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IMPACT BALLISTIC RESISTANCE OF HIGH-WORKABILITY CONCRETE REINFORCED WITH CRUSHED WIND-TURBINE BLADE

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AIM ANS SCOPE

The research shows the capacity of fibres from dismantled wind turbine blades to improve the properties of self-compacting concrete. Its final objective is to study the properties of that concrete type in terms of ductility and energy absorption, evaluating its flexural strength and ballistic-impact resistance. This study is the starting point to try to develop self-compacting concrete with that waste that have a high resistance to such stresses.

INTRODUCTION

The considerable increase of wind energy worldwide has generated great concern regarding the management of the waste from wind turbines that will reach the end of their useful life. It is worth noting that between 2020 and 2034, 200,000 tons of waste from wind-turbine blades, mainly composed of fibre-reinforced polymers [1], is expected to be generated, most of which is currently being disposed in landfills or incinerated [2].

One promising possibility for recycling the blades is the extraction of fibres from them through crushing. The incorporation of fibres to concrete improves flexural strength, fracture toughness, resistance to thermal shock, fatigue, and resistance under impact loads [3]. Therefore, fibres from wind-turbine blades can improve the impact ballistic resistance of concrete. This is a serious concern in conflict areas, in which concrete is the most widely used protective engineering material in buildings, bridges, dams, nuclear power plants, and military sites and infrastructures [4].

MATERIALS

The composition of the concrete in this study was 320 kg/m³ of cement CEM II/A-L 42.5 R, 155 kg/m³ of water, 6.7 kg/m³ of plasticizers, 680 kg/m³ of limestone sand 0/2 mm, 660 kg/m³ of silica sand 0/4 mm, and 600 kg/m³ of silica gravel 4/12 mm. The incorporation of fibres from wind turbine blades was done by volume, with the residue was added in four quantities: 0 kg/m³, 49.0 kg/m³, 73.5 kg/m³ and 90.0 kg/m³. The concrete mixtures were named according to fibre volume: R, W3.0, W4.5 and W6.0.

RESULTS

Concrete mixtures with high workability were obtained, with which specimens were manufactured to evaluate their flexural strength and ballistic-impact resistance, as shown in Fig. 1. The results obtained in this research are illustrated in Fig. 2.

Fig. 1: Graph of ballistic curves, obtained in the bullet-impact test.

