POZZOPLAST AND ITS EFFECT ON GEOTECHNICAL PROPERTIES OF LOW TO HIGH PLASTIC FINE GRAINED SOILS

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ABSTRACT: *Pozzoplast is a type of fly ash with better characteristics. Maximum Strength activity index of pozzoplast is 88.72% and its maximum chemical composition (SiO_2+Al_2O_3+Fe_2O_3) is almost 93%. Fly ash is a very important admixture to use in cement industry and soil stabilization. This research is carried out to examine the effect of pozzoplast on low and high plastic soils. Two fine grained soil samples were collected. One is low plastic soil sample (A-4) and other is high plastic soil sample (A-7-6). Total 8 samples were prepared from the natural samples by mixing the pozzoplast at the rate of 0%, 5%, 10% and 20%. Basic index properties tests were performed on all samples to classify the samples. Modified compaction test, direct shear test and unconfined compression tests were also performed to determine the mechanical properties. Samples were remolded on maximum dry unit weight and optimum moisture content for direct shear test and unconfined compression test. It was examined that some mechanical and index properties showed the same behavior for both low and high plastic samples by adding same percentage of pozzoplast and some geotechnical properties of both soils have opposite behaviors from each other.*

KEY WORDS: Pozzoplast, Fly Ash, Fine Grained Soils, Geotechnical Properties, Physical Properties, Mechanical properties

INTRODUCTION

Pozzolon is a type of fly ash with better constituents. When coal is burned to generate the electricity coal combustion products (CCP) produced as a result [1]. Fly ash includes in coal combustion products and it is a by-product of coal. Power generation is a big problem for many countries in world and that is the reason power generation with coal becomes a famous practice in the world. The amount of the fly ash produced by the thermal power plant and factories annually is enormous. For example, 111 million tons coal combustion products were produced by USA in 2004 [2] and about 375 million ton of coal ash was produced by china in 2009 [3]. The contribution of coal-fired electricity generation in Poland is 94.8%, South Africa 93.0%, India 78.3%, Australia 76.9%, China 76.2%, Czech Rep 66.7%, Greece 62.3% Germany 52.0%, USA 49.9%, Denmark 47.3%, and in the UK 32.9% [4]. The current annual production of coal ash worldwide is estimated around 600 million tones, with fly ash constituting about 500 million tones at 75–80% of the total ash produced [5]. Now, Pakistan is also going to install the coal- fired electricity generation plants which have almost 13,850 MW production capacities [6]. . Most of the fly ash which is produced is disposed of as landfill, a practice which is under examination for environmental concerns. The storage of these coal combustion by-products has constituted a serious economic problem.

Fly ash can use for the purification of water and it is also used in cement industry and for the stabilization of soils. Stabilization of soil is a process to increase the strength of soil by using admixtures and fly ash can be used as potential admixture in this process. Many researchers have been worked on the stabilization of soils by using fly ash [7-13]. The aims of this study is to compare the constituents and chemical composition of pozzoplast with C class fly ash and to observe the effect of pozzoplast on high plastic and low plastic fine grained soils

COMPARISON BETWEEN C CLASS FLY ASH AND POZZOPLAST

Pozzoplast is a more refine shape of fly ash and has better constituents as compared to C class fly ash for the use of an admixture in civil engineering projects. Chemical composition and requirements of both C class fly ash and pozzoplast are given in Table 1. The standard composition & requirements of C class fly ash are taken from ASTM C-618 and for pozzoplast these requirements are taken from the certificate given by Imporient Chemicals (Pvt) Ltd, Pakistan with pozzoplast sample. According to Table 1, pozzoplast is finer than C class fly ash because retention on sieve # 350 of pozzoplast is less than the C class fly ash and strength activity index with Portland cement of pozzoplast is 88.72% which is more than C class fly ash. Similarly chemical composition of both fly ashes as given in Table 1, C class fly ash has 70% of silica, alumina & iron but on the other hand pozzoplast has 93.19% of silica, alumina & iron. Maximum loss in weight of pozzoplast on ignition is 1.3% and in C class fly ash is 6%. All discussion in this section shows that pozzoplast is a siliceous/aluminous material which has better constituents for stabilization of soil than C class fly ash [14]. So in this study pozzoplast is used to observe the effect of fly ash on geotechnical properties of low and high plastic fine grained soils.

