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Analyzing of Geotechnical Optimization of Cartridge Filter Wastes of Water Treatment Machine in Improving Soil of Road Construction, Sandy Soils Type

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Abstract

Stabilizing sand through sticky powder particles such as cement plaster powder, lime, and reinforcing it with fibers causes that it can be used in constructing the roads, airports, stank, road embankments, and etc., It improves their capabilities. The aim of this research is to use the wastes of cartridge filter of water treatment machine in improving sandy soils (SP, SM types) that it has not meet the needed quality expectations in geotechnical parameters, therefor the acts of sandy soil that stabilized with cement and reinforced with reused fibers of Cartridge tested and studied through particles grading test, soil compaction, and CBR(cartridge bearing ratio). Therefor in different tests used constantly 6% sand, and two cartridge fibers with 1.5 and 3 centimeters length in different dry density soil (%0, %0.2, %0.4, and %0.6). The testes results show that using fibers cause reducing maximum dry density of soil and increasing optimum moisture of the SM soil and increasing maximum dry density of soil and decreasing optimum moisture in the SP soil. Also using fibers of cartridge cause improving California bearing capacity in the SP and SM soils. Use of %0.4 fibers of cartridge waste left 1.5 centimeters result better than other percentage.

Introduction

One of the traditional and usual method of consolidating and improving strength parameters of small grade soils is adding traditional particles such as lime, cement, and tar that by passing time particles and materials such as fibers, metal elements, belts, plants, Geotextiles as an added materials to soil studied and tested. Parameters such as forming, bearing and soil strength improved.

Polymeric products that used as a reinforcing in the soil, causes increasing forming besides increasing cutting strength. Physical, mechanical, chemical, and hydraulic specifics of polymeric products basically depend on the type of the used polymers and producing process that forms its structure. Medium weight and statistical distribution are of the main specifics of polymeric particles. We can refer to polymeric particles such as poly propylene, polyester, polyethylene, polyamide, and Aramid. Polypropylene made through polymerization of propylene in the form of line polymer and in short called PP. This fiber made artificially in Italy with the trade name Meracelon in 1960, and it is available in the market. Fibers and bandage threads that form

Polypropylene, comparatively made easily through melt spinning method. Easy making and low coast make it so interesting. With using improving strength particles against UV radius tried to eliminate its low strength against ultra violet radius.

Polypropylene has not differences in the strength and solidity with polyethylene.

Rezaei and Salehi in 2016 considered the effects of industrial polypropylene fibers on SM soil through CBR test, the results show that the adding fibers to soil causes softness and plasticity of stabilized soil and eliminates its brittleness and fragility.

With regarding to figure can be noticed that the most increasing in bearing capacity gets in the amount of 2.0 percent weight of fibers.

Dakar and his colleagues studied the improvement of CBR in the clay soils (CH) with polypropylene fibers. Yetimoglu and colleagues (2005) according to study on bearing capacity of reinforced sand with fibers, and distributed haphazardly in the clay soil, and in that test that they used CBR for studying the effects of sand and gravel consolidated with interrupted fibers and distributed haphazardly on the soft soil as a subgrade.

Studies done by Sabat and Prohdan (2014) on the extensive mixtures of soil that stabilized with reinforcing fibers and windy ashes as a subgrade in the flexible superstructure. The method of test was in the way that the polypropylene fibers tested with lengths (6, 12, and 24) millimeters, and %20 soil optimal percentage.

This study done in order to use west of cartridge filters in the water treatment machine for improving sand soils (SP, SM) types, that doesn't meet the quality expectation in the geotechnical parameters. Another important aim of this study is the environmental advantage that regarding to cartridge filters are irresolvable or long time for degrading their wastes in the nature, they can be used in the road construction and superstructure.

1- Study methods

The applied soils in the Unified classification are in the SM-SP class. It is mean the tested soils are silt sand and bad grading sand, which SM soil prepared from Senejan city (Arak), and SP soil supplied from Babolsar Sea.

Table 1) Mechanical Specifications of used soil.

