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Thermal deformability of concrete with wind-turbine blade waste

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INTRODUCTION & AIM

In order to provide a solution for both **thermal strain and sustainability** of Fiber-Reinforced Concrete (FRC), a novel residue was incorporated into concrete mixes, to provide an internal stitching effect and also **lower environmental** impacts by the use of sustainable fiber reinforcement: Raw-Crushed Wind-Turbine Blade.

RAW-CRUSHED WIND-TURBINE BLADE (RCWTB)

Residue from decomissioning of **end-of-life wind-turbine blades**, which underwent non-selective crushing and were incoroprated into concrete mixes to act as fiber reinforcement, made primarly out of **Glass-Fiber Reinforced Polymer (GFRP), polymeric particles and balsa wood** [1].

Fibers and micro-fibers (80.6 % wt.)

Polymeric particles (8.3 % wt.)

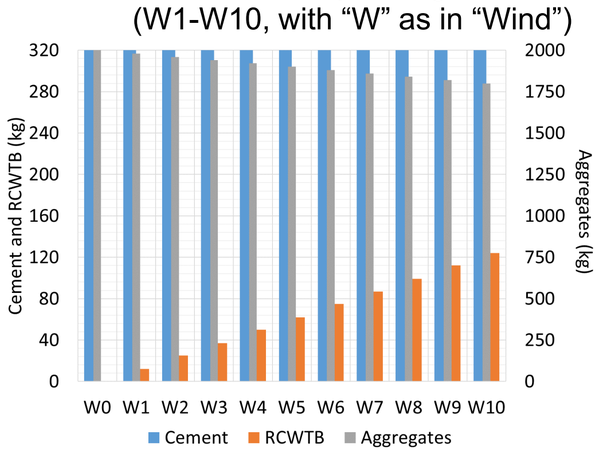
Balsa wood (6.3 % wt.)

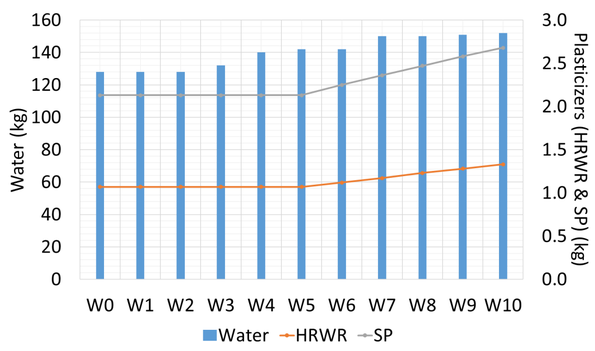
Non-separable fluff (4.8 % wt.)

METHOD

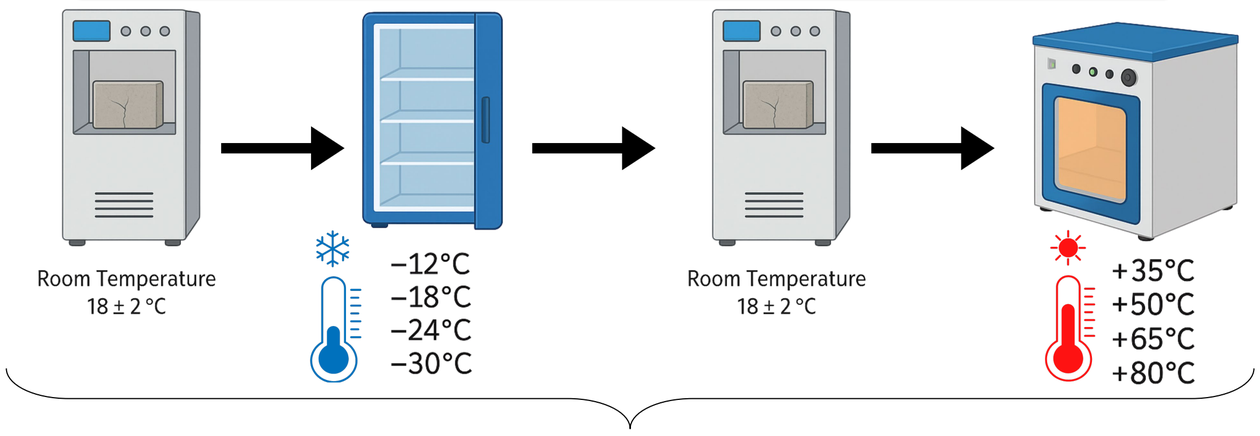
DOSAGE OF FRC

- One reference mix with **no** wind-turbine blade waste (W0)
- 10 mixes incorporating **RCWTB 1-10 % vol. as aggregate replacement** (W1-W10, with “W” as in “Wind”)

