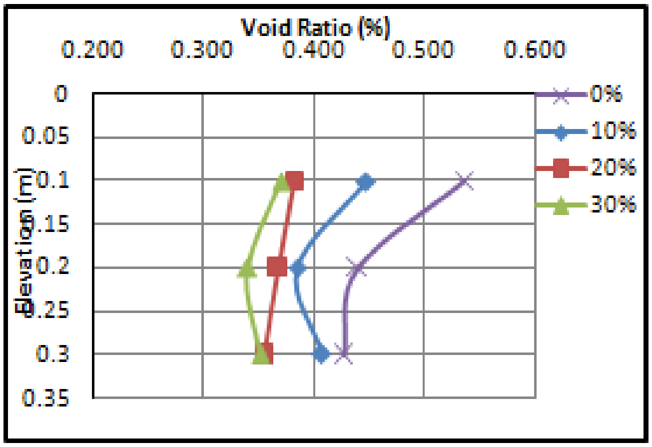

Fig. 7.Void Ratio Distribution With Elevation for the Four Samples Before Migration

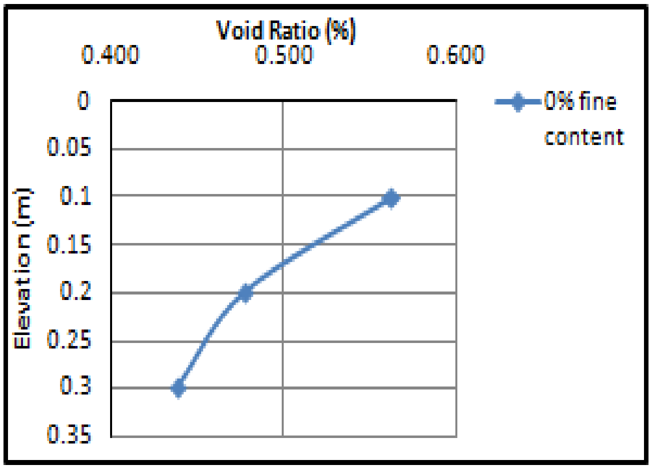

Fig. 8. Void Ratio Distribution for 0% Fine Sample After Migration

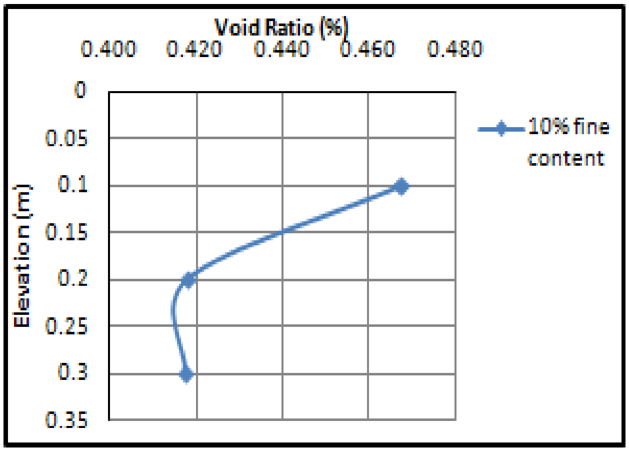

Fig. 9. Void Ratio Distribution for 10% Fine Sample After Migration

Void Ratio Distributions of the Specimens After Migration

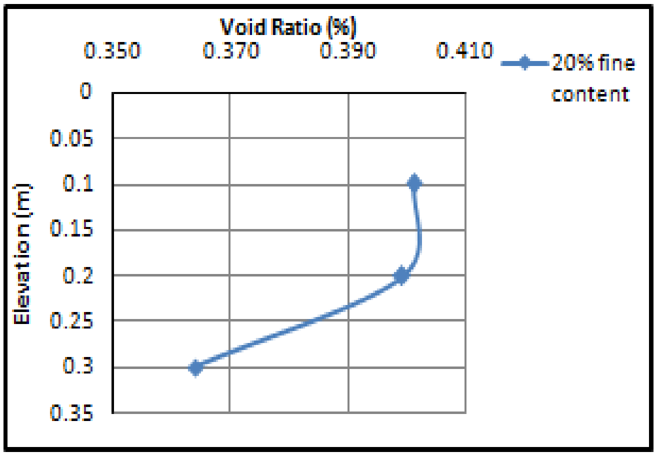

Fig.10. Void Ratio Distribution for 20% Fine

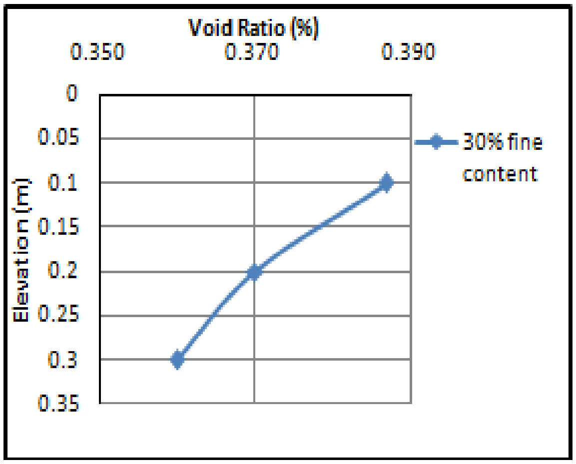

Fig. 11. Void Ratio Distribution for 30% Fine

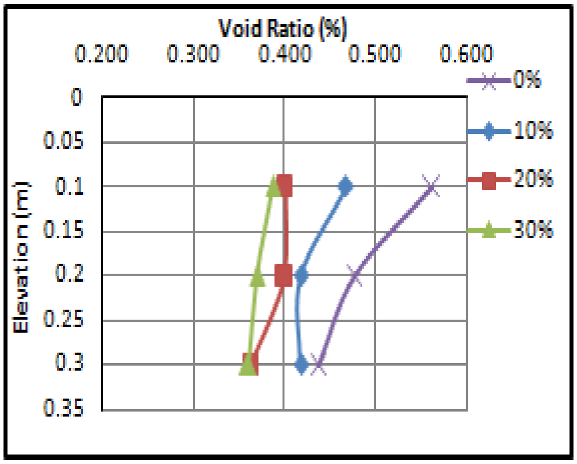

Fig. 12. Void Ratio Distribution for the Four After Migration

Conclusion

Through laboratory work and analysis of the results, several conclusions were reached, as follows: The value of the void ratio decreases with the increase in the percentage of fine particles. The fine particles are solved in the soil sample spaces. This percentage is reduced by increasing the depth of the increase of the effective stresses. The value of the original sample was 0.562, 0.477, 0.438 at a depth of 10,20,30 cm respectively. Containing 10% fine particles with a value of 0.527, 0.418, 0.418 at a depth of 10 ,20 ,30 cm, respectively, and in the sample containing 20% fine particles valued at 0.476, 0.399, 0.364, at a depth of 10,20,30 cm respectively and in the sample 30% fine particles of 0.479,0.370,0.360 at a depth of 10,20,30 cm, respectively, and the effect of the migration of fine particles was affected by working on The percentage of spaces where the migration of fine granules leaves behind a vacuum, increasing the void ratio. The difference was equal to 5.1% for the soil sample containing 0% fine particles while the difference was equal to 4.3% for the soil sample containing 10% granules. For the soil sample containing 20% fine particles, the difference was equal to 6.1%, and the difference was equal to 7.6% for soil samples containing 30% fine particles.

References

[1] Shwiyhat, M. N. (2010). "Geo- Mechanical Effect of Suffusion on Sand Kaolite Mixtures

[2] Ndriamihaja et al. (2016) studied Influence of the percentage of sand on the behavior of gap graded cohesion -less soils

[3] Khilar, K. C. and Fogler, H. S. (1983). "Water sensitivity of sandstones." Society of Petroleum Engineers Journal, 23(1), 55-64.

[4] Dullien, F. A. L. (1979). Porous Media: Fluid Transport and Pore Structure. Academic Press, New York.

[5] Lymberopoulos, D. P. and Payatakew, A. C. (1992). "Derivation of topological,geometrical, and correlational properties of porous media from pore-chart analysis of serial section data." Journal of colloid and interface science,150(11), 61-80.

