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AIT Research

SUITABILITY OF SELECTED NATURAL FIBRES FOR CONCRETE PERFORMANCE IMPROVEMENT

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1. Introduction

The addition of fibres to reinforce concrete (FRC) is required when concrete structures may be submitted to other types of stresses beyond the compressive. Post-crack tensile strength, resistance to abrasion and additional plastic deformation are examples of additional physical and mechanical properties that can be required from concrete elements. Steel, glass and polymer fibres are the most common concrete fibres at present. However, their high cost and low durability under abrasive conditions, along with their environmental impact are disadvantages associated with these materials[1-3]. This work examines the potential replacement of these synthetic fibres with more sustainable natural fibres.

2. Research Questions

1. Can the studied bio-composites containing natural fibres safely replace currently available synthetic fibre reinforced composites?
2. Can selected natural fibres be safely used to enhance the mechanical/energy or durability performance of concrete?

3. Methodology

Thorough desktop review to determine possible natural fibres with desired qualities. The following were then chosen:

Flax, Hemp and **Jute** fibres, extracted from **vegetable** sources.
Basalt fibres, produced from **mineral** sources
Steel and **polypropylene** used as benchmarks.

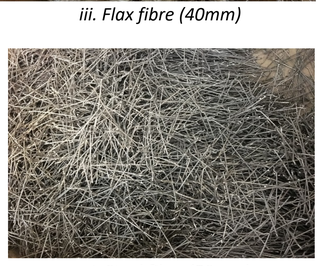
i. Basalt fibre (25mm)

ii. Basalt fibre (48mm)

iii. Flax fibre (40mm)

iv. Hemp fibre (40mm)

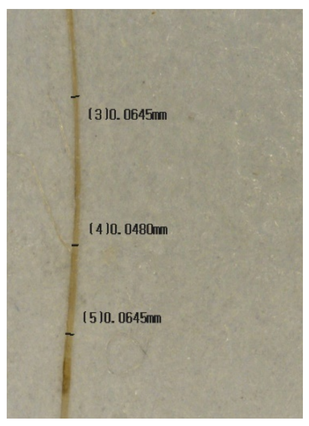
v. Polypropylene fibre (40mm)



vi. Steel fibre (50mm)

Figure 1: *Fibres ready for use.*

- **Mechanical, Physical** and **Chemical properties** of fibre types were evaluated.
- **13 different concrete** mixtures were made.
- **Flexural, Tensile** and **Compressive Strength** were tested after 7 days.
- Results were **analysed**.



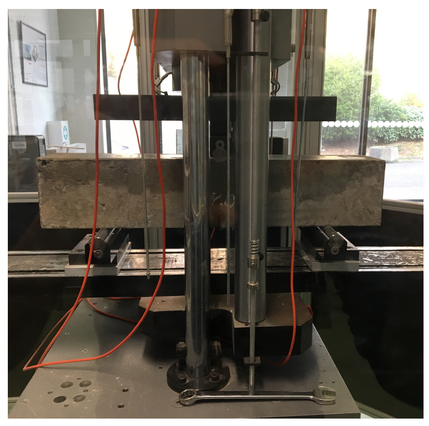


Figure 2: *Fibre Tensile Test(Left). Microscopy digital image for diameter measurement (Centre) and FRC Flexural Strength Test (Right).*

