Proceedings of the
Fourth International

Slag Valorisation Symposium

Zero Waste

15-17 April 2015
Leuven, Belgium

Editors Annelies Malfliet and Yiannis Pontikes

KU LEUVEN

PRODUCTION OF LOW COST SPIJKER-BED (HANGING CONCRETE) USING LOW CEMENT, NO REINFORCEMENT AND USING CONTAMINATED WASTE AGGREGATES BY MGX TECHNOLOGY

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Introduction

This study is based upon lab research which deals with the case study of Waddinxveen, using patented formulations called, "Mecalithe®". This study demonstrates the use of a low quantity of cement, 100 % waste materials as aggregates are used, no reinforcement (Steel) is used, leading to cost-reduction simultaneously reducing atmospheric CO_2 emissions.[1-5] This study finally converges into the production of eco-friendly green concrete, under most the challenging conditions of reduced cement, using waste as aggregates and with no reinforcement. The concept of a "Spijker Bed" can be defined as a concrete floor stabilised by stable concrete poles to avoid sinking of the concrete floor into loose organic sludge with time.

A temporary concrete working floor is made prior to the construction of the main concrete floor called, "Spijker-Bed Deck Plate". MGX technology has been used in the construction of working floor, the lower deck plate and the higher deck plate.

MGX Research succeeded in the successful production of eco-friendly green concrete (Spijker Bed), with a construction with a total of > 80,000 m^2 which are located at Waddinxveen, Gouda, Groot Ammers, Moordrecht etc in The Nederlands. Typically, the deck plate is 50 cm thick, and the working floor is 5-8 cm thick, with pole spacing of around 1.4 to 1.8 m.

Basic details of Spijker Bed and taking Waddinxveen, as a typical example

A 500 mm thick concrete, "Deck Plate" has been constructed over a working floor (just above groundwater), which is stabilised by High Speed Poles (HSP) solid concrete poles, spaced at a distance of 1.4 and 1.8 m as designed for expected load distribution, for higher and lower, "Deck plates" respectively. (1) Lower Deck Plate:

Area 2300 m^2, thickness 500 mm and 1150 m^3, (2) Higher Deck Plate: Area 2650 m^2 thickness 500 mm and 1325 m^3. This is placed over lower floor which is supported on HSP poles through working floor (Figure 1).

Some special features:

1. **Use of 100 % toxic waste as aggregates**: Contaminated waste (also toxic) is increasing due to stringent environmental legislation with strict leaching limits. 100 % waste has been used as aggregate. This reduces over-all cost significantly, as waste materials are either free or brings money as a negative cost.

2. **40-50 % reduction in cement, reinforcement, cost and CO_2 emissions:** Compared to 350 kg/m^3 of cement quantities used in traditional concrete only 180 to 200 kg/m^3 of Portland (CEM I or other types) are used in the production of a Spijker-Bed deck plate. This reduction of 40-50 % in cement quantities brings a significant cost reduction and also in atmospheric CO_2 emissions. Traditionally, steel reinforcement is used to provide a support system but no reinforcement is used in these studies. This leads to additional reduction in the cost of the project and also additional reduction of CO_2 emissions. In general, on an average, 1.8 tons of CO_2 are emitted for every tons of steel produced. According to the IEA, in 2010 the iron and steel industry accounted for approximately 6.7 % of total world CO_2 emissions. CO_2 produced from a cement manufacturing is combustion (40 % for fuel use) and calcination (60 % at 2500 °F), this accounts for approximately 3 % of global emissions. The manufacture of cement produces about 0, 9 ton of CO_2 for every 1 ton of cement. [1-5]

Materials and Methods

Following types of materials were used in the project:

(A) Deck Plate:

- Waste 1: (30-40 % of total aggregates used)
- Waste 2: (40-50 % of total aggregates used)
- Waste 3: (15-25 % of total aggregates used)

(B) Working Floor:

- Waste 4 & 5: (50:50 %)

(C) Cement CEM I or other types: 180-200 kg/m^3

(D) Mecalithe® at 2.5 % (w/w) of cement weight + Activators

(E) Water

Procedure for making Mecalithe® based concrete

2 or 3 types of contaminated waste materials are mixed, cement and Mecalithe® are added and mixed uniformly and a suitable quantity of water is added, to keep water cement factor (wcf) factor to around 0.60 -1.2.

