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# An Experimental Study of Soil Stabilization with Cement and Polymer

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## ABSTRACT

The aim of the study was to determine the value of Unconfined compressive strength and CBR values of Soil after stabilizing it with Cement and Polymer. Soil stabilization has been widely used as an alternative to substitute the lack of suitable material on site. The utilization of nontraditional compound stabilizers in soil improvement is developing every day. In this investigation a lab try was led to assess the impacts of waterborne polymer on unconfined pressure quality on sandy soil and CBR Test on clayey soil .The lab tests were performed including grain size of sandy soil, unit weight, and unconfined compressive quality test. The sand and different measures of polymer (2%, 3%, and 4%) and concrete (20%, 30%, and 40%) were blended in with every one of them into mixture utilizing hand blending in research center conditions. The examples were exposed to unconfined pressure tests to decide their quality following 7 days of restoring. The consequences of the tests showed that the waterborne polymer fundamentally improved the unconfined pressure quality of sandy soils which have weakness of liquefaction. Polymer altered the building properties of soil through physical holding. The amount of polymer required to modify the engineering properties was directly related to specific surface and soil particle coating thickness. Polymer amended soils displayed a reduced performance compared to cement amended soils.

***KEYWORDS:*** *Cement, Polymer, unconfined, pressure, quality, liquefaction*

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## I. INTRODUCTION

Soil stabilisation is a regulated process to improve the soil by using additives in order to use it as base or sub base courses and carry the expected traffic and pavement loads. There are several methods by which soils can be stabilised.

There are two methods to enhance the properties of sandy soils, one of them is the mechanical stabilization which is mixed the natural soil and stabilizing material together for obtaining a homogeneous mixture and the second one is adding stabilizing material into un-disturbed soils to obtain interaction by letting it permeate through soil voids . Chemical stabilization is the modification of properties of a locally available soil to improve its engineering performance. The two most commonly used chemical stabilization methods are lime stabilization and cement stabilization.

### Method of Soil Stabilization

### Polymer Stabilization

A variety of natural polymers, such as lignosulfonate, and synthetic polymers such as Polypropylene (PP),polyester(PET),polyethylene(PE),Glass fibres, etc. are available. It is known that the polymers consist of hydrocarbon chains, and it is thought that these chains become interwined within the soil particles thus producing a stabilizing effect. In effect, the polymers act as a binder to glue the soil particles together reducing dust, and even stabilizing the entire soil matrix.

Polymer amendment for improvement of soils is a growing industry and has been of particular interest in recent field applications. Polymers improve the soil by providing physical stabilization through the use of binding agents. Polymers are easily modified; therefore, a range of polymer combinations can be prepared to modify soils.

## II. LITRATURE RIVEW

**Wei-Yi Xia (2017),** engineered hydroxyapatite (HA) is a productive and condition neighborly material for the remediation of weighty metal polluted soils. Nonetheless, the utilization of ordinary HA powder in settling sullied soils is restricted, because of significant expense of definite items, troubles in combining sanitized HA precious stones. Another fastener named SPC, which makes out of single superphosphate (SSP) and calcium oxide (CaO), is introduced as an option in this examination. HA can shape in the dirt framework by a corrosive base response among SSP and CaO, bringing about a thick structure and improved mechanical properties of treated soils

**Mohammed N J Alzaidy (2019)**, using of concoction admixtures, for example, lime, concrete, bitumen and so forth in soil adjustment is profoundly costly. In this manner, it is desirable over supplant these produced materials by different sorts of soil added substances to lessen the expense. This examination researches an exploratory investigation for settling a clayey soil with eggshell powder as a substitution of business lime and plastic squanders strips so as to decrease the fragility of soil balanced out by eggshell powder, and its impact in the designing properties of the dirt. Three different extents of eggshell powder (2%, 5% and 8% by weight of dry soil) and plastic squanders strips (0.25%, 0.5% and 1% by weight of dry soil) have been utilized to make nine gatherings of settled soil tests to acquire the ideal level of every added substance. The examination was finished by leading compaction, unconfined pressure, expanding potential, direct shear and California bearing proportion tests. It was seen that eggshell powder, plastic waste fiber substance and restoring length had huge impact in the building properties of the balanced out soil. The outcomes demonstrated that the unconfined pressure quality, California bearing proportion esteems and shear quality boundaries had expanded with increment in eggshell powder content up as far as possible, from there on it will somewhat diminish, while an expansion in eggshell powder prompted a decrease of growing potential

Choudhary et al.(2020) detailed that the expansion of recovered HDPE strips to neighborhood sand builds the CBR worth and secant modulus. The most extreme improvement in CBR and secant modulus is gotten when the strip content is 4% with the angle proportion of 3, roughly multiple times that of an unreinforced framework. Also, base course thickness can be fundamentally decreased if HDPE strip strengthened sand is utilized as sub-level material in asphalt designing. As it very well may be seen natural intentions are the principle reason of utilizing PE strands or potentially strips in geotechnical building to land-fill the waste PE-based materials.

