International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 10 | Oct - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

# Stability of Expansive Soil Using Coir Fibre and Micro Shredded Waste Plastic for Better Pavement

**Nevedika[1] , Mandeep Kumar[2] , Aditya Pratap Singh[3]**

[1] Assistant Professor, Department of Civil Engineering , Sardar Beant Singh State University, Gurdaspur, Punjab, India

[2] Btech student ,Department of Civil Engineering , Sardar Beant Singh State University, Gurdaspur, Punjab, India

[3] Btech student, Department of Civil Engineering , Sardar Beant Singh State University, Gurdaspur, Punjab, India

mandeepkumara23@gmail.com

Thakuradityalalotra@gmail.com

## ❖ ABSTRACT

Expansive soils are difficult to work with as subgrade materials because they change a lot in size when the water content changes. This can lead to problems and damage in the roads built on them. This study looks at how natural coir fibre and waste plastic can help make expansive soil better for use in road building. The original soil without any changes was used as a base for comparison. Different amounts of coir fibre, waste plastic and a mix of both were tested. The findings show that adding coir fibre and waste plastic changes how the soil behaves. The original soil had a liquid limit of 40% and a plasticity index of 14%. When 0.3% coir fibre was added the liquid limit dropped to about 30%. The plasticity index dropped to about 11%. In a CBR test the original soil had a CBR of about 4.04%.. When coir fibre was used the CBR values went up. The highest was 9.60% with 0.3% coir fibre. A mix of 0.3% coir fibre and 10% waste plastic gave a CBR of about 6.08%. These results show that coir fibre and waste plastic can help make expansive soil better. They improve some of its properties compared to the soil. The mix of coir fibre and waste plastic also shows that it is possible to use waste and plastic waste in making better soil for roads. More lab tests are needed to find the mix and to check how long these materials last, in real road conditions.

## 1. INTRODUCTION

Expansive soils are hard to work with when building roads because they change a lot in size when the wetness changes. They get bigger when its wet and smaller when its dry. This can make roads bend, crack and move in a way. So making these soils better is important for building roads that last a time and stay strong.Traditional ways to make soil better use things like lime and cement to make the soil stronger and more stable.. People are now looking at other materials like things that are left over because they want to use less new stuff and use what's already around. Natural fibers and plastic waste are two of the things being looked at for this. Coir fiber comes from the outside of a coconut. It has a surface and a fibrous shape. When mixed with soil it helps hold the soil and adds strength. Plastic waste, when cut into the pieces can also change the way the soil behaves and add more strength. These materials can change things about the soil like how soft it is, how it holds together how strong it is, how much weight it can hold and how much it changes when wet. Using coir fiber and plastic together is interesting because each one helps in a way. The fiber helps by holding the soil and the plastic changes the soil itself and adds strength. But how well these materials work depends on how much's used how they are shaped how they are spread out and how they mix with the soil. This study looks at using coir fiber and

plastic waste to make soil better for roads. The normal soil is the starting point. Its features are compared to soil that has coir fiber, soil that has plastic and soil that has both. The study looks at what changes happen in some features and how well these waste materials can help improve the soil.

## 2. LITERATURE REVIEW

Earlier studies have found that coir fiber can make expansive soil stronger and better at holding weight by linking with the soil and creating friction. Also plastic that is cut into pieces has been tested as something to make weak and expansive soil better. These materials also help use waste from farming and plastic in a way. Recent studies are looking at using coir fiber and plastic together in expansive soil. This mix might help with both fiber support. Keeping the soil in place. But how it works depends on the mix, the type of soil how much fiber is used what shape the plastic is, in and how the tests are done. So more testing is needed for using these materials in road bases.

Research Gaps :

- Most previous studies have examined coir fibre and plastic waste separately. Limited research is available on their combined effect in expansive Black Cotton soil, particularly for flexible pavement subgrades.
- There is no clear agreement on the optimum proportion of coir fibre and shredded plastic. Different dosages can improve one property, such as CBR, but may reduce compaction quality or increase swelling; therefore, a balanced mix design is required.
- The suitable combination and proportion of coir fibre and waste plastic for expansive soil requires further investigation.

## 3. MATERIAL USED

The materials used in the present study are expansive soil, waste plastic and coir fibre.

1. Expansive Soil:

Expansive soil was selected as the primary soil material because of its high swelling and shrinkage characteristics, which can adversely affect pavement subgrades. The soil was collected, air-dried, pulverized and passed through the required sieve before laboratory testing.

