ZERO CARBON EMISSIONS FROM A WASTE WOOD BASED LIGHT WEIGHT ECO-FRIENDLY CONCRETE SYSTEM THROUGH MECALITHE®

Youva Raj TYAGI[1], Peter van BAKEL[2]

[1] Director, GreenCem BV Research Centre, 5234 GD, Mangaan 1, The Netherlands.
[2] Chairman, GreenCem BV, 5234 GD, Mangaan 1, The Netherlands

y.tyagi@greencem.nl, p.vanbakel@greencem.nl

Introduction

Global warming during the course of the twenty-first century is projected to be between 1.0 and 3.7°C and this continues to grow significantly in response to ongoing emissions of CO_2 and other greenhouse gases to the atmosphere which is surely matter of serious concern for the world.[1]

Waste wood remains one important source for CO_2 compensation. Typically, 1 m^3 of beech wood (= 720 kg) contains 1058 kg CO_2, which is 1.47 kg of CO_2 /kg wood.[2] One m^3 of pine wood (540 kg) stores 794 kg CO_2 which also amounts to 1.47 kg of CO_2/kg of wood. The calculation module, "Opslag van CO_2 in hout"[3] has been used to determine quantitative values for CO_2 compensation for the waste wood based produced concrete.

In addition, EU Waste Framework Directive (2008/98/EC)[4] prescribed the hierarchy of wood waste use; waste management options are ranked in order of environmental preferences with 1st preference being waste wood reduction. EU-27 member states (and others) generated around 2.6 billion tons of wood waste in 2008 of which 3.7% is hazardous.[4]

It is significant to mention in this context that 40 billion tons of sand and gravel are extracted worldwide. UNEP discovered that such extraction can cause major ecological, geological hydrological problems and causes a high magnitude of environmental damage.[5] Waste wood as aggregate is used in place of traditionally used sand and gravel.

This study addresses all these challenges issues and leads to the production of zero-carbon, eco-friendly, light weight green, waste wood concrete to achieve sustainable environmental protection through Mecalithe® Technology.

The produced concrete was tested for compressive strength (CS - N/mm^2), bending strength (BS - N/mm^2), density (D - kg/m^3), air (%) and related observations were made to understand the professional quality of the produced concrete.

Materials and Methods

Waste wood was obtained from a local (Dutch) supplier, which was processed through Mecalithe® Technology.

The following materials were used: (1) Cement (CEM I 52.5R), (2) Waste Wood (0 - 2 mm particle size), (3) Mecalithe® 20/14 powder, (4) Mecalithe® liquid additive (Mecacolour), (5) 0 – 2 mm sand as a filler. There are two stages: (1) the initial process to produce granulates with Mecalithe® additives and (2) the final production of concrete. The mixture consists of (1) 60% pre-processed waste wood with Mecalithe® formulations, (2) 20% sand (0-4 mm), (3) 20% sand-(0-2 mm), (4) 285 kg/m^3 of cement CEM I 52.5R, (5) 20 kg of Mecalithe® formulation. The water cement factor was 0.58. 45% of processed wood granulate was used in the final production of waste wood concrete.

Immediately the waste wood concrete mixtures were used to make cubes, beams and tiles under simulated lab. Models and reproduced at operational level.

Results and Discussions

Waste wood concrete and properties

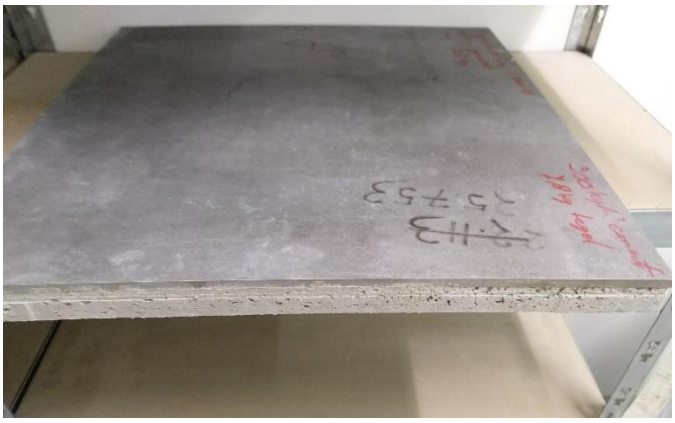
The produced concrete from waste wood was tested for compressive and bending strength (N/mm^2), according to NEN-EN 12390-3:2009 and NEN-EN 12390-5:2009 respectively after 3 days, 7 days and 28 days (Table 1).

Table 1: CS/BS and density of produced concrete from waste wood

	3 days	7 days	28 days
Compressive Strength (N/mm^2)	16.08	19.24	22.40
Bending Strength (N/mm^2)	4.97	5.04	5.58
Density (kg/m^3)	1361-1803 (wet)		

Typically, chemical composition of waste wood ash indicates 8.1 to 32.4% of SiO_2, 7.5 to 17.1% of Al_2O_3, and 3.5 to 35.3% of CaO *etc.*[6]. It is assumed that Mecalithe® formulations chemically activate the system through cation exchange process, in such a way that waste wood is incorporated into the over-all hydration process. More fundamental research is required to fully understand chemistry and molecular mechanism.

