Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2015/04/jls.htm
2015 Vol. 5 (S4), pp. 525-534/Kalkhoran et al.
Research Article

EMPIRICAL STUDY OF THE EFFECTS OF NANO-SILICA AND NANO-CLAY MATERIALS ON THE OCCURRENCE OF PIPING IN SANDY SOILS (GROUNDS)

Shayan Aghaalizadeh Kalkhoran, *Nader Abbasi and Shahin Aghaalizadeh Kalkhoran
Department of civil, Central Tehran Branch, Islamic Azad University, Tehran, Iran
**Author for Correspondence*

ABSTRACT
Sandy soils are of divergent type. Divergent soils show no resistance over water currents and move along with the water flow. These kinds of soils also show no resistance over the penetration of water and when water is inserted, they easily move with the flow and flee the environment. This issue is usually seen in the banks of the dams, which causes the internal erosion of the fundaments as piping and the boiling of the sand, which will eventually evacuate the banks of the structures and will destroy them. To solve this problem, utilizing Nano materials has attracted a lot of attention among researchers lately and many studies have focused on the matter. This study aims at the effects of two Nano materials - called Nano-silica and Nano-clay - on sandy soils or grounds such as the erosion rate.

Keywords: *Nano Silica, Piping, Sandy Soil*

INTRODUCTION
Based on the developing plans in the world and in Iran and the need for development projects such as building house and offices, subway stations and rail roads, dam building projects and other water structures, roads and highways, water transmission pipelines etc. has attracted more attention. Existence of troublesome soils or soils with weak features causes so many problems in such projects. Among them we can name the weakness of soil for loading and internal erosion against water flow. These kinds of soils show no resistance against water penetration and move with the water flow and flee their location. This is usually seen in the banks of the dams, which causes the internal erosion of the fundaments as piping and the boiling of the sand, which will eventually evacuate the banks of the water structures and will destroy them. Many solutions have been suggested that some focus on the modification of hydraulic flow features and some other on stabilizing on sandy soils. To stabilize soils we have many measures that can be used based on the fund, access of the materials and special situation of the project. Unawareness of soil features or choosing the wrong methods not only squanders the fund but also will result in human disasters. Using nano materials to modify the soil has attracted a lot of attention recently and many studies have shaped around the subject. In this study we test the effects of two nano materials called Nano-Silica and Nano-Clay on the erosion of sandy soils. This study is empirical and uses pin-hole experiment. First, various treatments have been implemented on the nano percentage of the erosion of the soil and then different dilutions of nano material were created. The 0, 3 and 6 day treatments were created of different percentage of nano and were tested through pin-hole method and using the pin-hole method the desirable percentage for the treatment was determined and the main experiment of Pin-hole was carried out.

Research History
Hosseini *et al.,* (2013) studied the effect of Mont Morilunit Nano-clay on the shear strength. To do so, in the straight cut they have used 5 different vertical stresses measured 0.229 and 0.478 and 0.726 and 0.975 and 1.223 kilograms per square centimeter, that this is to modulus stress in the depth of 1.5 and 3 and 4.5 and 6 and 7.5 meters, respectively, and then is applied to the samples and with the rise of nano-clay the shear strength also increases (Emad and Aliyayi, 2014). Mohammad *et al.,* (2010) studied the effects of nan-clay on the geotechnical features of clay sands, which was aimed at finding the desirable humidity and need weight for the experiment on the soil and after the straight cut and around Waterberg on the chosen soil that resulted in improvement of the soil with increase of the nano-clay (Mohammadzade *et al.,* 2010). Azizi *et al.,* (2013) studied the effects of nano-clay on the geotechnical features of sandy soils of Babolsar beach. To do so, they used different percentage of nano-clay and also some experiments as

density, pushing resistance of single base and absorption coefficient of that on the chosen soil (Azizi *et al.*, 2014).

