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Comparative Study on the Reinforcement of Sandy Soils Using Polypropylene and Natural Root Fibers

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Objectives of the study

- To evaluate the enhancement in shear strength parameters of the soil due to synthetic and root fibers inclusion
- To compare the shear performance of soil reinforced with synthetic and natural root fibers
- To identify the optimal dosage for each fiber type for effective and sustainable soil reinforcement

Properties of the synthetic fiber used

Polypropylene (polymer fiber)



Proportion used

- 0.5% by weight of soil
- 1% by weight of soil

Material properties:

- High tensile strength
- Chemical inertness
- Non-biodegradable.

Dimensional attributes

- Length: 6 mm
- Diameter of fiber: 0.1 mm
- Aspect ratio: 60

Properties of the natural fiber used

Liriope (Monkey grass or Creeping lilyturf)



Proportion used

- 0.5% by weight of soil
- 1% by weight of soil

Morphological properties

- **Leaves:** Long and arching
- **Roots:** Visible fibrous root system with strong ground-covering capabilities.

Dimensional attributes

- Root length: 6 mm
- Diameter of roots: 0.1-2 mm

Properties of Soil



Soil samples collected from an area near the Jagti campus of Indian Institute of Technology Jammu

S. No.	Soil properties	Result
01	Gravel (%)	0.80
02	Sand (%)	94.2
03	Fines (%)	5.00
04	Soil classification (ISSCS)	SP
05	Coefficient of uniformity (C_u)	3.68
06	Coefficient of curvature (C_c)	1.38
07	Specific Gravity (G)	2.62
08	MDD (g/cc)	2.02
09	OMC (%)	13.63
10	$\gamma_{d\max}$ (g/cc)	1.66
11	$\gamma_{d\min}$ (g/cc)	1.35
12	Cohesion (kPa)	4.46
13	Angle of internal friction($^\circ$)	39.96

Methodology

Collection of soil sample (IIT Jammu campus)

