Experimental Investigation on Strength Properties of Plastic Reinforced Cohesive Soil

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Abstract - *The waste plastic especially in the form of discarded plastic beverage bottles is shredded into strips and added as reinforcement with red earth, to improve the strength characteristics of red earth, and experiments like Conventional tri-axial (D = 36mm) and large scale tri-axial tests (D = 100mm) are conducted on specimens prepared from both unreinforced soil specimens and specimens prepared with varying percentages of plastic strips.*

***Key Words*: soil, strength characteristics, waste plastic bottle strips, reinforcement.**

1. INTRODUCTION

Strength improvement in soils in the form of Reinforcement very commonly referred as Soil-reinforcement is the method wherein soil is reinforced by using materials like fibres, metal and non-metal reinforcements like steel reinforcements, strips and other substances like Geogrids, geomats etc. The main purpose of providing the reinforcement is to improve the properties of soils like shear strength, bearing capacity

The usage of plastic based products, like carry bags, bottles, boxes, and packing materials, has alarmingly increased in the current years and though waste plastic is collected for recycling and reuse; it is not in proportion with the quantity in which they are generated. The recycled plastics are made available commercially in various forms and states, which upto a certain extent can be effectively used up for various purposes.

In this current study, an attempt has been made to reuse strips obtained from waste plastic bottle as a reinforcing material for improving the strength characteristic of Red earth.

2. Literature Review

R. Shanker, B. Ram Rathan Lal (2014) carried out the experimental study on the CBR behavior of plastic strip reinforced fly ash. A series of California Bearing Ratio Test were carried out on randomly reinforced fly ash by varying percentage of strips cut in different sizes from the used and wasted plastic bottles. The different sizes of the plastic strips are, 2x20mm, 4x20mm, and 6x20mm were used with different mix ratio proportions of 0.25%, 0.5%, 0.75%, 1%, and 1.25%. The thickness of the plastic was 0.6mm. The CBR values of all the specimens were evaluated corresponding to both 2.5mm and 5.0mm plunger penetration. The load penetration curve obtained from the CBR test for unreinforced and randomly reinforced fly ash with strip contents ranged from 0.25%to 1.0% for reinforcement size 2x20mm shows that, the load and penetration curve was nonlinear for all the mix proportions including unreinforced case. The initial slope of curve is increased with addition of plastic strips indicating increase in the stiffness of reinforced fly ash. It is evident that, for a particular mix proportion the CBR value increased, after reaching the optimum mix proportion the CBR value decreases. Similar behavior was observed for all other reinforcement sizes. CBR value is significantly influenced by reinforcement aspect ratio. The different aspect ratio are 2x20mm (RA=0.1), 4X20 mm (RA=0.2), and 6x20 mm (RA=0.3), with varying aspect ratio, the observed relation was that load and penetration curve was nonlinear. For a particular value of penetration, load on piston was decreased with increasing the aspect ratio values (RA) values. The CBR value is decreased with increasing the aspect ratio of reinforcement. Similar behavior was observed for all other reinforcement mix proportions.

Variation of CBR values with aspect ratios of reinforcement was found that, for each mix proportion, the observed shape of the curves between CBR value for 2.5mm penetration and aspect ratio is found to be bilinear. Similar behavior was observed for CBR value corresponding to 5mm penetration. The CBR value of the unreinforced fly ash corresponding to 2.5mm and 5.0mm penetration were found to be 14.9 and 14.1 respectively. The CBR test results shows that 5.0mm penetration gives more CBR values than 2.5mm penetration for plastic strip reinforced fly ash. This is due to the reason that, at a larger deformation the plastic strip reinforcement is more effective in improving the strength of fly ash by increasing the resistance penetration. CBR values were increased to 24.36% and 29.85% corresponding to 2.5mm and 5.0mm penetration when fly ash was reinforced with waste plastic strips having aspect ratio equal to 0.1. Similarly CBR values were increased to 16.29% and 21.22% for aspect ratio 0.2, 15.52% and 20.78% for aspect ratio 0.3 of reinforcement.

Based on the above results, following conclusion can be made CBR values of fly ash were significantly influenced by reinforcement aspect ratio and mix proportions. The CBR value was decreased with increasing the aspect ratio of reinforcement. When the reinforcement aspect ratio is 0.1, higher CBR values were observed for both 2.5 and 5.0mm penetration compared with other two aspect ratio. The CBR values were increased to 24.5% and 29.85% corresponding to 2.5mm and 5.0mm penetration. When fly ash was reinforced with waste plastic strips having aspect ratio equal to 0.1. For each mix proportion value, the observed shape of the curves between CBR values and aspect ratio is found to be bilinear. Nonlinear relation observed between load on the plunger and penetration for all the mix proportions including unreinforced sample. The initial slope of curve is increased with the addition of plastic strips indicating increase in the stiffness of reinforced fly ash.

