FIBER ADDED CONCRETE

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SUMMARY

Extensive research is currently going on to evaluate and quantify advantages of fiber added concrete in general civil applications. Different fiber additives can be combined with concrete to design for specific applications and optimize mechanical properties. It is anticipated that the new material shows an increased ductility, higher compressive strength and/or anisotropic stiffness values. Thus, applications of these materials are expected for seismic areas.

Experimental investigations are performed to evaluate the influence of fibers made of steel, glass, carbon or hemp on the overall behavior of concrete. Different materials are selected such that concrete properties can be designed to satisfy specific requirements. Some of these demands are alkali resistance, corrosion resistance, insensitivity to magnetism and increased beam-column ductility to dissipate energy during seismic activities.

Keywords: Fiber added concrete, steel, glass, carbon, hemp

1. INTRODUCTION

Test series are being carried out regarding the applicability of alternative materials as concrete reinforcements. Short fibers made of steel, glass, carbon or hemp are mixed with concrete, which builds the matrix. The addition of fibers to concrete makes it more homogeneous and isotropic and can improve the tensile response, particularly the ductility. The material properties of fibers made of glass, carbon and hemp are in some areas different than those of steel, which are already well known, but it is obvious, that only steel provides a region of plastic behavior (Fig.1).

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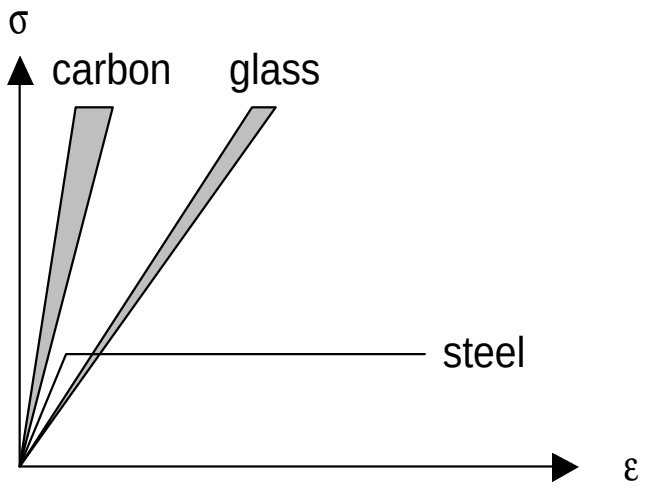

Fig. 1: stress-strain diagram

1.1 Steel fibers

Steel fibers are available unperforated, corrugated or with wide end for better bending. The fibers can be placed single or in the form of mats (SIMCON). The main fields of application of steel fibers are gunned concrete, tunnel constructions and high-loaded industrial floors. The addition of steel fibers increases the tensile strength of normal and high strength concrete. It also has positive effects on the Tension-Stiffening behavior, the formation of cracks, the tightness and the long-term deformation.

It is well known that after cracking the concrete between the cracks carries tension and hence stiffens the response of a reinforced concrete member subjected to tension. This stiffening effect, after cracking, is referred to as "Tension-Stiffening". After the formation of the first cracks develop, the average stress will be further reduced. Bond behavior is a key aspect of Tension-Stiffening since it controls the ability of the reinforcement to transfer tensile stresses to the concrete.

1.2 Glass fibers

Generally, glass has hardly any capacity to resist chemical attacks in alkaline milieu, so glass fibers were developed specifically to withstand high alkalinity, which grows out of the hydration of cement. It is possible to improve the deflocculation in aqueous solutions by using an impregnation.
Glass fibers are very notch sensitive and therefore should be better combined with mortar instead of concrete. An additional disadvantage is found in the missing scratch resistance.

1.3 Hemp fibers

Hemp is one of the oldest useful plants. Its fibers are used in all sorts of textiles and for many other purposes. During the last few years a growing deal of research focused on hemp. The research on bast fibers started about ten years ago in Germany. This new interest arose from efforts to exploit the enormous potentials of renewable resources in the non food areas as an economical alternative against decreasing incomes in agriculture and reduction of the use of petrochemical raw materials by more ecological products.
There are many reasons, why hemp fibers for reinforcement of concrete structures are doomed to failure. Concerning the mechanical properties, hemp fibers are far behind other materials. For a stable output of high quality products, it is necessary to equalize the natural variations of the material. Its tension strength and its Young`s modulus depend on the harvest time and on the harvesting process itself, the kind and the degree of retting and the sort of hemp. Hemp contains silicic acid, which is not alkali resistant and conducive to alkali expansion and cracking.