Type of soil	classification USCS	Cu	Cc	D60(mm)	D50(mm)	D30(mm)	D10(mm)
Bad grading sand	SP	9	0.7	1.8	1.25	0.5	0.2
Layered sand	SM	5.6	5.6	0.63	0.27	0.15	0.08

Figure 1) picture of SP and SM sand

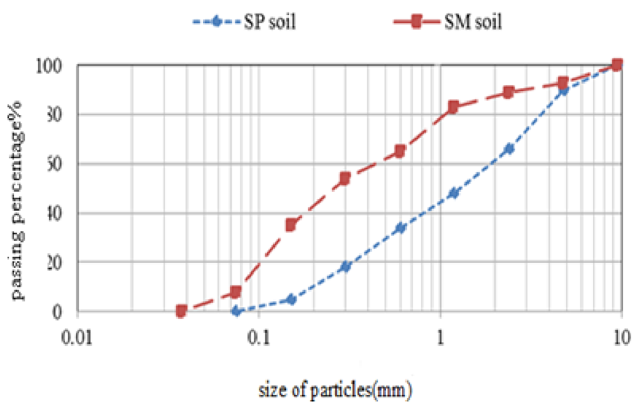


Figure 2) Diagram of grading SP and SM soil

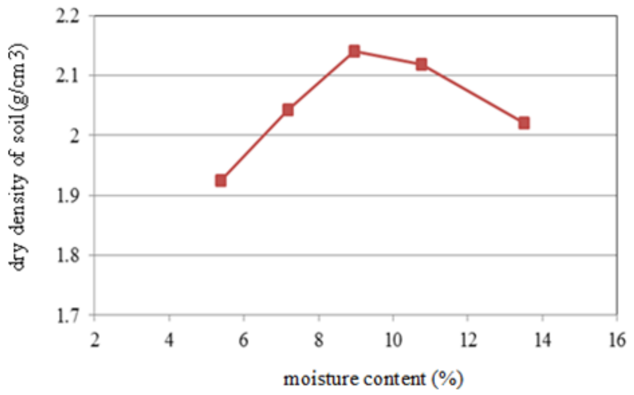


Figure 4) line graph of the compaction of SM soil

Curve of compaction maximum dry density of SP soil is 1.7 gr/cm^{3}that created in the best moisture of 13 percent. Also maximum dry density of SM soil is 2.14 gr/cm^{3}that created in the moisture 9.8.

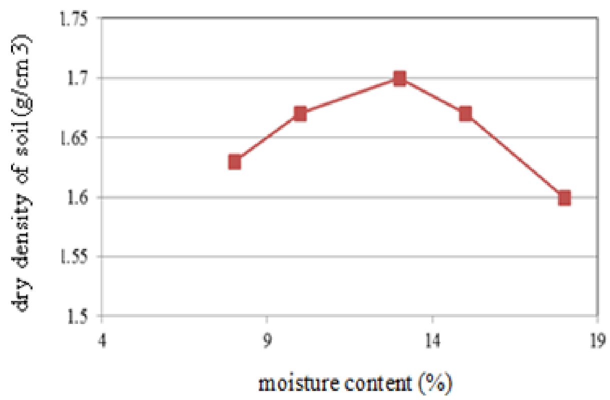


Figure 3) line graph of the compaction of SP soil

The cement used in Delijan was type 2 and density 3.15 gr/cm^3. The cement that applied in the test s, after preparation has used. Its specifications are in the table 2 and 3.

The fibers that used in this study are prepared from wastes of cartridge fibers f water treatment machine, it is from polypropylene. Upon studies on installing water treatment machines companions in Arak city in the areas such as Elahiye town and Shahre Sanati, because of hardness of water, the cartridge filters of consumers change every 5 months and in the other areas every 6 months. The length of usage fibers are rating 15 to 30 mm (figure and table 4).

