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Effect of Coarse Aggregate Columns on Angle of Friction in Fine Sandy Soil

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Abstract: the study adopted samples from Tigris river shoulders ,which has been subjected to such collapses and cracks. After testing and investigation it was found the soil is formed from river deposits , which can be classified as fine sand soil . It is known that many of the collapses that occurs in the sides of rivers are due to the influence of shear forces . A different of diameters coarse aggregates columns and aggregates sizes used in this study are tested by direct shear test.

The main objective of this research to increase the coefficient of friction between the soil particles in the test specimen by adding the coarse aggregate columns to the fine sand soil, In this regard the least void ratio was found as a beneficial index that relates with critical state of friction angle independent on soil gradation. The relations between critical state or high friction angles of the mixture with lower void ratio were determined as a function of addition pressure. The relationships could be useful to determination the strength parameters of (sand gravel mixtures).

Key Words: *Sand Column, Fine Sand Soil, Angle of Friction*

INTRODUCTION:

Several researchers have worked on theoretical, experimental and field study on behavior of stone columns .Ambily and Gandhi (2007) among the various methods for improving in situ ground conditions, columnar inclusions are considered one of the most versatile and cost-effective ground improvement techniques. The columnar inclusions can be in the form of stone columns/ granular piles, sand compaction piles, lime or cement columns, etc., which are stiffer and stronger than the ambient soil. Stone columns have been used extensively in weak deposits to increase the load carrying capacity, reduce settlement of structural foundations and accelerate consolidation settlements due to reduction in flow path lengths. Another major advantage with this technique is the simplicity of its construction method. The type and grain size of stone column material is one of the controlling parameters in the design of stone column.

Course sand columns are widely used in clay soils to investigate the effect of such columns on the strength soils. Course sand columns technique is widely used in different parts of the world to improve the geotechnical properties of soft saturated cohesive soils. Soft soils are identified by their high compressibility (c_c ranging between 0.19- 0.44) and low undrained shear strength (c_u< 40 Kpa) (Brand and Brenner, 1981). The bearing capacity and settlement of soft soil reinforced with sand columns depend on several factors such as dimensions and pattern of installation of sand columns in the field, area replacement ratio, the amount and rate of load application and the placement conditions of the backfill materials as this plays the major role in providing the stiffness of the columns. The technique is most effective in clayey soils with undrained shear strength ranging from 15-50 kPa (Barksdale and Bachus, 1983; Juran and Guermazi, 1988). However, it becomes unfeasible in more compressible soils, which do not provide sufficient lateral confinement.

Stone or sand columns in soft clays have been used to improve their geotechnical properties particularly the mechanical properties such as increasing the load carrying capacity, reducing the settlement, and decreasing the generation of excess pore water pressure during loading (Maakaroun et al., 2009). In soil improvement issues when sand columns are implemented as vertical drains, the possible reinforcing role that these columns can play in regards to improving the bearing capacity is usually neglected in design.

The previous laboratory studies on coarse grained soils have a problem due to the small dimensions scale of test specimens, In most cases the big grains size is limited to miner then 10 mm and tests perform on finer fraction of the soil which is usually called scalping method, Also in a few other cases a parallel gradation curve is used as representative of the original soil known as parallel gradation method, also in both methods a fraction of the soil should be neglected, which can affect in the mechanical properties. Another substitute is using the large scale in triaxial and direct shear test, which allows testing, soils with larger particles size and calculation parameters of the shear strength . These tests have been used by some researchers to study the mechanical behavior of coarse grained soils, Fragaszy et al. [1990 and 1992] used large scale in triaxial tests to study the effect of the large size particles on the mostly density of sandy soil. They defined the meaning of near and far field density , The near field density was defined as the density of the soil matrix adjacent to the oversized particles and the far filed density was defined as the density of the soil matrix at a distance far away from the large sized particles. It was presented that the far filed density rules the static strength of the mixture when the large sized particles are floated in finer matrix. They also reported that the increase in the gravel content decreases the value of far field density of the soil and the shear strength of the mixture. This was later showed for the recurring shear strength of sandy gravel combined by Evans and Zhou [1995].Many researchers showed the increase in the static shear strength of (sandy gravel) soils composites in floating state by the increase in the gravel content for example Yagiz [2001], Vallejo [2001] , and Kokusho et al [2004].

