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Assessment of Geo Technical Properties of Nano-Lime Treated Expansive Clay

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***Abstract:** In geotechnical engineering practice, expansive clay is widely encountered. It poses to be a serious problem especially in metropolitan areas by virtue of its low strength and high compressibility. Further, these soils undergo significant change in volume as a consequence of variation in the moisture content. Soil stabilisation is one such technique practiced to improve the shear strength and to control volume change in expansive clays. Among various stabilisation techniques, Lime has been found to be an effective stabilizer, which appreciably alters the properties of expansive clay. Further, the reaction will be very effective on the usage of nano size particles in the stabilisation of expansive clay. At the first step, the effect of lime stabilisation on geotechnical properties such as grain size distribution, index properties, compaction characteristics, differential free swell and unconfined compressive strength of expansive clay was studied by varying percentages of lime. At the second step, the effect of nano- lime on the properties of optimum soil-lime mixture was investigated. The percentage of nano- lime is varied from 0.25- 1.0% by dry weight of the soil. The measured results show that the use of nano- lime in expansive clay significantly improves its strength and reduces swell behaviour resulting in reduced pavement thickness.*

***Keywords:** Expansive clay, Differential free Swell, Nano-lime, Unconfined compressive strength.*

I. INTRODUCTION

The expansive clay taken up for stabilisation is made up of a clay mineral Montmorillonite. The structure of Montmorillonite is tetrahedral and size is about 10Å. It consists of central octahedral sheet of alumina sandwiched in between two tetrahedral silica sheets. The oxygen ions in the silica sheet get exchanged with the oxygen atoms in the water molecule causing swelling of the clay in the rainy season due to the imbibing of water by the montmorillonite mineral. The shrinkage of the same in the summer season is in view of the expulsion of water due to constant drying. This alternative process of change in volume is highly susceptible and structures constructed on it are highly vulnerable. Expansive clays exist nearly 20% of the land in India.

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During last few decades, expansive clay has been subject of research of many geotechnical engineers due to swelling behaviour of the expansive clay which results in the development of cracks in pavements, sidewalls, floors, pipelines and sewage lines. The stabilisation of soil using lime is one such method which has proved to be very effective in controlling the volume change behaviour of expansive clay. However, recent advancements in ground improvement techniques have prompted usage of new innovative materials in soil stabilisation. One such innovative material is nano- lime. The addition of small percentage nano particles in the soil could induce significant change in physical and chemical behaviour of soil due to their high specific surface area, presence of surface charges and morphologic properties.

II. LITERATURE REVIEW

Many researchers have investigated geotechnical properties of expansive clay and the various methods to control its swelling and shrinkage behaviour. Lime stabilisation is one such method used for controlling shrinkage and swelling behaviour of expansive clay. The addition of lime with expansive clay modifies its engineering properties as a consequence of changes in physico-chemical properties. (Nguyen at al., 2014).

Holister et al (2003) presented the effect of nano particles on strength behaviour of materials. It was found that, the strength of the material increases due to the occurrence of interactions between intermixed materials.

Daniele et al (2008) investigated enhancement of unconfined compressive strength of soil-lime mixtures by adding various percentages of nano- lime. An optimum nano-lime at four different curing periods is recommended for the studied soil-lime mixtures.

Taha [2009] conducted laboratory experiments to understand the geotechnical properties of natural soils mixed with nano material. The results from experimental investigation indicate that addition of nano material reduces plasticity index of natural soil.

Zaid Hameed Majeed and Mohd Raihan Taha, (2010), investigated the effect of various nano materials on the geotechnical properties of soft soil sample from Peneng state. It was concluded that the unconfined compressive strength of soil increases by adding nano material to the soft soil.

Mohd Raihan Taha and Omer Muhie Eldeen Taha (2012). conducted experiments to examine influence of the three type of nano-materials at different percentages on atterberg limits, compaction characteristics and swelling and shrinkage characteristics of expansive clay. It was observed that there is a decrease in swell and shrinkage strain with the addition of optimum percentage of nano material. However, there is no change in hydraulic conductivity of expansive clay.

Anandha Kumar and Manikandan (2016) carried out experimental study on influence of nano size silica and lime admixtures on properties such as unconfined compressive strength and compaction characteristics in expansive clays. It was found that addition of nano size blended with expansive clays results in reduction in maximum dry density and increase in optimum moisture content. It was also concluded that a mix of 5% nano-silica and 10% nano- lime yields unconfined compressive strength which is 1.4 times greater than non-nano admixed soil.

Panbarasi Govindasamy et al (2017) explored usage of nano- lime as a stabilizing agent for expansive clay by adding different percentages of nano- lime in soil-lime mixtures. The unconfined compressive strength of treated soil increased considerably over curing time with increasing percentage of nano- lime. The optimum strength is attained at 0.5% nano- lime admixtures.