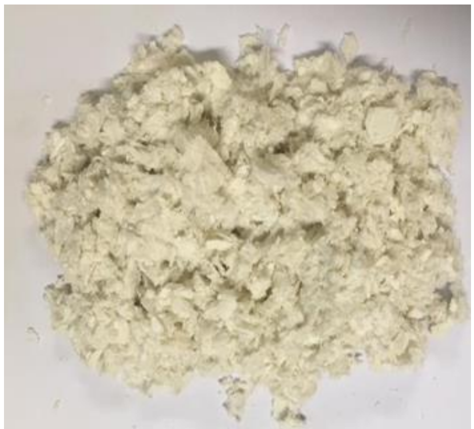


Figure 5) picture of artificial fibers

Amount of cement and polypropylene fibers are determined according to the relation (Figure 6).

$$\rho_c = {W_c}/{W} , \rho_f = {W_f}/{W}$$

Table 2) some physical specification of used cement.

specifications	Cement type	Type2
Percentage of mortar air	Maximum	8
	Minimum	6
Minimum compressive strength (MPa)	1 day	5
	3 days	11
	7 days	18
	26 days	31
Time of wicket needle grip(minute)	First grip (minimum)	45
	Final	375

Figur

Table 3) Percentage of chemical composition of used cement

Type of cement	percentage of chemical compounds					Temprature reduced (%)
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	
2	20.85	4.62	3.32	63.66	1.98	1.39

Table 3 continued

Na_nO eq	Percentage of potential compounds				Blaine test M^2/kg
	C3s	C2S	C3A	C4AF	
0.56	5.56	1.17	6.7	10.1	377

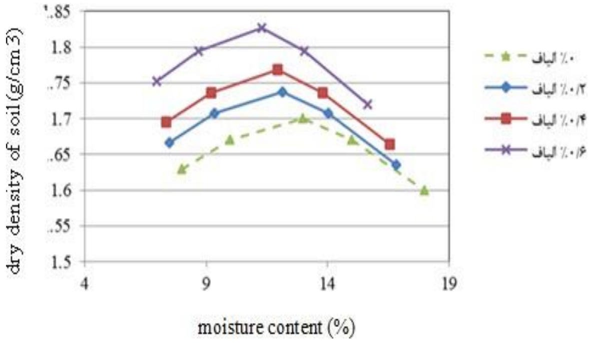
Table 4) Specification of used fibers

Chemical compound	Pol propylene
color	Milk-white
Length (mm)	15 to 30
Density gr/cm^3	0.91
Modulus of elasticity (MPa)	4700
Diameter (µm)	20

Figure 6. polypropylene fibers

Figure 7) the stages of making samples

In the relation (A) W_c is weight of cement W_f is weight of polypropylene, w is weight of soil dried in the air, ρ_c is percentage of added cement, ρ_f is percentage of polypropylene fibers that added to soil. Rated different amount for %0, %0.2, %0.4, and %0.6 fibers are percentage weight of soil. According to studies amount of used cement for stabilizing soil, in the Ashto classification and unified SP and SM is %6 of the weight of cement (Rushandel, 1999). The formed compactions all have done in the percentage of the optimal moisture, maximum dry density, and it done according to standard compaction test. For mixing the mixture plane, first cement added to soil to create a soft mixture then added separated fibers to mixture and the mixing continued to be sure



that fibers spread monotonously, at the end water added and started the required testes.

Figure 7) line graph of the compaction of SP soil with adding cartridge fibers**.**

Compaction Test

With increasing the amount of fibers in the SP soil, the maximum dry density of soil will increase and the percentage of optimum moisture will decrease. The reason of increasing the dry density of SP soil with using fibers cab be explained in the way that with regarding to weakness of grading of this soil and loading the empty atmosphere with fibers, the structure of grading of soil improved, and as the fibers don't have any water absorption but adsorption, when they used in the mixture, cause reducing water absorption, and as a result cause reducing the percentage of optimum moisture. The result has been reported in the previous studies (Mohammadzade Behrooz,2014).

But in the Sm soil the different procedure seen. In the SM soil adding fibers causes decreasing dry density of soil and increasing percentage of optimum moisture.

Adding fibers don't have positive effect on the grading structure of this soil, and due to its low density, maximum dry density of soil will decrease. With increasing amount of fibers and due to water adsorption fibers, and a type of grading of SM soil, the amount of optimum moisture increase. These results have been observed in the studies of (Mosavi Zade,2010), and Edincliner and his colleague (2010).