A laboratory investigation was carried out by **Dr. Sujit Kumar Pal (2008)** to evaluate the effect of waste plastic fibre on compaction and consolidation behavior of reinforced soil.In this experimental study, raw plastic bottle fibres has been used in three different aspect ratios (AR), i.e. 2 (size=10mm X 5 mm), 4 (size=10mm X 2.5mm) and 8 (size=10 mm X 1.25 mm). These different sizes of plastic strips have been mixed with local sandy-silt soil with clay (Fine Sand = 40.15%, Silt = 30.90%, and Clay = 28.95%) in four different percentages 0.00, 0.25, 0.50 and 1.00% by dry weight of the soil. Various consolidation tests were conducted on soil alone and soil mixed with waste plastic fibres. From the Figures 2.5, 2.6, 2.7 it is concluded that, with the increase of plastic fibres in soil, compression index (Cc) and coefficient of volume change (mv) of soil decreases up to 0.50% fibre content. But the values increases with further inclusion of plastic fibre of 1.00% in soil. The values of coefficient of consolidation increases with the increase of plastic fibres in soil for aspect ratios 2, 4 and 8.

Studies carried out by **A K choudhary et al (2010)** on the performance of paved and unpaved roads. The experimental study involved performing a series of laboratory CBR tests on unreinforced and randomly oriented HDPE strip reinforced sand specimen. HDPE having a width of 12mm and a thickness of 0.40 mm. These were cut into lengths of 12mm [Aspect Ratio (AR) =1, 24mm (AR=2) and 36mm (AR=3)]. They maintain the mould diameter remains at least 4 times the maximum strip length, which will ensure that there is sufficient room for the strips to deform freely and independent of mould confinement. The tests were conducted at various strip contents of 0.0%, 0.25%, 0.50%, 1.0%, 2.0% and 4.0%.

The CBR value of the unreinforced sand corresponding to 2.5mm and 5.0mm penetration were found to be 14.01 % and 18.88 %, which were increased to 24.23% and 29.20% respectively when sand was reinforced with 0.25% waste plastic strips having aspect ratio equal to 1. Further increase in strip content from 0.25% to 1% without changing the aspect ratio again enhanced the CBR value to 29.78% and 32.89% respectively corresponding to 2.5mm and 5.0 mm penetration. The trend remained unchanged even when the percentage of waste plastic strip content is further increased from 1% to 2% or 4% in the soil. The maximum value of CBR at 5 mm penetration is 41.65% when 4% waste plastic strip content having aspect ratio equal to 1 was mixed with the soil. Similar results have been observed for other values of aspect ratios. The variation of CBR for strip reinforced sand with different strip lengths at various strip contents is shown in Figure 2.3. On the other hand, Figure 2.4 shows the variation of CBR with different strip contents at various aspect ratios.

Based on the results, the following conclusions can be drawn:

The addition of reclaimed HDPE strips, a waste material, to local sand increases the CBR value. The reinforcement benefit increases with an increase in waste plastic strip content and length. The maximum CBR value of a reinforced system is approximately 3 times that of a unreinforced system. Base course thickness can be significantly reduced if HDPE strip reinforced sand is used as sub-grade material. This suggests that the strips of appropriate size cut from reclaimed HDPE may prove beneficial as soil reinforcement in highway sub-base if mixed with locally available granular soils in appropriate quantity.

Mercy joseph poweth et all.,(2013) carried out an experimental study on the suitability of plastic waste materials for pavement construction. In this study plastic waste was mixed in different proportions to the soil sample. The results of the tests indicated that plastic alone is not suitable for pavement subgrade. When quarry dust was added along with soil plastic mix, it maintains the CBR value within the required range. CBR tests were conducted in the laboratory on soil sample mixed with different percentages of plastic waste materials. CBR and standard proctor tests were carried out for finding the optimum percentages of waste plastics, and quarry dust in soil sample. Based on the laboratory studies, following conclusions can be drawn

1. As the percentage of plastic waste increases the maximum dry density decreases, thereby decreasing the CBR value. Hence quarry dust was mixed along with the soil plastic mix, to increase its maximum dry density.
2. Increase in percentage of quarry dust resulted in increase of maximum dry density and CBR value. Hence quarry dust was found to be suitable for pavement subgrade.
3. Soil plastic mix with quarry dust maintains the CBR value within the required range. Soil tyre-soil mix with quarry dust gives lesser CBR value than soil plastic quarry dust mix but it can be used for pavement subgrade.

The investigations carried out by **Achmed Fauzi et all (2013)** to analyse the utilization of High Density Polyethylene (HDPE) and Glass as material stabilizer in Kuantan clayey soil stabilization. In this study, they conduct soil engineering properties and strength test for various contents of HDPE and glass to different types of clayey soil. The samples were set up by mixing soil samples with various content of stabilizer at optimum water content. The variation content of stabilizer was 4%, 8% and 12% by dry total weigh glass to different types of clayey soil. From the experimental results it is concluded that the maximum dry density decreased and the optimum water content increased when the HDPE and Glass content increased. The CBR value increased when the HDPE and Glass content increased.

3. Materials

The materials used for the present study is Red earth and plastic strips obtained by shredding of waste water bottles.

3.1 Red earth

Table 1 presents the properties of the red earth used. The red earth is classified as Silt of Low compressibility/plasticity according to Indian standard classification system (ISCS).

