SOLIDIFICATION AND STABILISATION OF WASTE WOOD TO PRODUCE ENRICHED GREEN CONCRETE FOR ENVIRONMENTAL PROTECTION AND WASTE MINIMISATION THROUGH MECALITHE® TECHNOLOGY

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Introduction

This study is motivated as waste wood is available in abundance and it evaluates the potentials of Mecalithe® Technology used in the production of a new eco-friendly, green, value added waste-wood concrete, having applications in the construction industry. Reduction in environmental CO_2 emissions (sustainable environmental protection) is an associated benefit. The quality of concrete and its commercial viability have been evaluated through standard testing, as detailed in "Result and Discussion", keeping building rules and NEN norms in place.

Tests conducted are targeted to evaluate the viability of produced concrete for its eventual application in the making of non-bearing panels, sound absorbing panels for controlling noise pollution, light weight (density around 0.9 to 1.6 or as designed), fire resistance concrete for its applications for both in-door and out-door purposes.

Environmental protection through reduction in green-house gas

Cement production is associated with the production of significant amount of CO_2 emission. Multifunctional scientifically designed Mecalithe® induces cement reduction by 20-40% and if waste wood is used as an aggregate the CO_2 emissions can be further reduced and can be zero, because the use of wood has a positive effect on the CO_2 emissions calculation. CO_2 reduction is shown if part of the aggregate sand is replaced by wood (Figure 1). The amount of wood that is needed (replacing the same amount of sand) to compensate the CO_2 reduction for two types of cement used in the produced concrete is shown in Figure 2.

Figure 2 should be read as follows: select the type and amount of cement that is used in the concrete mixture (on the left-hand scale); determine the amount of CO_2 emission (on the horizontal scale); determine the required amount of wood as a sand replacement (on the right-hand scale).

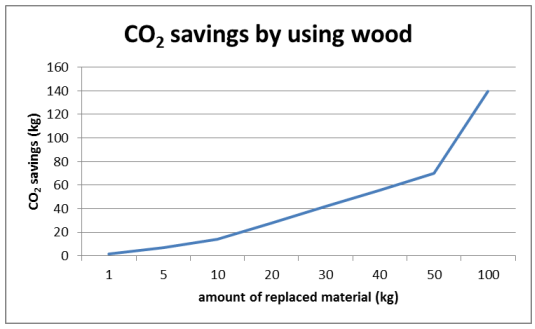

Figure 1: CO_2 savings by using wood in concrete

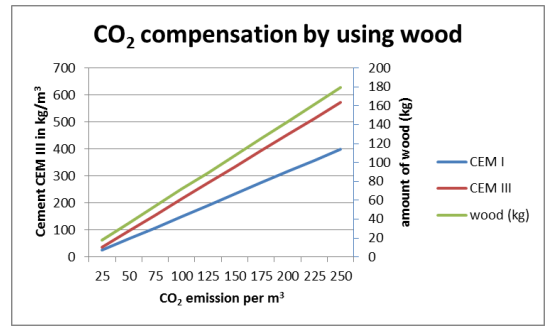

Figure 2: CO_2 compensation by using wood in concrete

Using Mecalithe® Technology, the results show that a wood based construction requires less energy, and emits less CO_2 to the atmosphere, than a concrete-framed construction. A net reduction of CO_2-emission can be obtained by increasing the proportion of wood-based building materials, relative to concrete materials. Aggregates such as waste-wood used in this type of concrete are free of cost or bring money (negative cost). This makes the whole concept cost-effective and leads to reduction in atmospheric CO_2.

Materials and Methods

Solidification and stabilisation is carried out through Mecalithe® Technology which consists of well researched chemical formulations. Portland or high oven slack cement (Like CEM I 52, 5 R or CEM III 42, 5/B LH/HS) cement is used. Waste wood of fine grade, has been used as 100% aggregate along with solid and liquid additives (plasticisers) and has been mixed with black pigments in a mixing unit. Wood has water absorption (23%) so wood is soaked in water to avoid shrinkage of the produced concrete. Black pigment is used to change the yellow colour to a grey colour. Water absorption, mixing time and chemical reaction dynamics in presence of Mecalithe® are critical elements in determining the final quality.

Results and Discussion

There are no international references or standards for this type of concrete but our own studies[1,2] are taken as a reference. Concrete is evaluated through these tests: (**1**) Compressive Strength - Table 1; (**2**) Bending Strength (BS) - Table 1; (**3**) Density (D) - Table 1; (**4**) Freeze-Thaw test – Figure 3; **(5)** Surface durability through abrasion resistance by sand blasting wheel test –Table 3 and Figure 4; (**6**) Basic sound absorption tests and (**7**) Basic Fire tests (Observation).