CBR test

Test of Californian Bearing Ratio (CBR) has done according to ASTMD 188-73 standard and its result has shown in the table 7.

In the CBR test the same results has been observed in the penetrations 5.2 and 5 mm piston in all the tests. In this way that with increasing fibers observed increasing the percentage of CBR up to %4/0 then happened reducing process.

The maximum percentage of CBR happened in the penetration of 5 mm, with using 5.1 cm fibers, and the minimum percentage of CBR observed in the 5.2 mm penetration and 3 cm fibers.

Discussion

Adding fibers lead to increasing Bearing Ration (CBR) of SP and SM soils. As in the SP soil with compression in the permeability 5.2 mm with adding %2.0 cartridge fibers 5.1 mm causes increasing 9 percent ratio of CBR. Adding %4.0 cartridge fibers increasing %18 in CBR's ration and with reaching amount of fibers to %6.0 causes increasing %13 CBR in SP soil with 5.1 cm fibers. In the penetration 5 millimeters of SP soil the same process happens, in this way that with adding %2.0 cartridge fibers will increase CBR ratio %14, and with increasing %4.0, and %6.0, of fibers the CBR ratio will increase %21 and %17.

About 3 centimeters fibers in the compression of the penetration 5mm with adding %2.0 cartridge fibers %6 will observe %6 increase in CBR ratio. Also with increasing %4.0 fibers will happen %17 increase and with increasing %6.0 fibers.

In the compression of the penetration 3 mm and 3 cm fibers with adding %2.0 fibers will create

%12 increase of CBR and with reaching the amount of fibers to %4.0, %27 increase in the CBR ratio, and in the 6.0 will create %18 increase.

In the SM soil and compression of the penetration 5.2 mm, and adding %2.0 cartridge fibers with length of 1.5 cm will create %5.4 increase in CBR ratio and with adding %4.0 and %6.0 fibers the CBR ratio will increase %34 and %14. In this soil and compression of the penetration 5 mm, the same process will happen, as with adding %2.0 fibers with 5.1 cm length causes %8 increase, at the same way, %4 an%6 fibers cause fibers cause %24 and %15 increase in CBR ratio.

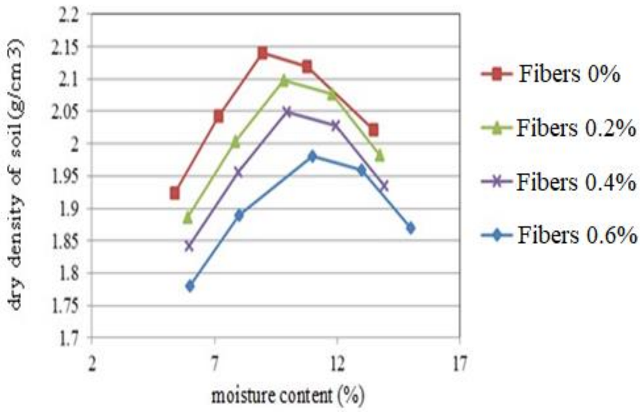


Figure 8) line graph of the compaction in SM soil with adding cartridge fibers

Table 5) Optimum moisture content and maximum dry density of SM soil

Percentage of fibers (%)	0	0.2	0.4	0.6
Maximum dry density (gr/cm^3)	2.14	2.09	2.05	1.98
Percentage of optimum moisture (%)	8.97	9.82	9.95	11

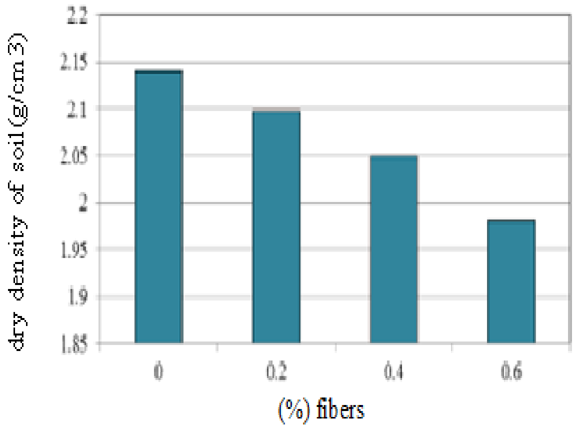


Figure 9) changes of maximum dry density of SM soil with increasing fibers

Table 6) optimum moisture content and maximum dry density of SP soi

Percentage of fibers (%)	0	0.2	0.4	0.6
Maximum dry density (gr/cm^3)	1.70	1.74	1.77	1.83
Percentage of optimum moisture (%)	13	12.15	11.96	11.31