Table 1: Properties of Red Earth

PROPERTIES	TEST RESULT
Specific gravity	2.78
Liquid Limit (%)	45
Plastic Limit (%)	25
Shrinkage Limit (%)	14
Dry unit weight (kN/m3)	18.2
Optimum Moisture Content (%)	18
Silt + Clay (%)	58 + 18 = 76
Soil classification (IS)	ML

3.2 Plastic

Used water bottles manufactured by a particular company are collected from restaurants and old scrap dealers. After splitting it open rectangular sheets are obtained. These sheets are cut in to required dimensions manually using small hand instruments like razors and cutters. The method of cutting is shown in Figure 1.

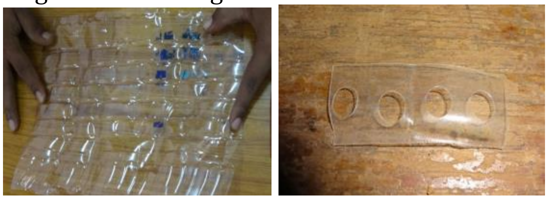

Figure 1: Cutting& shredding method of plastic bottles.

Preliminary experiments are conducted with shredded plastic with red earth. Further to improve the performance of such shredded plastic – a modification is made for the shredded plastic. 5mm diameter holes are punched in each of the shredded plastic strips at prefixed spacing. Providing such perforation in the shredded plastic is expected to provide confinement to the soil particles at the microlevel and thereby may contribute to the improvement in the performance of plastic reinforced red earth. The process of perforation and the prepared shredded plastic with perforation is shown in Fig. 1

4. Experimental work

Shredded plastic strips with perforation are mixed with red earth to improve the shear strength parameters and Conventional and large scale Triaxial tests were conducted on such mixtures. Tests were conducted on

i) Unreinforced red earth
ii) reinforced red earth (with plane and perforated plastic strips)

4.1 Preparation Of Reinforced Red Earth

For the present study, red earth is used as a foundation soil. The tank is divided into five equal layers each of 80mm depth. In order to avoid spilling of soil particles while compacting last layer at the top, a clearance of about 30mm-50mm is given. Test are conducted on red earth compacted at MDD of 1.8gm/cc at an OMC of 18%. From the MDD value, and by knowing volume of tank, the mass of red earth required can be calculated. This mass was divided into five equal parts of uniform moisture content throughout. Using the depth markings on the sides of the tank as a guide, the red earth is compacted in five equal layers. Then footing with connecting rod is placed at the top layer of the soil. (according to the ratio of depth of footing to width of the footing.ie. D/B=0).

4.2 Conventional Triaxial Compression Test (Unconsolidated Undrained)

The reinforced and unreinforced cylindrical red earth specimens of dimension 38mm x 76mm are obtained static compaction method. After extracting the samples of required dimensions, it is then transferred to the triaxial cell setup. The test is conducted at various confining pressures of 50kpa, 100kpa, 150kpa and 200kpa.

4.3 Large Scale Triaxial Test (D = 100mm)

The reinforced and unreinforced cylindrical red earth specimens of dimension 100mm x 200mm are obtained static compaction method. Samples are prepared with varrying perforated plastic content and varying aspect ratio 1 (10mm x 10mm) and 2(20mm x 10mm). The percentage of plastic added to red earth is in steps of 0.5% up to 1.5% perforated plastic, by weight of soil. The water content and dry density of the sample is same as maintained in the conventional triaxial test and direct shear test. The test is conducted at various confining pressures of 50kpa, 100kpa, 150kpa and 200kpa. Fig 2(a) and (b) shows the photographical view of the large scale Triaxial compression test apparatus.

Fig 2(a) Large Scale Triaxial Loading Frame (b) Large Scale Triaxial Cell

5. Testing Programme

TRIAXIAL COMPRESSION TEST (UU)	
Aspect Ratio (Length/Width)	**Perforated plastic (%)**
1	0.5
	1.0
	1.5
2	0.5
	1.0
	1.5

Table 2: Experimental Programme of Large Scale Triaxial Compression Test (UU)

Normal stress (kPa)	Perforated plastic (%)
50	0
	0.5
	1.0
	1.5
100	0
	0.5
	1.0
	1.5
150	0
	0.5
	1.0
	1.5

Table 3: Experimental Programme of Conventional Triaxial Compression Test (UU)

6. Results

6.1 Conventional Triaxial Test

UU Triaxial experiment are conducted on cylindrical sample with L x D ratio 2 (diameter = 3.6cm). Experiments are conducted both on unreinforced and 0.5%, 1.0% and 1.5% perforated plastic strip reinforced red earth samples. In these test, the perforated plastic strips had an aspect ratio nearly 1, with a concentric hole covering the entire strip size. Aspect ratio or the geometry of the hole is not altered in these experiments. However in case of large size Triaxial test these aspects of the plastic strips are covered and the results of large scale Triaxial tests are presented in the subsequent sections.

Fig 3 to Fig 6 presents the Triaxial test results (sample size 3.6cm) for unreinforced and 0.5%, 1.0% and 1.5% perforated plastic strip treated red earth samples.