MATERIALS AND METHODS

Nano Materials

The nano-clay used in this study is taken from Az-Chemicals, which is a company active in importing different kinds of chemicals to Iran. This Nano has the purity percentage of 99.5 percent. You could see the features of the material in the following table:

Table 1: Features of Nano-clay 15A

Organic modifier	2M2HT
Modifier concentration	125 meg
moisture	<2%
Weight loss on ignition	43%
density	1.66
color	Off white

Also the nano-silica material has the purity percentage of 99.5, the color is yellow and has 150 grams of nano-silica in per liter of the dilution. The pictures bellow shows the materials.

Picture 1.3: Picture of Nano-clay (on the left) and nano-silica (on the right)

A picture of dried nano-silica

Sandy Soil

Research Article

Real small gravel is called sand. You could find sand in the beaches. Based on the category of ATM stones smaller than 4.75 millimeter and bigger than 0.075 millimeter are called sand.
Accordingly, sand is divided in three groups of small, average, big (Shapour, 2008). The soil chosen for this study is from Kashan, Iran.

Relaxation Test

This is a kind of Kramb test, with the exception that the sample with certain density and size is gradually inserted into the water. The degree of opacity of water is the main criteria of chemical relaxation and no physical evaluation can be used. In the suggested tests first the sample with a desirable humidity was compressed in the Harvard mold. Then the compressed sample, which has the weight unit of a dry material. Next after the drying of the sample we gradually add it to water and write down the exact time needed for relaxation (Homan, 2011).

Standard Method for Realization and Categorizing Divergent Clay with Pin-Hole Test ASTM D4647

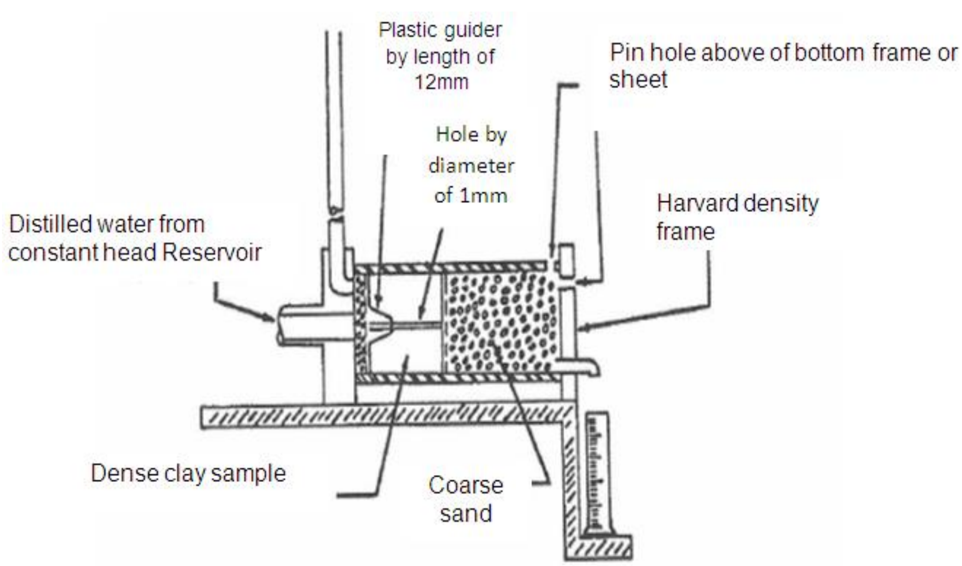
This test offers a direct and qualitative method for measuring potential divergent and colloidal erosion of clay soils that are created due the passing of water through a small hole. The dual Hydrometric test based on the D4221 standard complements this experiment. The method and the criteria are set based on some experiments on different soil samples related to channels and weirs which had erosion or did not have erosion. A, B and C is used to categorize soil relaxation. In A and C the soil is divided into six groups of divergent (D1, D2), average divergent (ND4, ND3) and non-divergent (ND) {1}.

Divergent Soils

Clay soils that with the presence of water easily separate with no physical trigger are called divergent. This kind of clay usually has high sodium absorption and often has high potential for shrinkage-swell, low resistance against erosion and high penetration resistance.