The test data indicate a gradual increase of the compressive strength from 16 N/mm^2 in 3 days to 22.40 N/mm^2 in 28 days and simultaneously, a good bending strength of 5.58 N/mm^2 in 28 days. The density ranged from 1361 to 1803 kg/m^3. Finished professional tiles (Figure 1) were produced in the field in combination with a ceramic tile (at the top). The tiles could be demoulded in 24 hours which is comparable to traditional sand and gravel based professional tiles. In general air% was 5 - 6%, (NEN-EN 12350-7:2009), the water-cement-factor (wcf) ranged from 0.42 - 0.58 and the weight loss was 1.4 - 3% (Table 2).



Produced at the field simulation

Typical concrete after Abrasion resistance (EN 1338)Test[7]

Figure 1: Concrete with processed waste wood treated with Mecalithe® formulations

Table 2: wcf, air (%) and weight loss of produced concrete in 28 days

wcf	Air (%)	Weight loss in 28 days
0.42 – 0.58	5 - 6.5%	1.4 – 3%

Freeze-Thaw results[7] with 3% NaCl were (average) at 0.30 kg/m^2 (loss in mass/area) against required ≤ 1.0 kg/m^2, confirming excellent performance. Abrasion resistance tests for surface durability (EN 1338), shows the width of 19 mm (average). These values show excellent durability of the concrete.[7]

All components used in the production of waste wood concrete were subjected to CO_2 emission analysis[2,3], which concludes that using waste wood, leads to production of Zero carbon emission concrete, it is in-fact sub-zero level, with a negative (-) value of - 84.82 kg of CO_2/m^3 of concrete. (Figure 2).

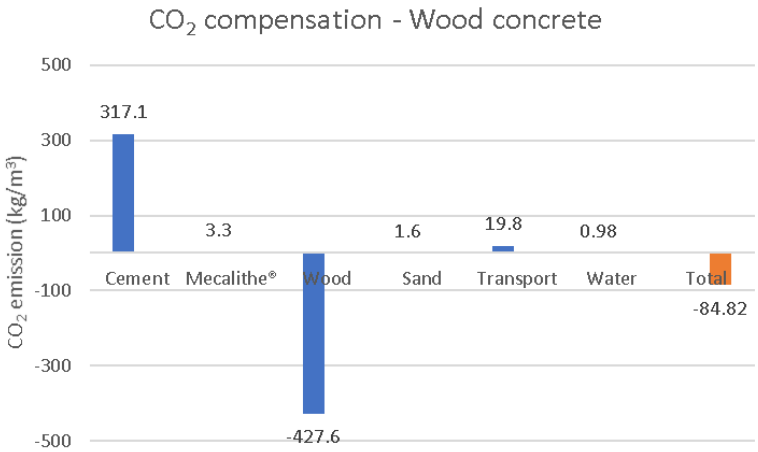


Figure 2: Carbon dioxide compensation balance (zero Carbon)

Conclusions

1. Traditional sand and gravel is replaced by waste wood in the production of green-concrete using Mecalithe® Technology.
2. 45% (w/w) of the pre-processed wood (granulate) has been used in production of final concrete.
3. CS of 22.40 N/mm^2 and BS of 5.58 N/mm^2 have been observed in 28 days with a density of 1361 – 1803 kg/m^3. CO_2 emission analysis show that the final status of CO_2 as - 84.82 kg/m^3. Freeze-Thaw at 0.30 kg/m2and Abrasion Test at 19 mm, indicates excellent quality of the innovative concrete product.
4. Research findings at bench, pilot and full scale were consistent while using ceramic tiles at the top of produced concrete. (Figure 1).
5. It needs some extended fundamental research to understand chemistry at molecular level.

References

1. T. R. Anderson, E. Hawkins, P. D. Jones, "CO_2, the greenhouse effect and global warming: from the pioneering work of Arrhenius and Callendar to today's Earth System Models", *Endeavour*, **40** (3) 178-187 (2016).
2. Nederlandse Branchevereniging voor de Timmerindustrie, Certificaat - Hoeveelheid vastgelegde CO_2 in houtproducten
3. Nederlandse Branchevereniging voor de Timmerindustrie, "Opslag van CO_2 in hout"
4. J. van Dam, NL Agency, Ministry of Economic Affairs, "Sustainable", Competition in wood waste: Inventory of policies and markets, April 2013 (Final version).
5. Warning of a worldwide shortage of sand and gravel, "Urban mining for sand and gravel", ®Dutch Waste Management Association, Partner in circular economy, may 2017, wastematters.eu.
6. Y. R. Tyagi - Solidification and stabilisation of waste wood to produce enriched green concrete for environmental protection and waste minimisation through Mecalithe© technology, in *Proceedings of the 5th International Slag Valorisation Symposium*, 3-5 April, 2017, Leuven, Belgium.