The cohesion and angle of internal friction for untreated red earth soil sample is 53kPa and angle of internal friction is 28^o (Fig 3) at the test condition. Fig 4 indicates that there is no change in angle of internal friction with the inclusion of perforated strip. In Fig 4 cohesion values increased to 62kPa at 0.5 perforated plastic from 53kPa of red earth alone, however similar trend of increase in cohesion value is exhibited by reinforced red earth soil sample. Fig 5 presents increase in cohesion values (C = 82kPa against 62 kPa) at 1.0% perforated plastic strips. There after it is observed that there is reduction in cohesion values(c = 58kPa against 82 kPa) and angle of internal friction (Φ = 27^o against 29^o) at 1.5% perforated plastic content.

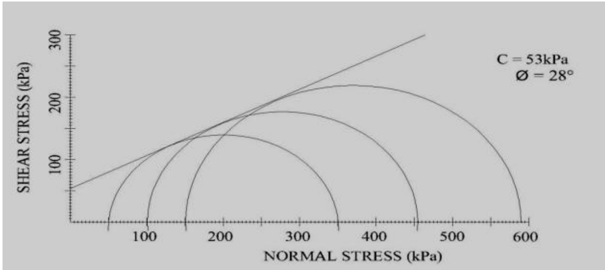

Fig 3: Mohrs circle for Red earth alone subjected to conventional Triaxial test

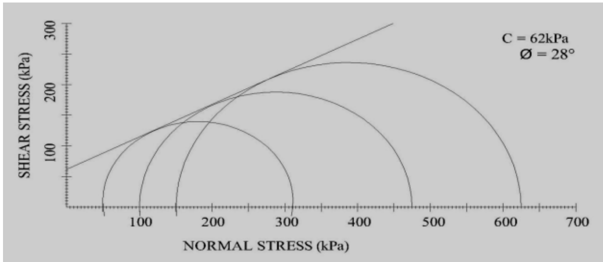

Fig 4: Mohrs circle for Red earth treated with 0.5% perforated plastic strips subjected to conventional Triaxial test

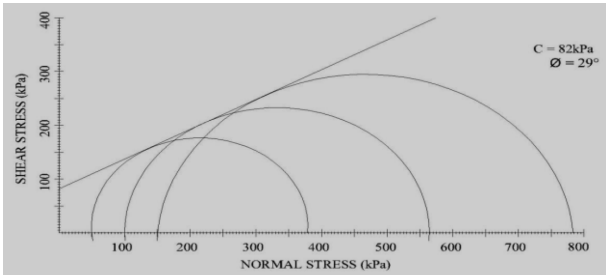

Fig 5: Mohr circle for Red earth treated with 1.0% perforated plastic strips subjected to conventional Triaxial test

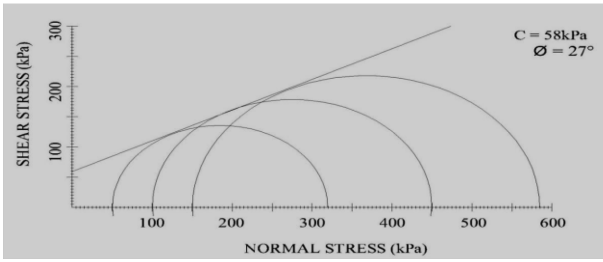

Fig 6: Mohr circle for Red earth treated with 1.5% perforated plastic strips subjected to conventional Triaxial test

The decrease in shear strength parameter at higher dosage of perforated plastic strip may be attributed to slippage between the soil particles and the smooth plastic surfaces. However the decrease in cohesion values at 1.5% perforated plastic strip when compared with the red earth was better. The discussion presented above establishes the fact that reinforcing the red earth sample is effective in increasing cohesion values, there by contributing to the increase in shear strength. It is observed to be true for samples treated with 1.0% perforated plastic.

6.2 Large Scale Triaxial Test

To overcome the difficulty in testing the soil sample with perforated plastic strips of different aspect ratios in conventional Triaxial samples of size 36mm, large size Triaxial test are conducted. Cylindrical samples of size 10cm in diameter and height 20cm are tested in UU Triaxial test. This size of the sample facilitated the inclusion of perforated plastic strips of different sizes and different perforation configuration. An aspect ratio of 1 (10mm x 10mm) and aspect ratio 2 (20mm x 10mm) is used. In case of strips with aspect ratio 1 a single hole of diameter 5mm is punched at the centre, whereas for strips with aspect ratio 2 two such holes are punched symmetrically in the plastic strips. A reinforcement percentage of 0.5, 1.0 and 1.5% is used. This section presents the results of all such experiments performed. Fig 7 presents the test results for untreated red earth sample. Fig 7 to Fig 10 presents the test results for red earth with perforated plastic strips having aspect ratio 1. Fig 11 to Fig 13 presents the similar data for plastic strips with aspect ratio 2.