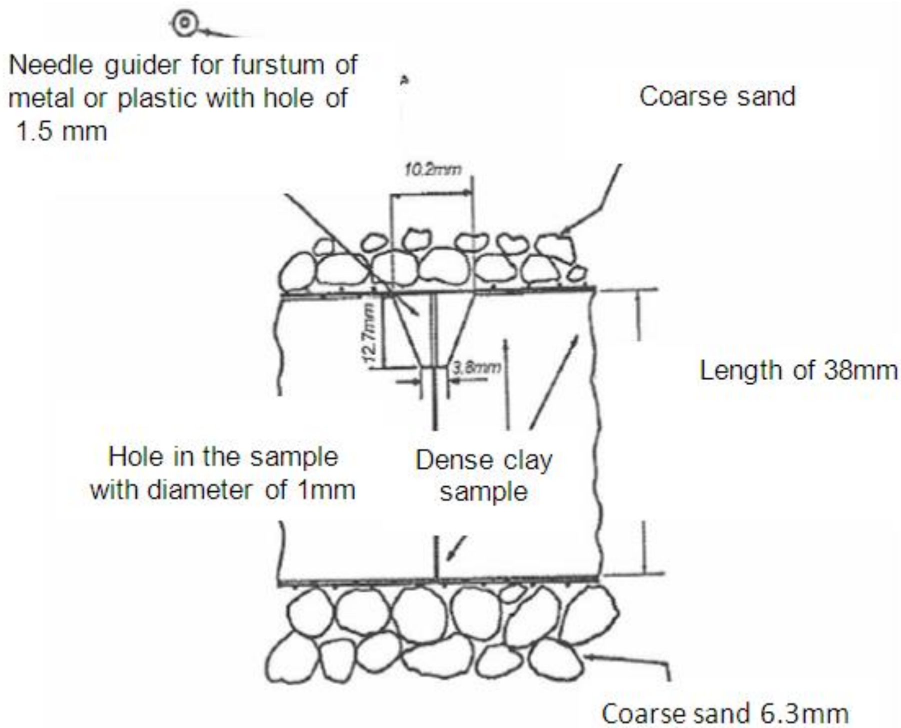
Summary of Experiment Method

The experiment with the horizontal current of distilled water with head of 50 mm (2in) through the hole created with the width of 1mm starts in the sample. Under this head, the quality of water is divided based on the resulted water for divergent and non-divergent clay soils. The resulted water from divergent water was totally dull, the width of the hole rapidly increased and in the end the speed of the flow increased, as well. The resulted water from clay soil with low relaxation was somehow dull but the width of the hole and the speed of the flow remained unchanged. Resulted water from non-divergent sample was clear and the width of the hole remained unchanged. Now we can categorize the potential divergence based on the clearness of the water and the width of the hole.



A sketch of pin-hole device

Research Article



A sketch of the sample in pin-hole device

A picture of the pin-hole device used in this study

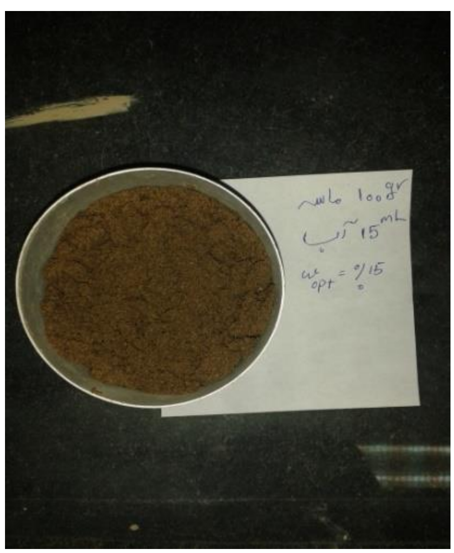
The pin-hole device components

Pin-Hole Divergence Test for Sandy Soils

With a few changes in the pin-hole device we can measure the physical divergence of sticky soils. In the samples the holed sand in the middle of the sample hardly remained unchanged and the water penetrated the whole sample and also caused the sample to be washed away too soon. To solve this problem we design a system to create a hole of 1mm width in the middle of the current cone that has no leakage from the around. Thus, we could stop the washing away and also forced the water to pass through the middle hole. Moreover, due to the physical existence of divergence the turbidity of the water could not be a criterion. Since the sand was washed and clean. Controlling the width of the water seemed impossible because of the destruction of the hole, and the resulted water also could not be used as the factor since it did not pass through the center hole merely. Therefore, in this study scour and destruction were used as the factor of divergence. Thus, the experiment on the whole samples were evaluated minding the resulted water and observations in the pin-hole device and the destruction of sample and physical divergence [13].