Reze Ziaie Moayed and Hamidreza Rahmani (2017), studied the effect of nano-Sio2 solution on the strength characteristics of kaolinite. The measured results indicate that the unconfined compressive strength of pure soil increases by 40% by adding nano solution.

Lavanya and Ravichandran (2018) had investigated the effect of nano- lime admixtures in geotechnical properties of two different expansive clays. It was reported that there is about 3 to 4 times strength increment in unconfined compressive strength results. The strength improved till the percentage addition of 0.75 and 0.9 for the two soil samples after which it decreases. Further, the swelling behaviour of both soil samples was also considerably reduced by the treatment. Hence, it is recommended to utilise the nano- lime as one of the effective stabiliser in transportation for considerable strength increment and reduced pavement thickness, which serves to be highly reliable and economical.

From the literature, it can be noticed that there is a positive outcome in the strength and volume change behaviour of expansive clay when stabilised with lime as well as nano-lime admixtures. However, very few experimental studies have been reported in the literature in particular with addition of nano- lime with expansive clay. Hence, a detailed experimental investigation has been executed on geotechnical properties of expansive clay by varying the percentages of both lime as well as nano- lime. Recommendations on the optimum percentage of lime and nano- lime admixtures are made based upon experimental results. The present proposed study is expected to produce results to enhance the understanding of the nano- lime as a stabilizing agent and also to construct a comparison between stabilisation using conventional materials such as lime and new materials such as nano- lime in soil-lime mixtures. This can be effectively used for the improved design of pavements in road construction.

III. OBJECTIVE AND SCOPE

The objective of our study is to understand the influence of various percentages of both lime and nano- lime admixtures on geotechnical properties of expansive clays and to establish the best blend of admixtures which produces optimum results in engineering properties.

The detailed scope of the study is summarized as below:

- Identifying the mineralogical composition present in the expansive clay, lime and nano- lime.
- To conduct experimental studies to measure the physical and index properties of expansive clay.
- Studying the effect of varying percentages of lime mixed with expansive clay on compaction characteristics and shear strength.
- Obtaining optimum dosage of lime admixtures based upon experimental test results.
- Conducting experimental studies on nano- lime blended with expansive clay mixed with optimum dosage of lime by varying different percentages of nano- lime in order to evaluate shear strength characteristics
- Obtaining optimum dosage of nano-lime admixtures based upon measured results.

IV. MATERIALS

4.1 *Soil Description*

The expansive clay used in the present investigation was obtained from Trichy. The soil was collected at a depth of about 3.0 m below the natural ground level. The soil was grey in colour with large clay content. The obtained soil was dried under sunlight and then it was pulverized manually using driving rammer used in core cutter method. The soil passing through 425µ IS sieve was used in the experimental study. The basic constituents of expansive clay obtained from dry and wet sieve analysis are presented in Table 1. The chemical composition of expansive clay obtained from Scanning Electron Microscope (SEM) is presented in Table 2.

4.2 Hydrated lime and Nano- lime Description

The powdered form of hydrated lime ($Ca(OH)_2$) and nano sized hydrated lime ($Ca(OH)_2$) is used in the experimental study. The chemical composition of both lime and nano- lime obtained from the Scanning Electron Microscope (SEM) is presented in Tables 3 and 4 respectively.

4.3 SEM analysis

The Energy-dispersive X-ray spectroscopy (EDS) spectrum of the expansive clay, lime and nano- lime is shown in Figs 1(a), 2(a) and 3(a). The structure of expansive clay, lime and nano- lime has observed from SEM analysis is presented in Figs 1(b), 2(b) and 3(b) respectively. Presence of calcium at peak in lime dust shows that pozzolanic reaction is taking place with expansive clay to form a cementitious material.

4.4 Experimental investigation and testing methodology

The experimental studies were carried out in two phases as described below: (a) the first set of experiments was conducted to investigate the effect of lime on index properties, compaction and strength characteristics of expansive clay. (b) The second set of experiments was carried out to understand the influence of nano- lime on the enhancement of optimum expansive clay-lime mixture properties.

The following tests were conducted on expansive clay and the same stabilised with lime and nano- lime admixtures of different percentages.

i. Grain Size Analysis
ii. Index Test
iii. Differential Free Swell Test
iv. Standard Proctor Compaction Test
v. Unconfined Compression Test
vi. pH Test

Grain size analysis, which includes both dry sieve analysis and hydrometer analysis, was performed on expansive clay. The index properties of expansive clay with different percentages of lime were conducted as per IS: 2720 (Part-5) 1985. Similarly, the differential free swell test was performed on the expansive clay stabilised with lime of varying percentages as per IS: 2720 (Part-40) 1977. The tests were also repeated on optimum dosage of expansive clay-lime mixtures stabilised with nano- lime of varying percentages. Standard Proctor compaction tests were performed on expansive clay blended with limes of 0, 2%, 4%, 6% &8% on a dry weight basis as per IS: 2720 (Part-7) 1980. The above tests were also performed on expansive clay-lime mixture stabilised with nano- lime of different percentages varying from 0.25 to 1.0%.