[6] Dullien, F. A. L. and Dhawan, G. K. (1974). "Characterization of pore structure by a ombination of quantitative photomicrography and mercury porosimetry," Journal of Colloid and Interface Science, 47(2), 337-349.

[7] Lymberopoulos, D. P. and Payatakew, A. C. (1992). "Derivation of topological, geometrical, and correlational properties of porous media from pore-chart analysis of serial section data." Journal of colloid and interface science, 150(11), 61-80.

[8] Grim, R. E. (1968). Clay Mineralogy. McGraw Hill, New York, New York.

[9] Lin, C. Y. and Slattery, J. C. (1982). "Three dimensional, randomized network model for two-phase flow through porous media." American Institute of Chemical Engineers Journal, 28(2), 331-324.

[10] Yang, S., Lacasse, S., and Sandven, R. (2006). "Determination of the transitional fines content of mixtures of sand and non-plastic fines." Geotechnical Testing Journal, ASTM, 29(2), 102-07.

[11] Hiemenz, P. C. (1986). Principles of Colloid and Surface Chemistry, 2nd Edition. Marcel ekker Inc., New York, New York.

[12] Sharma, M. M. and Yen, T. F. (1984). "Interfacial electrochemistry of oxide surfaces in oil-bearing sands and sandstones." Journal of Colloid and Interface Science, 98, 39-54.

[13] Paker, G. G. and Jenne, E. A. (1967). "Structural failure of western US highways caused by piping." 46th Annual Meeting Highway Research Board, Washington, D.C.

[14] Sherard, J. L., Decker, R. S., and Ryker, N. L. (1972). "Piping in earth dams of dispersive clay." Proceeding, ASCE Specialty Conference on Earth and Earth Supported Structures, Vol. 1, 589-626.

[15] Goldman, S., Jackson, K., and Brusztynsky, T. A. (1986). Erosion and Sediment Control Handbook. McGraw Hill, New York, New York.

[16] Dunn, R.J. and Mitchell, J.K. (1984). "Fluid conductivity testing of fine grained soil." Journal of Geotechnical Engineering, ASCE, 110(11), 1648-1665.

[17] Law, K. T., Yu, T. K., and Cheung, S. C. H. (2001). "Washing out of fines in Re compacted fill slopes." in International Conference on Landslides: Causes, Impacts and Countermeasures, Davos, Switzerland, 169-178.

[18] Au, A. S. K., Yeung,A.T., and Chow,C.M.(2007)."Fines migration in completely ecomposed volcanic." Proceeding, 4th Civil Engineering Conference in the Asian Region. Taipei.

[19] Valdes, J. R. (2002). Fines Migration and Formation Damage – Microscale Studies. PhD Thesis, Georgia Institute of Technology, August 2002.

[20] Kovács, G. (1981). Seepage Hydraulics. Elsevier Scientific Publishing Company, New York.

[21] Berrones,F.R. and Acosta,P.N. (2011). Internal Erosion Due to Water Flow Through Earth Dams and Earth Structures, Mexico.

[22] Takahashi,A.L.(2012).Strength reduction of cohesionless soil due to internal erosion induced by one-dimensional upward seepage flow, Japan.