Here is parameters and properties of expansion clay soil :

| Geotechnical Parameter | Standard Test Code | Virgin Black Cotton Clay Baseline Value |
|---|---|---|
| Specific Gravity (Gs) | IS 2720 Part 3 / ASTM D854 | 2.20 – 2.64 |
| Liquid Limit (LL, %) | IS 2720 Part 5 / ASTM D4318 | 40.0% |
| Plastic Limit (PL, %) | IS 2720 Part 5 / ASTM D4318 | 26.0% |
| Plasticity Index (PI, %) | IS 2720 Part 5 / ASTM D4318 | 14.0% (Low-Medium Plasticity) |
| Grain Size: Sand Fraction (%) | IS 2720 Part 4 / ASTM D422 | 25.0% |
| Grain Size: Silt & Clay Fraction (%) | IS 2720 Part 4 / ASTM D422 | 75.0% (Fine Active Fraction) |
| Free Swell Index (FSI, %) | IS 2720 Part 40 / ASTM D4546 | 57.89% (High Swell Potential) |
| Baseline Swelling Pressure | IS 2720 Part 40 / ASTM D4546 | 0.32 kg/cm² |
| Maximum Dry Density (MDD) | IS 2720 Part 8 (Std Proctor) | 1.98 g/cc (19.4 kN/m³) |
| Optimum Moisture Content (OMC) | IS 2720 Part 8 (Std Proctor) | 14.0% |
| Unsoaked California Bearing Ratio (CBR) | IS 2720 Part 16 / ASTM D1883 | 4.04% (Poor Subgrade Rating) |
| Soaked CBR (96-hour Saturation) | IS 2720 Part 16 / ASTM D1883 | 1.20% – 1.25% (Very Poor Subgrade) |
| Unconfined Compressive Strength (UCS) | IS 2720 Part 12 / ASTM D2166 | 200.0 kPa (Soft Consistency) |

2. Waste Plastic:

Waste plastic was used as a reinforcing material to improve the engineering behaviour of expansive soil. The plastic waste was cleaned, dried and cut into small strips/pieces of nearly uniform size before mixing with the soil. The waste plastic was cleaned, dried and mechanically shredded into fine particles/powder. The MSWPP used in the study is about 1 mm in size, ensuring relatively uniform mixing with the expansive soil.

3. Coir Fibre:

Coir fibre obtained from coconut husk was used as a natural fibre reinforcement. The fibres were cleaned, dried and cut into short, nearly uniform lengths to facilitate proper mixing with the expansive soil.

Here is parameters and properties of coconut coir fibre :

- Specific Gravity ($G_s$): 1.25–1.40
- Average Fiber Diameter: 150–350 $\mu$m (0.15–0.35 mm)
- Aspect Ratio ($L/D$): 50–150
- Average Tensile Strength: 120.4–220.0 MPa
- Elongation at Break: 15.0%–34.1%
- Water Absorption Capacity: 100%–130% (by dry fiber mass)
- Surface Morphology: High natural surface roughness with longitudinal micro-striation

The untreated expansive soil was used as the control sample, while soil treated with coir fibre, waste plastic and their combined mixture was used for comparison.

## 4. Methodology

The methodology of the study consists of the preparation, mixing and laboratory evaluation of expansive soil reinforced with coir fibre and waste plastic powder (MSWPP). Untreated expansive soil will be considered as the control sample.

First, the expansive soil will be collected, air-dried, pulverized and sieved. The waste plastic will be cleaned, dried and shredded into particles of less than 1 mm size, while the coir fibre will be cleaned, dried and cut into short fibres.

The treated soil mixture will be prepared by adding 0.3% coir fibre and 10% MSWPP by dry weight of expansive soil. Thus, for every 1 kg of dry soil, 3 g of coir fibre and 100 g of MSWPP will be added. The materials will be thoroughly dry-mixed to achieve uniform distribution, followed by the addition of the required water.

Both untreated and treated soil samples will then be prepared for the selected laboratory tests. The engineering properties obtained from the tests will be compared to determine the effect of the combined reinforcement. Finally, the suitability of the treated expansive soil as a pavement subgrade material will be assessed based on the observed changes in its engineering properties.

### 4.1 Experimental Mix Series Design

To isolate individual effects and quantify synergistic inter-actions, four experimental series were executed:

- **Series I (Control)**: Virgin Untreated Expansive soil.
- **Series II (Hybrid Coir-Plastic Mixes)**: combining coir fiber and MSWPP plastic powder: 0.3% Coir Fiber + 10% MSWPP Plastic

### 4.2 WORKING PROCEDURE

The experimental procedure will be carried out using untreated expansive soil as the control sample and expansive soil treated with 0.3% coir fibre and 10% MSWPP by dry weight of soil.