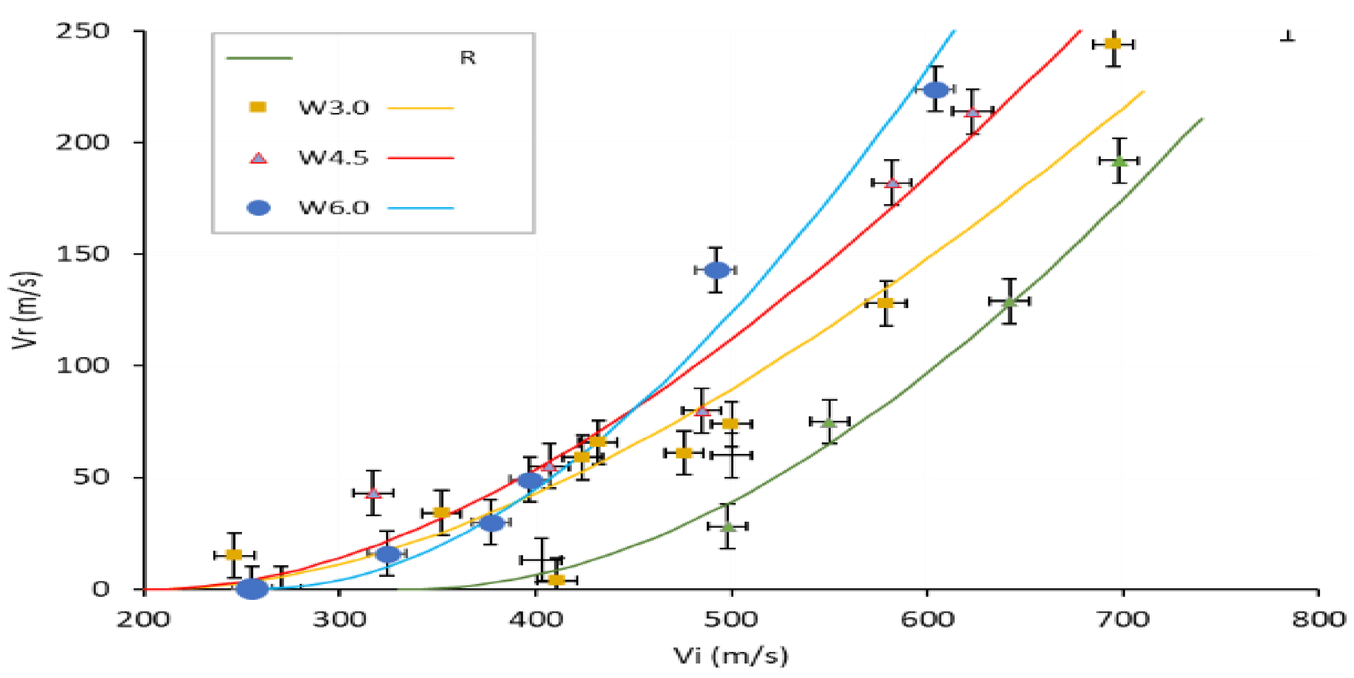
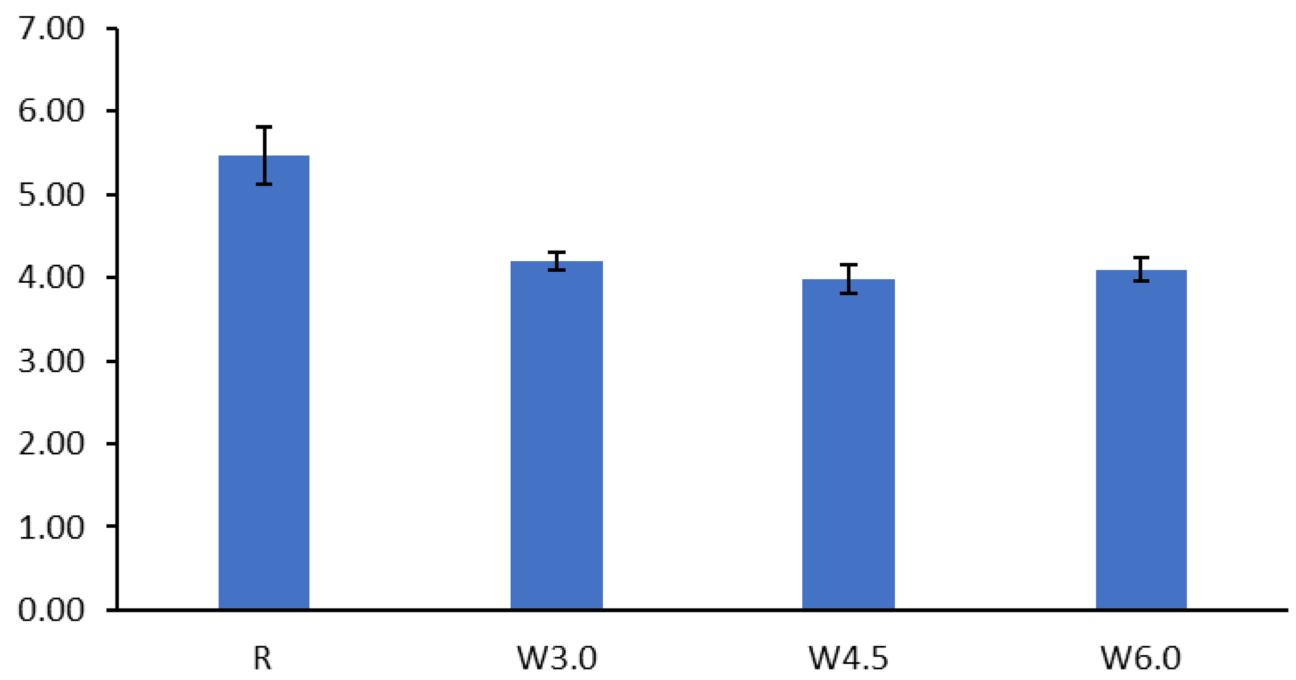


Fig. 2: Quasistatic flexural strength, obtained in the flexural-strength test.



CONCLUSIONS

1. **The flexural strength and ballistic-impact resistance of concrete with recycled fibres followed similar trends.**
2. **The flexural strength was reduced with increasing fibre contents from wind turbine blades up to a residue amount of 4.5%, from which flexural strength started to increase.**
3. **It is necessary to increase the water/cement ratio to maintain the workability of all mixtures with fibres, which in turn caused an increase in porosity and, therefore, a reduction in strength.**
4. **The penalizing factor generated by the porosity increase was compensated with percentages higher than 4.5% of fibres that effectively bridged the cementitious matrix, thus preventing the propagation of cracks and increasing energy absorption [5].**
5. **The stitching effect of the fibres favored the impediment of the passage of projectiles through the concrete and increased the safety of people against this type of attacks. The W4.5 mix had a ballistic resistance higher than that of the W3.0 mix, with 3.0% and 4.5% fibres, respectively.**

Fig. 3: Ballistic impact sequence in concrete mix R; Ballistic impact tested specimens (W6.0, W4.5 and W3.0, respectively); Laboratory Flexural Test Arrangement.

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