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Application of Recron 3S Fibre in Improving Silty Subgrade Behaviour

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Abstract: *The objective of the present paper is to check the usefulness of Recron 3S fibre in improving soil subgrade strength of local silty soil of Kurukshetra. For this purpose a series of experiments were conducted which include Modified Proctor Compaction, California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) tests. A total of four samples of soil - fibre mixture were made with fibre content as 0.15%, 0.30%, 0.45% and 0.60% of dry weight of soil. Other tests for index and physical properties like Atterberg limits, Specific gravity and sieve analysis of parent soil were also carried out. Experimental results revealed that addition of Recron 3S fibre increases the CBR and UCS value of the silty soil. From the results it is also observed that benefit is more appreciable at lower percentage of Recron 3S fibre i.e. 0.15% as compared to higher percentage.*
Keywords: *California Bearing Ratio, Kurukshetra Soil, Maximum dry density, Optimum moisture content, Recron 3S fibre.*

I. Introduction

In developing countries like India, the biggest handicap to provide a complete network of road system is the limited finances available to build roads. Use of local materials, including local soils, can considerably lower down the construction cost. If the stability of the local soil is not adequate for supporting wheel loads, the properties can be improved by soil stabilization techniques. The stabilization of soil for use in subgrade for pavement is an economical substitute of costly paving materials. There are many techniques for soil stabilization either mechanical or chemical, but all of them require skilled manpower and equipment to ensure adequate performance. Randomly distributed fibre, when used as insertion in highway subgrade, can produce a high performance stabilized subgrade. Many investigators have used various types of fibres under different test conditions. The most important findings of the previous research work is that the use of certain fibre, such as synthetic and natural, in road construction can significantly increase pavement resistance to rutting, as compared to the resistance of non-stabilized pavement over a weak subgrade. Permanent deformation in each layer is the indicator of rut formation at the road surface. Consequently this is used as a criterion of pavement performance. However, it is difficult to comprehensively include permanent deformation in structural design procedure. There are problems in assessing the contribution made by each individual layer to the total rut depth visible at the pavement surface. Hence, the deformation that appears at the surface of a pavement is the sum of deformation of each of the pavement layers, together with that in the subgrade [1].

The concept of reinforcing soil masses by including some kind of fiber was practiced by early civilizations which used soil mixed with straw or other available fiber to improve durability and strength of the dried brick used as building materials. They found that fibrous soil works better than natural soil. Reinforced soils can be obtained by either incorporating continuous reinforcement inclusions (e.g., sheet, strip or bar) within a soil mass in a defined pattern (i.e., systematically reinforced soils) or mixing discrete fibers randomly with a soil fill (i.e., randomly reinforced soils). However, randomly distributed fiber reinforced soils have recently attracted increasing attention in geotechnical engineering. In comparison with systematically reinforced soils, randomly distributed fiber reinforced soils exhibit some advantages. Preparation of randomly distributed fiber reinforced soils mimics' soil stabilization by admixture. Randomly distributed fibers offer strength isotropy and limit potential planes of weakness that can develop parallel to oriented reinforcement [2].

In the present study Recron 3S fibre which is a polypropylene fibre is used as a stabilizer to improve the CBR and UCS value of the local soil of Kurukshetra. Soil stabilization is a useful technique for improving the performance (strength) of subgrade soil. Experimental investigation consists of evaluation of index properties (Specific gravity, Atterberg's limits and Wet sieve analysis), maximum dry density, optimum moisture content, CBR and UCS tests of the silty soil and stabilized silty soil with Recron 3S fibre as an additive. A series of Modified proctor compaction, CBR (soaked with static compaction) and UCS were carried out on silty soil and silty soil mixed with Recron 3S fibre in 0.15%, 0.30%, 0.45 % and 0.60% by weight of dry soil.

II. Materials Used

2.1 Local soil

Local soil was collected from NIT campus Kurukshetra of State Haryana. According to IS soil classification system IS (1498) 1970 [3], the soil was classified as silty soil of low plasticity which was fine and inorganic in nature (ML) and having the particle size between 0.002 mm and 0.075 mm. The index properties of soil were determined as per Indian standard test procedure (IS 2720 Part 5 1970 [4] and IS 2720 Part 3 Sect 2 1981 [5]) and tabulated in TABLE 1.