1. The collected expansive soil will be air-dried, pulverized and passed through the required sieve.

2. The waste plastic will be cleaned, dried and shredded into MSWPP of about1 mm size.

3. The coir fibre will be cleaned, dried and cut into short pieces of nearly uniform length.

4. For the treated mixture, 0.3% coir fibre and 10% MSWPP will be added according to the dry weight of expansive soil. For example, for 1 kg of soil, 3 g of coir fibre and 100 g of MSWPP will be used.

5. The soil, coir fibre and MSWPP will be thoroughly dry-mixed to obtain a uniform distribution of the reinforcing materials.

6. The required quantity of water will then be added gradually and the mixture will be mixed thoroughly.

7. The prepared untreated and treated soil samples will be subjected to the selected laboratory tests to determine their engineering properties.

8. The test results of the treated soil will be compared with those of untreated expansive soil to evaluate the effect of the combined coir fibre and MSWPP treatment.

9. The obtained properties, particularly those relevant to pavement subgrade performance, will be considered for assessing the suitability of the treated soil in pavement applications.

**4.3 Atterberg Test Results**

Atterberg limit tests were conducted to evaluate the effect of coir fibre and micro-shredded waste plastic powder (MSWPP) on the plasticity characteristics of expansive soil. The untreated expansive soil showed a Liquid Limit (LL) of 40.0%, Plastic Limit (PL) of 26.0%, and Plasticity Index (PI) of 14.0%.

For the selected combined mixture containing 0.3% coir fibre and 10% MSWPP, the LL decreased to 30.0%, PL to 19.0%, and PI to 11.0%. Thus, compared with untreated soil, the LL decreased by 25%, while the PI decreased from 14% to 11%.

The reduction in plasticity indicates that the addition of coir fibre and waste plastic modified the consistency behaviour of the expansive soil and reduced its sensitivity to changes in moisture content. The non-absorbent plastic particles and the reinforcing action of coir fibres modify the soil structure, resulting in lower plasticity.

| MIX | LIQUID LIMIT % | PLASTIC LIMIT % | PLASTICITY INDEX % |
|---|---|---|---|
| Untreatend soil | 40 | 26 | 14 |
| 0.3% Coir + 10% MSWPP | 30 | 19 | 11 |

**4.4CBR TEST**

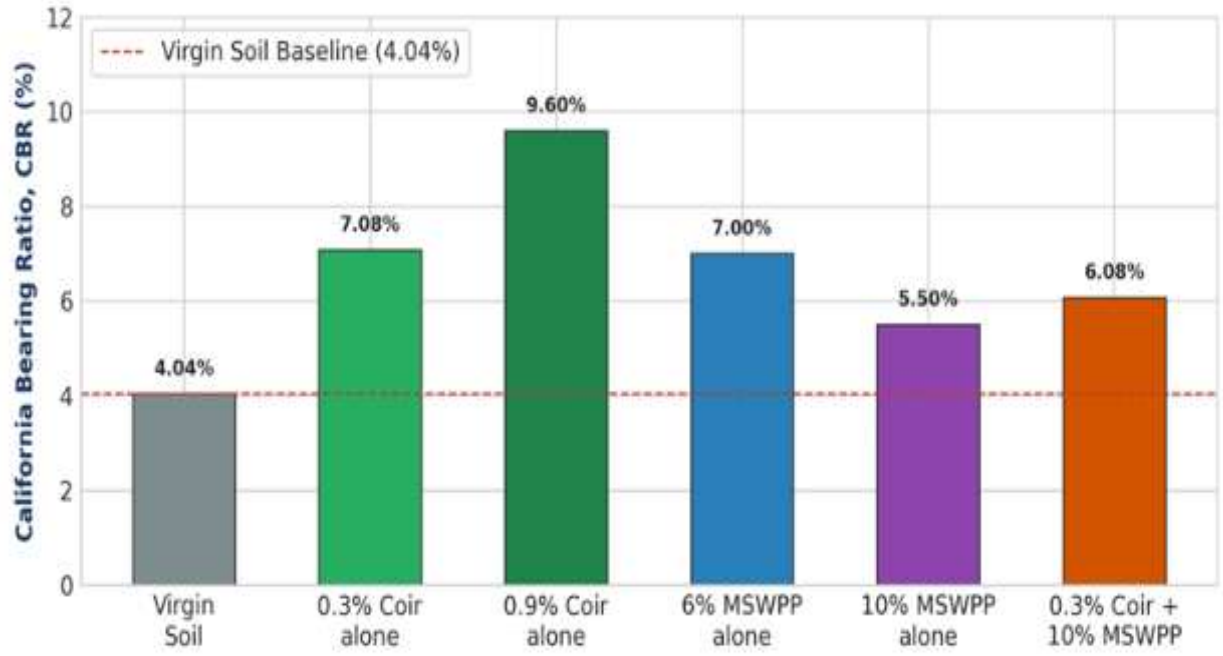
The California Bearing Ratio (CBR) test was used to evaluate the bearing capacity of the expansive soil and its suitability for pavement subgrade applications. The untreated soil showed an unsoaked CBR value of 4.04%.

