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MECHANICAL PROPERTIES OF REINFORCED CONCRETE

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ABSTRACT

This paper presents a discussion on the subject of fiber-reinforced concrete, FRC. It is intended as an overview of the types of commercially available FRCs and how they work. It discusses commonly applied terminology and models of mechanical behavior that form a basis for understanding material performance without presenting mathematical details. Concrete is a popular composite structural material valued for its high compressive strength, easy formability and resistance to aggressive environmental conditions. Its most serious drawback is its very low tensile strength. Because of this cracks develop and propagate in concrete structures, which can lead to a reduction in their durability or to their failure. This behaviour of concrete limits its use for elements with tensile stresses. The adverse consequences of the low tensile strength of concrete are most commonly reduced by incorporating reinforcement bars in it to take over tensile stresses. Another (increasingly used in practice) way of improving the performance of concrete consists in uniformly distributing fibres throughout its volume, whereby a material called fibre reinforced concrete is obtained.

Keywords: FRC, Mechanical Properties, Analysis, Investigation, Graphs.

I. INTRODUCTION

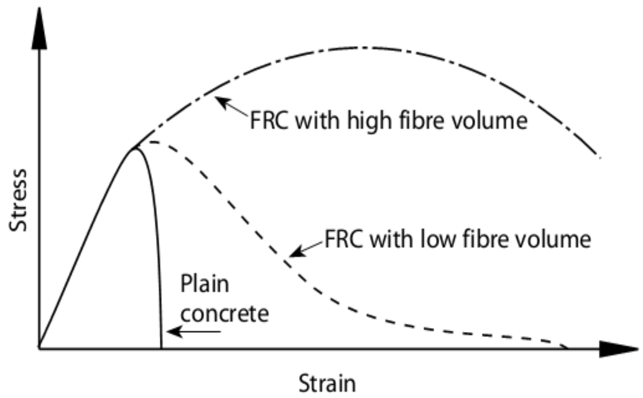
The effectiveness of the action of the fibres and the material's mechanical properties resulting from it are determined by a combination of several factors, such as: the properties of the fibre material, the capacity to form bonds between the matrix and the fibres, the content and concentration of fibres in the composite and the way of producing fibre reinforced concrete.

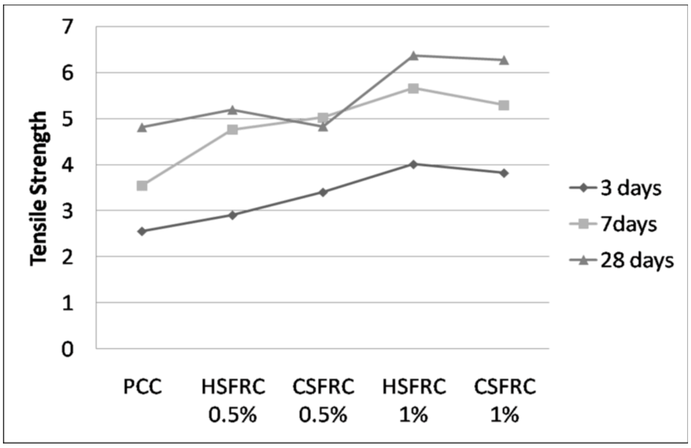
The growing popularity of recycling is also observed in the field of construction materials. Many ways of recycling the existing buildings and utilizing demolition waste have been developed. Another approach to recycling consists in utilizing waste materials from external sources to erect new buildings. The use of such materials as components of fibre reinforced concrete has great potential. Car tyre waste is usually used for this purpose. Tests have shown that steel fibres recovered from cut up tyres can be an alternative to commercial fibres or partially replace the latter in the concrete matrix. The use of such fibres is justified by the reduced costs and the improvement in some mechanical parameters of the concrete in the case of both mixed commercial and recycled fibres.

