Hemp-lime biocomposites: influence of hemp on the properties of hemp-lime biocomposite with pozzolans

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The construction industry is currently non-sustainable and responsible for the consumption of non-renewable raw materials and fossil fuels, and high CO_2 emissions. Cement production alone is responsible for 5-10% of total global carbon emissions[1]. In light of this, there is a critical need to develop sustainable alternatives to cement-based products and to this end hemp-lime biocomposites, may provide a possibility for certain applications.

This research aims at replacing the hydraulic binders (cement and imported hydraulic lime) currently used to produce Hemp-Lime biocomposites with materials with pozzolanic properties with a view to make such composites more sustainable. To pursue this aim, this project investigates the influence of hemp particles (shiv) on the properties of a lime:pozzolan binder including setting rates and early strength development. Scanning Electron Microscopy (SEM) was used to investigate the morphology of the binder on the surface of hemp particles. It was found that the presence of hemp slowed setting and delayed early strength development. The hemp particles also appeared to influence the carbonation and hydration of the lime:pozzolan binder.

Setting times and early strength development of the biocomposite cannot be accurately determined due to incompatibility with standard testing methodologies and for this reason lime:pozzolan paste samples (30% pozzolan by weight) were made with water and hemp water. Hemp water was made by soaking hemp in water for 45mins which releases water soluble constituents of the hemp producing a hemp liquor. Previous research has established that the water soluble constituents of the hemp are responsible for affecting the behaviour of other binders[2].

The soluble hemp compounds appear to have no effect on the hardening of the lime paste during the first 120 hours however hemp water delays the setting time of the lime:pozzolan pastes. (RHA was also included to investigate the effect of a pozzolan with an almost 100% amorphous siliceous pozzolan).

Pectin is a partially soluble constituent of hemp and research by other authors has shown that its presence in hemp fibres retards the setting time of cement and gypsum pastes [2][3]. Pectins react with the calcium ions in a lime solution[4] resulting in less calcium being readily available for the formation of hydration products.

The variable setting rates of the three pozzolans is due to the different hydration mechanisms occurring, however the lime:pozzolan reaction of all three appears to be affected by the presence of hemp water.

Scanning Electron Microscopy (SEM) was used to investigate the presence of hydration products in the mortar and on the surface of hemp particles. Carbonation manifests in a grain like appearance, while hydration products have a needle and/or sponge-like morphology.

Hydration products were clearly evident on the mortar but there was no evidence of hydration products on the surface of the hemp particles.

When hemp particles were washed to remove the water soluble constituents prior to mixing in the mortar, there is an increased presence of hydration products.

Water soluble constituents of the hemp inhibit the formation of certain hydration products in the lime:pozzolan mortar on the surface of the hemp.

The hemp particle itself contributes to the lack of hydration products likely due to the high absorption of water by the hemp particle resulting in insufficient water levels required for the hydration process.

References

[1] E. Worrell *et al,* (2001) *Carbon Dioxide Emissions from the Global Cement Industry, A*nnual Review of Energy and the Environment, **26**, 303-329
[2] P. Dalmay *et al*, (2010) *Properties of cellulosic fibre reinforced plaster: influence of hemp or flax fibres on the properties of set gypsum* , Journal of Material Science, **45**, 793–803
[3] D. Sedan *et al,* (2008) *Mechanical properties of hemp fibre reinforced cement: Influence of the fibre/matrix interaction*, Journal of the European Ceramic Society, **28**, 183–192
[4] D. Sedan *et al*, (2007) *Effect of calcium rich and alkaline solutions on the chemical behaviour of hemp fibres*, Journal of Material Science, **42**, 9336–9342

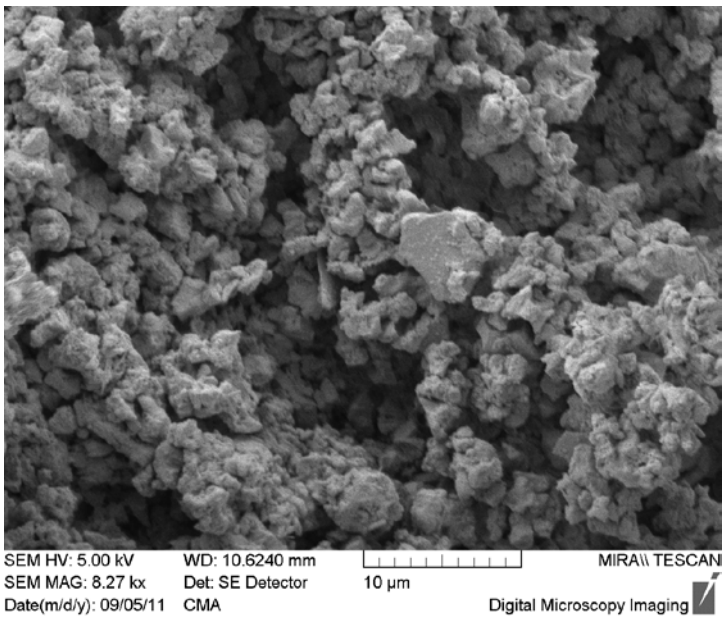

Figure 1. *Lime:metakaolin mortar on the surface of a unwashed hemp particle with no hydration products evident*

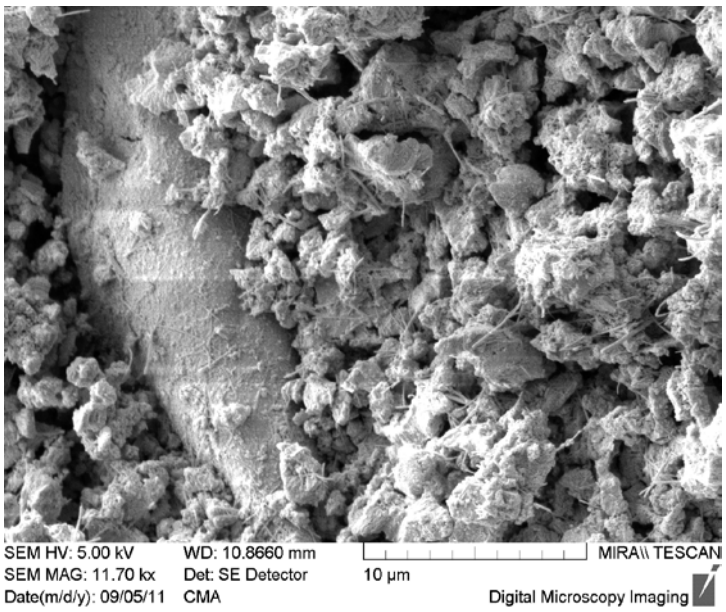

Figure 2. *Lime:metakaolin mortar on the surface of a washed hemp particle with some hydration products evident)*