Table 1: Comparison between the constituents of C class fly ash and pozzoplast

Test No.	Test	Unit	Fly Ash, C class [14]	Pozzoplast
1	Retention over sieve # 350 (45 micron)	% max	34	18.16
2	Water requirement	% max of control	105	98.90
3	Strength Activity index with Portland cement	% of control min. (28 days)	75	88.72
4	Soundness by means of Autoclave Expansion	% max	0.8	0.03
5	**Chemical Composition**			
a	$SiO_2+Al_2O_3+Fe_2O_3$	% min.	70	93.19
b	*Sulphuric Anhydride*	% max	5	1.04
c	*Loss on Ignition*	% max	6	1.30
d	*Moisture Content*	% max	3	0.31

MATERIALS AND EXPERIMENTAL PROGRAM

Two fine grained soil samples were chosen to accomplish this study. One sample (S.1) is taken from Raiwind road Lahore and other samples (S.2) is taken from Nandipur Gujranwala. The sample collection site map is presented in Fig 1. These are disturbed samples collected from 1 m below the ground surface. These samples were dried in oven at 104 ^oC for 24 hours and then subjected to following laboratory tests with and without adding the admixture.

- Specific gravity test (ASTM D-854)
- Grain size distribution tests (ASTM D-422 & 4221)
- Atterberg's limits test (ASTM D-4318)
- Soil Classification (AASHTO M-145)
- Modified compaction test (ASTM D-1557)
- Direct shear test (ASTM D-3080)
- Unconfined compression test (ASTM D-2166)

Grain size distribution tests and Atterberg's limits test were performed to find out the index properties and these properties are important for classification of soil. Soil samples were classified as fine grained according to AASHTO M-145 using index properties. S.1 sample is low plastic soil (A-4) with 16% liquid limit and S.2 is high plastic soil (A-7-6) with 43% liquid limit. Compaction characteristics (γ_{dmax} & OMC) were determined by performing modified compaction test and samples were remolded on maximum dry unit weight (γ_{dmax}) and optimum moisture content (OMC) for direct shear test and unconfined compression test. Afterwards, more artificial samples were prepared by mixing the pozzoplast at the rate of 5%, 10% and 20% (w.r.t dry weight of soil) form these two natural samples and again their index properties & mechanical properties were determined by performing the above mentioned laboratory tests. The effect of pozzoplast as an admixture on low and high plastic soils is then established.