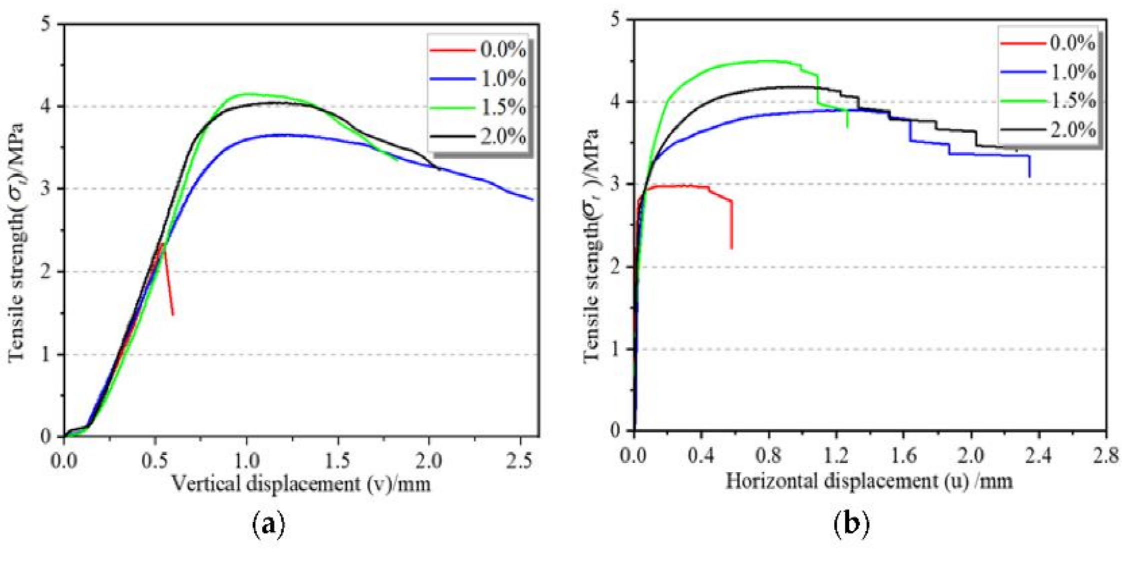
II. METHODOLOGY

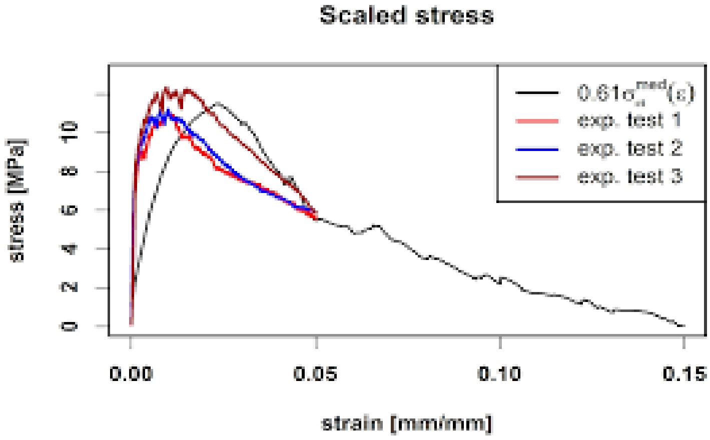
The fibres perform this work on both the micro- and macroscale. In the initial stage of cracking the fibres slow down the development of microcracks in the matrix and as the former become macrocracks, the fibres constrain their widening by absorbing energy, whereby the strength and resistance of the composite improve. This nonelastic behaviour of the material is the main characteristic distinguishing fibre reinforced concrete from plain concrete. The energy absorbed during a fibre reinforced concrete element failure is dissipated by debonding and by the pulling out of the fibres from the concrete matrix, whereby the resistance to dynamic loads further improves . The advantages of fibres as concrete reinforcement become apparent also in the case of high-speed impacts. In such cases the energy absorbing capacity of fibre reinforced concrete is much greater than that of reinforced concrete. The fibre reinforced concrete with the recycled fibres shows the characteristics of both the plain concrete and the fibre reinforced concrete with the reference fibres. The proposed recycled fibres, despite their similarity to the hook-end fibres, were found to be not sufficiently effective. The differences between the strength parameters of the particular series are not due to the presence of fibres, but to the differences between the concrete matrices. When typical fibre reinforced concretes are subjected to tension, once the member loaded in tension cracks it carries less of the tensile load due to the appearance of a single cumulative crack. In the case of high performance fibre reinforced cement (HPFRC) composites, after the first cracking the load-bearing capacity of the member increases owing to the high absorption of energy by the many fine cracks which appeared. The tensile strength of concrete is greatly reduced as a result of internal flaws and micro-cracks. The application of fracture mechanics concepts reveals that the tensile strength is proportional to the inverse square root of flaw diameter. High tensile strengths can be realized, however, when flaws are prevented from enlarging beyond certain limits. This is accomplished by means of closely spaced wire reinforcement. For wire spacings of less than a certain predictable range, the maximum size of flaw is equal to the wire spacing. Thus, the smaller the spacing the larger the tensile strength. Theoretical results are presented in detail. The theoretically predicted relationship between tensile strength and wire spacing is substantiated by tests.

