A study on the effect of waste plastic strips in the stabilization of clay soil

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Abstract. The black cotton soils is the kind of soils whose size of size modifications together with the variation in moisture content material. They will have a conduct of expanding and contracting that is a severe vulnerability to constructed building above them. The swelling behaviour of clay soil is existing in north Karnataka region. The study demonstrates the results of an effort to strengthen and stabilize the clay soil with waste synthetic strips. The synthetic pieces being kept ready and integrated at three diverse blending proportions (0.5%, 1% and 1.5%) by mass of soil with various aspect ratios (8*8mm, 8*16mm, and 8*24mm). The exploratory results demonstrated that there was obviously a development in the shear quality factors. The expanding and drying upwards conduct behaviour are additionally sensitively reduced. There was a reduction that is substantial the OMC and insignificant improvement in MDD. The maximum size of plastic (aspect ratio) and synthetic content that results in maximum outcome may be chosen based on the value for the selection parameter for a definite engineering work. Stabilizing black cotton soils with unwanted plastic containers at the same time solves the tasks of unsuitable plastic waste reutilizing that is presently a teething issue in many countries that are developing. The outcomes obtained from this investigation positively suggest that addition of this product in clay soils would succeed for ground enhancement in geotechnical engineering.

1.0 Introduction
The clay soils become kinds of soils that illustration a considerable variation in volume after they are in interaction with moisture. They develop whenever confronted with water that is excess shrink in summer circumstances where there is certainly scarce of water content. They are able to be easily recognized on the dry conditions because they reveal deep splits of many-sided models. This performance of inflammation and diminishing of clay soils in change influences the soundness of tissues that will be developed during these grounds causing a big risk. It impacts the bearing behaviour and capacity of
footings by tension force because they enlarge and can even result from fissures to movements that are differential structural disappointments [1]. So that you can establish on clay soils, they required to be strengthened to decrease its expansion of the soil.

Soil stabilization is the method by which the strength parameters on the soils are enhanced. This is used to reduce the consolidation and permeability characteristics of soil and improved the bearing resistance [2]. The strategy is generally followed for airfield and highway works. Commonly pre-consolidation and compaction are widely used to stabilize kinds of soils which are in good arrangement. The stabilization of soil has been used for chemically modifying the soil samples itself is actually furthermore the main focus with this process [3].

Many ways had established formerly to stabilize unsuitable and weak soils. Some of these strategies take account of thermal, granular, cement, lime, bituminous, chemical, and electrical stabilization, in addition to grouting stabilization by fabrics and geotextiles. In recent times, scientists have discovered alternative means of soil stabilization making use of waste products. Plastics are among the waste that is leading that can be found getting ideal for this reason. They reduce the cost of stabilization in a huge rate [4]. Making use of plastics for this function concurrently solves the difficulties of inappropriate plastic waste recycling cleanup this is certainly currently a teething problem in many countries that are developing.

Inappropriate plastic disposal convenience is becoming a pressing issue that is environmental in many Indian regions. These include currently cover soils and water body, clogging sewerage methods, interrupting the environmental pattern and generating aesthetically unpleasing circumstances. Polyethylene Terephthalate (PET) bottles become main-stream plastic bottles that presently were very used. Those are utilized to soft drinks, packaged water, and other liquid refreshments and their increasing demand, its disposal has become challenging. The degradation of used polyethylene terephthalate waste takes more than a hundred years in nature [5]. Reusing and making use of these plastic containers to stabilize clay soil is a strategy in a correct path deciding to make use in the construction industry with its more consumption. The present study shows the suitable and informal way to reusing waste bottles as reinforcing materials for soil stabilization.

2. Materials & Methods

2.1 Materials
There are two products utilized for this investigation: a disturbed clay soil extracted from Raichur, north Karnataka region, India and PET pieces. The pieces had been kept ready from waste plastic bottles which were gathered through the surroundings that are nearby. The waste plastic bottles were washed well after assortment and slashed into three kinds measured pieces, manually utilizing cutters and the plastic strips shown in Figure 1. The strip dimensions were found in Table 1.

![Figure 1. Plastic strips](image-url)
The categorization of soil sample was prepared with the engineering properties of soil, such that sieve analysis, specific gravity, liquid limit (LL), plastic limit (PL) of the soil sample. After preparing the soil sample, the sieve and sedimentation analysis were performed to investigate the distribution of soil through particle size analysis. The tests were performed based on the Indian Standard code provisions. The Atterberg’s limits were determined by performing the LL, and PL tests. The test was performed as per [9-10] using Casagrande’s apparatus. The specific gravity is taken since the proportion from the unit weight of soil to the unit weight of water in the room temperature.