The untreated red earth sample exhibited cohesion of 80kPa and angle of internal friction of 27o in the test condition (Fig 7). The cohesion value is increased to 103kPa and 135kPa when treated with 0.5% and 1.0% perforated plastic strip with aspect ratio1 respectively. However there was no appreciable change in the values of angle of internal friction (27° to 29°). Further the value of cohesion decreased slightly to 116kPa when treated with 1.5% of the same strip. However there is no change in angle of internal friction. Even with 1.5% perforated plastic strip the value increased considerably compared to the untreated red earth sample. The test results indicate clearly that the value of cohesion is significantly influenced by the inclusion of perforated plastic strips whereas the angle of internal friction is not affected.

Fig 11 to Fig 13 presents the results of large scale Triaxial test performed on red earth soil sample treated with perforated plastic strips of aspect ratio 2, for 0.5, 1.0% and 1.5% dosage respectively. At the outset it can be seen from these figures that the cohesion value of the treated sample increases with the inclusion of perforated plastic strips irrespective of dosage of plastics. For example the cohesion values increased from 80kPa to 104kPa for 0.5% perforated plastic strip content and to 146kPa when strip content is increased to 1.0%. The value of angle of internal friction was unaffected at 0.5% of perforated plastic strip where as it s increased to 32° at 1.0% strip content. Further at 1.5% strip content samples showed a reduction in cohesion and angle of internal friction values when compared to 1.0% perforated plastic strip treated soil sample. However even at 1.5% strip content there is a significant increase in the cohesion values compared to untreated samples.

The discussion presented above establishes the fact beyond doubt that the perforated plastic strip inclusion is effective in improving the shear strength parameter of the soil irrespective of the aspect ratio.

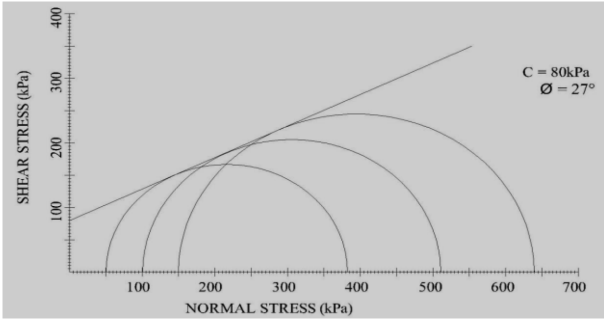

Fig 7: Mohr circle for Red earth alone subjected to large scale Triaxial test

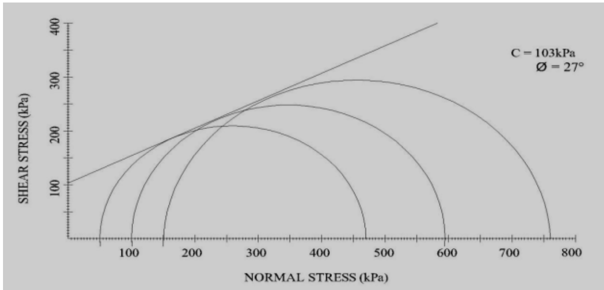

Fig 8: Mohrs circle for Red earth treated with 0.5% perforated plastic strips subjected to large scale Triaxial test at aspect ratio 1 (10mm x 10mm)

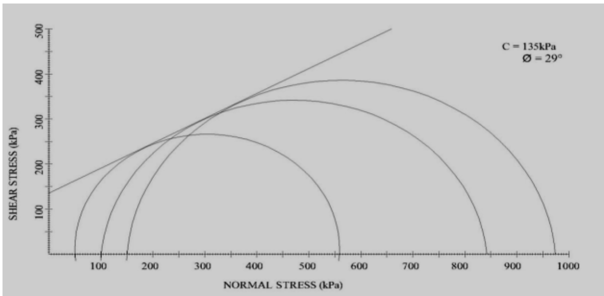

Fig 9: Mohr circle for Red earth treated with 1.0% perforated plastic strips subjected to large scale Triaxial test at aspect ratio 1 (10mm x 10mm)

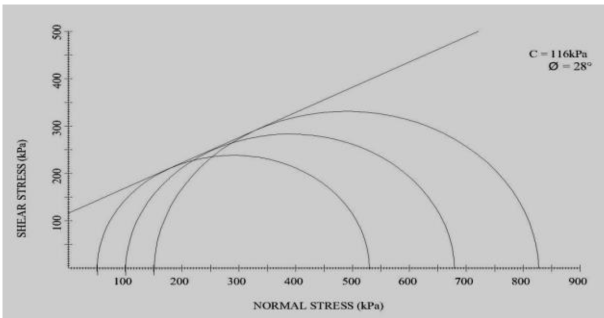

Fig 10: Mohr circle for Red earth treated with 1.5% perforated plastic strips subjected to large scale Triaxial test at aspect ratio 1 (10mm x 10mm)

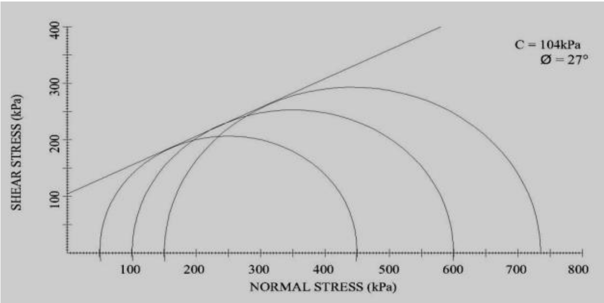

Fig 11: Mohr circle for Red earth treated with 0.5% perforated plastic strips subjected to large scale Triaxial test at aspect ratio 2 (20mm x 10mm)