EXPERIMENTAL WORK:

The study depended on experimental method by using the direct shear test to study soil properties. The size of aggregates with a diameter of less than 12 mm was estimated for the coarse aggregate model used in the research due to the small sample of cell dimensions (60*60*30)mm , which its considered to be one of the most important problems encountered in the study effect of coarse aggregate with large dimensions . The method depended on mechanical analysis of the use rough aggregate with use field density in the samples of the test to obtain the amount of real change on the field density and use of columns of rough aggregates with more than diameters of the column and more than gradient of rough aggregates.

Research different from the previous researches by increasing the depths of aggregates in soil layers that can be achieved through drilling columns in soil, reduce the amount of aggregates and less then deformation on the soil properties whose are to be improved .

Some of the previous research increased the internal friction coefficient of the soil, its depended on mixing the coarse aggregate with the sand soil only , Evans and Zhou [1995], by method depending on mixing the coarse aggregate with all layers of the soil Model , in addition to neglecting the density and cohesion of the models that want improve its properties.

- The shear device , Direct shear test , ASTM D 3080 - 89 :

A device for measuring the stresses exerted on the soil layers through the device to measure the strength of cohesion and adhesion between soil granules and calculate the amount of friction angle of the soil particles. The device consists of a circular meter to measure the amount of stress applied to the soil by the device and also on the forces of the user-installed in order to convert the force to the forces of pressure layers and in the plate (1) shown the device in general and parts.

Plate (1) Shear device

This test study determination of the consolidated drained shear strength of a fine sand soil in direct shear machine with maximum shear force 5000 N. A high-resolution stepper motor and worm reduction unit, speed range adjustable from 0.00001 to 9.99999 mm/min, drive the Digital shear test machine work with high digital control and display of speed. The vertical load is applied directly to the specimen through a load frame carrying weights and can be increased using the beam loading device used to magnify the load on the shear testing machine. It can receive up to 50 kg of weight so that the total load on the specimen test can to be reach from (500 N to 5000N) using 10:1 lever ratio device.The machine is provided with shear box assembly slotted steel weights and load displacement

measurement device which can be analogical dial gauges and load ring or electronic with data acquisition, displacement transducers , processing load cell, and data acquisition system.
The electronics are housed in modern molded shroud, which includes a large LCD display, and keyboard entry.
- *SIEVES, ASTM D 422:*
used multiple types of soil sieves varying in degrees and amount of clamp diameters in the plate 2.

No.	#4	#8	#10	#20
mm	4.75	2.36	2	0.841

Plate (2) Sand Sieves

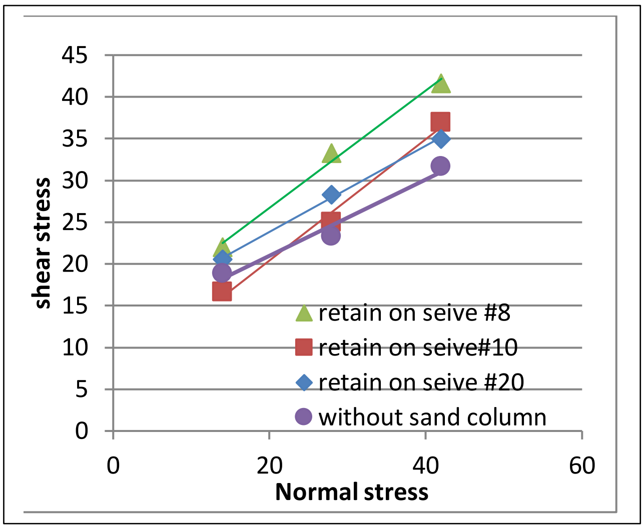
Preparation sample and Procedure

The model was prepared according to the ASTM 3080-98," Standard Test Method for Direct Shear Test of Soils under Consolidated Drained Conditions". by dividing the height of the model into three layers ,weight is calculated for each layer according to required density , compacted by a special hammer .
The column model equipped by cylinder with 1mm thickness , a different diameters, installed in the middle of the test mold as shown in plate (3) .
the specimen cell installed on the direct shear test as shown in plate (1). This process is repeated according to the size of the aggregates , diameters of the columns and the mixing ratio .