Unconfined compression tests were performed on three cylindrical samples of 38 mm diameter and 76 mm height prepared at the optimum moisture contents and maximum dry densities. The samples were kept for 24 hours and the tests were carried out in the unconfined compression testing machine with a constant strain rate of 0.5 mm/min. The PH tests were performed on expansive clay blended with various percentages of lime.

V. RESULTS AND DISCUSSION

The laboratory tests were conducted on expansive clay and expansive clay blended with varying percentages of lime. Further, the above tests were also executed on optimum dosage of expansive clay-lime mixtures stabilised with nano-lime of varying percentages (0.25%, 0.5%, 0.75% and 1%). The summary of test results is presented in Tables 5 and 6 respectively. The measured characteristics are also presented in Figs. 4 to 7.

5.1. Effect of lime stabilisation on index properties

The measured liquid limit and plastic limit of expansive clay with various percentages of lime is presented in Fig. 4. There is a decrease in liquid limit of expansive clay on account of increase in lime. It is observed from Fig. 4(a) that, the maximum reduction in liquid limit is about 21.12% on the addition of lime by 8%. The plastic limit of the expansive clay increases from 38.25% to 54.1% (Fig. 4(b)) on the addition of lime of 4%. Hence, the increase in plastic limit is about 41.44% on the addition of 4% of lime. The maximum increase in plastic limit about 52.86% on the addition of 8% lime. The measured results also indicate that, the plasticity index (Fig. 5(b)) decreases with increase in percentage of lime. The plasticity index reduces drastically reaching a lowest of almost 3.98% with addition of 8% lime. Hence, the maximum reduction in plasticity index is about 90.27% on the addition of lime by 8% to expansive clay.

5.2. Effect of lime stabilisation on compaction characteristics

The variation of optimum moisture content and maximum dry density with lime for different proportions of expansive clay- lime mixtures is presented in Figs. 6(a) & 6(b) respectively. It can be ascertained that, lime treated expansive clay exhibits decrease in maximum dry density and increase in optimum moisture content in comparison with non treated soil. Further, there is significant decrease in the maximum dry density of the soil-lime mixture in low percent of lime (0-6%) compared with high percent of lime (6-8%). This is primarily due to chemical reaction in the mixture which occurred rapidly between soil and lime particles and caused changes in the structure of soil (Sherwood 1995 – Osinubi et al 1998) at the lowest percentage of lime. The reduction in maximum dry density can be attributed to the fact that particles are surrounded by a diffuse hydrous double layer as a result of ion exchange of calcium. This reaction modifies the density of the electrical charge around the fine particles and the particles are attracted closer to each other to form flocks. The soil particles are slowly cemented increasing the particle resistance compactive effort. This results in decrease in maximum dry density of expansive clay. The increase in optimum moisture content with the increase in content of lime may be attributed to the addition of lime may require more water for any reaction other than the amount needed to cause bonding with clay particles.

5.3. Effect of lime stabilisation on differential free swell

The measured differential free swell of expansive clay blended with various percentages of lime is presented in Fig. 5(c). It can be recognized that, the differential free swell of expansive clay decreases with an increase in parentage of lime. The decrease in differential free swell is as much as 59% for the addition of 8% lime.

5.4. Effect of lime stabilisation on unconfined compressive strength

The influence of lime on unconfined compressive strength of expansive clay is presented in Fig. 6(c). The unconfined compressive strength of expansive clay increases from 234.45 kN/m^2 to 783.6 kN/m^2, as the lime increases from 0 to 6%. Hence, the maximum increase in strength is about 234.23% on the addition of 6% lime. The increase in unconfined compressive strength may be due to development of strong bond between the expansive clay and cementitious compounds. However, there is a decrease in compressive strength beyond the addition of 6% lime. It may be attributed to the addition of lime beyond this limit results in the formation of relatively weak bond between the soil and the cementitious compounds.

This results in the reduction of unconfined compressive strength. Hence the optimum lime obtained from this study is 6% based upon unconfined compressive strength results.

5.5. *Effect of lime stabilisation on pH*

The effect of lime on pH of expansive clay is shown in Fig. 5(a). It can be noticed that, the lowest percent lime that delivers a pH of 12.40 is obtained on the addition of 6% lime to the expansive clay.

5.6. Effect of Nano- lime + lime stabilisation on differential free swell

The influence of nano- lime on differential free swell of expansive clay blended with 6% lime is presented in Fig. 5(c). It is found that the addition of nano- lime in the lime admixed expansive clay further decreases its differential free swell. However, the decrease is marginal beyond the addition of 0.5% nano- lime. The reduction in differential free swell is 44.84% for the combination of 6% lime and 0.5% nano- lime soil mixture.