### Table 1. Plastic strip size

| Strip | Length (mm) | Width (mm) |
|-------|-------------|------------|
| 1     | 8           | 8          |
| 2     | 16          | 8          |
| 3     | 24          | 8          |

#### 2.2 Sample Preparation

The waste plastic strips (PS) are anticipated to perform as soil reinforcements and were included in soil with various percentages (0.5%, 1%, and 1.5%) by the soil mass. Table 2 reveals the treatment stages employed for each PS while performing the work.

### Table 2. Mix Proportions

| Strip size (mm) | % of mix |
|-----------------|----------|
| 8 * 8           | 0.5      |
|                 | 1        |
|                 | 1.5      |
| 8 * 16          | 0.5      |
|                 | 1        |
|                 | 1.5      |
| 8 * 24          | 0.5      |
|                 | 1        |
|                 | 1.5      |

#### 2.2 Testing of soil properties

When the categorization of both ingredients had been done, the synthetic PSs were included with the soil sample for treating the soil explained above. Proctor compaction test, free swell test, shear test, Unconfined Compressive strength test (UCS), and California Bearing Ratio (CBR) tests were examined to study the consequences with the inclusion of this plastic strip pieces on clay soil. The expansion behaviour of soil was investigated by performing free swell test. A small quantity of soil sample passing through 425 micron sieve size was taken with graduated jar of 100 ml capacity, and water was filled. The sample got left until they achieved maximum level of their optimum level of swelling. The expansion level of the soil was determined.

The maximum bulk unit weight and peak water content were found by performing the light compaction test. The soil was compacted in a proctor mould with different moisture contents until the bulk density initiated to reduce. Moisture content of soil at different water content additions got received, while the density that is dry each compaction levels was actually graphed along with its particular water content.
The peak of the curve given the maximum dry density occurrence that the soil tends to be compressed to, because of the maximum water content that will give the maximum compaction.

The behaviour of the consolidated and drained sample for shear test, and results in the strength of the sample was found by performing direct shear test. The experiment was done by collapsing a sample at a managed strain rate on just same shear plane, and dependent on the configuration in the device. Normally, three specimens had been tested, each within a different typical stress, to validate the influence of addition and mechanical load upon shear resistance and movement. The shear information at a three normal stresses are plotted on a single chart and linearly suited to outcomes the normal shear strength (C) on the soil, whereas the internal friction angle (ϕ) was determined from the gradient of slope of line, which is used to match the shear strength properties.

Clay soil could be assessed based on their particular shear resistance whenever subjected through load that is compressive with no confinement. The unconfined strength that is compressive examination was used to ascertain shear capability from the test soil under compression. The sample had been extruded and slashes in to some cylindrical shapes. The UCS device was utilized to compress the soil sample and after applied the loads, the change in the length of specimen was observed.

CBR test had been performed to evaluate the bearing resistance of compacted soil, and is observed as an outstanding base-course product. The outcomes of the CBR values help to realize the bearing and strength capability of a soil. In this study, compaction and penetration procedures were adopted and used to simulate the influence of additional load and additional moisture content on the compacted soil.

3. Results and Discussions

The soil has been categorized based on the index properties such as Atterberg’s limits, particle size analysis, and specific gravity of soil. The results indicated that the soil is a fine-grained by having a specific gravity of 2.61 along with a LL of 51%, PL of 24.5% and PI is 26.5%.

3.1 Compaction test results

Table 3. Strength properties of soil with plastic strips

| Strip size (mm) | % of Plastic strips added | OMC (%) | MDD (g/cc) |
|----------------|--------------------------|---------|------------|
| None           | 0                        | 14      | 1.911      |
| 8 * 8          | 1                        | 14.5    | 1.612      |
| 1              | 14                       | 1.623   |
| 8 * 16         | 0.5                      | 14.5    | 1.515      |
| 1.5            | 13                       | 1.55    |
| 8 * 24         | 0.5                      | 13      | 1.63      |
| 1              | 12                       | 1.635   |
| 1.5            | 11.5                     |         |

All strip proportions demonstrated reduction in OMC since the portion of PS size increased. A major reduction is found with a PS size of 8mm × 24mm in a 1.5% of inclusion which yielded a 29.6% reduction.
in the water content. The motive behind the reduction of the OMC could be as a result of zero absorption ability associated with the plastic strips. Consequently, soil is compressed to its optimum dry unit weight at minimum water content. Figure 2 indicates the assessment between addition of plastic and OMC of the soil.