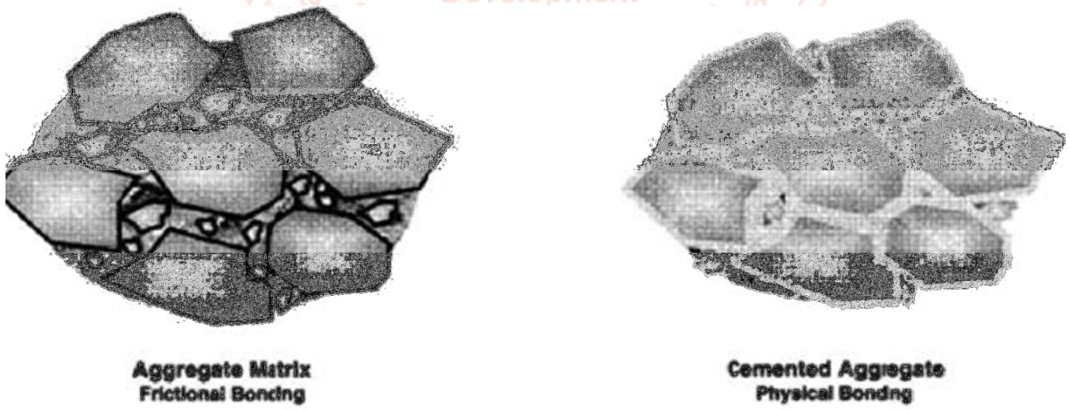


**Figure 2.3: Cemented bond between Soil particles**

## III. METHODOLOGY

### Experimental Program

Testing was performed in accordance with all applicable Indian Standard Codes IS: 2720 (Part 16) 1979.The index properties tests are conducted first, then the soil optimum moisture content and dry density tests are conducted and at OMC, maximum dry density, the tests are performed. Soil index properties such as maximum dry unit weight, optimum moisture content, and specific gravity were used to classify soils. These tests were performed in accordance with their respective standards.

**Material Used**

**Sandy Soil**

**Table 3.1: Engineering properties of sandy soil**

| Property | Sample |
|---|---|
| Specific gravity | 2.75 |
| Grain size: | |
| (4.75-20) mm (%) | 2.5 |
| ( < 4.75mm) (%) | 97.5 |
| Max. void ratio (emax) | 0.8 |
| Min. void ratio (emin) | 0.42 |
| Void ratio, (%) | 1.024 |
| Optimum moisture content (%) | 15 |
| Maximum dry unit weight ($g/cm^3$) | 1.86 |
| Soil classification (USCS) | S |

**Clayey Soil**

Index property: The result of index properties such as liquid limit, plastic limit, PI value are presented in Table below:

**Table 3.2 Index properties**

| Description of Index properties | Experimental Value |
|---|---|
| Liquid limit | 30% |
| Plastic limit | 18.50% |
| Plastic Index | 11.50% |
| Shrinkage limit | 14.65% |

Particle size distribution - The grain size distribution of this soil sample has been shown in Table 3.3 below:

**Table 3.3 Grain size distribution of soil**

| IS sieve no | Wt. retained in gm | % wt. retained in gm | % wt. passing |
|---|---|---|---|
| 4.75 mm | 18.84 | 1.884 | 98.51 |
| 2.36 mm | 17.2 | 1.72 | 95.25 |
| 1.18 mm | 15.56 | 1.556 | 93.21 |
| 425 µm | 12.51 | 1.251 | 92.13 |
| 300 µm | 3.12 | 0.312 | 91.15 |
| 150 µm | 22.3 | 2.23 | 89.91 |
| 75 µm | 42.45 | 4.245 | 86.43 |

Based on the above properties the IS Soil Classification for the soil sample under test is 'CL' Modified Proctor Compaction Test The result of modified proctor compaction test are represented in figure 3.1