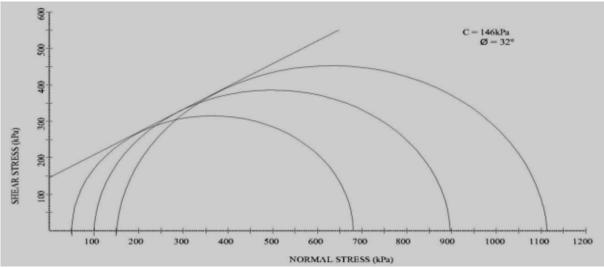

Fig 12: Mohr circle for Red earth treated with 1.0% perforated plastic strips subjected to large scale Triaxial test at aspect ratio 2 (20mm x 10mm)

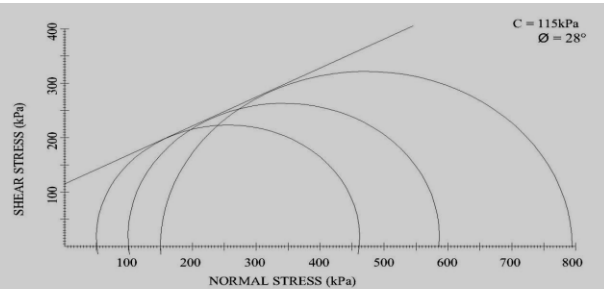

Fig 13: Mohr Circle for red earth treated with 1.5% perforated plastic strips subjected to large scale Triaxial test at aspect ratio 2 (20mm x 10mm)

6.3 Angle Of Internal Friction

(a) Conventional Triaxial Test (D = 36mm)

Fig 14 and table 4 presents the conventional Triaxial test data conducted on samples treated with different percentage of plastic strip content. The plastic strip content varied up to 1.5% in steps of 0.5%. It is evident from this data that angle of internal friction is almost unaffected by the presence of perforated plastic strips. The value remains at about 28o. It is to be noted that the test are limited to 1.5% perforated plastic strip content only. Experiments with higher percentage of perforated strips could not be done. As the good quality sample could not be prepared. Since the plastic content becomes voluminous. However attempts are made to overcome these difficulties in large scale Triaxial test.

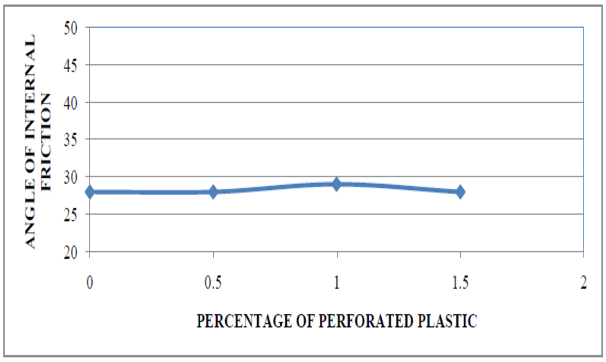

FIG 14 Effect of inclusion of perforated plastic strips on the angle of internal friction in conventional Triaxial test

Percentage of plastic	Angle of internal friction
Red earth alone(RE)	28°
RE + 0.5% plastic	28°
RE + 1.0%plastic	29°
RE + 1.5% plastic	27°

Table 4: Angle of internal friction of perforated plastic treated Red earth in conventional Triaxial test

(b) Large Scale Triaxial Test (D =100mm)

Large scale Triaxial test are conducted with unreinforced and perforated plastic strips reinforced soil samples of size 100mm in diameter in undrained condition. Samples are prepared directly in the Triaxial split mould with appropriate plastic content. The density and water content of these samples are maintained same as density and water content used for direct shear test and conventional Triaxial test. Experiments are conducted with perforated plastic strips having aspect ratio 1 and 2 and the strip content is varied upto 1.5% in steps of 0.5%

Figure 15 and table 5 presents the result of large scale Triaxial test. It is evident from these test data that the angle of internal friction of the reinforced red earth soil samples treated with strips having aspect ratio 1 is almost unaffected by the dosage of plastic strips. the value varied from 26° to 29°. Further it is interesting to observe that, when the soil samples are reinforced with plastic strip having aspect ratio 2, exhibited an appreciable increase in the angle of internal friction. It is increased from 26° to 32°.

