COMPARITIVE PERFORMANCE OF BACILLUS SUBTILIS AND NANO SILICA ON VARIOUS CLAYEY SOILS

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Abstract: *This paper deals with comparison study of performance of stabilisers namely Bacillus subtilis and Nano silica on three different clayey soil having different clay mineralogy. Now days there are many techniques and stabilizing agents for improving the basic properties of clayey soil, but most of them are costly techniques and are not environment friendly solution for stabilisation of soil. The use of conventional soil stabiliser like lime, gypsum..etc. though are effective stabilisers but their effectiveness may vary based on different mineral constituent of the clay minerals contained in the soil that need to be stabilised. So a stabiliser should be selected based on the mineral composition of the soil that needs to be stabilised and also on the basis of purpose of use of such stabilised soil. This project involves comparison study of two stabilisers on three different clay soils. The stabilisers chosen were microbe, Bacillus subtilis which have agricultural importance and are not polluting in nature and the other one Nano silica which is an emerging Nano technological product were being chosen for the comparative study of performance of both stabiliser on mainly three clayey soil: paddy clay collected from local paddy field, black cotton clay whose major mineral constituent is montmorillite content and marine clay. The study result shows that the use of stabilisers on these three soil had shown results which had varied considerably from that of unstabilised soil samples. There was both positive and negative effect of these stabilisers on the selected soil sample. The main objective of this project is to investigate the effect of microbe and Nano silica in geotechnical application and hence to compare the results obtained.*

1. INTRODUCTION

Soil is a natural material which can be used for construction purpose and also can be used as a supporting material. It is composed of broken pieces of rocks which when exposed to different atmospheric conditions such as erosion, freezing, and thawing may result in change in their inherent properties such as texture, color, physical and other chemical properties. This change in their properties may affect the construction process by making it more difficult to work with and may cause unwanted delays in construction process and hence may make the construction uneconomical. So it is more important to stabilize the problematic soil using suitable stabilizing technique in order to alter and enhance their engineering properties in order to make them suitable for a particular construction work.

Use of conventional stabilisers like lime and all cause carbonation, sulphate attack, and other environmental impact. Some of the effective stabilisers like enzymes are very costly too.So we go for looking forward some cheap and easily available stabilisers which also cause contribute less environmental impact.

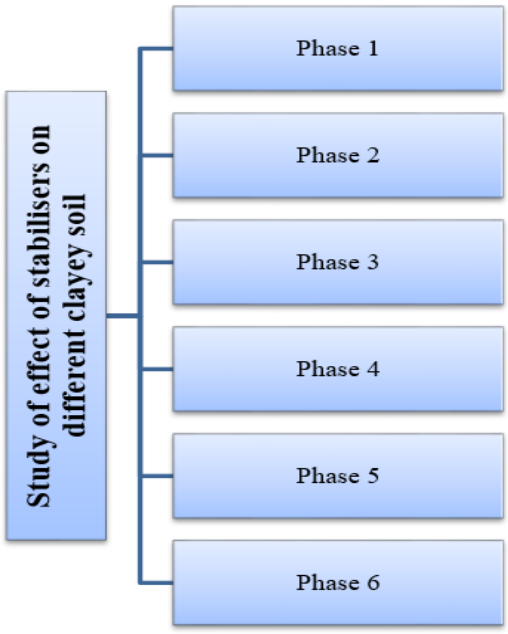
2. OBJECTIVE OF STUDY

- To perform comparative study of stabilizers : Bacillus subtilis and Nano silica on three different clayey soil
- To classify collected clayey soil based on

1. Plastic index or liquid limit(LL<35: low compressibilty, 35<LL<50: Medium comp, LL>50 : High comp)
2. Mineral composition

- To obtain the basic properties of the test soil collectected
- To obtain the properties of soil stabilised using microbe and Nano silica separately
- To compare the results of stabilised soil with that of unstabilised soil for each stabiliser
- To compare the results of properties obtained in respective soil when stabilised using the stabilisers, microbe and nano silica separately

3. METHODOLOGY



1. Selecting the suitable clay soil
2. Determination of basic properties of soil
3. Determination of physical and engineering properties of stabilized soil
4. Comparative study between stabilised and unstabilsed soil
5. Comparative study between soil stabilised by each stabiliser
6. Analysis of results

4. MATERIALS

- CLAYEY SOIL :

1. Paddy clay – Muthuvara
2. Black cotton clay – Kaliyanpara
3. Marine clay – Mathilakam

- Stabilisers

1. Microbe – *Bacillus subtilis*

- Precipitate calcium carbonate -biomineralisation
- Used for study in self healing concrete
- Promote plant growth
- Can grow in room temperature
- Commonly found in soil

2. Nano silica

- Silicon dioxide Nano particle
- Stable
- Very low level of toxicity
- Nano silica in concrete mix have shown results of increase in compressive, tensile and flexural strength of concrete

5. TESTS CONDUCTED

- INDEX PROPERTIES :

- Specific gravity (IS 2720 PART 3 1980)

- Ratio of mass per volume
- To know physical property how strong the soil is to make it use for building purpose

- Sieve analysis

- Particle size distribution – find out different size of aggregate and hence to classify as fine or coarse
- Fineness modulus – max amount of aggregate lying in one particular size of sieve
- Size of aggregate influence the strength