With the addition of 0.3% coir fibre, the CBR increased to 7.08%, while the addition of 10% MSWPP increased the CBR to 5.50%. For the combined mixture containing 0.3% coir fibre + 10% MSWPP, the CBR value was 6.08%.

Compared with untreated soil, the combined mixture increased the CBR from 4.04% to 6.08%, representing an improvement of approximately 50.5%. This indicates an improvement in the bearing performance of the treated expansive soil and shows its potential for use as a pavement subgrade material.

| SOIL MIX | UNSOAKED CBR |
|---|---|
| Untreated soil | 4.04% |
| 0.3% Coir Fibre | 7.08% |
| 10% MSWPP | 5.50% |

| | |
|---|---|
| 0.3% Coir + 10% MSWPP | 6.08% |




## 5. Advantages and Benefits

1. **Improved Bearing Capacity** – The combined treatment increased the CBR from 4.04% to 6.08%, indicating better subgrade performance.

2. **Reduced Soil Plasticity** – The treatment reduced the Liquid Limit and Plasticity Index, helping to reduce moisture-related volume changes.

3. **Waste Plastic Utilization** – Waste plastic is converted into a useful material for expansive soil stabilization instead of being disposed of.

4. **Natural Fibre Reinforcement** – Coir fibre provides reinforcement within the soil and helps modify its engineering behaviour.

5. **Potential Cost Reduction** – The use of waste and coir fibre reduce the requirement for soil binderss and some conventional stabilization materials.

6. **Sustainable Pavement Construction** – The approach combines agricultural waste (coir fibre) and plastic waste to develop a more sustainable method of improving expansive soil for pavement subgrades.

## 6. Conclusion

- The addition of 0.3% coir fibre and 10% MSWPP modified the engineering behaviour of expansive soil.
- Liquid Limit reduced from 40% to 30% and Plasticity Index from 14% to 11%.
- CBR increased from 4.04% to 6.08%, showing improved subgrade bearing performance.
- The treatment provides a practical way to reuse waste plastic and coir fibre in soil stabilization.
- The combined approach has potential to improve expansive soil for pavement subgrade applications.
- Further field trials, durability studies and detailed cost analysis are required before large-scale implementation.

**7. References**


- Khalak, A. A., & Juremalani, J. (2024). Evaluation of combined coir fibre and micro-shredded waste plastic for stabilising black cotton soil in road subgrades. Journal of Environmental Protection and Ecology, 25(6), 1866–1879.

- Hassan, H. J. A., Rasul, J., & Samin, M. (2021). Effects of plastic waste materials on geotechnical properties of clayey soil. Transportation Infrastructure Geotechnology,

- Peter, L., Jayasree, P. K., Balan, K., & Raj, S. A. (2016). Laboratory investigation in the improvement of subgrade characteristics of expansive soil stabilised with coir waste. Transportation Research Procedia,

- Jayasree, P. K., Balan, K., Peter, L., & Nisha, K. K. (2015). Volume change behavior of expansive soil stabilized with coir waste. Journal of Materials in Civil Engineering,

- Kumar, M., Pratap, B., Azhar, M., Mondal, S., & Singh, R. P. (2025). The utilization of plastic waste for stabilizing expansive soil subgrade: A critical review. Civil Engineering Infrastructures Journal

- Naresh, T., Bandipally, S., Prasad, N. S. S., Skrzypkowski, K., Zagórski, K., & Zagórska, A. (2025). Sustainable stabilisation of expansive clay with shredded PET fibers: Multi-scale performance and microstructural analysis. Resources,