Laboratory testing for basic characterisation of soil

Shear strength evaluation of PP fiber reinforced soil using direct shear test

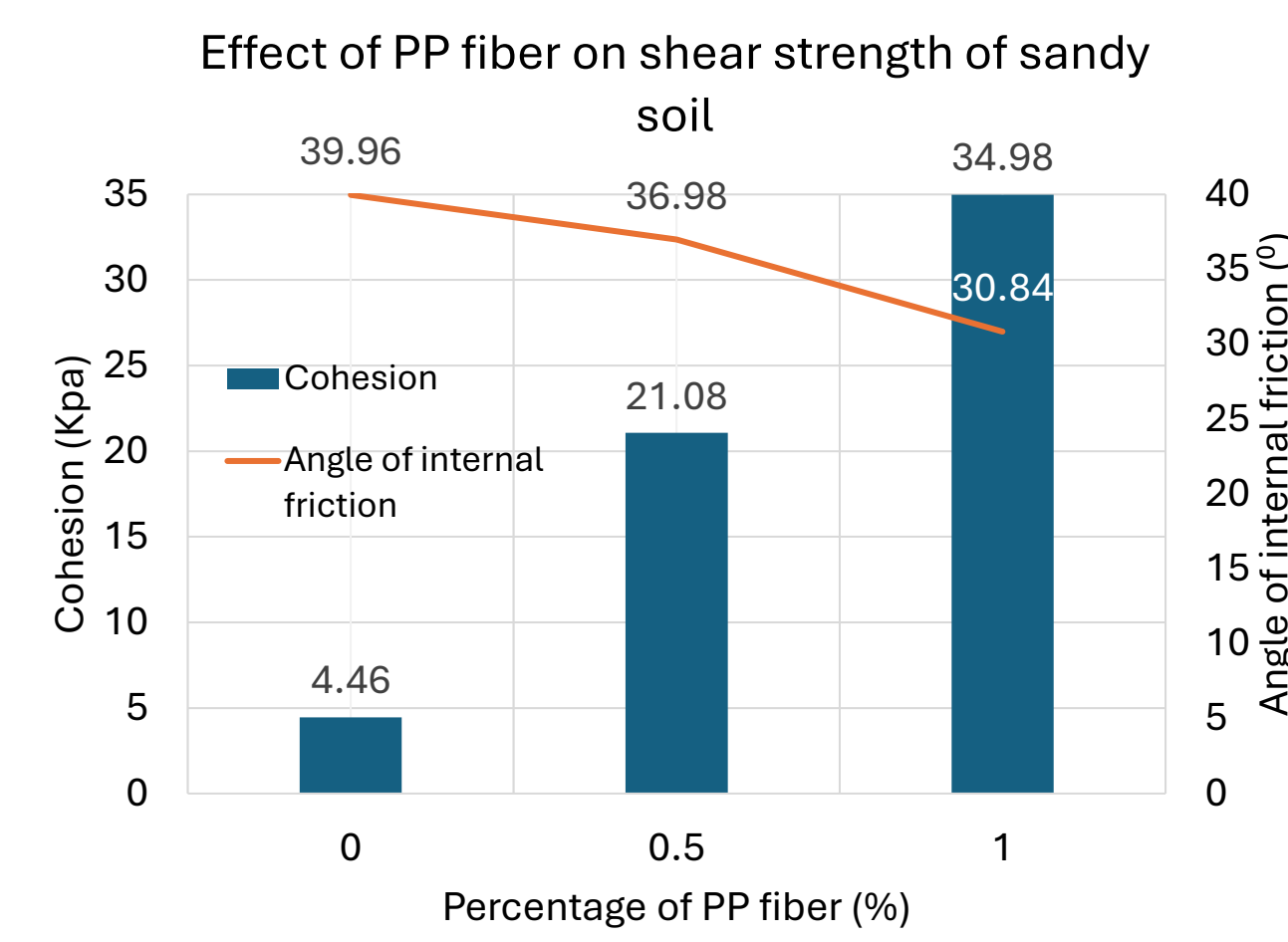
Shear strength evaluation of root fiber reinforced soil using direct shear test