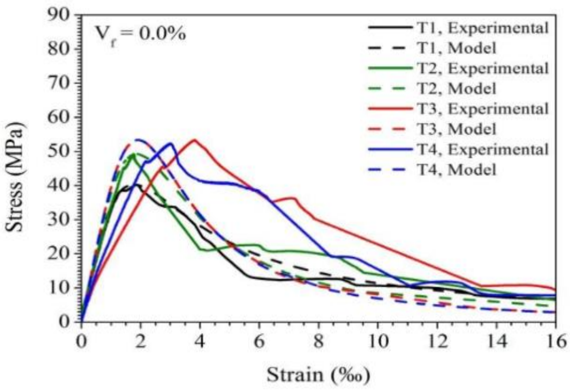
III. GRAPHICAL ANALYSIS

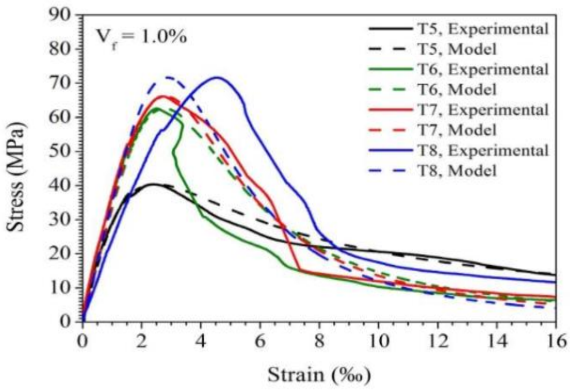


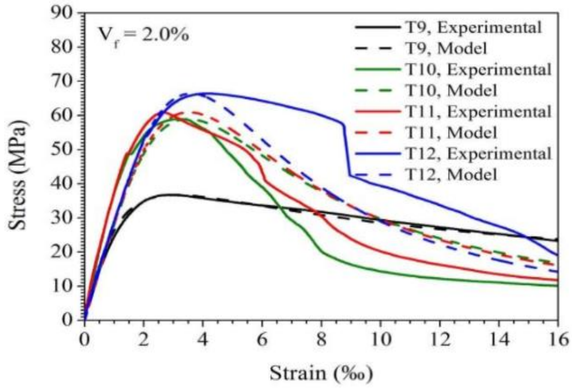


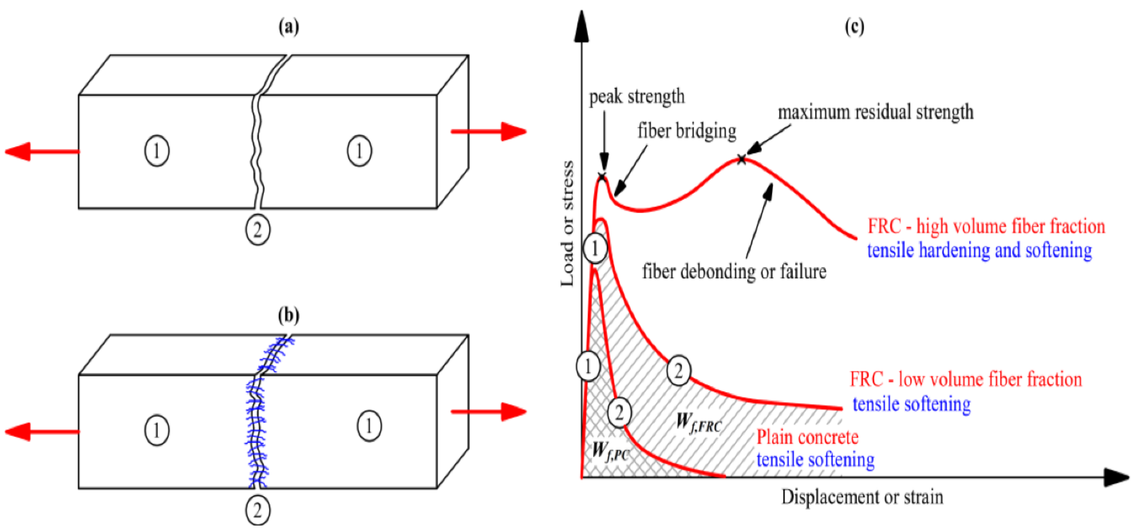



Scaled stress
stress [MPa]
strain [mm/mm]
exp. test 1
exp. test 2
exp. test 3


V_f = 0.0%
T1, Experimental
T1, Model
T2, Experimental
T2, Model
T3, Experimental
T3, Model
T4, Experimental
T4, Model
Stress (MPa)
Strain (‰)