5.7. Effect of Nano- lime + lime stabilisation on compaction characteristics

The results of compaction tests on the expansive clay-lime mixture with 0-1% of nano- lime based on the dry soil mass is illustrated in Fig. 7(a) and 7(b) respectively. The maximum dry density and optimum moisture content of expansive clay +6% lime +0.5% nano -lime are 1.456 g/cc and 23% and whereas for the same combination, non-nano particles admixed expansive clay exhibits maximum dry density value of 1.424g/cc and optimum moisture content of 26.4%. It is ascertained that the maximum dry density increases and the optimum moisture content decreases on the addition of nano- lime in the lime admixed expansive clay. The increase in maximum dry density may be due to addition of finer nano particles which results denser packing. Further, addition of nano- lime may not require more water for any reaction other than the amount needed to cause bonding with clay particles. Hence, the reduction in optimum moisture content is observed with increase in percentage of nano- lime.

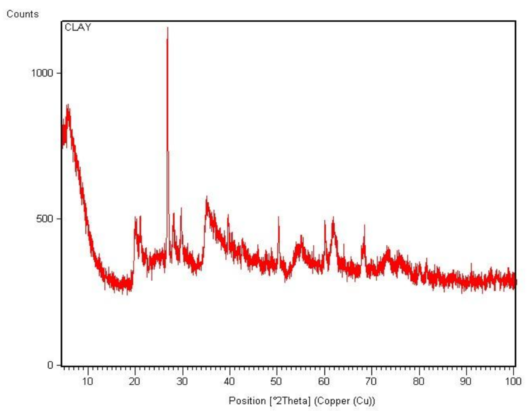
5.8. Effect of Nano- lime + lime stabilisation on unconfined compressive strength

The variation in unconfined compressive strength for nano- lime blended with optimum dosage of expansive clay-lime soil mixtures is shown in Fig.7(c). The unconfined compressive strength increases from 234.45 kN/m^2 to 783.6 kN/m^2 for 6% lime. It is further increased to 868.18 kN/m^2 for the combination of 0.5% nano- lime and 6%lime and then decreases for further addition of nano- lime. Further it is also observed that, the unconfined compressive strength of nano - lime admixed expansive clay is 1.11 times higher than that of expansive clay admixed with non-nano particles. This may be attributed to higher reactivity of nano- lime with lime- expansive clay admixes as a result of the enhanced specific surface area of nano- lime particles

VI. SUMMARY AND CONCLUSIONS

The stabilisation of expansive clay with lime and nano- lime is investigated and the effect of stabilisation on the geotechnical properties of expansive clay is presented. The following conclusions can be drawn from the present study.

- The addition of lime to expansive clay increases the maximum dry density up to 4% lime, beyond which it decreases. However, the optimum moisture content of the expansive clay increases with increase in percentage of lime.
- The plasticity index and differential free swell of the expansive clay decreases with the increase in percentage of lime. .
- The unconfined compressive strength of the expansive clay is increased upon addition of 6% lime and the increase is marginal beyond any further addition of lime.
- Addition of nano- lime additives on soil increases maximum dry density and decreases optimum moisture content regardless of percentage of nano- lime.
- The unconfined compressive strength of the nano- lime blended with lime- expansive clay admixes is 1.11 times higher than lime-expansive clay mixtures.
- The optimum proportion obtained from the investigation is found to be in the ratio of expansive clay: lime: nano- lime: - 93.5%: 6%: 0.5%.



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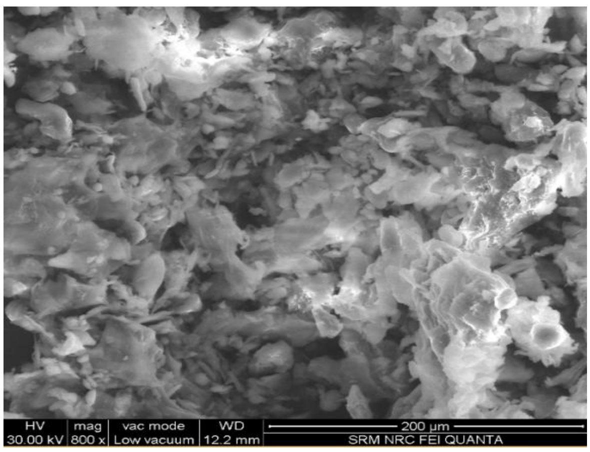
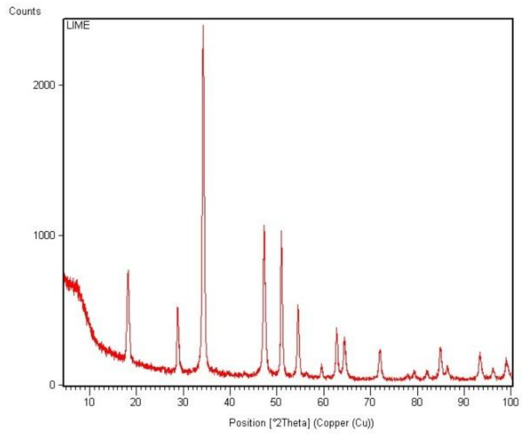