1.4 Carbon fibers

Some of the carbon fibers we used, are a waste material which results from the fabrication of various carbon products. The fibers are made of carbonized Polyacrylnitril, each fiber has a diameter of 5 µm. Usually carbon fibers are produced and sold in the form of rovings.
Three different types of carbon fibers were tested, first the material was shredded, second the material was cut into little shapes and third little sticks were used. As shown on the next page, lots of material properties of carbon fibers can be compared with those of steel, additionally their resistance against corrosion and magnetism can be regarded as a great advantage (Fig. 2).

1.5 Comparison of some material properties

Fig. 2 shows a comparison of density, tensile strength and Young`s modulus of the fibers used.

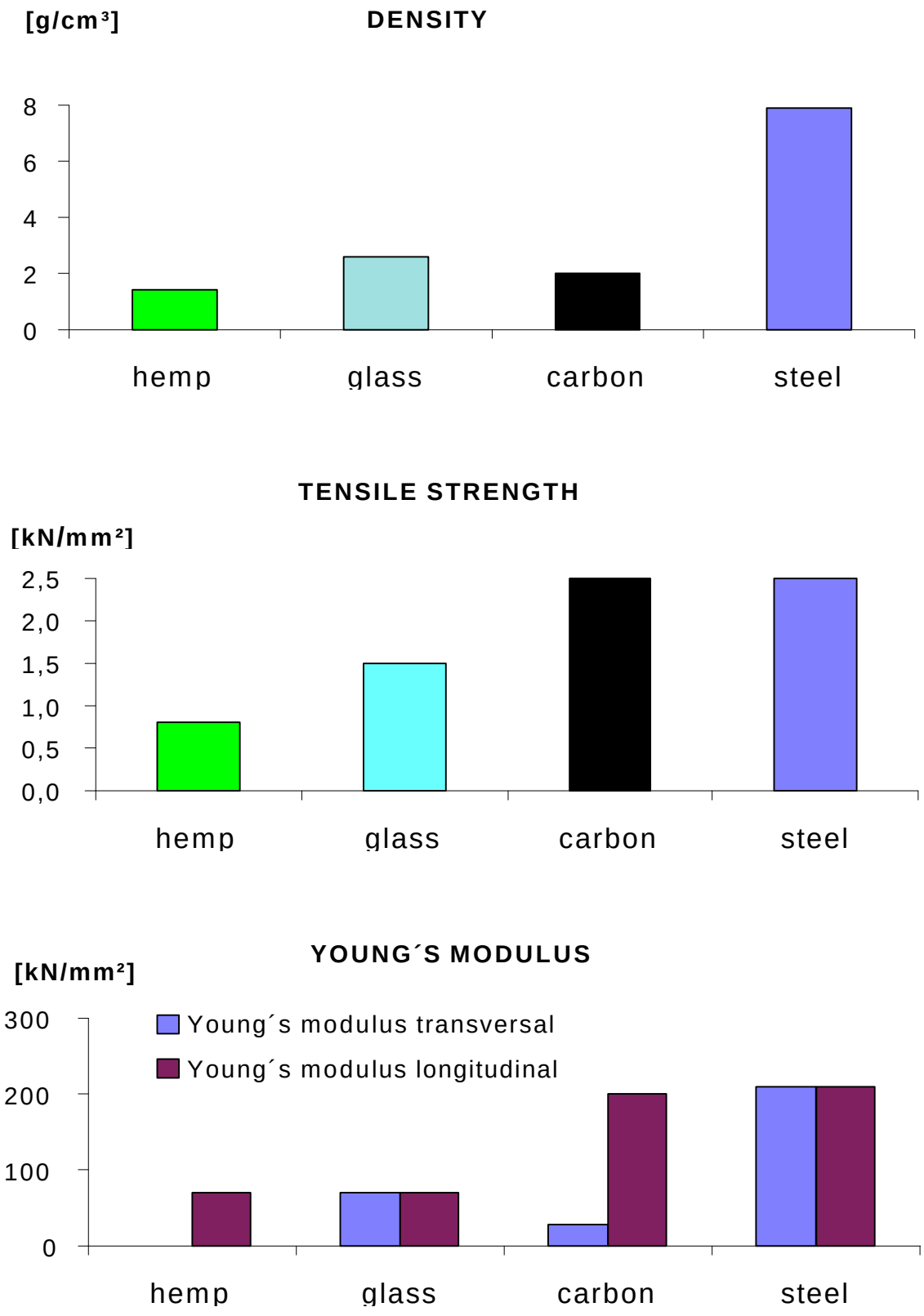

Fig. 2: Comparison of some material properties

2. RESULTS OF TENSILE BENDING TESTS

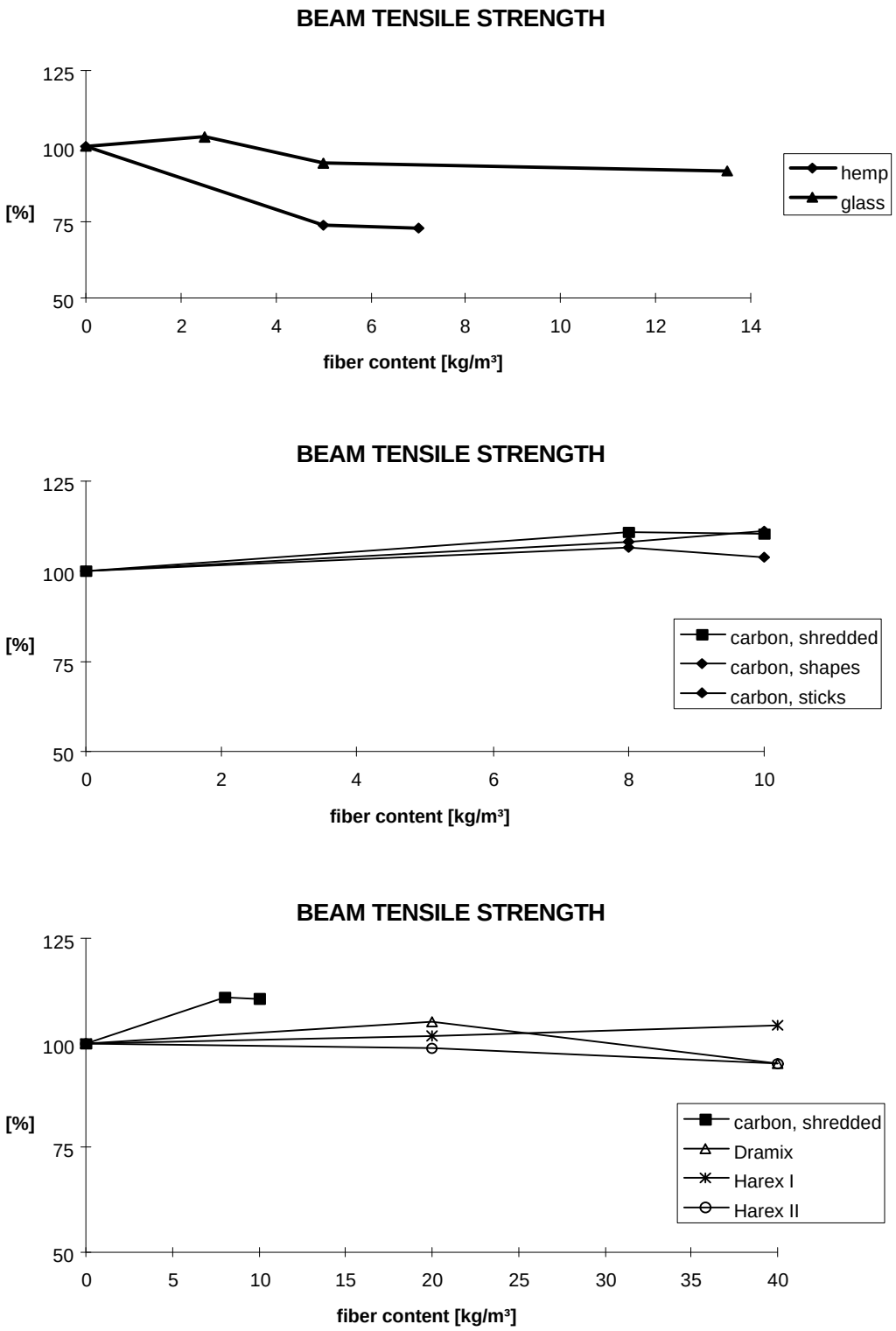

Fig. 3: Results of tensile bending tests

Because of the low contents of fibers and the low mechanical properties of the concrete used, the tensile bending tests do not show a significant increase of the beam tensile strength (Fig. 3). The test results of the glass fibers and the steel fibers are in accordance with those out of literature and give a standard of comparison. We made several attempts we tried to improve the bond between hemp fibers and concrete matrix, but we failed because of the variable behavior of waterabsorption of the fibers. The tests show that, independent of what kind of hemp fibers and what kind of concrete are used, the only result is a weakening of the concrete cross section.
The results of the tests with carbon fibers show the lowest rate of dispersion and an increase of the beam tensile strength in combination with high-strength concrete.

3. CONCLUSION AND PROSPECTS

Besides steel fibers, carbon fibers are regarded as the most promising fiber types for civil engineering applications, but creating a fiber-reinforced concrete means more than just adding fibers to an ordinary concrete. It involves the optimization of the granular skeleton to guarantee workability and mechanical properties in spite of the high proportion of fibers. Thus, the carbon fibers are going to be tested in the form of mats and single fibers which are infiltrated with a special kind of slurry. Based on the pilot tests the carbon mats are expected to behave similar to steel mats without the disadvantages of steel like corrosion and magnetism.

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