NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF RESEARCH PUBLICATIONS IN ENGINEERING AND TECHNOLOGY [IJRPET]
NATIONAL CONFERENCE ON INNOVATIVE TRENDS IN ENGINEERING & TECHNOLOGY-2017
15TH & 16TH MARCH 2017
CONFERENCE PROCEEDINGS ISSN NO - 2454-7875

Paper ID: NITET08

UTILIZATION OF BOTTLED PLASTIC WASTE FOR STRENGTH IMPROVEMENT OF SOIL

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ABSTRACT

Due to an inefficient and faulty waste collection and transit system, a large amount of plastic waste fails to reach landfills or incinerators. Recycling plastic waste from water bottles has become one of the major challenges worldwide. The present study provides an approach for the use of plastic waste as reinforcement material in soil. To study effect of size and shape, plastic chips of different sizes (4mm x 12mm and 5mm x 15mm) had been used. A series of unconfined compression(UCC), direct box shear tests and swell pressure tests have been performed at four different percentages of fibers (0%, 0.5%, 0.75% and 1.0% by dry weight of soil) to determine stress-strain and swelling behavior of plastic waste mixed soil and the influence on plastic waste on shear strength of soil has been observed. The experimental results in the form of stress-strain response are presented. Based on experimental test results, it is observed that the strength of soil is improved significantly with addition of a small percentage of plastic waste to the soil. The improvement in strength due to inclusion of plastic waste can be advantageously used in bearing capacity improvement and settlement reduction in the design of shallow foundations and pavement design on a weak soil.

Keywords: Soil reinforcement, soil strength, utilization of plastic waste

INTRODUCTION

After studying plastic waste production, it's found that bottled waste contribute significantly to plastic waste and pollution. One can say that Bottled water is the 'new eco-disaster because the bottled water is the fastest growing beverage industry in the world. This study presents a simple way of reusing plastic water bottles in the field of civil engineering as reinforcing material. Engineers try to improve the physical properties of local soils through different methods and techniques. The plastic waste mixed soil behaves as reinforced soil similar to fiber-reinforced soil.

The introduction of the soil reinforcing techniques has enabled engineers to effectively use unsuitable in situ soils as reliable construction materials in a wide range of civil engineering applications. Here considering the inherent dual advantage, increasing shear strength of soil and reusing bottled plastic, it has been decided to use the plastic water bottle waste as a reinforcement to improve the existing properties of locally available weak soil in Solapur city.

LITERATURE REVIEW

Hataf and Rahimi (2006) and Yoona (2008) conducted experiments on tire shreds as reinforcing material. It was found that addition of 10% shreds by volume contributed to improvement of bearing capacity, expressed in terms of Bearing Capacity Ratio (BCR) in the range of 1.17-1.83 whereas use of 50% tire shreds increased BCR values to the range of 2.95-3.9 for different sizes of shreds. Sivakumar Babu and Chouksey (2010) showed that coir fiber reinforced soil is a potential composite material which can be advantageously employed in improving the structural behavior of soil.

PROPERTIESOF UNREINFORCES SOIL

The soil taken for this study is locally available soil in Solapur from Manorama Nagar. For purpose of classification of soil and to know the nature of soil following laboratory tests are carried.

TABLE 1: PROPERTIES OF UNREINFORCED SOIL

Test performed	Referred IS code	Result
A) Index Properties		
Specific gravity	IS 2720 (Part 3) - 1980	2.723
Liquid Limit	IS 2720(Part 5) - 1985	48.50%
Plastic Limit	IS 2720(Part 5) - 1985	36.01%
Shrinkage Limit	IS 2720(Part 6) - 1985	16.83%
Plasticity Index	-	9.787
B) Strength Properties		
Direct Box Shear Test	IS 2720(Part13) - 1986	C= 16kN/m^2 Φ= 12°
Unconfined Compression Test	IS 2720(Part10) - 1991	C= 23kN/m^2
C) Swelling Properties		
Free Swell Index	IS 2720(Part40) - 1997	50%
Swell Pressure Test	IS 2720(Part41) - 1997	56.96kN/m^2

EXPERIMENTATION ON REINFORCES SOIL

A. REINFORCED SOIL PREPARATION

Plastic water bottle wastes in the form of chips are used as reinforcing material. The size of plastic chip used is 12 mm long and 4mm in width. Specific gravity of the plastic is taken as 1.4gm/cc. Dry soil of specified weight (MDD) mixed with required quantity of water (OMC) and kept in desiccators for equilibrium. Subsequently, the wet soil was taken out from the desiccators and the specified weight of

plastic waste percent by dry weight of soil was distributed uniformly over the soil and mixed uniformly. The plastic waste-soil mixture was then kept in a plastic container for equilibration of moisture content of mix. The entire mixture was filled in the compaction mould and statically compacted, and kept for saturation for 72 hours and specimens for testing are obtained.