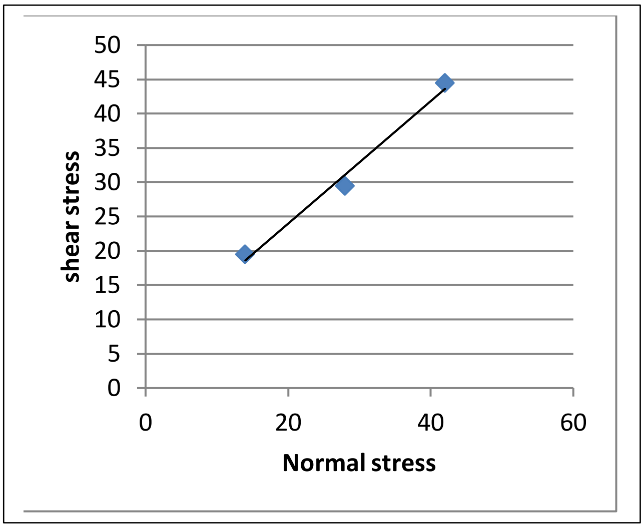
Plate (3) specimen preparation

Results data and Analysis:

Shear strength characteristics of six samples are studied by conducting direct shear test at three normal stresses (14 , 28 and 42) kpa , and at two different diameter of Sand column (1.22 and 2.6)cm. After testing a specimen of field soil and compare it with the result of samples soil with improvement the coefficient of internal friction angle for it by using aggregate with three different diameter of particles as retain on sieve no (8 , 10 and 20), and column area reach to 4.5% from test area of specimen (1.22 cm diameter column) we noticed increasing in value of friction angle with increasing aggregate diameter as shown in figure(1).Figures (2 and 3) respectively with the same column area replaced by aggregate (4.5%) illustrates that the use of mixed aggregates in equal proportion mixing from that three particles size used and mixed aggregates in proportion mixing to the ratio of increased coefficient of friction.



Figure(1)Effect size particles in sand column with 4.5% area replaced on friction angle



Figure(2) Effect uniform mixing particles in sand column with 4.5% area replaced on friction angle

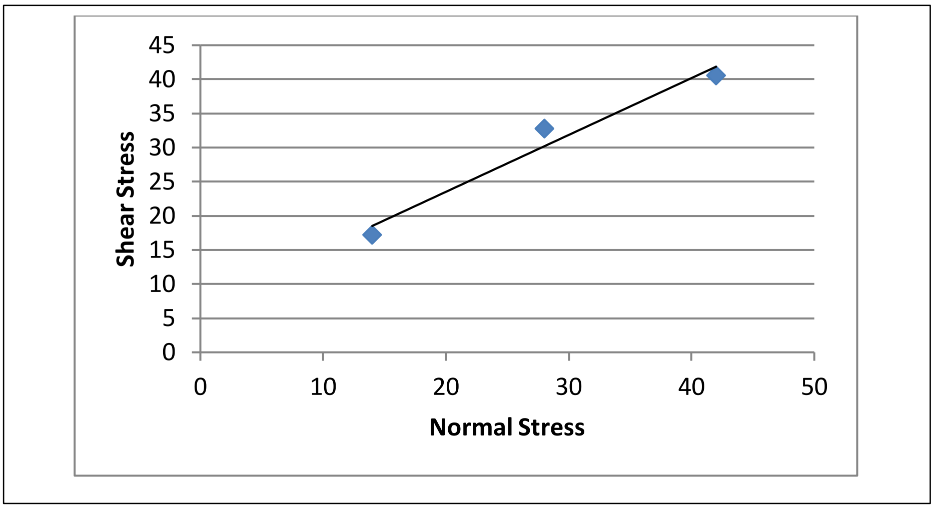


Figure (3) Effect non-uniform mixing particles in sand column with 4.5% area replaced on friction angle

Figure (4) shown increase in area of the columns of aggregates and reaching a ratio of 10% from test area has increased the coefficient of friction of the soil according to the diameter of aggregate used. the figures (5and 6) respectively observed that the use of mixed aggregates in equal proportion mixing from that used particles size and mixed aggregates in proportion mixing to the ratio of increased coefficient of friction for 2.6 cm diameter column.

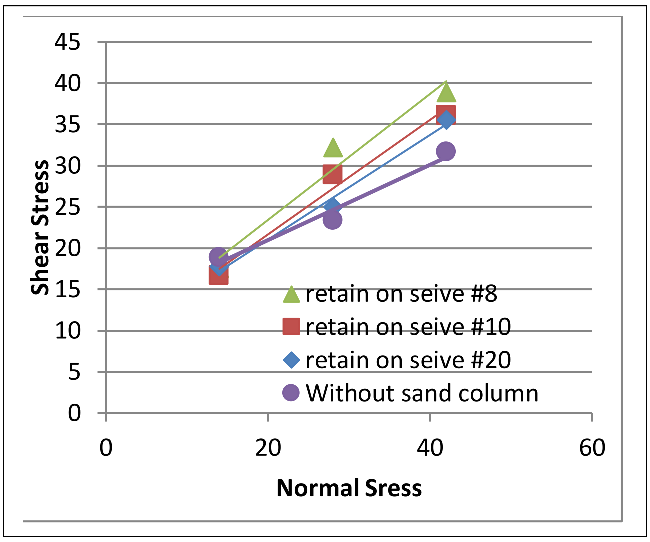


Figure (4) Effect size particles in sand column with 10% area replaced on friction angle