(b)

Fig. 1 (a) Energy-dispersive X-ray spectroscopy (EDS) spectrum of the expansive clay (b) Scanning Electron Microscope Image of expansive clay



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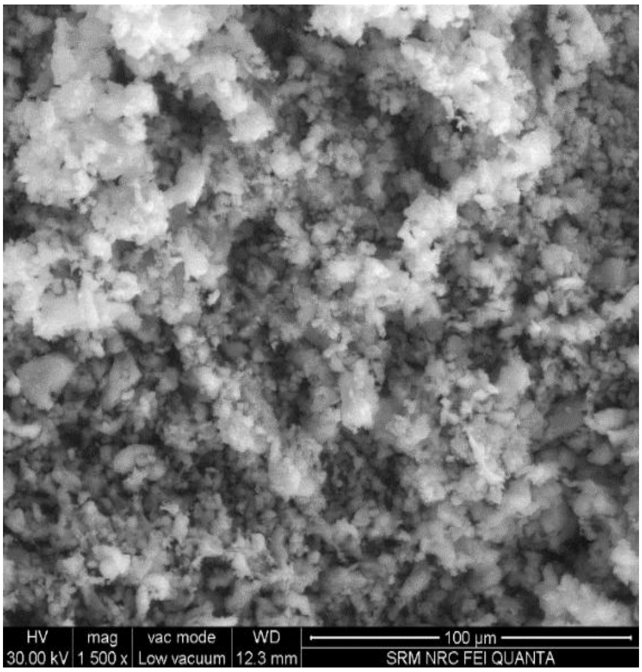
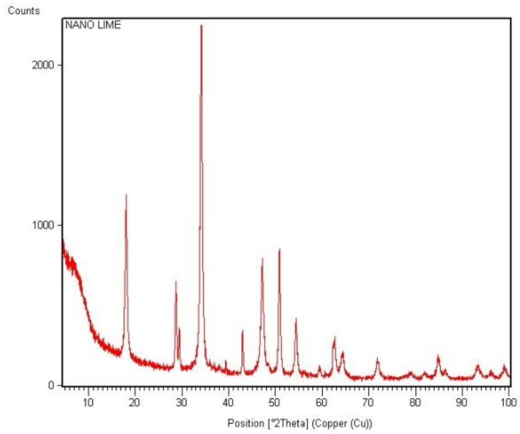


(b)

Fig. 2 (a) Energy-dispersive X-ray spectroscopy (EDS) spectrum of lime (b) Scanning Electron Microscope Image of lime



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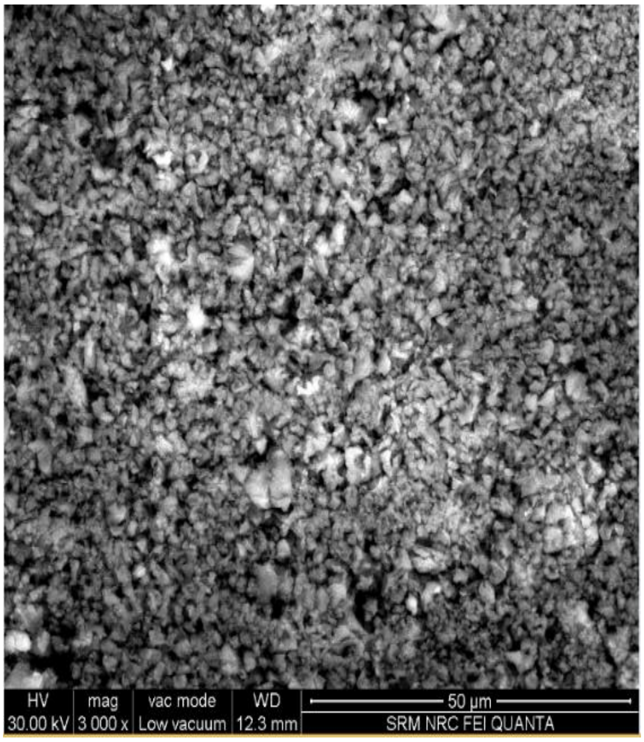
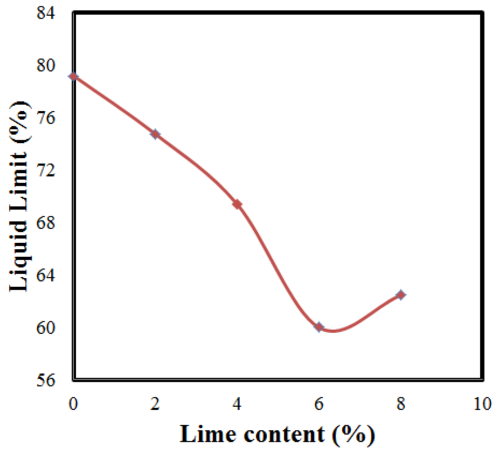