Results and Discussion

- Compressive Strength (CS) for deck plate" is from 24.8 to 29.8 N/mm^2 in 28 days (Table 1);
- Ultra sound values are 3933 to 4089 m/sec (Table 1);
- Bending Strength (BS) is from 5->6 N/mm^2 for the deck plate, not shown in Table 1;
- The density is 2,116 -2,167 kg/m^3 for deck plate (Table 1);
- CS (N/mm^2) of the working floor ranges from 5.2 to 8.8, the density is 1,837 to 1,926 kg/m^3 and the ultra sound values are from 2,235 to 2,620 m/sec using <150 kg/m^3 of cement (Table 2);
- Table 3 shows the results of the quick indicative test for leaching according to NEN-EN 12457 (LS-10)[6,7];
- Diffusion Test (DT) (NEN 7375) for 15 metal and 4 non-metal ions (Table 3) passed[6,7];
- We passed leaching tests, as reported by an EN-ISO 17025 accredited laboratory. Sulfate passed in DT NEN 7375[6,7];
- All results are impressive and show the powerful effect of the use of Mecalithe®;
- The leaching profile is important. It shows that all 15 metal ion and 4 non-metals conform to the norms. Research has shown that lab results and field (Operations) results match;
- Projects have been made since 2006 (total > 80,000 m^2) and all are performing as expected.

Table 1: Compressive Strength (CS) N/mm$^{2;}$ density, ultra-sound results for 7, 14 and 28 days conforms to BRL 9322 for Deck Plate (Cubes)

Code	H	W	D	Weight	Ultra Sound	Density	CS (N/mm^2)		
	mm	mm	mm	Kg	m/sec	Kg/m^3	7 days	14 Days	28 Days
CCS1	150	150	150	7,222	3,933	2,142	20.5	23.1	24.8
CCS2	150	150	150	7,192	3,873	2,142	20.1	22.9	25.3
CCS3	150	150	150	7,326	3,980	2,167	25.0	28.8	29.8
CCS4	150	150	150	7,130	3,913	2,116	18.0	20.9	23.9
CCS5	150	150	150	7,278	4,089	2,151	26.3	27.0	27.7
CCS6	150	150	150	7,235	4,116	2,138	25.1	25.8	25.6

Table 2: Compressive Strength (CS) N/mm$^{2;}$ Density, Ultra-Sound results for 7, 14 and 28 days conforms to BRL 9322 for Working Floor (Proctors)

Code	H	D	Weight	Ultra Sound	Densiy	CS (N/mm^2)		
	mm	Mm	Kg	m/sec	Kg/m^3	7 days	14 Days	28 Days
PCS1	113	100	1,721	2,620	1,915	5.2	-	8.8
PCS2	114	100	1,681	2,450	1,837	3.8	-	8.1
PCS3	114	100	1,726	2,540	1,926	4.5	-	7.6
PCS4	113	100	1,684	2,575	1,869	2.7	-	5.9
PCS5	114	100	1,687	2,235	1,884	2.1	-	5.2
PCS6	112	100	1,719	2,315	1,845	2.7	-	5.8

Table 3 (a): Leaching profile of working floor: SAM APO4, LS=10 NEN-EN12457, DT NEN 7375 and Proctors Chemical Analysis showing the leaching profile of 15 cations and 4 anions. Leaching profile of deck floor: DT NEN 7375 and Proctors Chemical Analysis showing the leaching profile of 15 cations and 4 anions [6, 7]