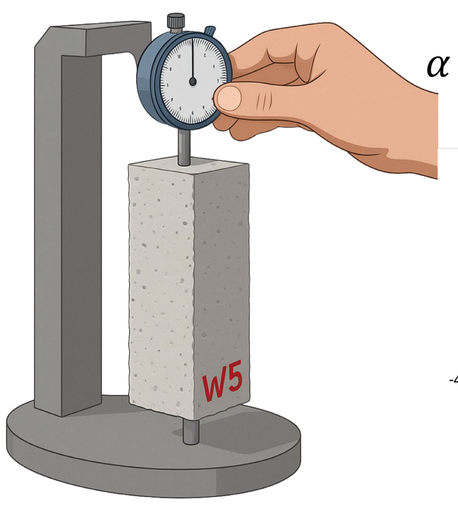




LINEAR COEFFICIENT OF THERMAL EXPANSION (LCTE - α): TESTING PROCEDURE

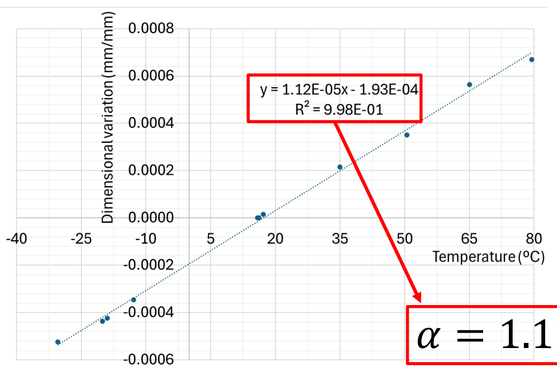


3-DAY INTERVALS PER TEMPERATURE STEP, 3 SPECIMENS PER MIX



$$\alpha = \frac{\Delta L / L_0}{\Delta T} = Slope\ of\ the\ linear\ regression$$

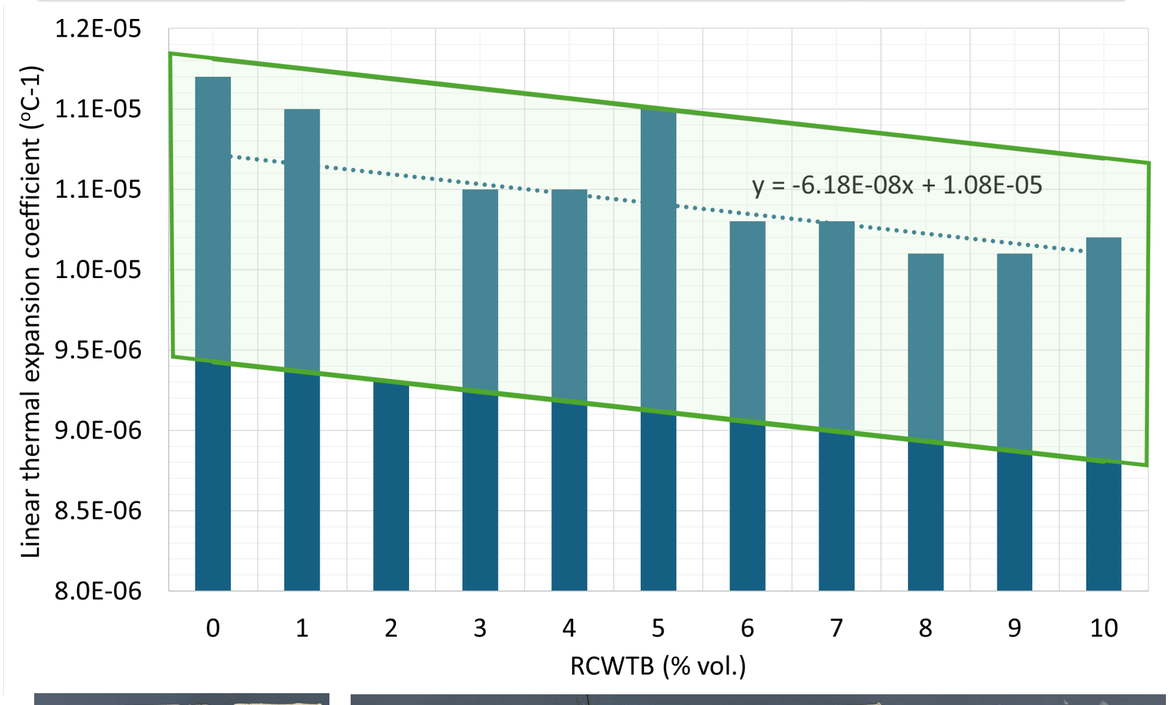
(EN 1770) [2]