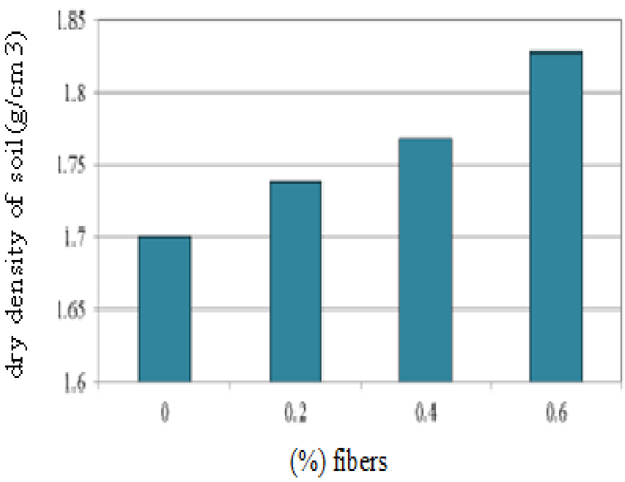


Figure 10) changes of maximum dry density of SP soil with increasing fibers

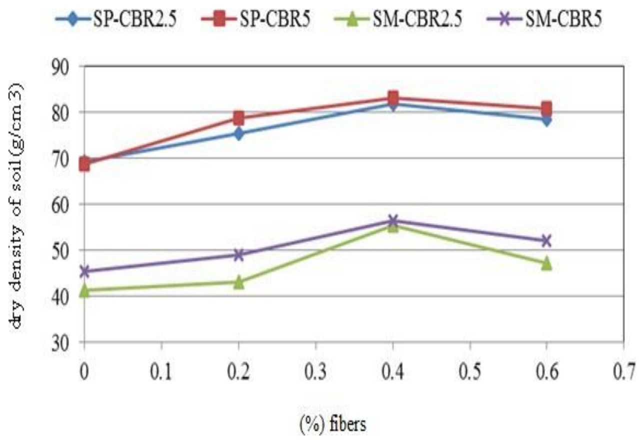


Figure 11) Changes of CBR percentage of SM soil with increasing fiber.

Table 7) result of CBR test of SM soil

Length of fibers(cm)	% CBR	Compression in the Penetration 5mm (Kpa)	% CBR	Compression in the penetration 2.5mm (KPa)	% fibers
1.5	45.52	4780	41.33	2893	0
	49.10	5156	43.23	3026	0.2
	56.40	5922	55.37	3876	0.4
	52.24	5485	47.28	3310	0.6

Table 7 continued

Length of fibers(cm)	% CBR	Compression in the Penetration 5mm (Kpa)	% CBR	Compression in the penetration 2.5mm (KPa)	% fibers
3	37.36	3923	33.14	2320	0
	40.06	4206	36.07	2525	0.2
	45.83	4812	45.79	3205	0.4
	43.05	4520	39.71	2780	0.6

Table 8) result of CBR test of SP soil

Length of fibers(cm)	% CBR	Compression in the penetration 5 mm (K pa)	% CBR	Compression in the penetration 2.5 mm (K Pa)	% fibers
1.5	68.76	7220	69.18	4843	0
	78.82	8276	75.43	5280	0.2
	83.25	8741	81.76	5723	0.4
	80.88	8493	78.43	5490	0.6

Table 8 continued

Length of fibers(cm)	% CBR	Compression in the penetration 5 mm (K pa)	% CBR	Compression in the penetration 2.5 mm (K Pa)	% fibers
3	59.33	6230	57.28	4010	0
	66.77	7011	60.83	4258	0.2
	75.28	7905	67.47	4723	0.4
	70.02	7352	64.00	4480	0.6