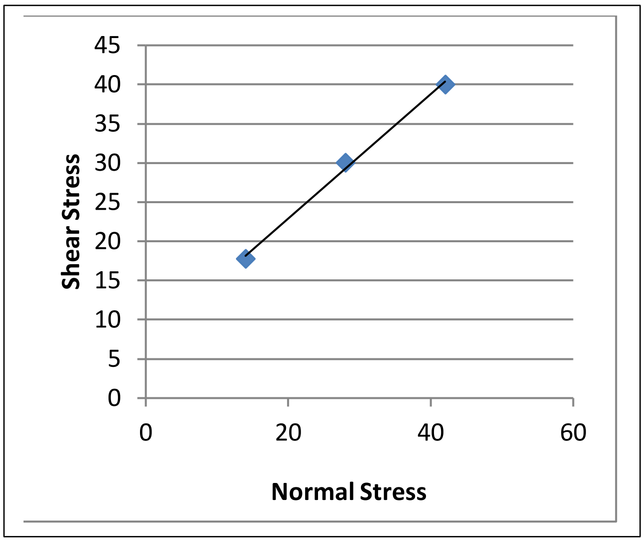


Figure (5) Effect uniform mixing particles in sand column with 10% area replaced on friction angle

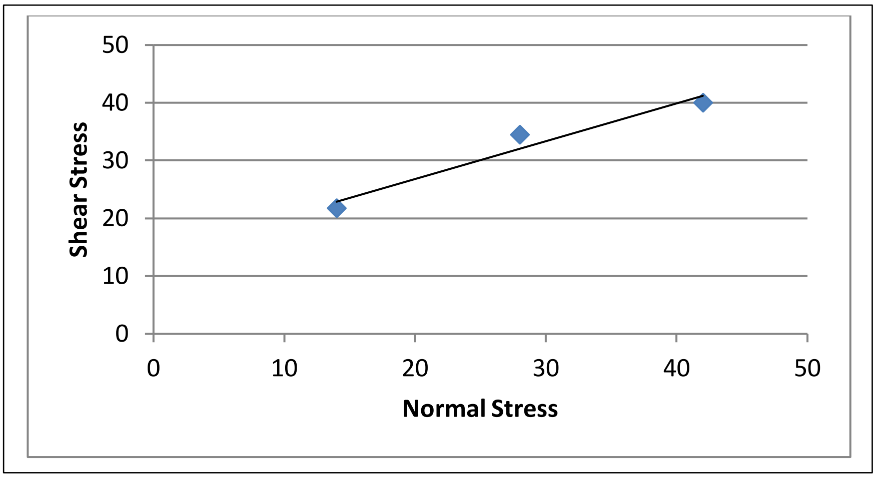


Figure (6) Effect non-uniform mixing particles in sand column with 10% area replaced on friction angle

- Effect internal friction angle by diameter of the Coarse Sand column:

From the figure (7) notice the diameter of Coarse Sand column has a significant impact on the amount of internal frication angle for the particles soil.

Note that the diameter of the retained Coarse Sand on the sieve no.8 against the diameter of column Coarse Sand (1.22)cm the value of its internal friction angle was (28) while in diameter (2.6) cm the value of the internal friction angle increased to (33)due to the increase in replaced area by the sand column.

-Effect internal friction angle by proportion of mixing Coarse Sand column:

Figure (8) shows the relationship between the use of ratios mixing of Coarse Sand columns to amount of internal friction soil . We note increase in the value of the internal friction angle for used soil through use Coarse Sand columns calculated as an improving ratio for all sizes.