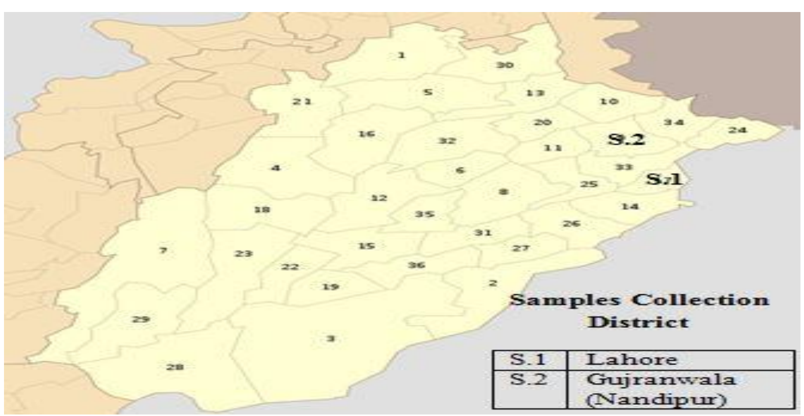

Figure 1: Soil Samples Location Map

Table 2: Summary of physical properties of samples

Sample #	Pozzoplast	Gs	LL	PL	PI	Grain Size Distribution					Classification Symbol
	%		(%)	(%)	(%)	Gravel (%)	Sand (%)	F_{200} (%)	Silt (%)	Clay (%)	(AASHTO M-145)
S.1(0)	0	2.63	16	0	N.P	0	34.9	65.1	53.1	12	A-4
S.1(5)	5	2.63	16.5	0	N.P	0	32.4	67.4	63.6	14	A-4
S.1(10)	10	2.59	17.2	0	N.P	0	31.4	68.6	55.6	13	A-4
S.1(20)	20	2.52	18.8	0	N.P	0	26	74	60.5	13.5	A-4
S.2(0)	0	2.75	43	21	22	0	22.3	77.7	37.7	40	A-7-6
S.2(5)	5	2.71	41.3	21	20.3	0	21.6	78.4	39	39.4	A-7-6
S.2(10)	10	2.68	40.4	23	17.4	0	20.8	79.2	40.5	38.7	A-6
S.2(20)	20	2.55	37	25	12	0	19.3	80.7	43.3	37.4	A-6

Table 3: Summary of mechanical properties of samples

Sample #	Pozzoplast	Modified Compaction Characteristics		Shear Strength Parameters		Unconfined Compressive Strength
	%	OMC (%)	γ_{dmax} (KN/m^3)	φ (degree)	c (KN/m^2)	q_u (Kpa)
S.1(0)	0	10.8	21.1	39.4	33	124
S.1(5)	5	11.2	20.25	44.5	28.29	140
S.1(10)	10	11.5	20.15	52.7	24	153
S.1(20)	20	12.2	19.8	56.6	19	163
S.2(0)	0	14.2	17.6	44.5	48	150
S.2(5)	5	13.6	18	50	40	177
S.2(10)	10	13.2	18.6	55.9	38	205
S.2(20)	20	12	20.1	63.1	29	226

TEST RESULTS AND ANALYSIS

Tests results of both low plastic soil sample and high plastic soil samples in natural composition and with different percentage of pozzoplast are given in Table 2 &3. Table 2 shows the trend of physical properties of both samples with increase in percentage of pozzoplast. According to AASHTO M-145 standard, S.1 sample is a low plastic silty sample (A-4) which remains A-4 sample up to 20% of pozzoplast but S.2 sample is a highly plastic clayey sample (A-7-6) with more than 41% liquid limit and it remains A-7-6 sample upto 5% of pozzoplast but at 10% and 20% of pozzoplast it become A-6 sample. Table 3 shows the trend of mechanical properties of both samples with increase in percentage of pozzoplast.

Effect of Pozzoplast on Physical Properties of Low and High Plastic Soils

Fig 2 (a) shows the effect of pozzoplast on specific gravity of both low and high plastic samples. Increase in the percentage of pozzoplast causes the decrease in specific gravity because specific gravity of pozzoplast is less than native soil samples. Specific gravity of pozzoplast is 2.38 determined by water pycnometer method. The specific gravity of fly ash usually ranges from 2.1 to 3.0 while its specific surface area may vary from 170 to 1000 m^2/kg [15-17]. Specific gravity of S.1 is decreased from 2.63 to 2.52 and it is decreased from 2.75 to 2.55 for S.2 with increase in the percentage of pozzoplast from 0 to 20%.

Effect of pozzoplast on grain size distribution can be observed from Fig 2 (b). Pozzoplast is silt size non cohesive material which causes to increase in percentage of silt like fines (F_{200}) in soil samples. With increase in percentage of pozzoplast, quantity of fines in low plastic soil (S.1) increased from 61% to 74% and increase for high plastic soil (S.2) was observed from 77% to 80%. Addition of pozzoplast in high plastic soil causes the increase in the silt size particles and decreases the clay size particles. In case of low plastic soil addition of pozzoplast increased the both silt size particles and clay size particles but its effect on increment of clay size particles is very small.

Atterberg's limits were determined for both soil samples with the increment of pozzoplast. The results are presented in Fig 3 (a) & (b). In case of high plastic soil, liquid limit and plasticity index are decreased from 43% to 37% & 22% to 12% respectively with increase in the percentage of pozzoplast. A possible explanation of the above results may be that the addition ofpozzoplast quantity of clay size particles decreases in sample and sample become rich in coarser size particles. Because particle size of pozzoplast is larger than maximum particle size of clay. In case of low plastic soil which have zero value of plasticity index, that soil shows an opposite behavior with the addition of pozzoplast. Liquid limit of S.1 sample increased from 16% to 18.8% with increase in the quantity of pozzoplast from 0 to 20%. It's a very minor effect on liquid limit due to pozzoplast but explanation of this may be that the addition of pozzoplast causes increase in the percentage of fines (F_{200}) and these fines have some cohesion which increases the plasticity of low plastic soil.