Comparative analysis of soil reinforcement using PP and root fibers

Results and discussion

Results and discussion

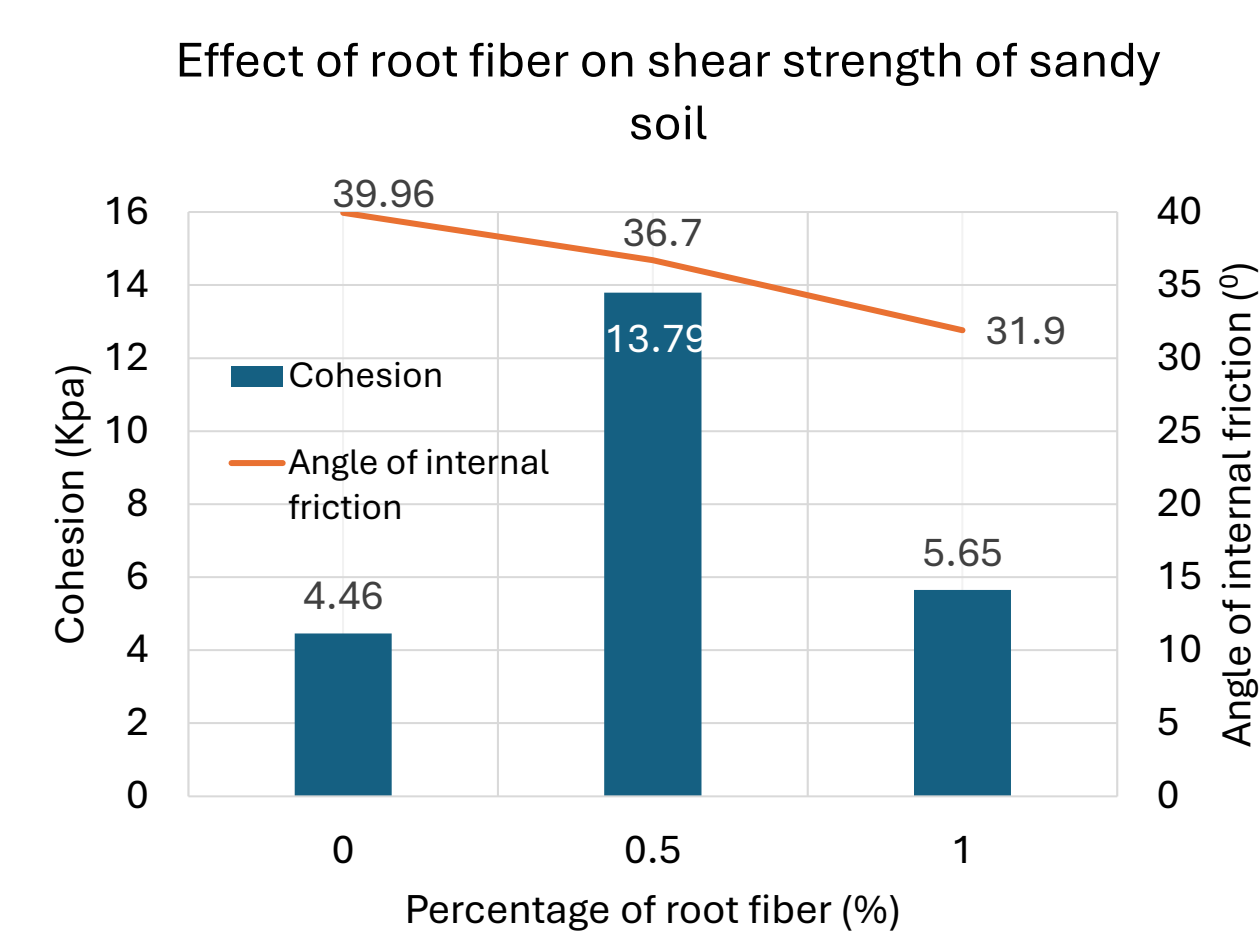
Effect of PP fibers on shear strength of sandy soil



➤ Inclusion of polypropylene (PP) fibers resulted in a noticeable improvement in the overall strength of the soil due to consistent increase in the cohesion component of shear strength

➤ However, it was also observed that the angle of internal friction decreased slightly as the fiber content increased

Effect of root fibers on shear strength of sandy soil



➤ The addition of 0.5% root fiber led to a noticeable increase in cohesion.

➤ However, when the root fiber content was increased to 1%, a reduction in cohesion was observed, resulting in less consistent and less predictable outcomes