Silt is produced by the mechanical weathering of rock, as opposed to the chemical weathering that result in clays. This mechanical weathering can be due to grinding by glaciers, abrasion (sandblasting by the wind) as well as water erosion of rocks on the beds of rivers and streams. Silt is sometimes known as 'rock flour or 'stone dust', especially when produced by glacial action. Mineralogically, silt is composed mainly of quartz and feldspar. Silt has little plasticity; dries quite quickly on the hands and can be dusted off. Silt has a smooth or silky touch, but grittiness can be detected between the teeth. Lumps dry quickly, and when dry have a granular appearance and can be powdered easily [6].

Table 1. Engineering and Geotechnical properties of soil.

Serial No.	Properties	Test Results
1.	Wet sieve analysis (Sieve Size)	% Passing
	4.75 mm	100.0
	2.0 mm	100.0
	1.0 mm	100.0
	425 µ	99.4
	75 µ	73.0
2.	Specific gravity	2.68
3.	Liquid limit (%)	19.7
4.	Plastic limit (%)	18.9
5.	Plasticity index (%)	0.8
6.	Optimum moisture content (%)	12.09
7.	Maximum dry density (g/cc)	1.997
8.	California Bearing Ratio (%)	3.50
9.	Unconfined Compressive Strength (kg/cm²)	2.8132

2.2 Recron 3S fibre

Recron 3S is a modified polyester fibre. It is generally used as secondary reinforcing material in concrete and soil to increase their performance. Recron 3S sample used in experiment was of 12mm length and manufactured by Reliance Industries Limited. Physical parameters of Recron 3S fibre as obtained from RIL Safety data sheet are given in TABLE 2.

Use of Recron-3S as a reinforcing material is to increase the strength in various applications like cement based precast products, filtration fabrics etc. It also provides resistance to impact, abrasion and greatly improves the quality of construction during foundation, retaining wall design etc [7].

Polypropylene fibre is the most widely used inclusion laboratory testing of soil reinforcement [8-9].

Currently Polypropylene fibre is used to enhance the soil strength properties, to reduce the shrinkage properties and to overcome chemical and biological degradation [10].

During last 25 years, much work has been done on strength deformation behavior of fiber reinforced soil and it has been established beyond doubt that addition of fibre in soil improves the overall engineering performance of soil. Among the notable properties that improved are greater extensibility, small loss of post peak strength, isotropy in strength and absence of planes of weakness. Fiber reinforced soil has been used in many countries in the recent past and further research is in progress for many hidden aspects of it. Fiber reinforced soil is effective in all types of soils (i.e. sand, silt and clay) [11].

Mixing of randomly oriented fibres to a soil sample may be considered same as an admixtures used to stabilize soil. Material used to make fibres for reinforcement may be obtained from paper, metal, nylon, polyester and other materials having widely varied physical properties [12].

Table 2. Physical parameters of Recron 3S Fibre (Ril Safety Data Sheet) [13].

Serial. No.	Parameter	Value
1	Appearance	Short cut staple fibre
2	Diameter	35 – 40 micron
3	Viscosity	Not applicable

4	Ignition temperature	> 450 ºC
5	Melting point	162-167 ºC
6	Flash point	> 329 ºC
7	Relative density	0.89-0.94 g/cm³
8	Color	White

2.3 Water

Potable water which was fit for drinking was used for the experiments and was procured from Highway Engineering Laboratory of NIT Kurukshetra.

III. Testing Methodology

Testing for index properties of the soil, Modified proctor compaction, CBR and UCS were carried out as per the procedures and guidelines laid down in Indian Standards Codes of practice. A total of four samples of soil – Recron 3S fibre mixture were made (0.15 %, 0.30 %, 0.45 %. 0.60 % of the total dry weight of the soil). After the determination of various index properties of soil, Modified Proctor compaction tests were conducted, followed by CBR tests and UCS tests.

IV. Results And Discussions

4.1 Modified Proctor Compaction Test Results

Modified Proctor Compaction tests were carried out on untreated parent soil and parent soil mixed with 0.15 %, 0.30 %, 0.45 % and 0.60 % of Recron 3S fibre in accordance with IS: 2720 (Part VIII) 1983[14]. It is recommended to use a mould of 1000 ml capacity having an internal diameter of 100 mm and an internal effective height of 127.5 mm. The rammer has a mass of 4.89 Kg with a drop of 450 mm. Soil sample was filled in five layers in the mould and each layer was given 25 blows. Fig. 1 and TABLE 3 shows the maximum dry density (MDD) and corresponding optimum moisture content (OMC) for silty subgrade soil and variation in silty soil mixed with Recron 3S fibre in different percentages.

