CHAP-YT – RECYCLED AERATED CONCRETE AGGREGATES IN TRADITIONAL SCREED FOR FLOORING

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Summary

Aerated concrete is one of the few constituent parts of demolition rubble for which no valid recycling technology has been developed. Anno 2010 aerated concrete is a problem waste fraction. It is undesirable in the stony fraction (concrete rubble, mixed rubble) because of the poorer technical characteristics for the traditional applications in foundations and under foundations of roads. In addition, the chemical composition (leaching of sulphates) may also cause problems in other applications (embankment, supplement, concrete) or in landfills.

Recycling the aerated concrete in the production itself (closing the loop) is only possible if the waste product is pure enough, which is after demolition works is not easy to guarantee. There is a need for applications within which this fraction of construction and demolition waste can be recycled, and preferably in as high as possible applications so that a direct or good market can be generated for aerated concrete waste.

This paper discusses results from a MIP-project called “Chap-Yt”, in which milled recycled aerated concrete was used as an aggregate to partially replace sand in traditional hand-spread sand-cement screed for flooring purposes.

Keywords: Aerated concrete, recycling, screed

1 Introduction

Each year 92000 tons of aerated concrete waste is produced in Flanders. [1] This amount of waste is expected to grow in years to come. The waste is collected at recycling centres, on demolition sites but a large-scale organized collecting system for aerated concrete has not been set up yet. Some dealers of construction materials distribute big bags to collect aerated concrete waste at the construction site. The producer of aerated concrete takes back the collected waste if the waste is pure. These quantities are limited. The producers recycled a limited amount of their own processing waste as sand fraction into aerated concrete products.

‘OVAM’, the Public Waste Agency of Flanders, aims, as with other wastes, to obtain a as high as possible reuse of this kind of waste. In the ideal scenario aerated concrete waste would be used as much as possible in the production of new high-grade cellular concrete or similar construction materials. For technical reasons this cannot be achieved and other solutions have to be investigated, such as use in concrete.

Recycling of aerated concrete gives inter alia an elevated sulphate leaching and by the structural properties of this waste, problems in finding suitable applications remain.

This study aims to use recycled aerated in applications in which the leaching of sulphate plays no role and where the intrinsic properties of the material can be valorised, in particular the use of recycled aerated concrete in screed.

A pilot run on a real scale to use recycled aerated concrete waste as partial replacement for sand in traditional sand-cement screed was performed by “Jochems Chapewerken NV”, a screed placing firm. This pilot case was commissioned by “Chap-Yt BVBA”, a new firm that wants to sell this kind of screed for sub-flooring. The screed-composition in this pilot project is called “Chap-Yt”, according to the name of the company. The technical aspects and feasibility to use recycled aerated concrete to replace sand in traditional screed were investigated by the research-group “RecyCon” of the Department of Construction of the Catholic University College of Bruges & Ostend, Faculty of Engineering Technology. This paper describes the assessment of the mechanical properties of “Chap-Yt”-mixtures which were made during the pilot project.

2 Properties

To assess the possible use of recycled aerated concrete waste as an aggregate in sand-cement-screed-mixtures, several compositions were made with an increasing percentage of recycled aerated concrete aggregates (RACA). The percentages for replacement are 5 % to 25 % with an interval of 5 %. To prepare the samples, the different RACA-screed-mixtures were made on a test-surface and after 28 days of hardening and drying samples were taken out of the screed-surface. These samples were tile-shaped with a size of 30 x 30 cm^2. On these RACA-screed-sample-tiles tests were run to determine the physical and mechanical properties.

In 2002, the European standard EN 13813 "Screed material and floor screeds: Properties and requirements" was published. This standard came into effect in Belgium in January 2003. Since 2004 ready-mix screeds have to have a CE-label to go on the market. Since it is the aim to produce Chap-Yt as a ready-mix screed, it has to comply with this standard.

The Belgian version of this standard NBN EN 13813 [2] describes screed mortar as a mixtures consisting of binder, aggregates and possibly a fluid that ensures the hardening of the binder, possibly supplemented with additives and fillers. This standard also provides an overview of the required and optional tests to be performed, depending on the binder used: cement, gypsum, magnesite, mastic asphalt or synthetic resin. In case of Chap-Yt, the tests the have to be run are marked in light blue in “Table 1”. Although Chap-Yt is not intended to be used for wearing surfaces, it was still tested for wear resistance according to the Böhme wear resistance test.