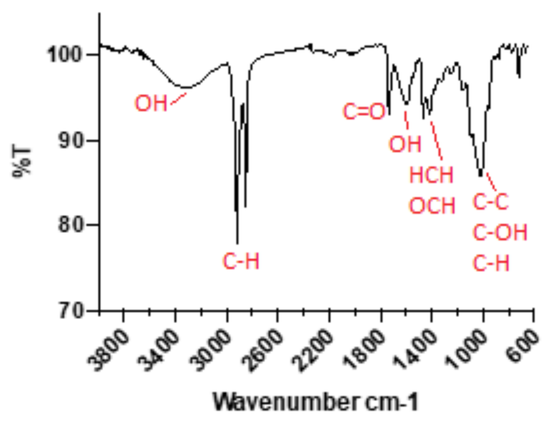
4. Results and Discussion

4.1 Chemical Characterisation of Fibres (Figure 3)

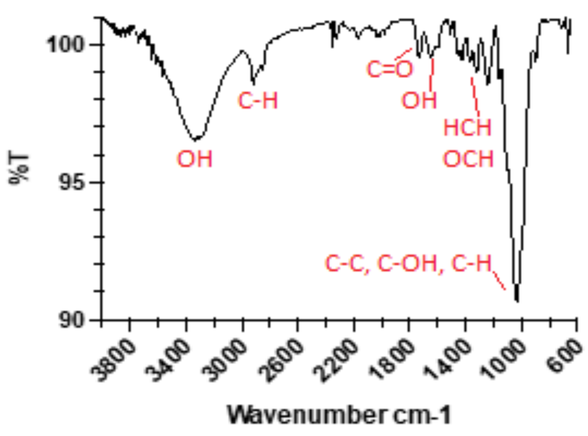
- Figure 2 presents the FTIR spectrum obtained from flax and jute fibres for chemical characterization.

4.2 Tensile Strength of Fibres (Table 1)

40 specimens of each type of fibre were tested. Table 1 presents the average of the results obtained for the mechanical and physical properties evaluated.
Max. fibre tensile strength: **Flax** (865.96MPa)



i. Flax fibres.



ii. Jute fibres.

Figure 3: *FTIR Spectrum.*

Table 1: *Mechanical properties of tested fibres.*

Material	Diameter (µm)	Tensile Strength (N/mm2)	Young`s Modulus (GPa)	Elongation at Break %	Density (g/cm³)
Basalt	14.0	1519.15	136.18	1.67%	2.172
Flax	82.4	865.96	40.78	2.09%	1.124
Hemp	73.0	262.68	22.44	1.47%	1.109
Jute	60.2	362.96	21.61	1.63%	1.114

4.3 FRC Flexural Strength (Figure 4)

Optimum Post-Crack Concrete Tensile Strength: **0.5% hemp** mix (similar to 0.05% steel and 1% polypropylene mixes.

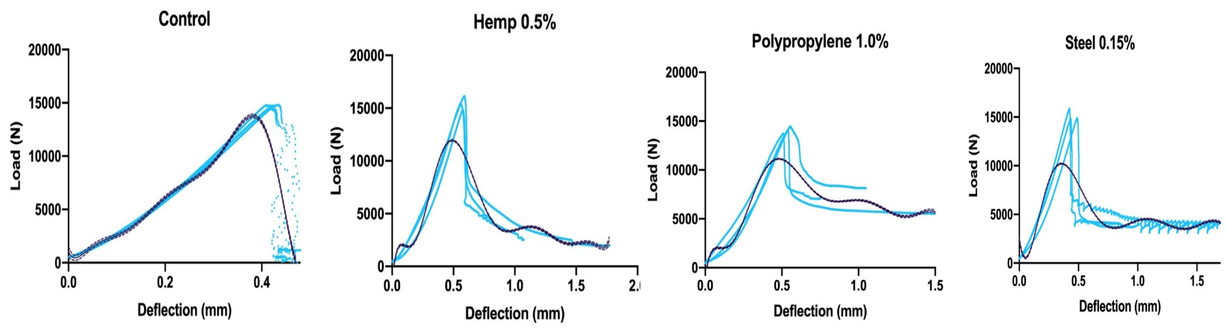


Figure 4: *Load vs Deflection diagrams for post-crack tensile strength of FRC analysis.*

5. Conclusions

- The concrete mixture containing 0.5% of hemp fibres can present enhanced flexural tensile strength, residual tensile strength comparable to mixtures containing polypropylene in 1.0%.
- Independent to the length of the basalt fibres, in 0.5% their behaviours are mathematically comparable.

6. Ongoing Work

6.1 Chemical Surface treatments of Fibres

- Fibres were submitted to 6 different surface treatments (Figure 5);
- Properties will be re-evaluated and compared to the previous results;
- Concrete mixtures containing surface treated fibres will be studied.

Figure 5: *Samples of Jute, Hemp and Flax fibres during treatment (Left), drying (Centre), ready for tests (Right).*

References Cited

[1]Sanjay M. R. et al, Characterization and properties of natural fibre polymer composites: A comprehensive review, Journal of Cleaner Production 172 (2018), 566-581.
[2]Akil H. M. et al, Kenaf fibre reinforced composites: A review, Materials and Design 32 (2011), 4107-4121
[3]Ehrenbring H. Z. and Tutikian B. F., Concrete reinforced with natural and recycled fibres, 7º Forum internacional de resíduos Number 13 (2007), 4850-4857

Acknowledgements

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