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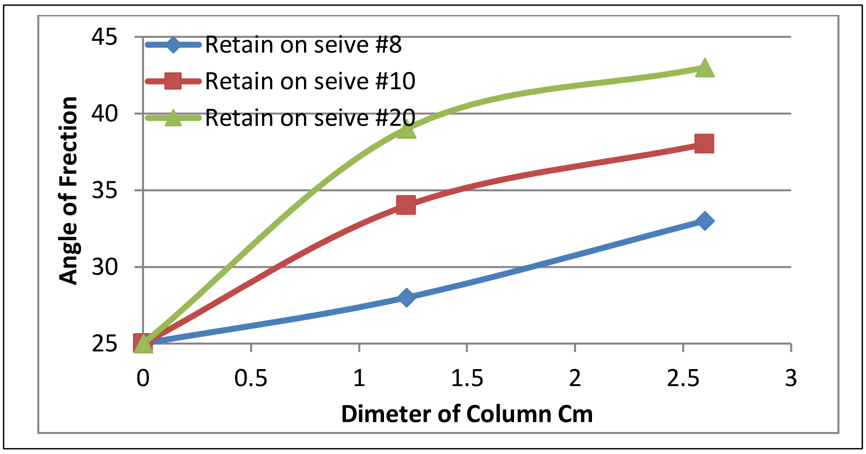

Figure (7)Effect the diameter and size of particles of coarse sand column on angle of friction

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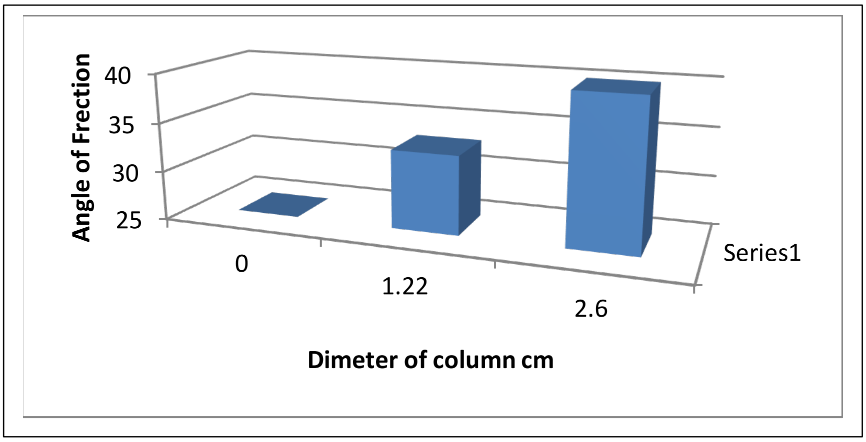

Figure (8) Effect the non-uniform mixing of particles size in different diameter of coarse sand column on angle of friction

In fig (9) mixing Coarse Sand in equal rate according to three sizes of Coarse Sand they added to improving soil. That increasing in amount of the internal friction soil due to decrease the voids ratio in soil which contributed to improve the properties .

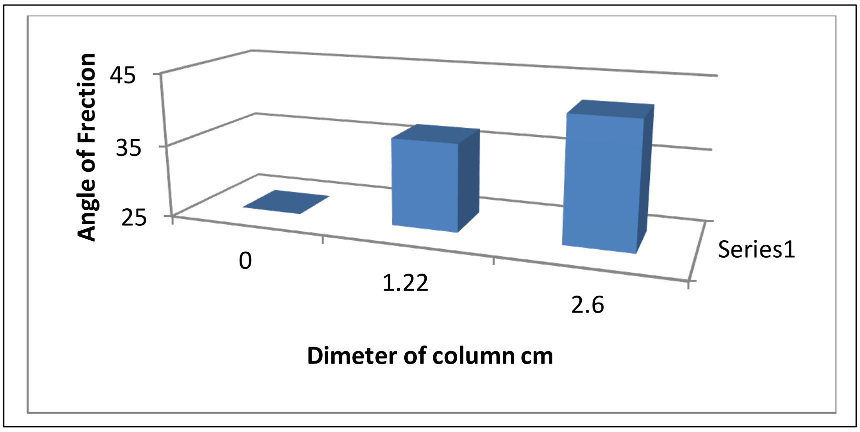

Figure (9) Effect the uniform mixing of particles size in different diameter of coarse sand column on angle of friction

Summary and conclusion

The study tested the possibility of improving the (fine sand) soil properties especially soils formed by the influence of river deposits ,which can be found in shoulders of rivers with low soil cohesion , samples were taken from the Tigris river which was exposed to such landslides and cracks .

After analysis the soil in sieve analysis test founded it formed from river deposits , which can be classified as (fine sand) soil .

The research dealt with the possibility of improving soil properties and reduce the collapses that occur in river shoulders or soils dams by increasing the coefficient of internal friction angle in soil by adding coarse aggregates to improve its strength, included on the drilling columns to several meters with different diameters inside the soil, add coarse aggregates of different sizes and a different ratios of aggregate size.

constant field density used in laboratory, so as to reach accurate results closer to reality , increase in the amount of internal friction coefficient of soil has been achieved , The relations between critical state or peak friction angles of the mixture with minimum void ratio were determined as a function of surcharge pressure.

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