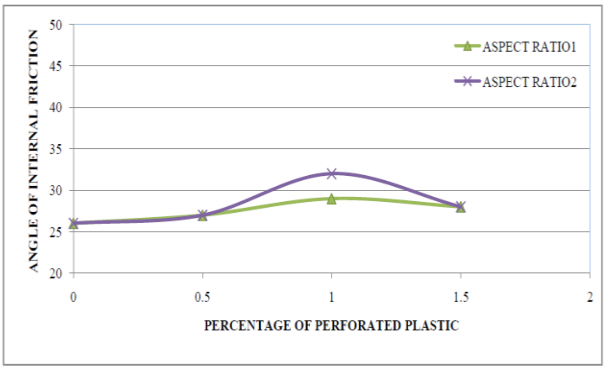

FIG 15 Effect of inclusion of perforated plastic strips on the angle of internal friction in large scale Triaxial test

Percentage of plastic	Angle of internal friction	
	Aspect Ratio 1	Aspect Ratio 2
Red earth alone(RE)	26^0	26^0
RE + 0.5% plastic	27^0	27^0
RE + 1.0%plastic	29^0	32^0
RE + 1.5% plastic	28^0	28^0

Table 5: Angle of internal friction of perforated plastic treated Red earth in large scale Triaxial test

		% Change in angle of internal friction		
Percentage of plastic (%)		0.5	1.0	1.5
Conventional Triaxial test		0	3	0
Large scale Triaxial test	Aspect ratio 1	3	11	7
	Aspect ratio 2	3	23	7

Table 6: Percentage change in Angle of internal friction of perforated plastic treated Red earth in Conventional & large scale Triaxial test.

6.4 Cohesion

(a) Conventional Triaxial Test (D = 36mm)

Figure 16 and table 7 represents the conventional Triaxial test data conducted on samples treated with different percentage of perforated plastic strip content. The experiment is conducted by varying plastic content in steps of 0.5%. It is observed from this data that, with the inclusion of perforated plastic the reinforced red earth exhibited increase in cohesion value. The cohesion value of untreated red earth sample is 53kPa. However at 0.5% perforated plastic strip content the cohesion value increased to 62kPa from 53kPa of red earth alone. Similar trend of increase in cohesion value is observed at 1.0% perforated plastic content(c = 82kPa against 62kPa).Beyond 1% perforated plastic strip these reinforced soil sample exhibited decrease in cohesion value of 58kPa at 1.5% perforated plastic.

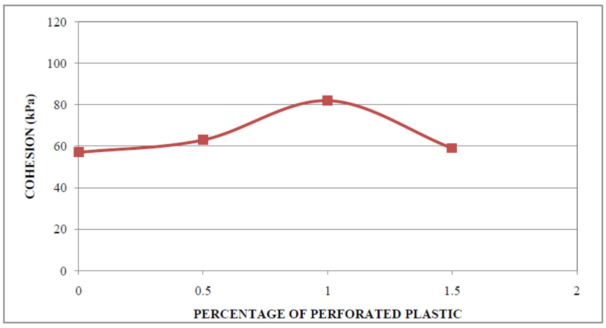

FIG 16: Effect of inclusion of perforated plastic strip on cohesion in conventional Triaxial test

Percentage of plastic	Cohesion (kpa)
Red earth alone(RE)	53
RE + 0.5% plastic	62
RE + 1.0%plastic	82
RE + 1.5% plastic	58

Table 7: Cohesion of perforated plastic treated Red earth in conventional Triaxial test

(b)Large Scale Triaxial Test

Large scale triaxial test are conducted with unreinforced and perforated plastic strip reinforced soil sample of size 100mm in diameter in un-drained condition. Experiments are carried out with perforated plastic strips having aspect ratio 1 and 2 and the strip content is varied up to 1.5% in steps of 0.5%. Table 8 and figure 17 presents the results of large scale Triaxial test it is observed from the test results that with the inclusion of perforated plastic strip the cohesion values increase steadily up to 1% and beyond this percentage of plastic content the reinforced soil sample exhibited a decrease in cohesion value at 1.5% perforated plastic strip content. However there was a marginal change in angle of internal friction. Whereas for aspect ratio 2 the cohesion value and angle of internal friction value increase steadily upto 1% of perforated plastic strip content. The increase in cohesion value at 1% perforated plastic strip content is 135kPa and 146kPa for aspect ratio 1 and for aspect ratio 2. However at 1.5% of perforated plastic strip treated red earth exhibited a decrease cohesion value of 116kPa and 115kPa at aspect ratio 1 and 2.

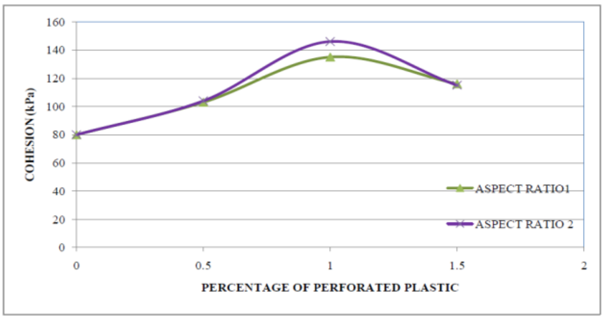

FIG 17 Effect of inclusion of perforated plastic strip on cohesion in large scale Triaxial test

Percentage of plastic	Cohesion (kpa)	
	Aspect Ratio 1	Aspect Ratio 2
Red earth alone(RE)	80	80
RE + 0.5% plastic	103	104
RE + 1.0%plastic	135	146
RE + 1.5% plastic	116	115

Table 8: Cohesion of perforated plastic treated Red earth in large scale Triaxial test

		% Change in cohesion		
Percentage of plastic (%)		0.5	1.0	1.5
Conventional Triaxial test		16	54	9
Large scale Triaxial test	Aspect ratio 1	28	69	45
	Aspect ratio 2	30	82	43

Table 9: Percentage change in Cohesion of perforated plastic treated Red earth in Conventional & large scale Triaxial test.