Sampling Methods

In this study as first we poured 100 grams of the chosen sand in special tubes. Then added desirable nano-clay and nano-silica (which is 15 perecent) based on the humidity of the sand and used special devices to spread the material in the sample and dilution.



Sample with 15 milliliter water (0 percent nano)

Next, put the sample in the pin-hole device using spoons in 5 layers and then each layer was beaten and compressed 15 times using the special hammer of the device. After compressing the soil, we put the cone shape component on the top of the sample and a 1mm pin made a hole was penetrated through the cone and the sample.

Special hammer of Pin-hole device used to compress the soil

Picture of the sample in pin-hole experiment tubes

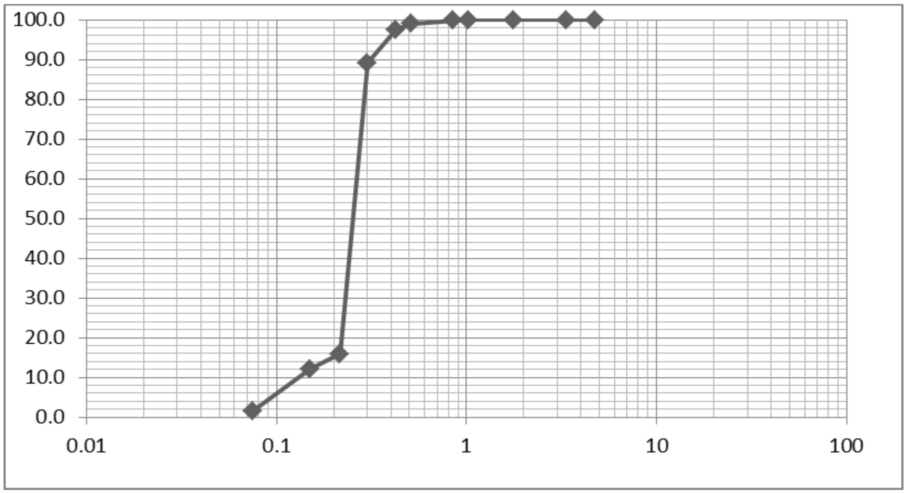


Table of categorizing sandy soils

The above table shows the horizontal axe of the size of the particles based on algorithm and the vertical table is based on passing percentage through the hole, which this is the sandy soil of SP or the bad categorized sand particle.