Interaction mechanism between fiber and soil

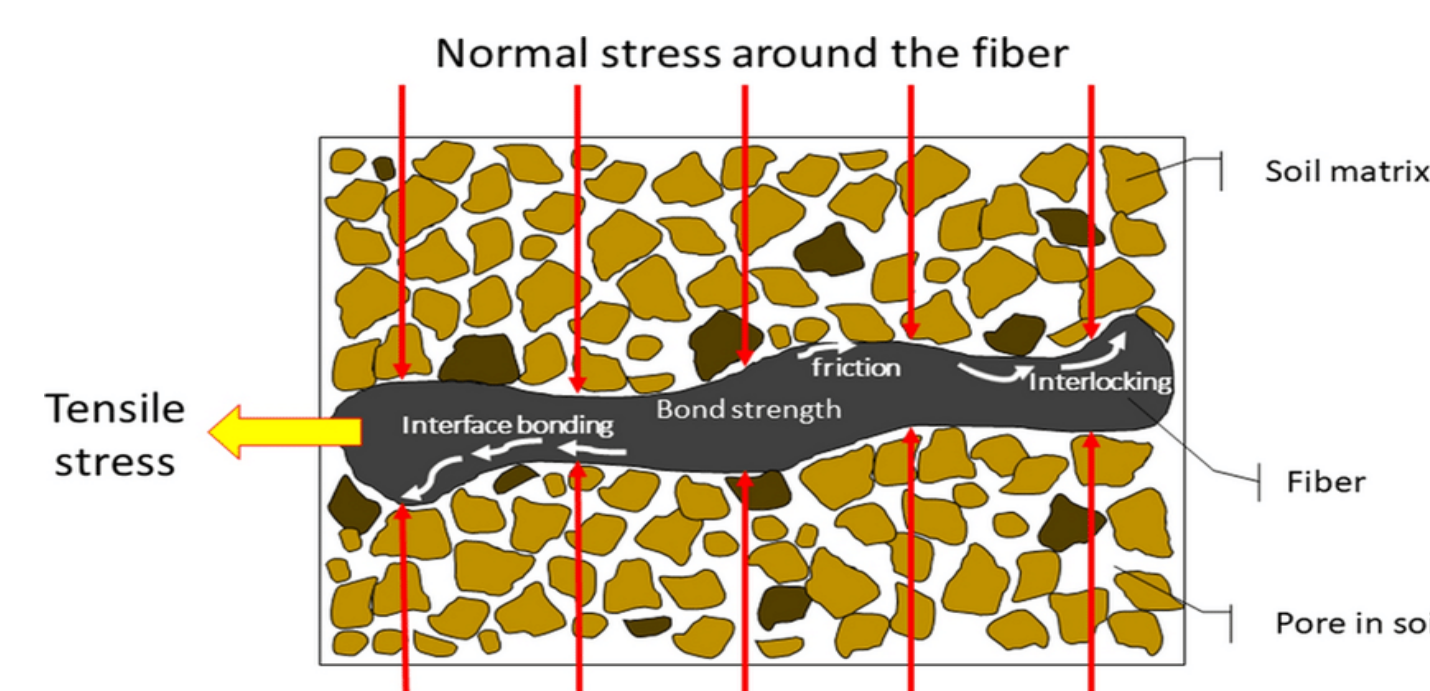


Fig:-Schematic of the interaction mechanism between PP fiber and soil (Ayeldeen et al., 2021)



Fig:- PP fiber- soil interaction after shear test showing bridging and interlocking along the failure plane

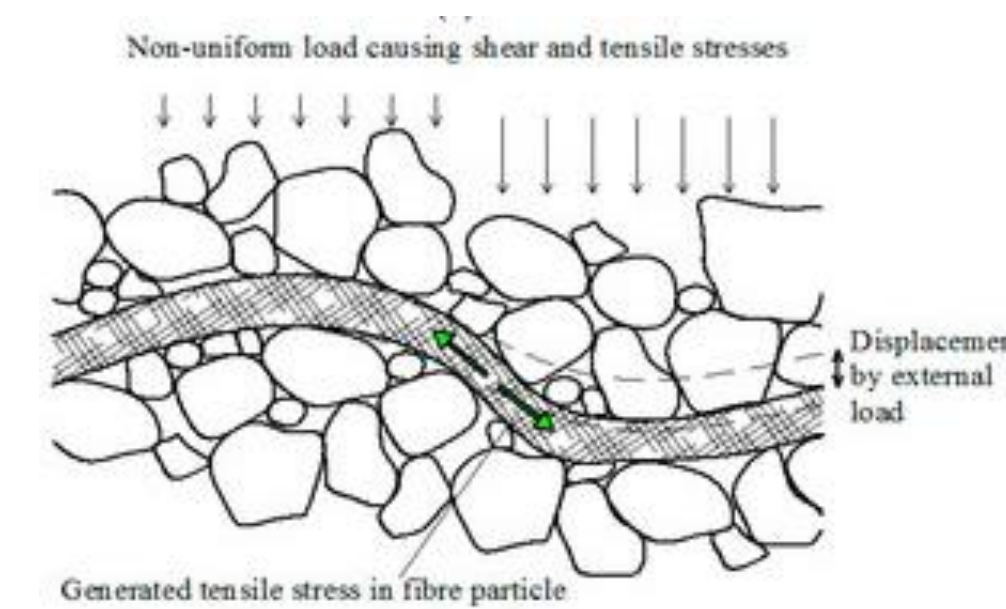


Fig:-Schematic of the interaction mechanism between root fiber and soil (Nguyen and Indraratna, 2023)

