USE OF TOXIC WASTE AS AGGREGATE TO PRODUCE ECO-FRIENDLY CONCRETE WITHOUT REINFORCEMENT IN SLUDGY AREAS FOR MINIMISING WASTE AND ATMOSPHERIC CO_2 USING MECALITHE® TECHNOLOGY

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Introduction

Mecalithe® Technology has been used in this study for minimising toxic and non-toxic waste to produce eco-friendly green concrete to be used in sludgy and loose formations. This is innovative and specialised concrete (called Spijkerbed) as it is produced to hang on concrete poles with segmented calculated spacing, so that the produced concrete does not sink into the loose formation. This study, conforms to waste reduction, like the Dutch government will commit that in 2030 50% and in 2050 100% of all materials will be re-used. Critical elements are to make concrete in land below sea level (Figure 2) and load distribution and pole spacing. The concept of Spijkerbed is used in a number of locations – all located in the lowest part of The Netherlands. A modern lifestyle, alongside the advancement in industry has led to an increase in the amount and type of waste being generated, leading to a waste disposal crisis[2]. But this is a potential step in waste disposal and environmental technology.

In a traditional concrete system 350 kg/m^3 of CEM I (Portland) is used with sand and gravel as aggregates with a significant amount of steel-reinforcement. Mecalithe® based concrete uses only 180 kg/m^3 of slack based cement (48% cement reduction), only recycled toxic and non-toxic wastes are used as aggregate and despite the fact that there is a huge spacing of poles by ~3 m, still no steel reinforcement is used. This is cost-effective because of the low cement system; also, waste as aggregate brings money (negative cost) and most importantly this leads to a substantial reduction in atmospheric greenhouse gas CO_2.

Extensive lab experiments have been conducted over a period of time and the techno-economic viability is established by constructing >90,000 m^2 Mecalithe® based working floor concrete and top layer concrete at Moordrecht, Groot Ammers, Gouda, Waddinxveen[1] and Reeuwijk *etc.* The study includes life cycle analysis for CO_2, quality/strength parameters (CS/BS/D), leaching of 15 metals and 5 non-metals and organics according to NEN/NEN-EN norms. Lab findings have been implemented in the fields.

Reduction in atmospheric greenhouse gas CO_2 due to reduced cement and using no re-enforcement

CO_2 emission plays an important role in the control of our environment. There is a constant pressure to reduce the CO_2 emission. One of the most important sources for CO_2 emission is the concrete industry, with cement as the most dominant part. By using Mecalithe® less cement can be used to produce concrete with the same strength. In Figure 1 the CO_2 emission for various types of concrete is shown compared with a reduced use of cement in combination with Mecalithe®.

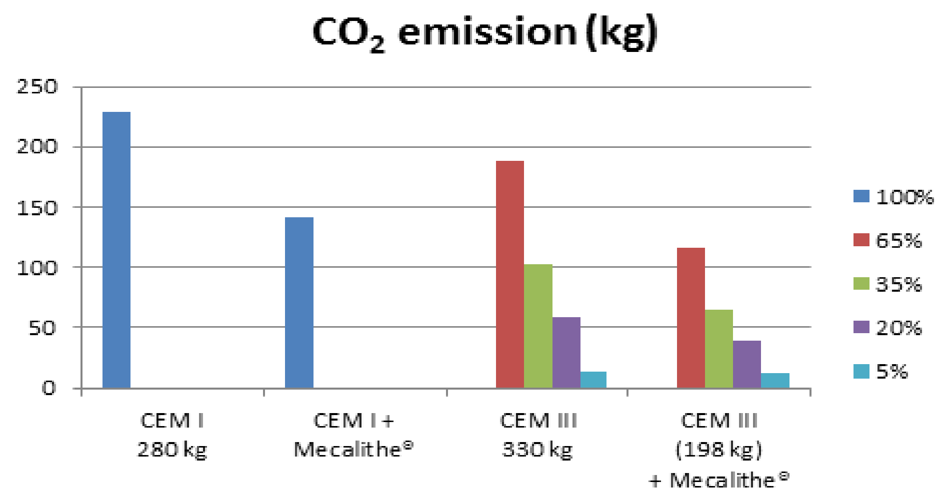

Figure 1: Graphical reduction in atmospheric greenhouse gas CO_2 due to reduced cement and using no reinforcement (CEM III with different percentages of clinker)

If reinforcement is used one can also choose to lower the amount of cement less, but also use less or no reinforcement. This will save 1.65 kg CO_2 per kg steel.

Specialised value addition

This study has distinct specialised elements which are: a) use of 100% re-cycled toxic and non-toxic waste, as a substitute of sand and gravel; b) 48% reduced cement causing reduction in atmospheric CO_2; c) no reinforcement steel used while spacing of poles of 3 meter apart, causing reduction in atmospheric CO_2.