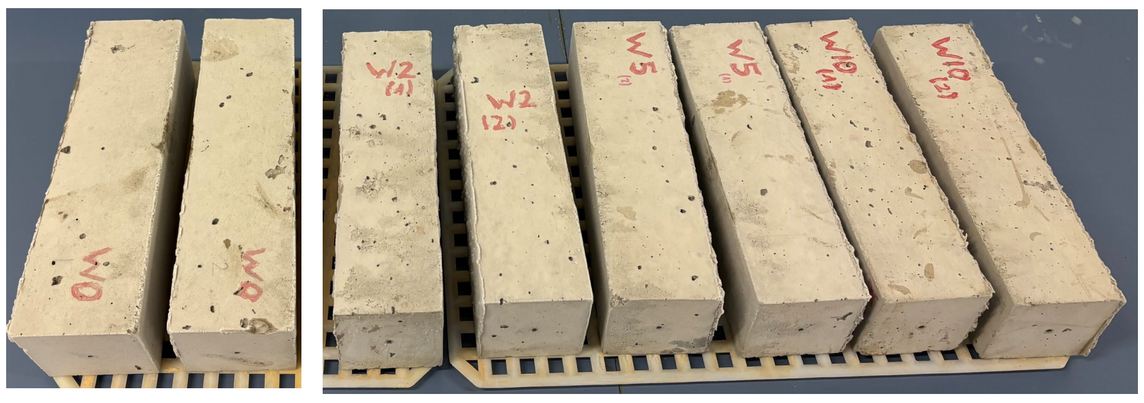


$$\alpha = 1.12 \times 10^{-5}\ {}^{o}C^{-1}$$

RESULTS & DISCUSSION

RESULTS OF TESTING





Two of the three specimens per mix: W0 (reference mix), W2 (mix with lowest LCTE), W5 (mix with highest LCTE), and W10 (mix with highest amount of RCWTB). No visual damage to the specimens was observed.

DISCUSSION

This behavior was primarily be attributed to the incorporation of GFRP fibers into the concrete mix. These **fibers** not only helped **restrict volumetric variations thanks to their stiffness**, but they were also less susceptible to deformation, as GFRP possesses a lower linear coefficient of thermal expansion (LCTE) than concrete (approximately $0.84 \cdot 10^{-5}$ $°C^{-1}$) [3]. In contrast, the **balsa wood particles** were able to retain significant amounts of water, **making them highly deformable** under both elevated and reduced temperatures [4]. This effect may have **offset the beneficial thermal** stability provided by the GFRP fibers, as well as the reduced thermal deformability resulting from the denser matrix created by waste fines and higher admixture contents, thereby accounting for the nearly constant LCTE values observed from W6 to W10 [5].

CONCLUSION

The lower thermal deformability of the components in RCWTB, mainly glass fiber-reinforced polymer, yielded **enhanced results, with up to 17% strain reductions** recorded, and all mixes exhibited values below conventional plain concrete. Additionally, **no cracking or visible damage** was observed in any specimen, regardless of the RCWTB percentage incorporated. Therefore, **enhanced thermal behavior of the mixes** was achieved while providing a **solution for RCWTB recycling and increasing concrete sustainability**, which facilitated the creation of greener materials.

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