(b)

Fig. 3 (a) Energy-dispersive X-ray spectroscopy (EDS) spectrum of nano - lime (b) Scanning Electron Microscope Image of nano - lime



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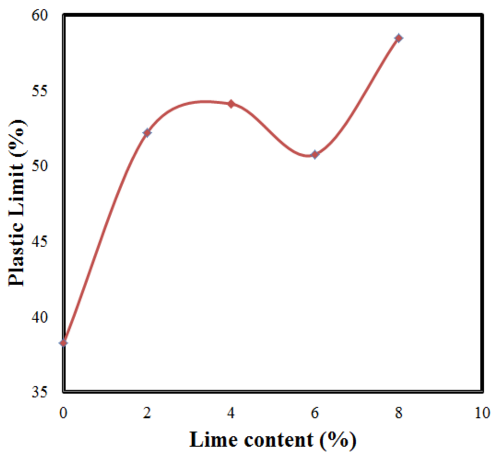

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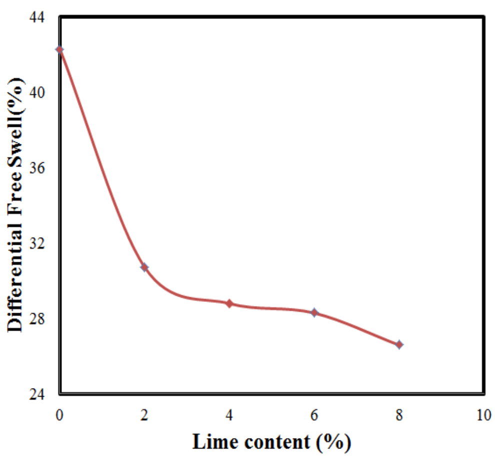

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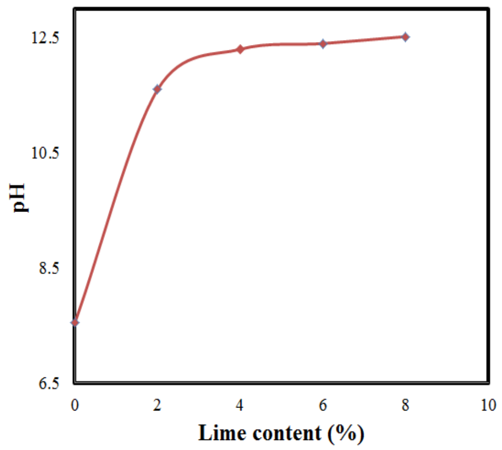
Fig. 4 Variation of (a) Liquid limit (b) plastic limit (c) differential free swell as a function of lime.



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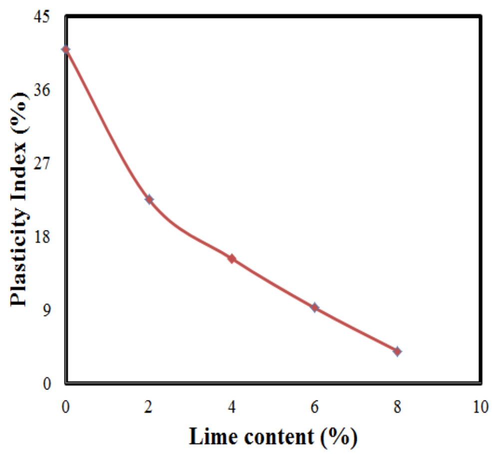

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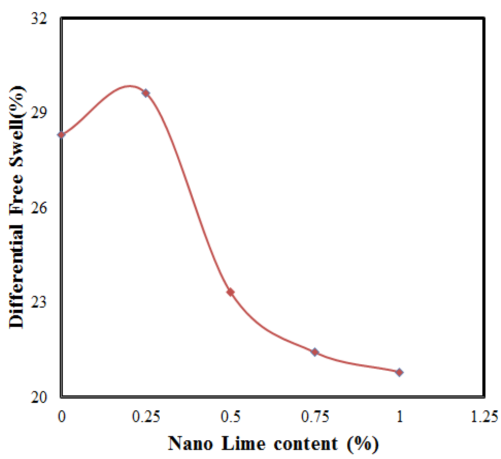