![Figure 2. Soil Behaviour between Plastic strips and OMC](image)

A reduction in dryweight of soil can also be observed but it was limited. The maximum compression takes place with the waste strip size of 8mm × 16mm at 0.5% content which was 26%. Just the 1.5% content material of 8mm × 8mm strip continued the MDD of this soil and is 1.9 g/cc. The inclusion of plastic waste, which is less dense in nature, in the soil results decrease in the MDD of the soil. However the decrease in unit weight of soil is counter balanced by the reducing OMC. This engineering phenomenon will be used in the light weight embankment construction [9]. Figure 3 indicates the relationships between addition of plastic and MDD of soil.

![Figure 3. MDD vs. percentage of plastic strips](image)
3.2 Unconfined Compressive Strength test results
The outcomes discovered through the UCS tests, were different from the shear test results. The UCS of without reinforcement in soil was found as 0.251N/mm². The maximum development in the UCS is 0.391 N/mm² that was a net increase of 56% which is a remarkable gain. An upswing in UCS are received at little strip proportions and dimensions. Rise in proportions normally reduces the UCS advantages.

When the used compressive strain forced the soil mass to slip over the area of plastic strips and the shortage of confinement may have contributed for the reduction of the UCS value. The UCS sampler is also small also it might have caused big un-compressible shear strength planes. Table 4 reviews the UCS results for the PS that is different dimensions and mix ratios of reinforced soil examples.

| % of plastic strips | Strip size (mm) | Unconfined Compressive strength kN/m² |
|---------------------|----------------|--------------------------------------|
| 0                   | 8*8            | 169.2                                |
|                     | 8*16           | 224.3                                |
|                     | 8*24           | 189.6                                |
| 0.5                 | 8*8            | 254.3                                |
|                     | 8*16           | 249.3                                |
|                     | 8*24           | 189.6                                |
| 1                   | 8*8            | 286.1                                |
|                     | 8*16           | 249.3                                |
|                     | 8*24           | 177.2                                |
| 1.5                 | 8*8            | 301.2                                |
|                     | 8*16           | 211.6                                |
|                     | 8*24           | 133.7                                |

The reduction in water content of clay soil leads to deep and wide cracking. The decrease in volume and with excessively compression of soil occurred when reduce the moisture content. Many buildings lost its stability and collapsed due to unawareness. The addition of PS can help to decrease the cracking and shrinking behaviour of the soil by bridging amongst the fractures. It was experienced whenever the soil that is compacted and extruded from the mould and left to air dry until it fully cracked [10]. The cracks discussed on top of soil surface that is molded being able to continue its unique spherical shape are compared by aesthetic inspection. The strip size of 8*24mm lead a rather substantial reduced total of cracking, while large dimensions especially at higher rates diminished the power with the soil to keep up their spherical model of shape. It was obvious that the more expansive surface with the plastic material, the easier for any soil to crack. The results reveal the mode that is cracking of soil for strip dimensions of 8*24mm, 8*16mm, and 8* 8mm. It may clearly be indicated through the results that the sample containing 8*24mm synthetic strip sizes demonstrated extreme reduction of strength.

3.4 California Bearing Ratio Test results
The resistance of the soil has determined by performing the CBR. The Soaked CBR test is presented the exact site condition, hence the soaked test only was performed on the soil sample. This study focuses the CBR value in clay soil with addition of plastic strips.
Table 5. CBR Values

| % of plastic strips | Strip size (mm) | CBR (%) |
|---------------------|-----------------|---------|
| 0                   | 0               | 1.34    |
|                     | 8*8             | 1.52    |
| 0.5                 | 8*16            | 1.92    |
|                     | 8*24            | 2.21    |
| 1                   | 8*8             | 1.65    |
|                     | 8*16            | 2.1     |
|                     | 8*24            | 2.54    |
| 1.5                 | 8*8             | 1.43    |
|                     | 8*16            | 2.3     |
|                     | 8*24            | 2.77    |

The CBR value without adding the strips was found as 1.34 and enhancement is attained with addition of 1.5% of strips with soil and the CBR value obtained as 2.77. There is marginal increment found with addition of strips, which shows 107% increment. The values are indicated in the Table 5. The same proportions, the increase in size of strips results in increase in soaked CBR value, but increasing the content of plastic with same size results decrease in CBR value.

4. Conclusions
The following results are summarized based on the experimental results are as follows,

- The swell potential index was reduced significantly with increase in the strip content.
- When plastic strip are added to clay it increase the friction between clay soil and strips, thus improve the bonding force between soil particles.
- Compressive strength increases with the addition of plastic strip.
- CBR value increases, the thickness of flexible pavement reduces, it save cost of construction of pavement.
- Using plastic bottle as a soil stabiliser is an economical and gainful utilisation since there is scarcity of good soil for embankment and fills.
- The maximum dry density decreases with the increase in the plastic strip content which is due to the lower density of plastic strip than soil particle.

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