

High Strength Natural Fibre Composites for Construction

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Introduction

It is suggested that as much as 10% of all carbon emissions are generated by the manufacture of construction products. Governments worldwide are looking for ways to reduce their carbon emissions. As a consequence, there is now a better awareness of the issues related to the sustainable design and construction of the built environment which has led to an increased interest in the use of alternative construction products. The use of natural fibres can be traced back to the Egyptians 3000 years ago, especially for rope and bagging fabrics. Although a number of high-tech fibres (e.g. glass, carbon) have entered and dominated the composite industries since 1970's because of their superior mechanical and thermal properties, the composite materials made from crop-based fibres are now receiving much interest and attention since they are considered to be an environmentally friendly product (e.g. Bonfield and Fan 2000, Fan 2010, Dai and Fan 2010a and 2010b).

However, studies on the natural fibre composites for building construction have highlighted some of the difficulties in moving the concept forward into market place due to the lack of knowledge on how to deal with natural differences in plant components and characteristics, and uncertainty of reactivity and functionality of crop-based fibre composites. Important development breakthroughs are urgently required at a technical, economical and organizational level to ensure a sustainable and continuing development of crop-based fibres as building construction materials. Brunel University, UK has been engaged in a comprehensive programme to develop a range of innovative products from crop-based fibres and also has carried out a trial for

commercial production. This paper is one of a series of papers presenting some of the summarised results from the research programme.

Materials and procedure

Hemp plants were sourced from a hemp farm in the north of England in UK. One part of the hemp plants were dried and then subjected to different processing treatments. The second part of the hemp plants were subjected to processing treatments immediately after harvesting. See Figure 1 as an example of the treated hemp fibres.



N1 N2 N3 N4 N6 N7
Figure 1 An example of the treated fibres

All the treated and novelly processed hemp fibres were further processed as the strips. The resin was then applied to develop various composites.

Summarised results and discussion

Tensile strength of various hemp fibres

An average tensile strength of hemp fibres is illustrated in Figure 2. It is apparent that there is a significant effect of processing treatments on the properties of hemp fibres. The processing treatments NATCOM1 and USO31 have a very similar efficacy, having an average tensile strength about 500 MPa, while the treatments NATCOM 2, 4 and Santhica result in an average strength of 600 MPa. The highest average strength (970MPa) is about 2 times

that of the lowest average strength, indicating the potential of treatments.

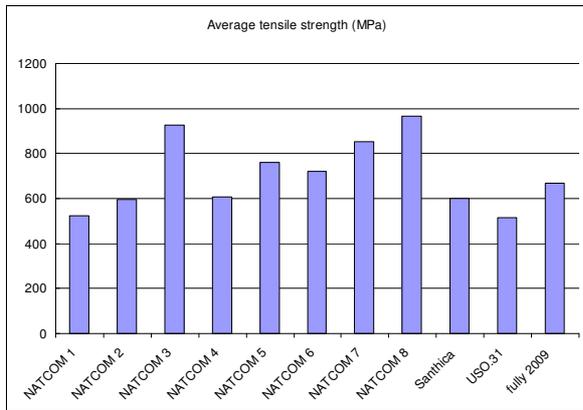


Figure 2 Effect of treatments and processing technologies on tensile strength

It is apparent that the strength of natural fibres varies considerably depending on many factors. Therefore, cautious should be taken when one uses the published data from literatures. Our research showed that these data do not represent the real strength of hemp fibres. Scrutiny of all test results shows that there is a significant variation between test pieces, whether diameter, length or maximum failure load, see Figures 3 as an example. And the tensile strength is closely related to the diameter of test pieces and sampling. More detailed discussion is presented in author’s separate papers.

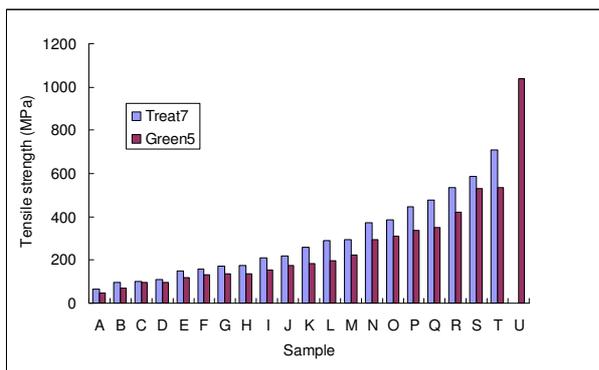


Figure 3 Variation in tensile strength

Composites made from the treated fibres

An example of the composites made and failure modes is given in Figure 4. It was found that the strength of hemp fibres has a significant effect on the properties of hemp fibre composites. However, the results seem

to follow the principle of the Rule of Mixtures, although constraint should be introduced when modelling the properties of hemp fibre composites. More details on this subject have been presented in one of the author’s paper.

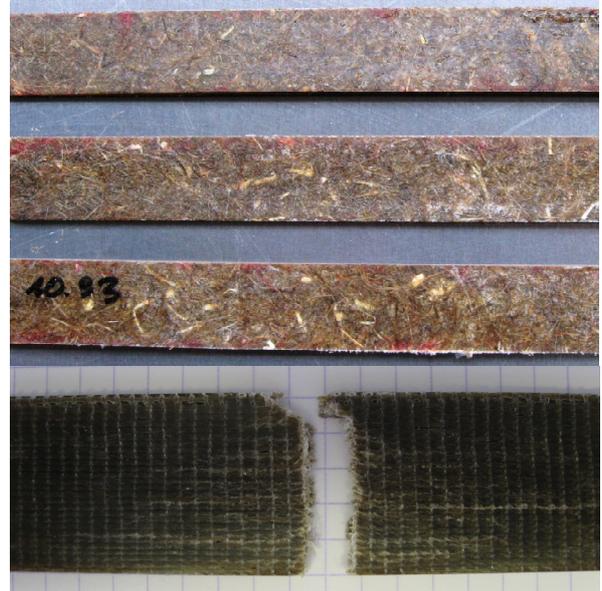


Figure 4 Hemp fibre composites and failure mode

Conclusions

1. Optimised hemp fibres have been developed with the TS of 2 times original fibres.
2. Strength of composites made with these fibres basically followed the rule of mixtures.

References

Bonfield P and Fan M 2000. The future of wood based panels: What can the wood based pnael sector learn from synthetic composite materials? The proceeding of 4th European Panel Products Symposium. Wales.

Fan, M. 2010. Characterization and performance of elementary hemp fibres: Factors influencing tensile strength. *BioResources*, 5(4):2307-2322.

Dai, D and Fan, M. 2010a. Investigation of the dislocation of natural fibres by Fourier transform infrared spectroscopy. *Vibrational Spectroscopy*.

Dai, D and Fan, M. 2010b. Characteristic and performance of elementary hemp fibre. *Materials Science and Applications*. 6(1) 28-36.