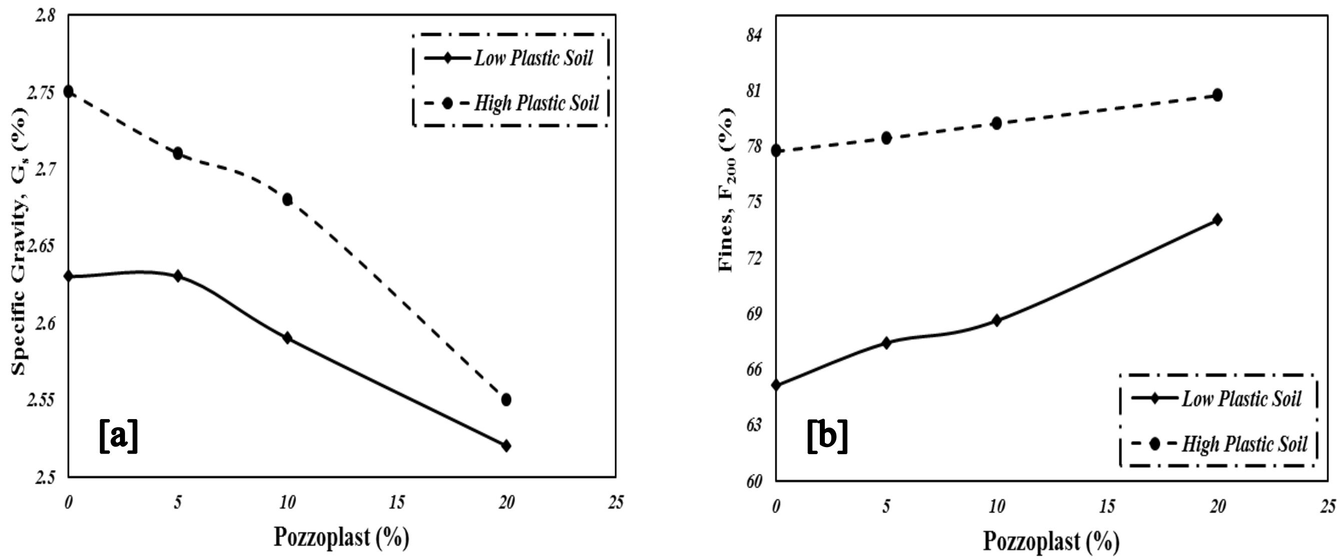

Figure 2: Effect of pozzoplast on a) Specific gravity b) Fines (F_{200})