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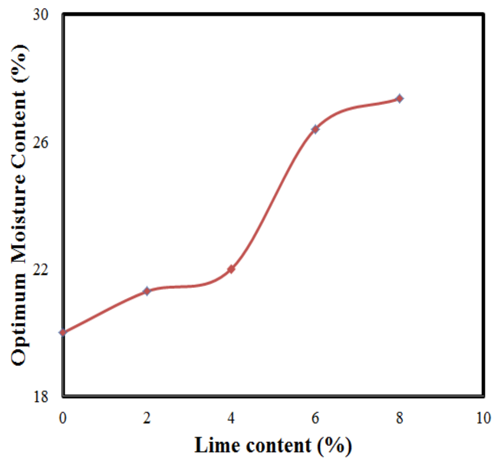
Fig. 5 Variation of (a) pH and (b) plasticity Index with lime (c) differential free swell as a function of nano- lime



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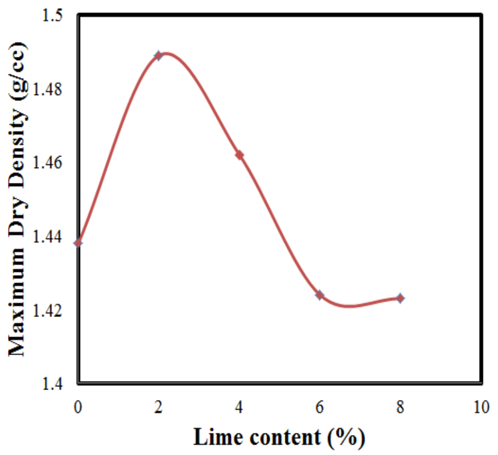

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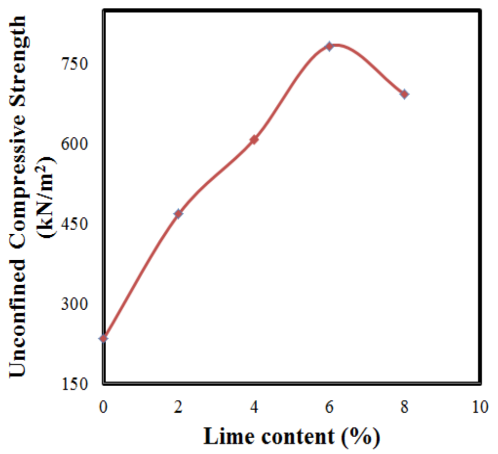

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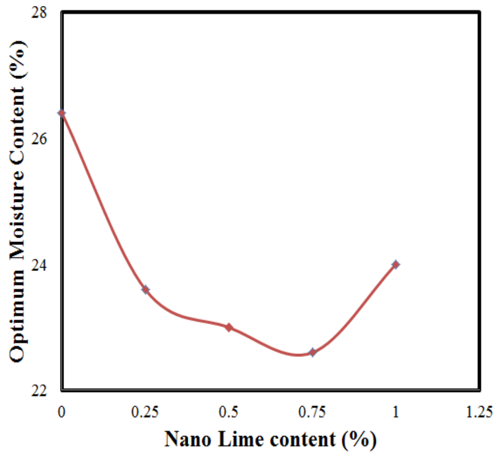
Fig. 6 Variation of (a) optimum moisture content (b) maximum dry density (c) unconfined compressive strength as a function of lime.



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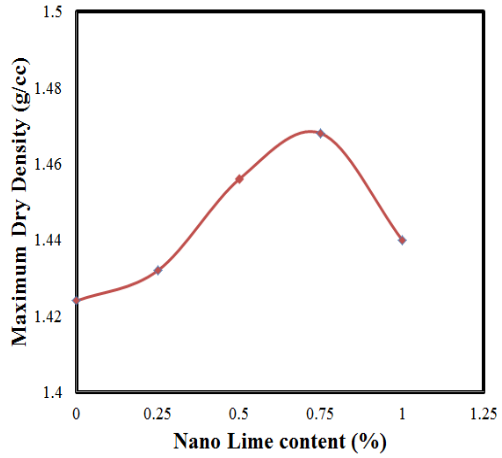

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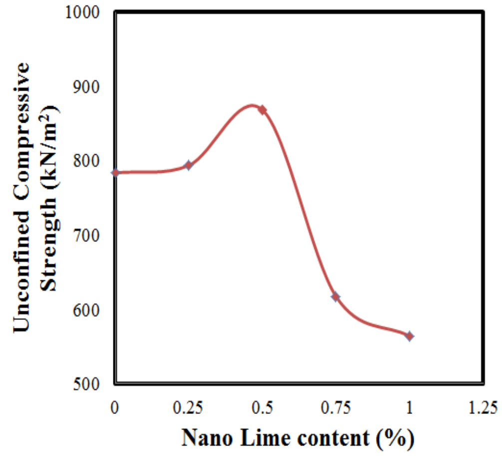

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Fig. 7 Variation of (a) optimum moisture content (b) maximum dry density (c) unconfined compressive strength as a function of nano- lime

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Table 1 Basic constituents of expansive clay