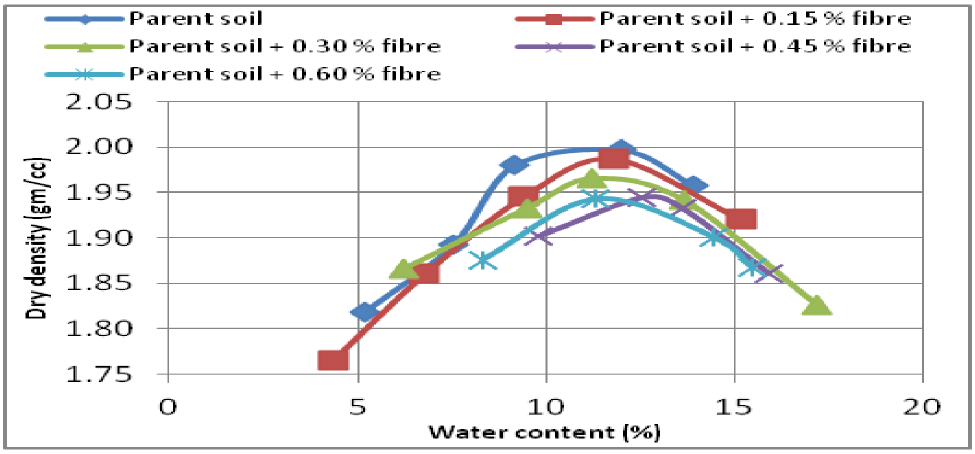

Figure 1. Dry density v/s water content curve of soil stabilized with Recron 3S fibre.

Table 3. Modified Proctor Compaction test results on soil stabilized with Recron 3S Fibre.

Soil stabilized with Recron 3S fibre	Maximum Dry Density (g/cc)	Optimum Moisture Content (%)
Soil	1.997	12.09
Soil + 0.15 % Fibre	1.987	11.78
Soil + 0.30 % Fibre	1.966	11.23
Soil + 0.45 % Fibre	1.945	12.52
Soil + 0.60 % Fibre	1.943	11.32

4.2 CBR Test results

California Bearing Ratio (CBR) tests were carried out as per IS 2720: Part 16: 1987[15] using static compaction on local subgrade soil and local soil mixed with different proportion of Recron 3S fibre under soaked condition. CBR moulds were filled at MDD and OMC obtained from Modified proctor compaction test. Fig. 2 and TABLE 4 shows the CBR value of local soil and local soil mixed with Recron 3S fibre in different percentages i.e. 0.15 %, 0.30 %, 0.45 % and 0.60 % of total weight of soil in soaked condition.

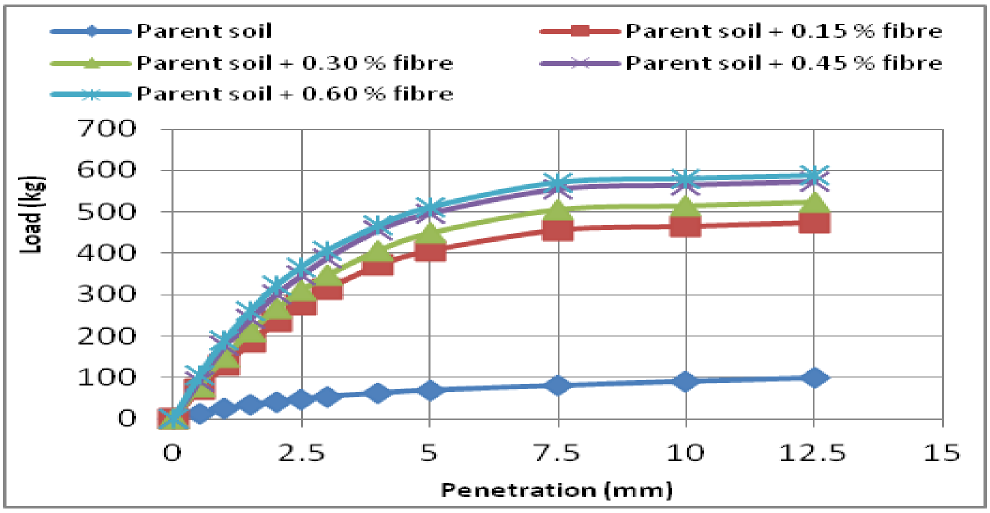

Figure 2. Load v/s penetration curve of soil stabilized with Recron 3S fibre.