V_f = 1.0%
T5, Experimental
T5, Model
T6, Experimental
T6, Model
T7, Experimental
T7, Model
T8, Experimental
T8, Model
Stress (MPa)
Strain (‰)


V_f = 2.0%
T9, Experimental
T9, Model
T10, Experimental
T10, Model
T11, Experimental
T11, Model
T12, Experimental
T12, Model
Stress (MPa)
Strain (‰)


(a)
(b)
(c)
peak strength
fiber bridging
maximum residual strength
FRC - high volume fiber fraction
tensile hardening and softening
fiber debonding or failure
Load or stress
FRC - low volume fiber fraction
tensile softening
Plain concrete
tensile softening
Displacement or strain

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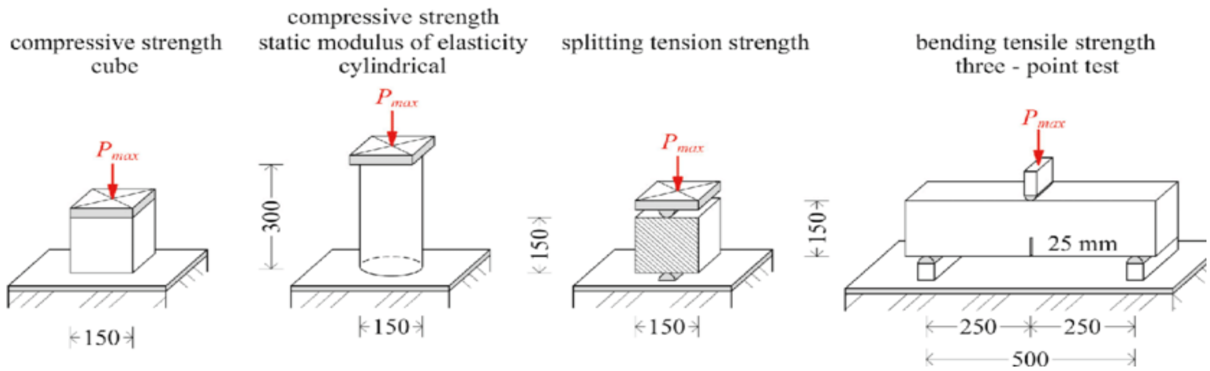
Type concrete	Dosage [kg/m³]	Density [kg/m³]	Standard deviation [kg/m³]	Compressive strength - cube [MPa]	Standard deviation [MPa]	Splitting tensile strength [MPa]	Standard deviation [MPa]	Bending tensile strength [MPa]	Standard deviation [MPa]
Plain concrete	0	2205	49.13	55.87	1.02	2.99	0.37	3.14	0.23
	40	2248	19.26	57.10	3.53	4.18	0.27	4.58	0.38
FRC - MasterFiber 482	75	2273	25.59	64.01	2.73	5.01	0.55	4.78	0.16
	110	2294	23.39	59.32	2.44	5.88	0.35	5.45	0.29
	40	2267	34.46	56.59	2.61	5.18	0.49	5.96	0.71
FRC - Dramix® 5D 65/60 BG	75	2289	20.01	60.39	2.31	7.35	0.30	9.65	1.54
	110	2305	27.30	57.55	3.06	7.63	0.35	12.11	1.41



Experimental program – test scheme

IV. MATERIALS

Fiber-reinforced concrete (FRC) is concrete made primarily of hydraulic cements, aggregates, and discrete reinforcing fibers. Fibers suitable for reinforcing concrete have been produced from steel, glass, and organic polymers (synthetic fibers).

V. CONCLUSION

The various strength properties studied are cube and cylinder compressive strength, split tensile strength, modulus of rupture and post cracking performance, modulus of elasticity, Poisson's ratio, and strain corresponding to peak compressive stress. The variables considered are grade of concrete, namely, normal strength 35 MPa, moderately high strength 65 MPa, and high-strength concrete 85 MPa, and the volume fraction of the fiber Vf=0.0, 0.5, 1.0, and 1.5%. The strength of steel fiber-reinforced concrete predicted using the proposed models have been compared with the test data from the present study and with various other test data reported in the literature. The proposed model predicted the test data quite accurately. The study indicates that the fiber matrix interaction contributes significantly to enhancement of mechanical properties caused by the introduction of fibers.

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