Figure 12) Changes of CBR percentage of SP soil with increasing fibers

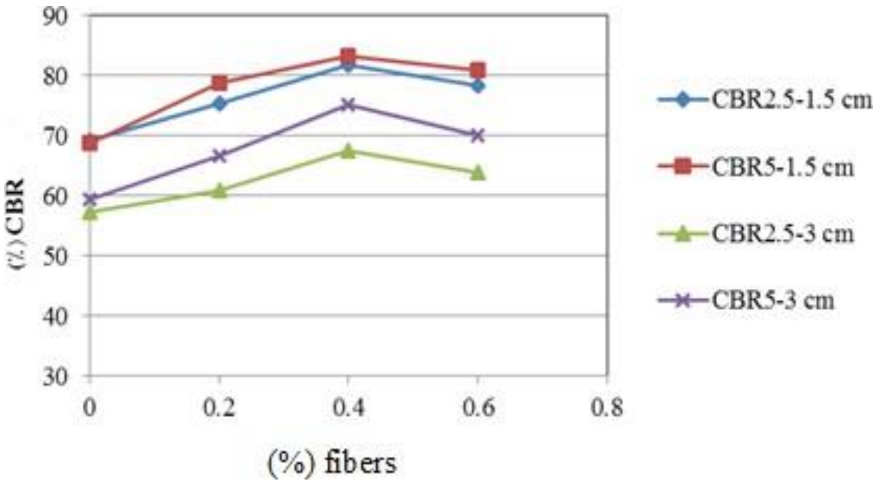


Figure 12) Changes of CBR percentage of SP soil with increasing fibers.

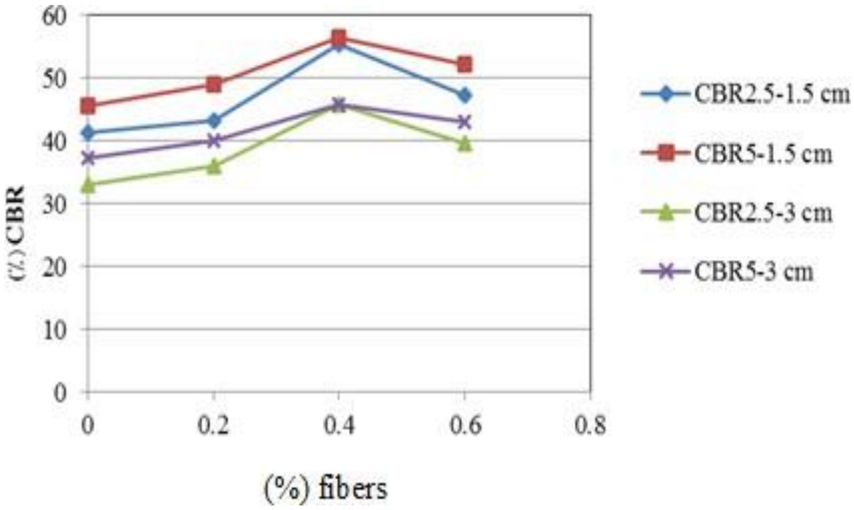


Figure 13) Changes of CBR percentage of SM soil with increasing fibers.

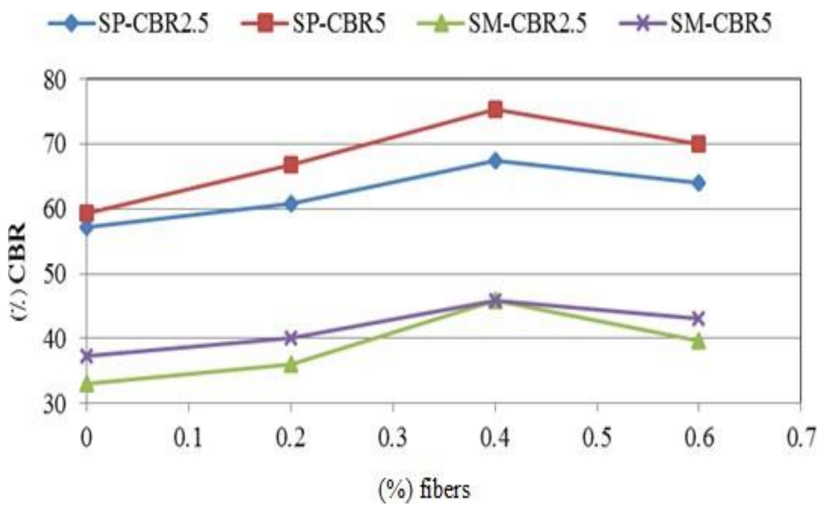


Figure 14) changing the amount of bearing ratio with percentage of fibers for SM soil