6.5 Shear strength of perforated plastic strip treated red earth

An attempt has been made to calculate and compare shear strength properties of perforated plastic strip treated red earth specimen using mohr coloumb theory.

$$\tau = C + \sigma \tan\Phi$$

where,

c is cohesion

Φ is angle of internal friction

σ is over burden pressure,

For the calculation of overburden pressure, the unit weight is taken as 20kN/m3 and the depth is taken as 1m.

Therefore, $\sigma = \gamma \times z$

$= 20 \times 1$

$= 20 kN/m^2$

(a) Conventional Triaxial Test

The trend of results for the computed shear strength based on conventional Triaxial test exhibited marginal increase in shear strength is (Fig 4.25 and table 4.10, 67kPa for soil alone sample and a maximum of 93kPa for 1.0% strip content sample). In general it can be said that the improvement in shear strength based on the conventional test data is marginal.

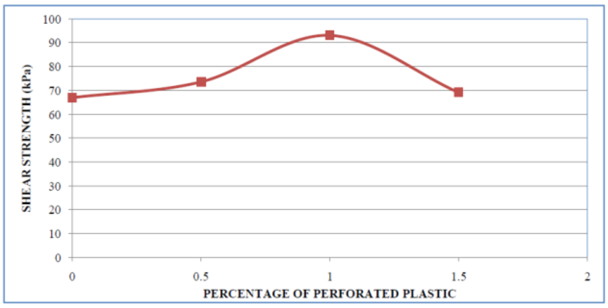

FIG 18 Effect of inclusion of perforated plastic strip on shear strength in conventional Triaxial test

Percentage of plastic (%)	Triaxial test (kpa)
Red earth alone(RE)	67
RE + 0.5% plastic	73
RE + 1.0% plastic	93
RE + 1.5%plastic	69

Table 10 Shear strength of perforated plastic treated Red earth in conventional Triaxial test

(b) Large Scale Triaxial Test

The computed shear strength values of soil sample reinforced with perforated plastic strip of aspect ratio 1 and aspect ratio 2 is presented in fig 19 and table11. The data presented in this clearly depicts that the computed shear strength value is greatly affected by the inclusion of perforated plastic strips. At all the percentage of plastic strip content an increase in shear strength is observed. And the maximum value of shear strength is observed at 1.0% plastic content. Further it is interesting to observe that the aspect ratios do not have a significant effect on the shear strength. Two aspect ratios i.e., aspect ratio 1 and aspect ratio 2 are tried in the present investigation and both of them have intended almost the same results. However it is expected that at higher aspect ratios the shear strength values may be affected.

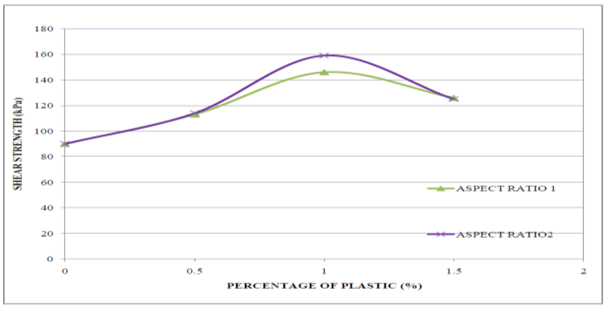

FIG 19 Effect of inclusion of perforated plastic strip on shear strength in large scale Triaxial test

Percentage of plastic (%)	Shear strength (kpa)	
	Aspect ratio 1	Aspect ratio 2
Red earth alone(RE)	90	90
RE + 0.5% plastic	113	114
RE + 1.0% plastic	146	159
RE + 1.5%plastic	127	125

Table 11: Shear strength of perforated plastic treated Red earth in large scale Triaxial test

		Percentage change in shear strength		
Percentage of plastic (%)		0.5	1.0	1.5
Conventional triaxial test		8	38	3
Large scale triaxial test	Aspect Ratio 1	25	62	41
	Aspect Ratio 2	27	77	39

Table 12 Percentage change in shear strength of perforated plastic treated red earth in different test

7. CONCLUSIONS

Based on the results of experiments presented and discussed the following conclusions are drawn:

i) The addition of perforated plastic strips is found effective in enhancing the shear strength of the Red earth. Though considerable improvement of cohesion is obtained, there is marginal increase in the angle of internal friction value. The development of cohesion is due to the confinement provided by the provision of perforation.

ii) The percentage of perforated plastic strip has considerable influence on shear strength of plastic Red earth mixture. An optimal dosage of about 1.0% is observed for maximum development of cohesion.

iii) After the percentage of perforated plastic increases beyond 1.0%, the shear strength parameter decreases. This may be due to slippage between the soil particles and the plastic.

iv) The stress-strain behaviour of reinforced Red earth improved considerably due to increase in perforated plastic content.

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