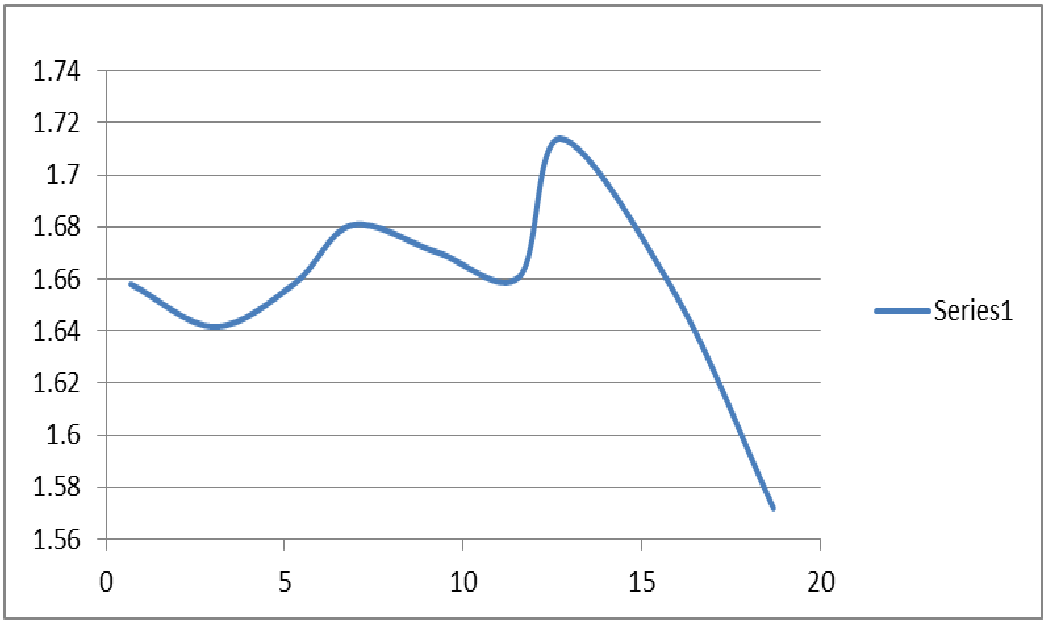


Table of humidity percentage based on the weight of dried sandy soil

The above table shows that horizontal axe for humidity and vertical axe for dried sandy soil. According to the table we can see that desirable humidity for the experiment is 15 percent.

Table of provided treatments with Nano-clay in relaxation test

Sample number	Weight of the sample	Weight of nano in 10ml water	The amount of nano dilution	The amount of added water to the soil	The mass of the whole dilution	Duration of relaxation in water
1	1oo gr	0/5 gr	3 ml	17 ml	20 ml	5 sec
2	1oo gr	0/5 gr	3 ml	10 ml	13 ml	5 sec
3	1oo gr	1 gr	6 ml	14 ml	20 ml	15 sec
4	1oo gr	1 gr	6 ml	10 ml	16 ml	20 sec
5	1oo gr	1 gr	6 ml	4 ml	10 ml	3min
6	1oo gr	1/5 gr	10 ml	0 ml	10 ml	4 min
7	1oo gr	1/5 gr	10 ml	5 ml	15 ml	5 min
8	1oo gr	1/5 gr	10 ml	10 ml	20 ml	1 min
9	1oo gr	3 gr	20 ml	0 ml	20 ml	2 min
10	1oo gr	3 gr	20 ml	5 ml	25 ml	2 min
11	1oo gr	6 gr	40 ml	0 ml	40 ml	3 min
12	1oo gr	6 gr	80 ml	0 ml	80 ml	5 min

Table of provided treatments with Nano-silica in relaxation test

Sample number	Weight of the sample	Weight of nano in 10ml water	The amount of nano dilution	The amount of added water to the soil	The mass of the whole dilution	Duration of relaxation in water
1	1oo gr	5 gr	0 ml	10 ml	10 ml	2 sec
2	1oo gr	5 gr	0 ml	15 ml	15 ml	2 sec
3	1oo gr	5 gr	0 ml	20 ml	20 ml	2 sec
4	1oo gr	5 gr	10 ml	0 ml	10 ml	2 min
5	1oo gr	5 gr	10 ml	0 ml	15 ml	5 min
6	1oo gr	5 gr	20 ml	0 ml	20 ml	24 hour

Based on the above table you could see that in nano-silica sample, since the humidity is 15 percent and the treatment in the dilution is 15ml, the sample has reached the maximum compression and the duration of the relaxation is 5 minutes (sample number 7). Also you could see that in the treatment with high nano-silica percentage with desirable humidity the relaxation duration has increased. In nano-clay we see that as nano-clay the duration for relaxation is dependent of humidity and the amount of nano material. (You could see the process of all these experiments in the picture and video folder.)

Pin-Hole Experiment

Before the beginning of the experiment the sand must be washed and clean. We talked about pin-hole device in the last chapter. Therefore, in this chapter we only show the results and the picture of each treatment…

At first the pin-hole experiment was implemented on sole sand in different situations. That is because in the beginning some questions as below were posed:

1. Does the water pass exactly through the 1mm hole in the sand?
2. If the water does not pass through the 1mm hole what shall we do?
3. What kind of lace can be used in the sandy soil so that the washing sand could be seen easily?

RESULTS AND DISCUSSION

The Results of Nano-Clay Samples in Pin-Hole Device:

Based on the table below, it is seen that the compressed sample with sand compression percentage of nano-clay the resistance against internal erosion which is low and with increasing the nano-clay the resistance increases as well in a way that the sand will not be washed up any more.