In the compression of the penetration 5.2 mm of SM soil and using 3 cm fibers with %2.0 will causes%9 increase in CBR.

Also adding %4.0 and %6.0 cartridge fibers cause increasing %38 and %19 in CBR. In the compression of the penetration 5mm of th SM soil and adding 3 cm fibers of cartridge will observe %7 increase in CBR. With adding 54.0 and %6.0 fibers will create %23 and %13 increase in CBR ratio.

Increasing in the amount of CBR with adding fibers have been seen in the studies of (Mosavi, zahed, 2010), (Mohammad Zade Behrooz, 2014), (Hasranjani, 2015), (Rezaei and Salehi 2016), and (Sharam and Tiwari, 2013).

Figure 13) changing the amount of bearing ratio with percentage of fibers for SP soil.

Upon the figures 13 and 14 both in the SP and SM soils, and in the penetrations of 5.2 mm of piston and 5 mm of piston adding %4.0 cartridge fibers with 5.1 cm length has a better result in comparison with other percentage. Also observed, the result of penetration of 5 mm piston shows the less increase in SP soil, that this difference in the SM soil is considerable, except in using%4.0fibers.

In the SP and SM soils, and in the 5.2 mm and 5 mm penetrations of piston, adding %4.0 cartridge fiber gives a better result in comparison with other percentage in the 3 cm fibers. Also the result of 5 mm penetration of piston in comparison with 5.2 mm penetration of piston shows the less increasing in SM soil, that this differences in the SP soil expect in the instance sample without fiber is considerable.

We can get the result that existing fibers cause soft damage of soil's mixture and causes increasing the flexibility of the materials used in the superstructure. Also among the lengths in this study the test result of CBR in the artificial fibers with 5.1 cm has a better result, and it' reason is in the easy distribution of fibers and not changing to ball after getting moisture and mixing with cement. The result of studies of (Sabat and Pradham 2014) and (Yetimoglu, 2005) confirmed this claim.

Results:

With adding cartridge fibers in the SP soil the maximum dry density increases and reduces the percentage in the Sm soil, adding fibers causes reducing dry density and increasing percentage of optimum moisture.

Weakness of the SP soil's grading structure and filling the empty atmospheres by cartridge fibers cause positive result of this articles on the dry density and reducing the percentage of the optimum moisture. In the CBR test the same results has been observed in the penetrations 5.2 and 5 mm piston in all the tests. In this way that with increasing fibers observed increasing the percentage of CBR up to %4/0 then happened reducing process.

The maximum percentage of CBR happened in the penetration of 5 mm, with using 5.1 cm fibers, and the minimum percentage of CBR observed in the 5.2 mm penetration and 3 cm fibers.

Increasing the amount of fibers causes increasing the bearing ratio of CBR in the SP and SM soils.

Adding the cartridge fibers in the SP soil has a better results than the SM soil that its reason can be because of the more suitable compression of SP soil with exciting of fibers. In the compression test its perfect result observed.

In the both SP and SM soils, the penetrations of 5 and 5.2 mm of CBR test using of %4.0 cartridge fibers with 5.1 cm length showed the better result and the penetration of 5 mm in comparison with penetration 5.2 showed the less increasing.

With regarding to get results in this study and publication 234, using SM soils, although has used fibers and cement, in the base layer is not recommended, but with the more testing and assurance, this soil can be used in the under layer of base, Using the SP soil with %4.0 cartridge fibers, %6 cement in the bases layer and under the base layer is possible, Of course for complication of this study needed more testes as unconfined compressive strength test.

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