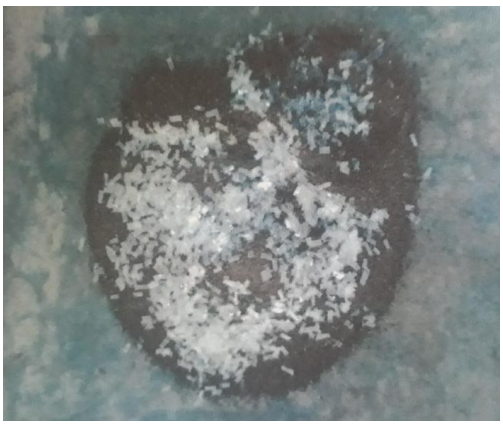

Fig.1. Reinforced Soil sample preparation

To study effect of size and shape plastic chips of different sizes can be used. Initially considering aspect ratio study of plastic chips of size 4mmX12mm (Slenderness ratio 3) are added. Further experimentation is carried out with plastic chip size 5mm X 15mm.

B. REINFOECED SOIL TESTS AND RESULTS

In experimentation on reinforceed soil, a series of Unconfined Compression (UCC), Direct Box Shear test and Swell Pressure tests had been performed at four different percentages of fibers (0%, 0.5%, 0.75% and 1.0% by dry weight of soil) to determine stress-strain and swelling behavoir of plastic waste mixed soil and observe the influence of plastic waste on shear strength of soil. The results indicate that the plastic waste mixed soils have higher strength than unreinforced soil which is a useful consideration in the use of plastic waste in soil improvement.

1. DIRECT BOX SHEAR TEST RESULTS:

To study the effect of plastic addition on strength properties (i.e. C and φ) of silty soil, this test is performed. Obtained results are compared in the following graphs. From this test results, it is observed that for this soil there is gradual and considerable increase in C value with increasing plastic percentage. The change in φ parameter values is not consistent. But to conclude the ultimate effect of reinforcement shear strength of soil is calculated for a constant value of normal stress (150 kN/m²) and it is found that shear strength of soil is improved effectively and corresponding results are presented in following tables.

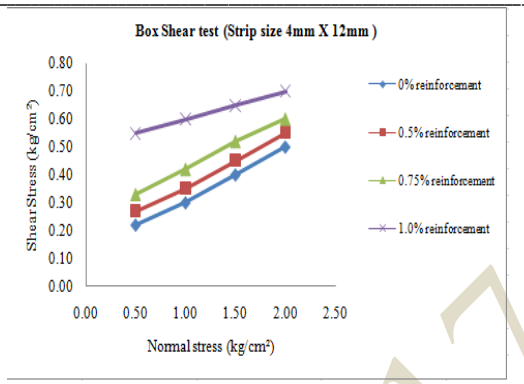

Fig.2. Box shear test results comparison for strip size (4mm X 12mm)

TABLE 2 : BOX SHEAR TEST RESULTS COMPARISON FOR STRIP SIZE (4mm X 12mm)

Reinforcement (%)	Cohesion C (kN/m²)	Angle of Internal friction φ	Shear strength S = C+σ tan φ(kN/m²) at 150 kN/m²
0.00	16	12	47.88
0.50	23	10	49.44
0.75	26	10	52.44
1.00	48	7	66.41

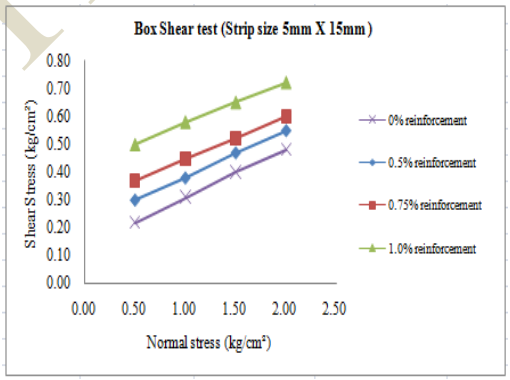

Fig.3. Box shear test results comparison for strip size (5mm X 15mm)

TABLE 3 : BOX SHEAR TEST RESULTS COMPARISON FOR STRIP SIZE (5mm X 15mm)

Reinforcement (%)	Cohesion C (kN/m²)	Angle of Internal friction φ	Shear strength S = C+σ tan φ(kN/m²) at 150 kN/m²
0.00	16	12	47.88
0.50	24	10	50.44
0.75	30	12	61.88
1.00	44	9	67.75

UNCONFINED COMPRESSION TEST (UCC):

This test is carried out to study stress-strain response of soil on plastic addition. The corresponding test results are presented in the following graph.