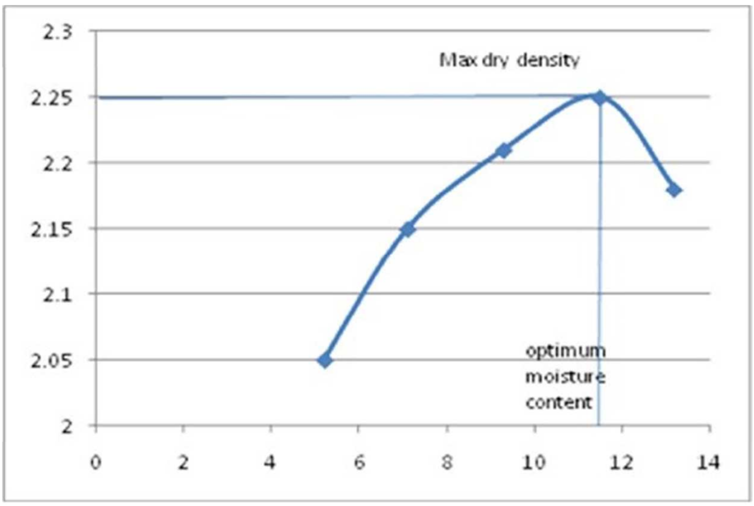


**Figure 3.1: Result of modified proctor compaction test**

From the figure 3.1 it is clear that, MDD = 2.25 g/cc

OMC = 11.5%

**Cement**

The cement used for the study is Portland cement 43 grade and the properties of which are given in Table 3.4.

**Table 3.4: Properties of cement**

| Properties of 43 Grade OPC | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fineness (sq.m/kg) min | Soundness by | Setting time | | Compressive strength | | | |
| | Lechatlier (mm) Max | Initial (mts) min | Final (mts) Max | 1 day Min Mpa | 3 day Min Mpa | 7 day Min Mpa | 28 day Min Mpa |
| 225 | 10 | 30 | 600 specified | NS | 23 | 23 | 43 |

**Polymer**

A commercial product of Acrylic Polymer was used, which is an emulsion synthetic elastic chemical substance that increases the bound with the substrate as additive in optimum moisture as well as the cohesion and the strength. Some important properties were given in Table 3.5 below:

**Table 3.5: Important physicochemical properties of as-received emulsion**

| Name | Acrylic-Copolymer watered solution |
|---|---|
| Physical state | Liquid-white colour |
| Solvability in water | Solution |
| Boiling point | 100° |
| Water Absorption | 1% max |
| Non-self-burning | Nonexplosive |
| Applicable temperature | Not less than 10° |
| Density (g/$cm^3$) | 1.11 (20°) |
| Toxicity | Non Toxic |

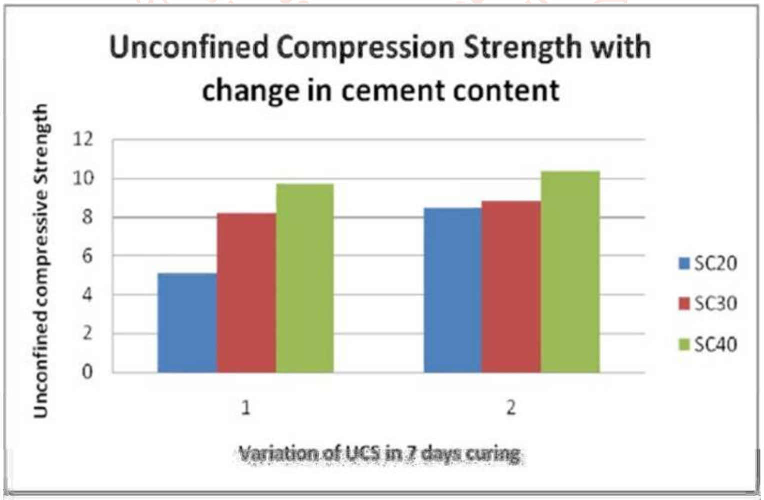


**Fig 4.1 Tests for Investigation**

## IV. RESULT & DISCUSSIONS

### Unconfined Compression Test Results

The results of 7 days curing on unconfined compression strength results were shown in Figures 4.1and 4.2.The unconfined compression strength of stabilized samples increases with curing time. Both specimens containing polymer content of 2–4% by wt.% and cement content of 20–40 wt.% were cured in air during 7 days. So, by increasing the polymer contents, cross-linking between polymer network increased and the strength of soil increased. It is clear from Figures 4.1 that compressive strength of the stabilized soils was increased while increasing the curing time in air curing conditions.