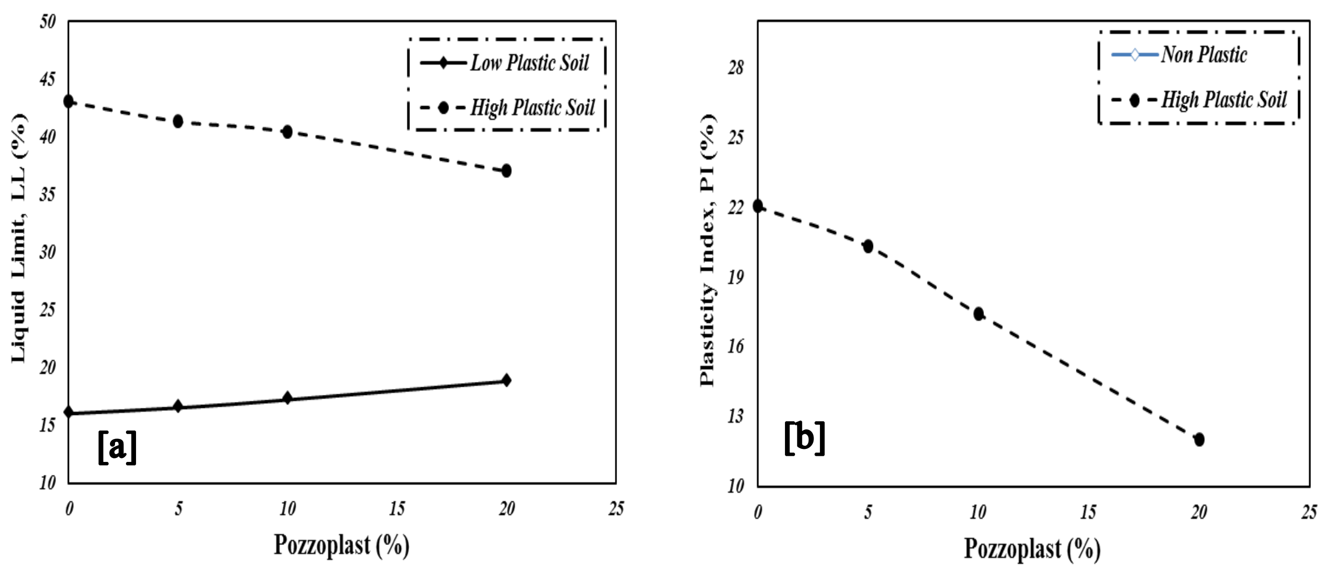

Figure 3: Effect of pozzoplast on Atterberg's limits a) Liquid limit b) Plasticity index

Effect of Pozzoplast on mechanical Properties of Low and High Plastic Soils

Fig 4 (a) & (b) show the effect of pozzoplast on compaction characteristics (γ_{dmax} & OMC) of fine grained soil samples which were determined with modified compaction test in laboratory. Maximum dry unit weight (γ_{dmax}) of high plastic soil (S.2) increased from 17.1 KN/m^3 to 20.1 KN/m^3 and optimum moisture content (OMC) decreased from 14.2% to 12% with increased in the percentage of pozzoplast. Due to the addition of pozzoplast percentage of clay fraction in sample decreased and attraction between particles also decreased. So less water is required to break the attraction and rearrange the particles to achieve the maximum dry unit weight and specific gravity of water is less than specific gravity of soil particles. These are the reasons which increased the γ_{dmax} and decreased the OMC with addition of pozzoplast in high plastic soil. But in case of low plastic soil (S.1), Maximum dry unit weight (γ_{dmax}) decreased from 21.1

KN/m^3 to 20.1 KN/m^3 and optimum moisture content (OMC) increased from 10.8% to 12.2% with increased in the percentage of pozzoplast. The explanation is that quantity of fines increased with pozzoplast in sample which required more water for lubrication of soil particles to compact the sample. That is the reason which decreased the γ_{dmax} and increased the OMC with addition of pozzoplast in low plastic soil.

To determine the shear strength parameters (c & φ), direct shear test was performed on natural and artificial samples without curing who was remolded on maximum dry unit weight and optimum moisture content. Effect of pozzoplast on shear strength parameters is shown in Fig 5 (a) & (b). In Fig 5 (a), cohesion (c) of both low and high plastic samples decreased with increasing the pozzoplast from 33 KPa to 29 KPa & 48 KPa to 29 KPa respecivtly. In Fig 5 (b), angle of internal friction (φ) of both low and high plastic samples increased with increasing the pozzoplast from 39.4° to 56.6° & 44.5° to 63°.

To determine the unconfined compression strength (q_u) of fine grained soil samples, samples with and without pozzoplast were remolded in a constant volume mold whose height to diameter ratio is 0.5. These samples were prepared on maximum dry unit weight and optimum moisture content and tested after 7 day curing. Unconfined compression strength (q_u) of both low plastic sample (S.1) and high plastic sample (S.2) increased from 124 KPa to 163 KPa & 150 KPa to 226 KPa respectively due to addition of pozzoplast presented in Fig 6. Pozzoplast increased the strength of fine grained soils due to cementation and pozzoplanic reaction between the clay minerals and pozzolon particles. Increment in unconfined compression strength of high plastic sample (S.2) is more than the low plastic sample (S.1) because clay particles in S.2 sample ios more than S.2.

