Mechanical and thermal properties of the lightweight mortar made of wood biomass ash and sunflower particles

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1. Introduction

Impact of cement and building sector on the environment

Cement industry [1,2]

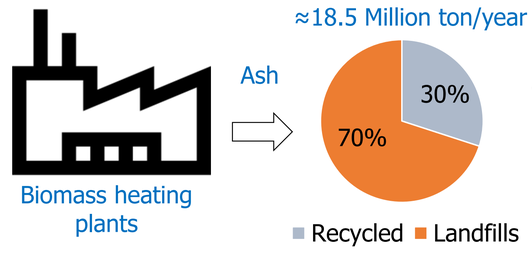
CO_2

≈1 ton of CO_2/ 1 ton of Cement

4-5 GJ/ton energy use

In France

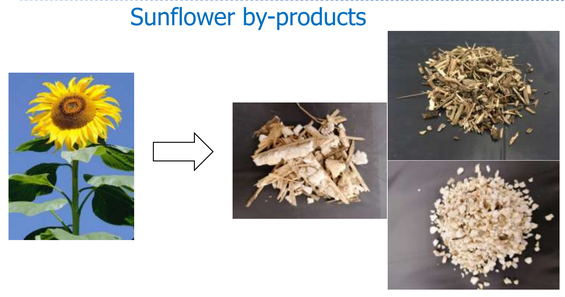
44% of energy consumption [3]



Construction : Mineral admixture in cement-based materials (Cement replacement)

Agriculture : Fertilizer (rich in Calcium, Phosphorus, Potassium, etc.)

Sunflower by-products



Agriculture : Animal feed

Building insulation, decoration :
- Use in bulk
- Particleboard panels
- Lightweight mortars and concrete

This study aims at investigating the mechanical and thermal properties of the wood biomass ash and sunflower-based mortar.

2. Materials and methods

Raw materials

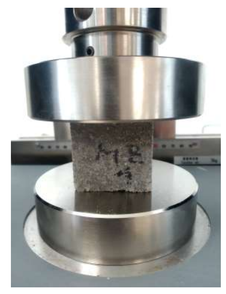
- Ordinary Portland cement C (CEM II) 32.5N
- Wood biomass fly ash : WFA (supplied by Coriance MAEV); The main oxide compounds: *CaO, SO_3, K_2O, MgO, P_2O_5 SiO_2.*
- Sunflower bark and pith (from Groupe Dauphinoise)

Mixture proportion

Mixtures	WBA (%)	C (%)	SP (%)	SB (%)	W/C ratio	W/WBA ratio	W/B ratio
100C	0	100	-	-	0.35	-	-
100WFA	100	0	-	-	-	0.5	-
80WFA-20C	80	20	-	-	-	0.5	-
90WFA-10C	90	10	-	-	-	0.5	-
80WFA-20C-5SP	80	20	5	-	-	-	1.1
80WFA-20C-10SP	80	20	10	-	-	-	1.6
80WFA-20C-15SP	80	20	15	-	-	-	2.2
80WFA-20C-20SB	80	20	-	20	-	-	0.9
80WFA-20C-25SB	80	20	-	25	-	-	0.95
80WFA-20C-30SB	80	20	-	30	-	-	1
90WFA-10C-5SP	90	10	5	-	-	-	1.1
90WFA-10C-10SP	90	10	10	-	-	-	1.6
90WFA-10C-15SP	90	10	15	-	-	-	2.2
90WFA-10C-20SB	90	10	-	20	-	-	0.9
90WFA-10C-25SB	90	10	-	25	-	-	0.95
90WFA-10C-30SB	90	10	-	30	-	-	1