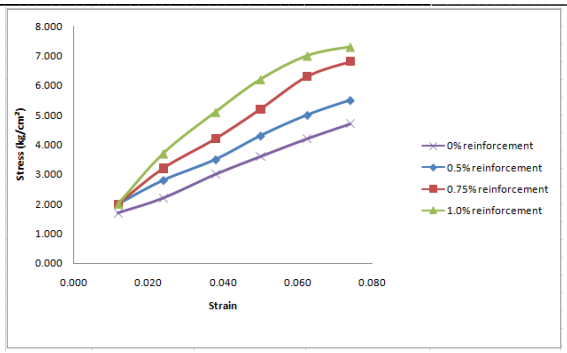

Fig.4. UCC results comparison for strip size (4mm x 12mm)

TABLE 4: UCC TEST RESULTS FOR STRIP SIZE (4mm X 12mm)

Reinforcement (%)	Cohesion C (kN/m^2)
0.00	23
0.50	24
0.75	26
1.00	29

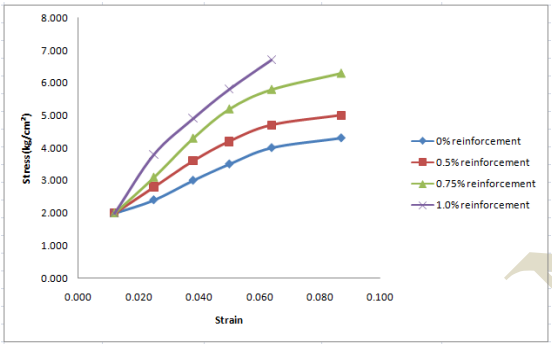

Fig.5. UCC results comparison for strip size (5mm x 15mm)

TABLE 5: UCC TEST RESULTS FOR STRIP SIZE (5mm X 15mm)

Reinforcement (%)	Cohesion C (kN/m^2)
0.00	23
0.50	25
0.75	30
1.00	32

SWELL PRESSURE TEST:

Swell pressure test of soil is an important property of soil to study its expansive nature and which ultimately affects the soil stability. Swell pressure is carried out with different percentage of plastic addition. Test observations indicated considerable reduction in swell pressure value of unreinforced soil. Following graph shows comparative results of swell pressure test with different percentage of plastic chips reinforcement.

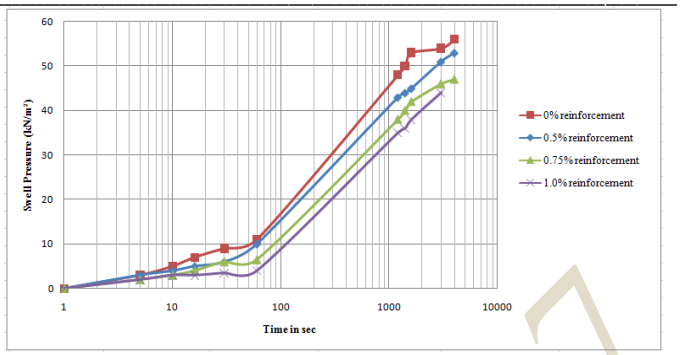

Fig.6. Free swell pressure graph

TABLE 6: SWELL PRESSURE TEST RESULTS

Reinforcement (%)	Swell Pressure (kN/m^2)
0.00	55.71
0.50	52.82
0.75	47.45
1.00	42.91

CONCLUSION

The experimental test results showed that there is significant improvement in the strength of locally available silty soil and considerable reduction in swell pressure with inclusion of small quantity of bottled plastic waste. Strength improvement depends on size of plastic chips. Generally strength increases with increase in size of plastic chips.

The observations noted in the present study are useful in the reuse of plastic waste and contribute better practices in geotechnical aspects of waste management. The introduction of the soil reinforcing techniques has enabled engineers to effectively use unsuitable in situ soils as reliable construction material in a wide range of civil engineering applications. As proposed concept is an efficient and reliable technique for improving the strength and stability of soils.

FUTURE SCOPE

1. Different slenderness ratio of plastic chips can be used and corresponding change in strength improvement can be studied. Aspect ratio study can be studied in detail.
2. Consolidation test for different percentage of plastic addition can be performed to study effect of reinforcement on settlement and stability of soil.
3. CBR test results will also be useful to study application of this concept in pavement design on weak soils.
4. This concept of reinforcement can be used along with other additives like lime, fly ash etc have more improvement in strength of weak soil.
5. Practical suitability and feasibility of this technique can be studied by field testing and experiments.

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