	SAM, AP04	LS=10, NEN-EN12457		DT, NEN 7375		
	Working floor	Limit	Working floor	Limit [2]	Working floor	Deck plate
	mg/kg ds	mg/kg ds		result[1] in mg/mm^2		
As	<10	0.9	<0.05	260	1.93	3.48
Cd	0.89	0.04	<0.001	3,80	0.05	0.07
Cr	35	0.63	0.018	120	0.49	6.96
Cu	105	0.9	1.4	98	8.86	9.39
Hg	0.24	0.02	0.00045	1,40	0.02	0.03
Ni	33	0.44	0.28	81	2.44	3.48
Pb	195	2.3	<0.10	400	2.41	6.96
Zn	355	4.5	<0.30	800	4.82	13.91
Ba	315	22	1.1	1500	27	42
Co	6.80	0.54	0.037	60	1.45	2.09
Mo	3.65	1	0,62	144	8.82	0.70
Sb	6.15	0.16	0.011	8.70	0.99	1.11
Se	3.85	0.15	0.035	4,80	0.65	0.67
Sn	7.95	0.4	<0.030	50	1.45	2.09
V	37	1.8	0.58	320	7.48	13.91
Fluoride	-	55	1.60	2,500	89	96
Bromide	-	20	1.195	670	40	43
Chloride	-	616	305	110,000	8.543	8,798
Sulphate	-	1,730	16,000	1,65,000	90,632	52,188
1: Measured cumulative leaching in 64 days in mg/m^2						
2: Maximum emission value in 64 days in mg/m^2.						

Table 3 (b): LS10 NEN-EN12457, DT NEN 7375, Proctors Chemical Analysis showing the leaching profile of 15 cations and 4 anions (working floor)

	DT		LS=10	
	Limit	avg	Limit	avg
Fluoride	2,500	88.9	55	1.60
Bromide	670	40.5	20	1.20
Chloride	110,000	8,543	616	305
Sulphate	165,000	82,954	1,730	16,000

Some illustrations: Figures represent the model of "Spijker Bed" the construction of the poles, "Working Floor" and "Deck Plates".

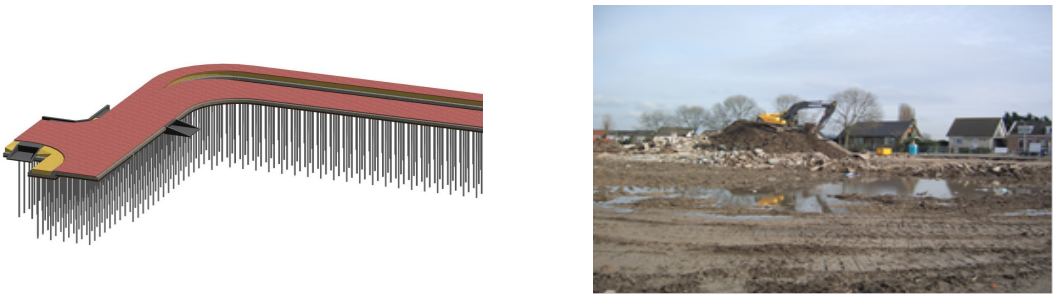

Figure 1: Concept of "Spijker Bed" representing, "Working Floor", "Deck Plates" and "HSP Concrete poles" (Left), "Working Floor" in progress (Right)

Figure 2: A High Speed Poles (HSP) special concrete mixture is being introduced through a drilling unit to make of HSP at Waddinxveen (left hand photo). (right hand photo) This is how the final construction of "Spijker Bed" looks after applying the top layer.

Conclusions:

- MGX conducted in-depth studies and constructed > 80,000 m^2 (since 2006), using MGX Technology (Mecalithe®) one example (Waddinxveen) is discussed;
- CS/BS (N/mm^2), density, leaching and other related parameters are qualifying;
- 100 % toxic waste is used, cement was reduced more than 40 %;
- The leaching profile of 15 cations and 4 non-metal ions is passing the DT (NEN 7375) for the deck plate and all DT (NEN 7375) and ST (LS0-10) for the working floor;
- This leads to environment protection, as CO_2 emissions are reduced due to cement and steel and (hazardous) waste reduction;

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Abbreviations:

HSP: High Speed Poles
CS: Compressive Strength
BS: Bending Strength