Table 4. California Bearing Ratio test results on soil stabilized with Recron 3S Fibre.

Soil stabilized with Recron 3S fibre	CBR (%)
Soil	3.50
Soil + 0.15 % Recron 3S fibre	20.2
Soil + 0.30% Recron 3S fibre	22.6
Soil + 0.45 % Recron 3S fibre	25.2
Soil + 0.60 % Recron 3S fibre	26.7

4.3 UCS Test results

Although UCS tests are best recommended for clayey soils yet an attempt has been made for evaluating the changes in the properties of silty soil stabilized with different percentages of Recron 3S fibre. Samples were made on maximum dry density and optimum moisture content obtained from the modified proctor tests as per the procedure laid down in IS 2720 Part (10) 1991[16]. Samples were tested after curing of seven days. Recron 3S fibre was mixed with soil in different percentages of 0.15 %, 0.30 %, 0.45 % and 0.60 % of dry weight of soil. UCS test results are shown in Fig. 3 and summarized in TABLE 5.

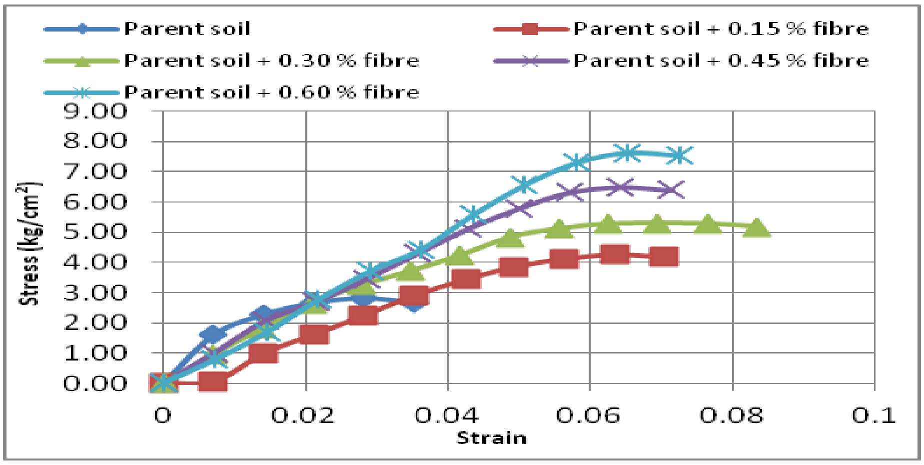

Figure 3. Stress v/s strain curve of soil stabilized with Recron 3S fibre.

Table 5. Unconfined Compressive Strength test results on soil stabilized with Recron 3S Fibre.

Soil stabilized with Recron 3S fibre	UCS (kg/cm²)
Soil	2.8132
Soil + 0.15 % Recron 3S Fibre	4.2622
Soil + 0.30 % Recron 3S Fibre	5.2895
Soil + 0.45 % Recron 3S Fibre	6.4884
Soil + 0.60 % Recron 3S Fibre	7.6259

V. Conclusion

The conclusions derived from present experimental investigations to evaluate performance and strength characteristics of local silty soil of Kurukshetra mixed with Recron 3S fibre as an additive are summarized as follows.

In case of soil – fibre mixture as the content of fibre is increasing; its dry density goes on reducing. This may be because of the reason that as fibre content increases, soil-fibre packing becomes loose and it’s become difficult to make samples even. No trend of Optimum moisture content was observed during the experiments. The probable reason for this could be the difficulty in maintain a constant temperature and humidity in laboratory during the experiments.

Recron 3S fibre helps in improving soil subgrade strength of silty soil. It is evident from the CBR test results that CBR value of untreated soil increases from 3.50% to 20.2% with addition of 0.15% Recron 3S fibre. From the results it is also observed that addition of further Recron 3S fibre to the soil in the quantity of 0.30%, 0.45% and 0.60% of dry weight of soil has very little further increase in the CBR value.

In case of unconfined compressive strength testing Recron 3S fibre is showing an increasing trend in UCS value of treated soil. It is evident from the UCS test results that UCS value of untreated soil increases from 2.8132% to 4.2622% (more than 50%) with addition of 0.15% Recron 3S fibre. From the results it is also observed that further increase in the quantity of Recron 3S fibre (0.30%, 0.45% and 0.60% of dry soil) increases the UCS value but to a lesser extent.

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