Traditionally concrete is made with sand and gravel which is now a rare and depleting resource and on the contrary waste wood is an environmental hazard, this is from this point of view that results achieved through this study are excellent. 22 N/mm^2 for CS and > 5 N/mm^2 for BS (3.0 - 5.47 N/mm^2) provides an excellent option to use waste

wood for the purpose of producing multifunctional green concrete. Seeing the range of density (0.9 - 1.6 kg/m^3), there is a flexibility of designing segmented concrete of the desired quality. Basic fire and sound absorptions tests were conducted according to norms and observations which were made indicated that this concrete has fire resistance and potentials to absorb sound. Advanced testing is further required to obtain quantitative data both for sound and fire tests.

Freeze-Thaw results with 3% Sodium Chloride (NaCl) are: 2 cubes (15x15x15 cm) are 0.23 and 0.37 kg/m^2 (loss in mass/area) with an average of 0.30 kg/m^2 (Table 2), which is much below the norm of 1.0 kg/m^2, confirming a good performance against Freeze-Thaw. A normal pre-fab concrete conforms to 0.8 or 0.9 kg/m^2, so waste wood concrete is performing even better. An Abrasion Testing Machine test for surface durability (according to the norm EN 1338) shows the width of the 2 tested cubes at 19 mm (average) (Table 3), which is excellent and indicates excellent durability of the concrete.

Figure 3: Freeze-Thaw Sample

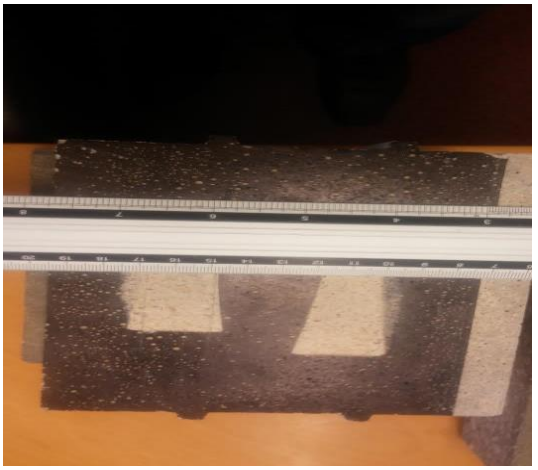

Figure 4: Wide wheel Abrasion Test

Table 1: CS/BS/Density –Waste Wood used 100%

Cement (kg/m^3)*	Air (%)	wcf	Density kg/m^3	CS (N/mm^2)	BS (N/mm^2)
200 - 450	6 - 8%	0.7 - 1.04	0.9 -1.6	12.0 - 21.50	3.0 - 5.47

* CEM I or CEM III type based cement

Table 2: Freeze-Thaw with 3% NaCl (m/m) resistance according to EN 1338

Cube (sample) number	Size of test area (mm^2)	Loss in mass (mg)	Loss in mass/area (kg/m^2)
I	18.495	4.300	0.23
II	17.822	6.600	0.37
Loss in mass/area - average (kg/m^2)			0.30

Table 3: Abrasion Testing Machine test for surface durability: EN 1338

Tested cubes	Surface exposed (mm)	Surface exposed- average (mm)
1	19 mm	~19 mm
2	18 mm	
3	19 mm	

Conclusions

1. The study is targeted to use waste wood as a replacement of conventional aggregates like sand and gravel which is used in a traditional concrete by using scientifically designed chemical formulation Mecalithe®.
2. Production of concrete from waste wood leads to tremendous reduction in atmospheric emissions of CO_2 (as represented in graphics) which leads to sustainable environmental protection, so this concrete is termed as value added waste-wood based green concrete[3,4].
3. Standard tests have been carried out according to established norms and the results are excellent. CS is ~ 21 - 22 N/mm^2; BS is 3 - 5.47 N/mm^2; Density ranging from 0.9 to 1.6 kg/m^3.
4. Freeze-Thaw tests with 3% NaCl according to EN 1338 - loss in mass/area as 0.30 kg/m^2 which is comparable to traditional concrete made with sand and gravel.
5. Abrasion Testing Machine Test for surface durability: EN 1338 indicate 19 mm of surface exposed which is excellent and is comparable with traditional concrete.
6. Basic fire and sound tests indicated the potentials of waste wood concrete as fire resistant and sound absorbing concrete. Advanced studies can be generated to get quantitative data in future.
7. There are enormous potentials for commercialisation of this concrete.
8. There are several possibilities of producing different shades, designs and decorative surfaces which conform to contemporary trends in cosmetic concrete designing.

References

1. Y. R. Tyagi, “Production of value added light-weight, eco-friendly green concrete by MGX Technology”, in *Proceedings of the fourth International Slag Valorisation Symposium Zero waste*, Leuven, Belgium, 2015.
2. A. H. Buchanan and B. G. Honey, “Energy and carbon dioxide implications of building construction”, *Energ Buildings*, **20** (3) 205-217 (1994).