Materials and Methods

Mecalithe® Technology, which consists of a well-researched chemical formulation, was used to develop in the research lab as a prototype model to be used in the field applications. This technology was used in the production of (1) Working floor; (2) Deck Plate. Two types of wastes were used in the production of the working floor and 3-4 different types of hazardous and non-hazardous wastes were used in production of the Deck Plate. Slack cement CEM III 42.5/B LH/HS was mixed with Mecalithe® powder and water based slurry was produced to make concrete mixtures.

Results and Discussion

A critical element of the study is to qualify leaching parameters which contains 15 metals ions and 4 non-metal ions in a diffusion test (DT-NEN 7375) according to BRL 9322/AP04 which is valid for both the working floor and the deck plate from field samples of Moordrecht, Groot Ammers, Gouda, Waddinxveen[1] and Reeuwijk *etc.* This is a mandatory legal requirement, according to the norms. All field samples passed but only one example is provided here for a general overview[1], it is due to limitations of space - Table 1.

Table 1: DT NEN 7375, SAM APO4 and LS10 NEN-EN 12457 chemical analysis of proctors showing leaching profile of 15 metals and 4 anions (representative example - Waddinxveen)[1]

	DT, NEN 7375		SAM AP04	LS10, NEN-EN 12457	
	mg/m^2		mg/kg ds [3]	mg/kg ds [3]	
	limit [1]	result [2]	result	limit [1]	result [2]
As	260	1.92	10	0.9	0.050
Cd	3.80	0.05	0.99	0.04	0.0010
Cr	120	0.49	36	0.63	0.017
Cu	98	8.71	99	0.9	1.5
Hg	1.40	0.02	0.10	0.02	0.00050
Ni	81	2.40	35	0.44	0.29
Pb	400	2.40	210	2.3	0.10
Sn	800	4.80	370	4.5	0.30
Ba	1500	28	320	22	1.1
Co	60	1.44	7.1	0.54	0.036
Mo	144	8.69	3.7	1	0.65
Sb	8.70	1.18	9.1	0.16	0.015
Se	4.80	0.66	4.2	0.15	0.035
Sn	50	1.44	8.4	0.4	0.030
V	320	7.31	40	1.8	0.60
Fluoride	2.500	101	-	55	1.9
Bromide	670	38	-	20	1.4
Chloride	110,000	9,666	-	616	310
Sulphate	165,000	80,573	-	1,730	16,000

[1]Maximum emission value in 64 days in mg/m^2, [2]Measured cumulative leaching in 64 days in mg/m^2, [3]ds = dry soil

Load distribution applied on concrete makes the bending strength (BS) and compressive strength (CS) very critical because of the balance of load applied on the deck plate. Mecalithe® formulation through chemical mechanism leads to BS is 4.76 - 5.02 N/mm^2 and CS is 22 - 27 N/mm^2 for the deck plate at 180 kg/m^3 cement and to CS 6 – 8 N/mm^2 for the working floor at 150 kg/m^3 cement (Tables 2 and 3).

Table 2: Working Floor: CS (N/mm^2) and Density in 28 days (conforms to BRL 9322)

Tested	Height (mm)	Diameter (mm)	Weight (g)	Density (Kg/m^3)	CS (N/mm^2)
Proctor	115 - 120	98 - 100	1,681 – 1,726	1,837 – 1,926	6 – 8 N/mm^2

Table 3: Deck Plate CS (N/mm2) BS (N/mm2) Density 28 days (Conforms to BRL9322)

Tested	Height (mm)	Width (mm)	Weight gram	Ultra Sound m/s	Density Kg/m^3	CS N/mm^2	BS N/mm^2
Cube	~150	~150	7,130 – 7,326	4,116 - 3,873	2,138 - 2,167	22 - 27	4.76 - 5.02

The quantification of saving of CO_2 emissions is represented in Figure 1. Mecalithe® has potentials to reduce cement with different cement types (CEM I and CEM III with different % of clinker). The traditional concept of using steel reinforcement in Spijkerbed constructions has been avoided due to the use of Mecalithe® formulations, thus further reducing CO_2 emissions. 1.65 kg CO_2 per kg steel is saved[3].

Figure 2: Water level critical

Figure 3: Construction of poles

Figure 4: Work in progress

Figure 5: Final construction

Conclusions

Mecalithe® Technology has been used to use toxic and non-toxic waste as a replacement of traditionally used sand and gravel both in working floor and deck plate (Spijkerbed). 48% cement reduction and without steel reinforcement makes the whole concept eco-friendly by massive reduction in CO_2 emissions. Absence of steel reinforcement makes the study techno-ecomically an excellent technology. Water level are higher than construction so making working floor with concrete is challenging, all working floors were hardened Figure 2. Poles were spaced according to engineering calculations Figure 3; Figure 4 and 5 shows construction progress and final floor (Deck Plate); Passing all the leaching parameters and achieving CS of 22 - 27 N/mm^2 and BS of 4.76 - 5.02 N/mm^2 makes the technology a potential option in over-all environmental protection.

References

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