Compressed sand with 30 percent of nano-clay in desirable humidity (3 day sample)

Turbidity	Outcome (mlits/s)	Mass (cc)	Time (min)	Water head (mm)
Clear	0.33	100	5	
Clear	0.33	200	10	50
Clear	0.38	350	15	
Clear	0.83	250	5	180
Clear	1	300	5	380
Clear	2	600	5	1020

The result of pure sand sample in pin-hole device:

Based on the table below it is seen that sandy soil shows no resistance over internal erosion.

Compressed sand with 0 percent nano in desirable humidity (3 day sample)

Turbidity	Output (mlits/s)	Mass (cc)	Time (min)	Water head (mm)
Turbid	0.36	110	5	
Turbid	0.41	250	10	50
Turbid	0.36	330	15	
Washed	-	-	5	180
-	-	-	5	380
-	-	-	5	1020

The Results of Nano-Silica Samples in Pin-Hole Device

Based on the table below it is seen that the compressed samples with low nano-silica percentage the resistance over internal erosion is low and with increasing of nano-silica the resistance also increases to the point that the sand will not be washed away.

Table 22-4: Compressed sand with 10ml of nano-silica dilution in 50 grams of sand (3 day sample)

Turbidity	Output (mlits/s)	Mass (cc)	Time (min)	Water Head (mm)
Clear	0.33	100	5	
Clear	0.31	190	10	50
Clear	0.31	280	15	
Clear	1	300	5	180
Clear	1.66	500	5	380
Clear	3.66	1100	5	1020

Compressed sand with 2 ml of nano-silica dilution and 5.5 ml of water in 50 grams of sand (3 day samle)

Turbidity	Output (mlits/s)	Mass (cc)	Time (min)	Water head (mm)
Clear	0.16	50	5	
Clear	0.13	80	10	50
Clear	0.13	120	15	
Clear	0.7	210	5	180
Clear	1.43	430	5	380
Turbid and somehow washed away	2.66	800	5	1020

Conclusion

According to the results of the experiment and reviews in this study the following results are gained:

1. Using the relaxation test that seems like Kramb test we can say that whether the added material to the soil has any effects. Since the relaxation tests the samples contain 20 percent of nano-clay and relaxed in the water but in the pin-hole experiment the sample compressed with more than 0.1 nano resisted against being washed. As you can see the difference in these measures (20 percent and 0.1 percent) is really high.
2. In the pin-hole test time has no effects on the washing. At first when the sample is wet until the sand is dry the internal resistance increases but after it dries you see no effects on the resistance.
3. Adding the nano-clay to the soil the resistance increases and 0.1 percent of the sample is washed away and only the shape changes in the tube; from this percent washing is resisted.
4. Adding nano-silica to the soil the resistance increases and around 2 mm in per 100 grams of the sample soil is washed up (0.3 grams in per 100 grams of soil) and only the shape changes and this will resisted after that.

REFERENCES

Azizi Mahdi, Janalizade Asgar and Nemati Marzie S (2014). Review of the effects of geotechnical features on clay sand. *The Eighth Congress Of Civil Engineering, Civil College of Babol, May 7th and 8th, 2014.*

Heydarian Homan S (2011). *Standard Methods of Lab Experiments of Soil Mechanics* (Avand Andishe publication).

Hossini Mir Emad and Aliyayi Mohammad S (2014). Lab review of the effects of nano-clay Mont Morlunit on shear strength of clay sand. Articles of the *First National Conference of Geotechnical Engineering in Iran, Technical University of Ardebil*, *October 22nd*, *2013*, 1 to 7.

Mohammadzade Sani Abolfazl, Arbani Mahyar, Khodaparast Haghi Akbar and Jamshidi Chenari Reza S (2010). The effects of Nano-clay on the geotechnical features of clay sand. *Fourth International Conference of Geotechnical and Mechanics of Iran's Soil, November 2nd and 3rd, 2010, Tehran*, Article no 1TNRMOH039 to 7.

Tahoni Shapour S (2008). *Geotechnical Engineering Principle* (Pars Ayyin publication).