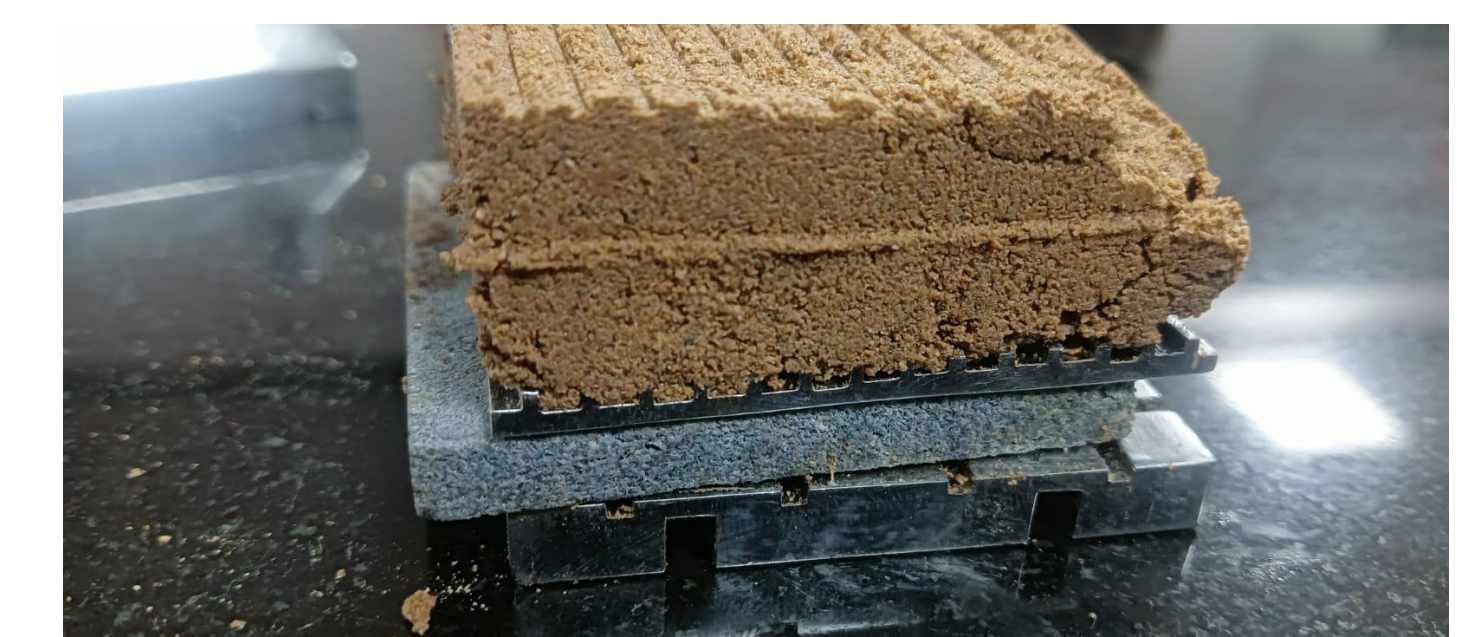


Fig:- Root fiber- soil interaction after shear test

Conclusions

- Polypropylene fibers yielded a significant increase in shear strength parameters, particularly cohesion. The maximum cohesion (34.98 kPa) was observed at 1.0% fiber content, demonstrating their suitability for long-term and high-strength soil stabilization.
- Monkey grass root fibers provided optimal performance at 0.5% content, resulting in moderate strength enhancement. At 1.0% content, cohesion declined (5.65kPa), indicating diminished effectiveness and greater variability in performance.
- The observed improvements in shear strength due to both the fibers are attributed to the tensile bridging action of fibers across the shear plane, enhanced frictional resistance between fibers and soil particles, and increased particle interlocking due to random fiber orientation.
- Polypropylene fibers exhibited greater consistency, durability, and bonding within the soil matrix, but is not an eco-friendly option. Although natural fibers offer sustainable and eco-friendly reinforcement, they may present limitations due to their lesser tensile strength and biodegradable nature.

References

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