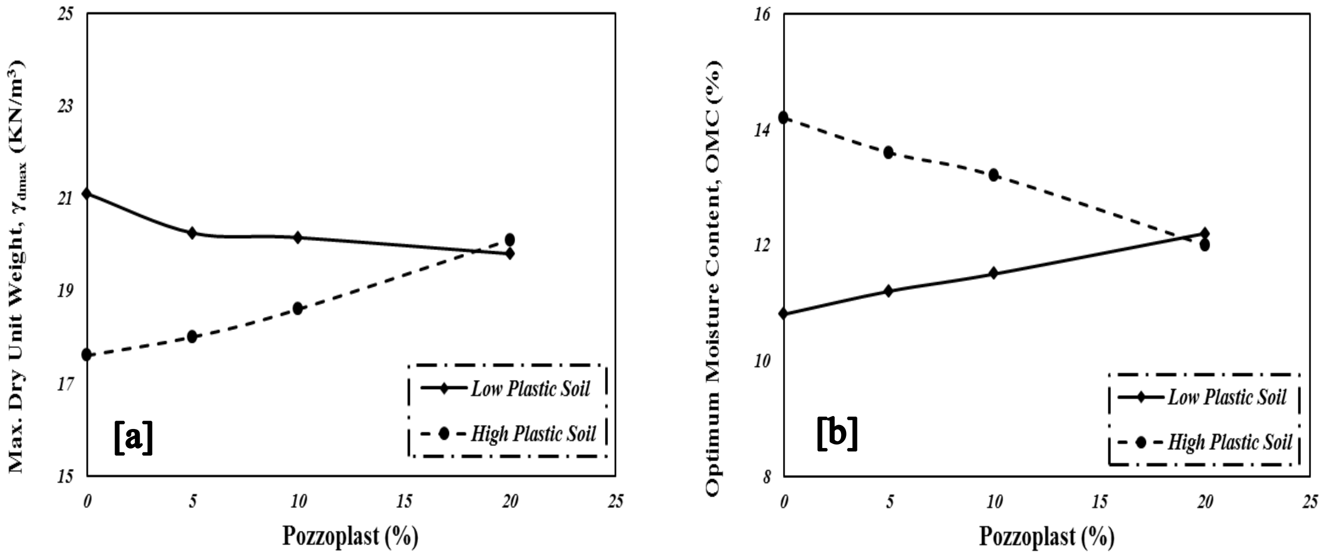

Figure 4: Effect of pozzoplast on compaction characteristics a) Maximum dry unit weight b) Optimum moisture content