Main experiments

Flexural strength : prismatic specimen, dimensions: $40x40x160\ mm^3$

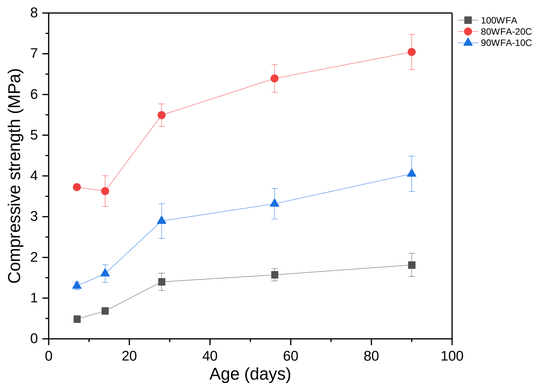


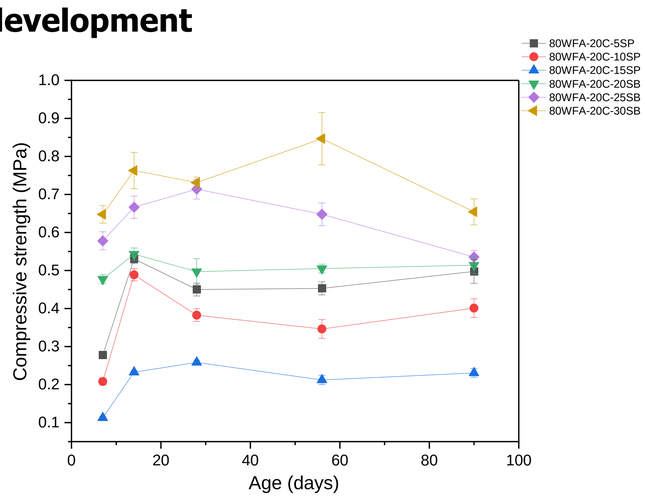
Compressive strength : Cubic specimen , dimensions: $40x40x40\ mm^3$

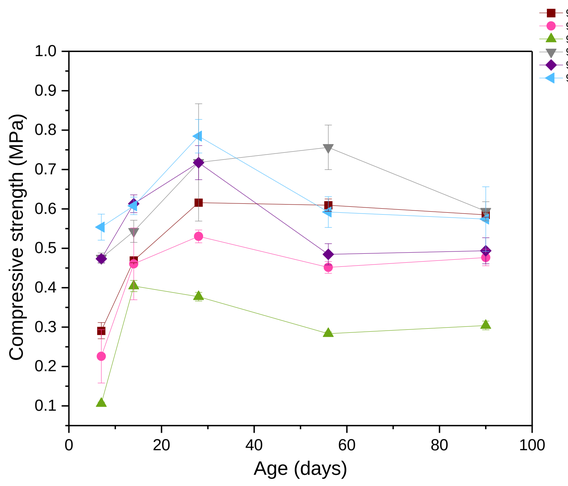
Thermal conductivity (λ) : dimensions $150x150x50\ mm^3$

3. Results and discussion

Compressive strength (Rc) development

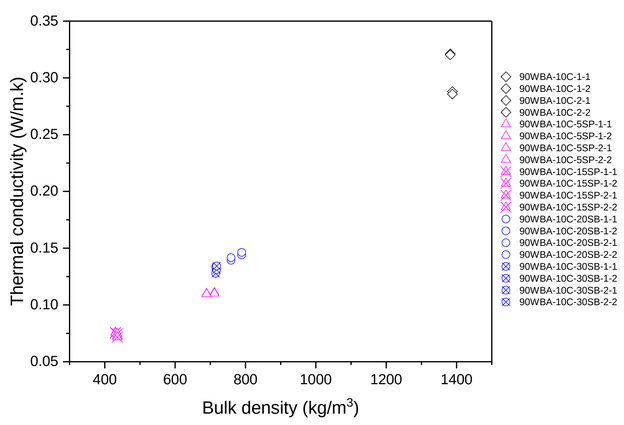






- The compressive strength of the reference samples progressively increased as the age was increasing.
- A significant development in Rc was observed between the age of 7 and 28 days.
- After the age of 28 days, slight variations were observed on all the samples containing sunflower particles.

Thermal conductivity (λ) at the age of 28 days



- ✓ The bulk density and thermal conductivity of the mortar declined as a result of the sunflower particles' incorporation.
- ✓ The variation of the bulk density and thermal conductivity of the samples containing sunflower pith was relatively higher compared to sunflower bark-contained samples.

4. Conclusions

1) The addition of sunflower pith and bark significantly reduced the compressive strength of the mortar.
2) The compressive strength of the reference samples 100WFA, 80WFA-20C, and 90WFA-10C gradually increased with increasing curing time.
3) The overall compressive strength of the sunflower-contained mortar samples ranged between 0.1 and 0.9 MPa while for the reference samples, Rc varied from 0.5 to 7 MPa.
4) The incorporation of sunflower particles as aggregates did not only reduce the density but also, improved the thermal properties of the mortar. The thermal conductivity (λ) of the mortar containing sunflower aggregates and reference samples varied from 0.074 to 0.143 W/m.K and 0.304 W/m.K, respectively.

5. References

[1] P.P. Li, H.J.H. Brouwers, W. Chen, Q. Yu, Optimization and characterization of high-volume limestone powder in sustainable ultra-high performance concrete, Construction and Building Materials. 242 (2020) 118112. https://doi.org/10.1016/j.conbuildmat.2020.118112.

[2] J. Skibsted, R. Snellings, Reactivity of supplementary cementitious materials (SCMs) in cement blends, Cement and Concrete Research. 124 (2019) 105799. https://doi.org/10.1016/j.cemconres.2019.105799.

[3] Énergie dans les bâtiments | Ministère de la Transition écologique, (n.d.). https://www.ecologie.gouv.fr/energie-dans-batiments (accessed November 3, 2021).