**Table 4.1: Variation in Cement vs polymer content**

| | Variation in cement content | | | Variation in Polymer Content | | |
|---|---|---|---|---|---|---|
| Unconfined Compression Strength(Mpa) | 20% | 30% | 40% | 2% | 3% | 4% |
| | 5.1 | 8.2 | 9.7 | 4.9 | 7.8 | 9.56 |
| | 8.5 | 8.8 | 10.4 | 8.2 | 8.6 | 10.35 |

**CBR Test Results**

The result of CBR test of soil sample taken at 20% cement content and 2% polymer content under different times of soaking are presented in

- Figure – 4.3, Un-Soaked (0 day)
- Figure – 4.4, Soaked (1 day)
- Figure – 4.4, Soaked (2 days)
- Figure 4.5, Soaked (3 days)
- Figure – 4.6, Soaked (4 days)

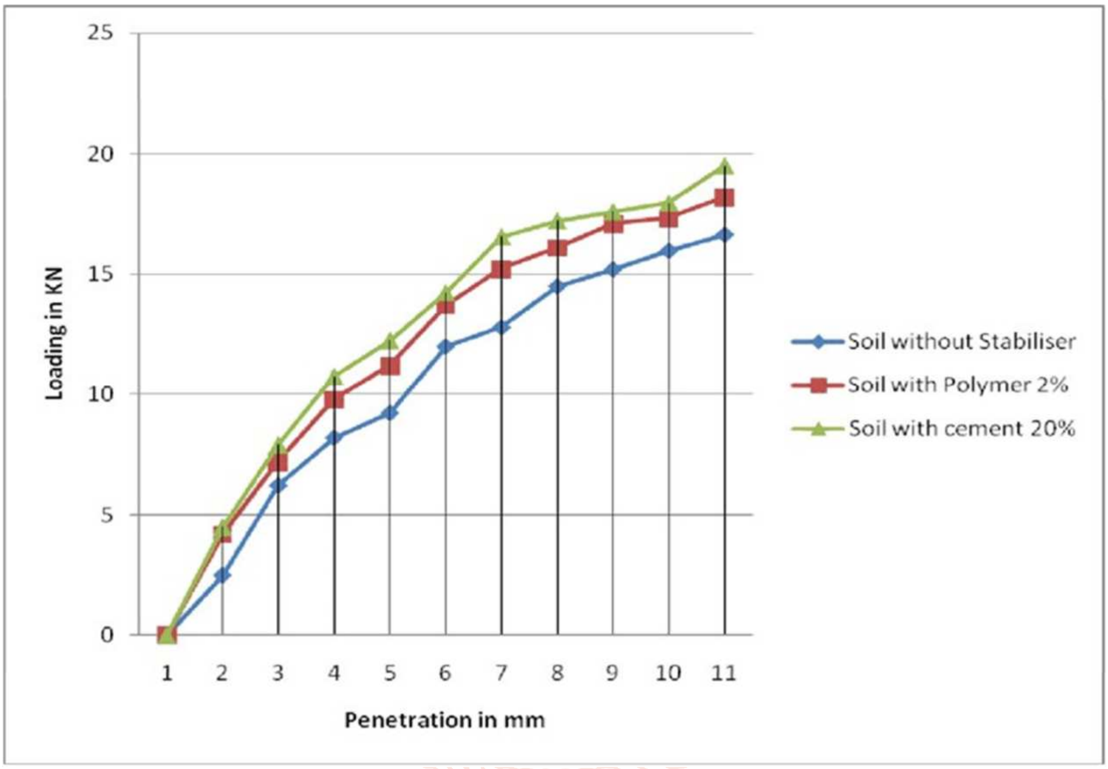


**Figure 4.3: Unsoaked (0 day)**

**Conclusion**

The results of the study were presented in following conclusions.

- The addition of polymer to the natural soil produced an improvement in its mechanical capacities that were determined by unconfined compression tests, from the first period of curing examination. From the strength aspect of liquefiable sandy soils, the optimum polymer content estimated polymer at 2%.
- The strength of sandy soil mixtures has increased with increment of cement contents up to about 30% and above 30% cement content; the strength of the soil almost becomes constant. This phenomenon is explained by the fact that the fine grains of cement were covered and positioned around and among the sand grains.
- From Fig.4.1, it is clear that the increase in polymer content also increases Unconfined compressive strength of soil if it is maintained less than 4 %, this phenomenon is explained by the fact that increment of polymer and the polymer cover all of sample's area and increases cross-links And the impact on strength with variation in cement content and polymer content is not much.
- The increase in Unconfined compressive strength is more at start of 20% cement addition in the sand, then its increase is not much when cement content is increased.
- It has been observed that the CBR values increases with increase in cement and Polymer content, CBR values is much increased in the first and second days of Soaking but its values not increases much with increase in days of Soaking.

- CBR values have much impact when soil is stabilized with cement and polymer but cement and polymer content does not give much variations when their impact is observed closely.
- Polymer and cement addition into the clayey soil reduces the pavement thickness and hence the cost of pavement to a good extent.

**Scope for Future Study**

Fly ash along with another additive like lime, murrum, cement, and other such materials can be used together, and may be varied in quantity to obtain the best possible stabilizing mixture.

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