S. No	Components	Results
1	Gravel	0.38%
2	Sand	1.22%
3	Silt	49.04%
4	Clay	49.36%

Table 2 Chemical composition of expansive clay

S.No.	Constituents	Wt (%)	At (%)
1	O	50.86	59.05
2	Si	19.76	13.07
3	C	11.57	17.90
4	Al	8.80	6.06
5	Fe	5.07	1.69
6	Ca	2.55	1.18
7	Mg	1.38	1.06

Table 3 Chemical composition of Lime

S.No	Constituents	Wt (%)	At (%)
1	Ca	49.07	27.79
2	O	41.72	59.20
3	C	6.52	12.32
4	Cu	1.12	0.40
5	U	1.02	0.10
6	Zn	0.55	0.19

Table 4 Chemical composition of Nano- lime

S.No	Constituents	Wt (%)	At (%)
1	O	45.79	45.66
2	C	34.10	45.29
3	Ca	11.21	4.46
4	Si	2.84	1.61
5	Mg	2.20	1.45
6	Al	1.57	0.93
7	Fe	1.04	0.30
8	Cu	0.72	0.18
9	Zn	0.53	0.13

Table 5.Geotechnical properties of expansive clay stabilised with lime

S.No.	Parameters	Percentage of lime added				
		0%	2%	4%	6%	8%
1	Specific gravity	2.36	--	---	--	---
2	Liquid limit (%)	79.17	74.74	69.4	60	62.45
3	Plastic limit (%)	38.25	52.2	54.1	50.74	58.47
4	Plasticity index (%)	40.92	22.54	15.3	9.26	3.98
5	Maximum dry density (gm/cm^3)	1.438	1.489	1.462	1.424	1.423
6	Optimum moisture content (%)	20	21.3	22	26.4	27.35
7	Unconfined compressive strength (kN/m^2)	234.46	468.53	607.93	783.62	692.98
8	Cohesion (kN/m^2)	117.23	234.26	303.96	391.81	346.49
9	Differential Free swell (%)	42.3	30.73	28.8	28.3	26.6
9	pH	7.55	11.6	12.3	12.4	12.52
10	IS classification	CH	CH	CH	CH	CH

Table 6.Geotechnical properties of Nano- lime stabilised with expansive clay-lime mixtures

S.No	Parameters	Percentage of Nano- lime added				
		0%	0.25%	0.50%	0.75%	1%
1	Lime	6%	6%	6%	6%	6%
2	Maximum dry density (gm/cm^3)	1.424	1.432	1.456	1.468	1.44
3	Optimum moisture content (%)	26.4	23.6	23	22.6	24
4	Unconfined compressive strength (kN/m^2)	783.6	793.6	868.18	617.53	564.08
5	Cohesion (kN/m^2)	391.8	396.8	434.09	308.77	282.04
6	Differential Free swell (%)	28.3	29.63	23.33	21.42	20.8

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REFERENCES

1. Anandha Kumar and Manikandan (2016),"Influence of Nanosized Additives on the improvement of clay soil", International journal of advanced science and engineering research, volume 1(1), pp.23-30.
2. Daniele, V., Taglieri, G., and Quaresima, R., (2008) "The nanolimes in Cultural Heritage conservation: characterisation and analysis of the carbonatation process," Journal of Cultural Heritage, vol. 9(3), pp. 294–301.
3. Holister, P., Weener, J.W., Roman, C., and Harper, T., (2003) "Nanoparticles," Technology White Papers 3.
4. James L. Eades, Ralph E. Grim (1966), "Behaviour characteristics of lime-soil mixtures", 45th annual meeting of Highway research board.
5. Lavanya and Ravichandran (2018), "Influence of nanolime admixtures on strength characteristics of clay soils", International conference on Theoretical and Experimental Advances in Civil Engineering
6. Nguyen, L.D., Fatahi, B. & Khabbaz, H. (2014), 'A constitutive model for cemented clays capturing cementation degradation', International Journal of Plasticity, vol. 56, pp. 1-18.
7. Panbarasai Govindasamy, Mohd Raihan Taha, Jamal Alsharef, Kowstubaa Ramalingam (2017), " Influence of nanolime and curing period on unconfined compressive strength of soil", Hindawi, Applied and Environmental Soil Science, article ID 8307493, 9 pages
8. Reze Ziaie Moayed and Hamidreza Rahmani (2017), "Effect of Nano-Sio2 solution on the strength characteristics of Kaolinite ", International Journal of Geotechnical and Geological Engineering, Vol.11 (1), pp.83-87.
9. Taha, M. R., (2009) "Geotechnical properties of soil-ball milled soil mixtures," in Nanotechnology in Construction 3: Proceedings of the NICOM3, pp. 377–382,
10. Zaid Hameed Majeed and Mohd Raihan Taha, (2010), 'Effect of Nano material treatment on geotechnical properties of a penang soft Soil', Journal of Asian Scientific Research, pp.587-592.

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