- Atterberg limits(IS 2720 –PART 5 1980)

- Liquid limit - moisture content of soil at a point where soil water mass just flows under applied force and fails to retain its shape
- Film of oriented molecule become so thick that cohesion is decreased and entire soil mass flows freely under applied force
- Plastic limit – moisture content of soil at a point where its consistence changes from plastic to friable and soil water mass is unable to change shape continuously under influence of applied force and ultimately the mass break in to fragments
- It represent the minimum moisture percentage at which soil can be puddled
- Orientation of particle and subsequent sliding over each other takes place at this point since sufficient water has been added to provide a film around each particle
- Plastic index :
- Difference between liquid limit and plastic limit
- Measure of force required to mold the soil
- Function of number of film
- Represent amount of water to be added to increase the distance between the particles of maximum tension and the tension at which flow is produced
- Flow index(high value low shear strength),

- Toughness index(less than 100 % easily crushed at plastic limit) : rate at which soil loses shear strength
- Consistency index : firmness of soil, water holding capacity or relative resistance of soil to pressure

6. PROPERTIES OF STABILISED AND UNSTABILISED SOIL

The properties of unstabilised and stabilised soil are tabulated in the table below for three types of soil ie paddy clay, black cotton and marine clay.

Paddy Soil	Unstabilised	Microbe stabilised	Nano Sillica stabilised
UCC strength	0.97kg/cm2	0.87kg/cm2	1.23kg/cm2
Liquid limit	59.7%	56%	60%
Plastic limit	30.27%	35.71%	34.11%
Shrinkage limit	33.87%	4.23%	20.33%
Plasticity Index	29.44%	20.29%	25.89%
Flow index	5.06%	7.42%	12.05%
Toughness index	581.55%	273.45%	214.83%
Consistency index	100%	100%	100%
Free Swell index	3.57	30.76	13.33
OMC	25.5%	29%	24%
Max Dry Density	1.5g/cc	1.3g/cc	1.32g/cc
CBR	4.5%	5.31%	3.68%

Black Cotton soil	Unstabilised	Microbe stabilised	Nano Sillica stabilised
UCC strength	1.06kg/cm2	1.71kg/cm2	0.72kg/cm2
Liquid limit	32%	38.7%	60%
Plastic limit	15.43%	17.21%	20.45%
Shrinkage limit	9.02%	3.05%	11.21%
Plasticity Index	16.57%	21.49%	39.55%
Flow index	8.53%	7.36%	13.75%
Toughness index	194.14%	292.07%	287.55%
Consistency index	100%	100%	100%
Free Swell index	40	9.09	0
OMC	17%	18.65%	18%
Max Dry Density	1.8g/cc	1.78g/cc	1.72g/cc
CBR	1.22%	0.81%	4.90%

Marine clay	Unstabilised	Microbe stabilised	Nano Sillica stabilised
UCC strength	0.75kg/cm2	1.33kg/cm2	1.18kg/cm2
Liquid limit	61.8%	85%	90%
Plastic limit	44.33%	46.12%	20.28%
Shrinkage limit	7.94%	10.04%	44.83%
Plasticity Index	17.47%	38.88%	69.72%
Flow index	23.16%	23.87%	36.95%
Toughness index	75.55%	162.86%	188.67%
Consistency index	100%	100%	100%
Free Swell index	25	14.28	23.52
OMC	30%	29%	26.6%
Max Dry Density	1.22g/cc	1.12g/cc	1.26g/cc
CBR	6.54%	16.77%	14.72%

7. CONCLUSION:

1. PADDY CLAY :
   - When stabilised using microbe changes incured :
   - ❖ Positive changes : Reduction in plastic index(fineness of soil and its capacity to change its shape), increase in plastic limit, increase in cbr value
   - ❖ Negative changes : ucc strength,liquid limit, Shrinkage limit, free swell, mdd, flow index, toughness , omc
   - When stabilised using Nano silica :
   - ❖ Positive change :Ucc, LL, PL, PI, omc
   - ❖ Negative change : SL, flow index, toughness index, MDD, Free swell, CBR
   - ❖ Considering cbr : microbe stabilised paddy will be better option
   - ❖ Without considering cbr : nano silica stabilised paddy will be better
2. BLACK COTTON CLAY :
   - ❖ When stabilised with microbe :
   - ➢ Positive changes : ucc ,LL, PL,Flow index, Toughness index,free swell
   - ➢ Negative changes : SL, PI, OMC, MDD(slight), CBR
   - ❖ When stabilised using Nano silica :
   - ➢ Positive changes : LL, PL,SL,toughness index, free swell, cbr
   - ➢ Negative changes : PI, FI, OMC, MDD
   - ➢ Considering cbr : nano silica stabilised soil is better
   - ➢ Without considering cbr : microbe stabilised soil is better

3. MARINE CLAY :
   - ❖ When stabilised with microbe :
   - ➢ Positive changes : ucc, LL, PL, SL, TI, OMC, CBR
   - ➢ Negative changes : PI,FI,MDD
   - ❖ When stabilised with Nano silica :
   - ➢ Positive changes : ucc, LL, SL, TI, Free swell,OMC,MDD,CBR
   - ➢ More workable when marine clay stabilised using Nano silica
   - ➢ Easy to pump on using microbe stabilised marine clay

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