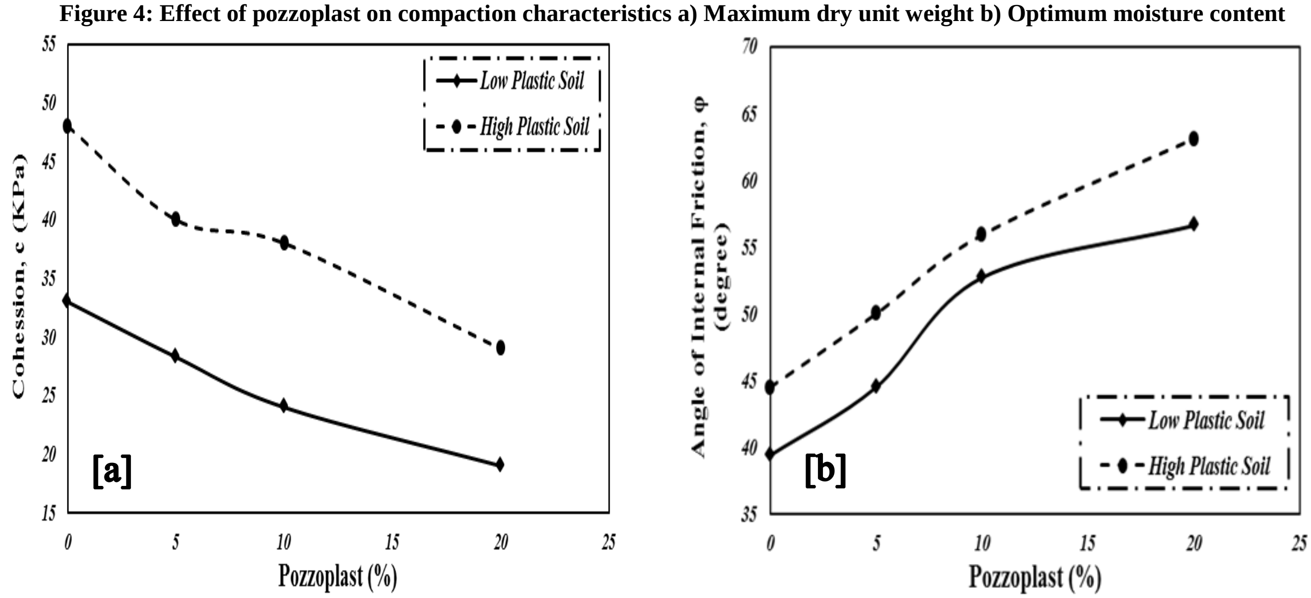

Figure 5: Effect of pozzoplast on shear strength parameters a) Cohesion b) Angle of internal friction

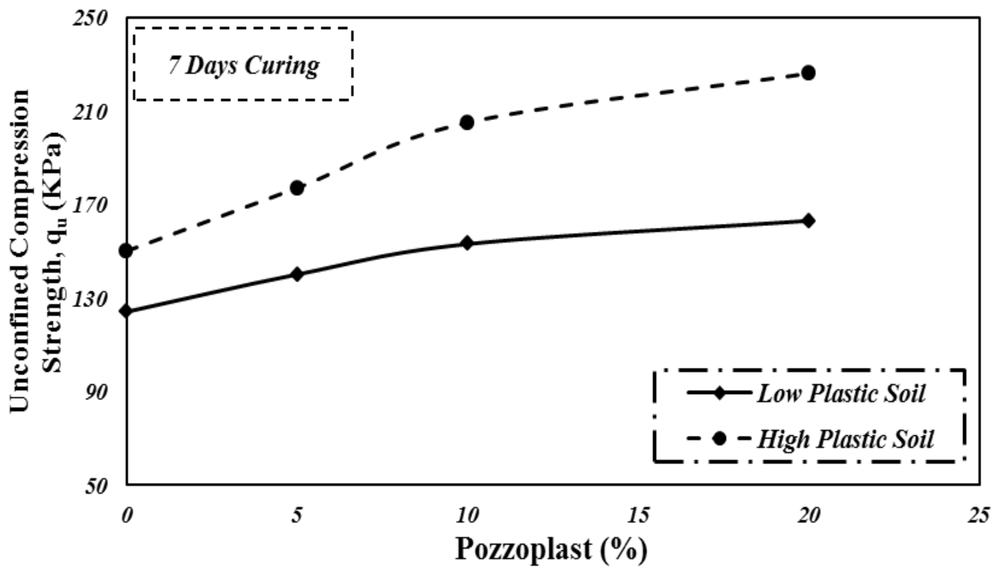

Figure 6: Effect of pozzoplast on unconfined compression strength

CONCLUSION

The results of this research show that sub groups of fine grained soil have not the same behavior under the stabilization of pozzoplast. Low plastic soil (A-4) and high plastic soil (A-7-6) are two fine grained soil samples which showed totally different behavior for some geotechnical properties. For specific gravity, percentage of fines, shear strength parameters (c & φ) and unconfined compression strength (q_u), both samples have the same behavior of trend lines but these samples have opposite behavior for Atterberg's limits (LL & PI) and compaction characteristics (γ_{dmax} & OMC) against pozzoplast stabilization.

For low plastic soil (A-4), specific gravity, maximum dry unit weight and cohesion are decreased with increase the percentage of pozzoplast and fines, liquid limit, optimum moisture content, angle of internal friction and unconfined compressive strength are increased with the addition of pozzoplast.

For high plastic soil (A-7-6), values of specific gravity, liquid limit, plasticity index, optimum moisture content and cohesion are decreased with increase in percentage of pozzoplast and fines, maximum dry unit weight, angle of internal friction and unconfined compressive strength are increased with the addition of pozzoplast.

Pozzoplast is better type of fly ash for stabilization of soils than C class fly ash because strength activity index and chemical composition (SiO_2+Al_2O_3+Fe_2O_3) of pozzoplast is better than C class fly ash.

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