Using Hemp Fibres for Sustainable Engineering Development in Roading

Lance Aldwin Pasaol 3rd year BEngTech 2020

Project Background

This poster is going to view ways hemp fiber can be implemented in the current New Zealand roading systems. It also covers the research on the use of and Hemp fibers to strengthen building materials like concrete whether or not these sustainable fibers can be used in newer and more sustainable engineering development in the roading department. Especially in New Zealand roads, where bitumen is used to make asphalt through chipsealing. In doing so, the aim of this research project is finding ways to implement these sustainable fibers into designing a long-life concrete pavement and other subjective roading developments like footpaths, bridges and many other roading infrastructures in a sustainable manner. The engineering problem that was recognized was finding out whether the use of coir and hemp fibers are a viable option to strengthen the design of concrete pavements. Keep in mind that other fibers like fibrillated polypropylene has commonly been used to strengthen concrete, but these fibers do not come from plant-based sources.

Hemp Fibers

Hemp fibers are known to have the strength and stiffness that are comparable with glass fibers. An important property of natural fibers such as hemp is their tensile behavior. From the Hindawi journal article on the “Study of the Physical and Mechanical properties of Hemp Fibers”, a study was done on the use of hemp fibers of varying diameters, starting from 4 μm up to 800 μm, for tensile testing. The tensile properties were found to be clearly dependent on the diameters of the fibers, decreasing gradually with increase in fiber diameter. This is also known to happen to synthetic fibers, that as the fiber diameter decreases, the number of flaws in the fibers also decreases, therefore resulting in increase in tensile properties of fibers.

Concepts

The concept was to make a concrete reinforced with hemp fibers shaped as a cylinder, designed to withstand roading pavement specifications.

The four concepts that have devised are listed below:

0% Hemp Hurd Fiber

The first concept was to make a normal concrete mix, using a concrete cylinder mould shown on Appendix I. The concrete mix will contain, 0.907kg of cement, 1.814kg of fine sand, and 1.814kg of 9.5mm sieved coarse aggregate.

1% Hemp Hurd Fiber

The second concept concrete mix will contain one percent hemp fiber of its total volume, 1.769kg of 9.5mm sieved coarse aggregate. 0.907 kg of cement mix, and 1.814kg of fine sand. This second concept will also be made using the cylinder mould on Appendix I. This concept is commonly used for making concrete mix with the likes of synthetic fiber and or steel fibers used in reinforcing concrete.

5% Hemp Hurd Fiber

The third concept will also be made from the cylinder mould on appendix I, five percent of the total volume of the concrete mix will be hemp fibers. The concrete mix will contain 0.907kg of cement, 1.587 of 9.5mm sieved coarse aggregate, and 1.814kg of fine sand.

100% Hemp Hurd Fiber (Hempcrete)

The fourth and final concept is based on a concrete design that contains 100% hemp fibers, this design will not have any coarse aggregate, and will rely heavily on the physical and mechanical aspects of the hemp fibers to strengthen the concrete. The mix will still contain 1.814kg of fine sand, and 0.907kg of cement mix. According to hempcrete-walls.com, the mix is purported to be a strong insulator, flame resistant, pest resistant, moisture balancing and biodegradable, when exposed to water. Further, it is said to be more sustainable than concrete and a carbon sink. Hempcrete can also be reused through milling and rehydration.

Testing

A compression test was done on the four concrete cylinder concepts to determine the concretes behavior under applied crushing loads. The aim of this test is to determine whether the hemp fibers mixed with concrete can withstand a crushing load similar to when vehicles go over roads. the concrete cylinders were cured for 28 days to reach maximum strength of the concrete. High traffic concrete pavements can withstand around 137.90 MPa, while low traffic concrete pavements are designed to withstand between 20.68 and 34.47 MPa.

Results:

0% Hemp hurd fiber: 158kN applied force and comprehensive strength 20.12 MPa

1% Hemp hurd fiber: 28.3kN applied force and comprehensive strength 3.60 MPa

5% Hemp hurd fiber:2.5kN applied force and comprehensive strength 0.318 MPa

100% Hemp hurd fiber (Hempcrete):4.10kN applied force and comprehensive strength 0.522 MPa

Discussion

The chemical reaction between the hemp and the alkaline concrete, seem to have affected the rigidity of the surface of the concrete and as well as increasing the initial impact strength of the concrete cylinder. Although the comprehensive strength of the concrete with hemp fiber did significantly decreased, the presence of the hemp fiber did allow ductile flexural performance, instead of brittle failure found in concept one, which contained 0% hemp fiber.

The use of hempcrete (100% hemp hurd fiber) to replace a normal concrete pavement, simply is not feasible. As shown in the compression test the hempcrete just does not offer the same critical performance as standard concrete. Hempcrete may have very good environmental benefits, but when it comes to engineering developments, especially in roading, the most important aspect is safety and ensuring that the pavement will support itself under immense pressure.