Tab. 1 *Screed materials and tests which apply to each type*

Screed materials and tests which apply to each type														
Screed materials based on	Compressive strength	Flexural strength	Wear resistance			Surface hardness	Resistance to indentation	Resistance to rolling wheel with floor covering	Setting time	consistency	pH value	Modulus of elasticity	Impact resistance	Bond strength
			Böhme	BCA	To rolling wheel									
Cement	N	N	N[1]			O[2]	/	O	O	O	O	O	O[1]	O
Calcium sulphate	N	N	O	O	O	O[2]	/	O	O	O	N	O	/	O
Magnesite	N	N	O	O	O	N[1]	/	O	/	O	O	O	/	O
Mastic asphalt	/	/	O	O	O	/	N	O	/	/	/	/	/	/
Synthetic resin	O	O	/	N[1]		O[2]	/	O	/	O	O	/	N[1]	N

N: Normative /: not relevant O: Optional, where relevant
(1) Only for screed material intended for wearing surfaces
(2) Only for screed material with fine aggregates (<4 mm)

2.1 Mix-design and Particle Size Distribution

The mix-design of Chap-Yt-screed is quite basic and only consists of a mixture based on a volumetric cement/sand-ratio. In this study a ratio of 1/7 was used. The used cement is CEM I/ 32,5 R. The mean value of the particle size distribution of an ordinary Chap-Yt--screed-mix is depicted in “Figure 1” and “Table 2”.

Tab. 2 *Particle size distribution of Chap-Yt*

Sieve size [mm]	Cumulated passing [%]	Stdev [%]
16	99,97%	0,02
8	99,94%	0,02
4	99,00%	0,2
2	92,96%	0,36
1	77,69%	0,86
0,5	46,38%	0,83
0,31	17,41%	0,32
0,25	7,63%	0,29
0,125	1,37%	0,02
0,063	0,44%	0,02
0	0,00%	0

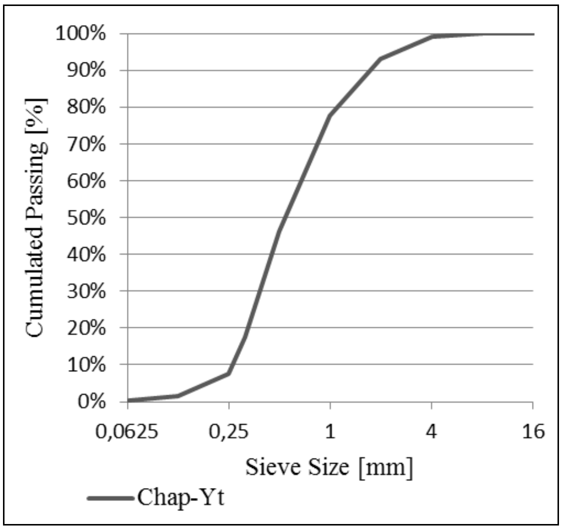


Fig. 1 *Particle size distribution of Chap-Yt screed*

2.2 Density

Upward of 15% replacement of sand by crushed RACA there is a clear decrease in the apparent density noticeable. At even higher replacement rates, 20 and 25 %, there is no significant difference noticed in the density. The lowest value is about 1,700 kg / m³, as shown in "Table 3". The difference in grain size distribution between the mixtures, resulting in a different packing density, can be the reason why the density remains the same above 15% replacement of sand by RACA. It could also been caused by the way the screed was compacted. Since this is manual labour, there is ample control of the compaction of the screed and the quality of the work depends on the skill of the workmen. The crew that made these screed-sample-floors was well skilled personnel, so their work was presumed to be of quality level.

Tab. 3 *Density*

Density of Chap-Yt screed mixtures					
Aerated concrete in the screed [%]	5%	10%	15%	20%	25%
Density [kg/m^3]	1939	1818	1711	1732	1714

2.3 Flexural and compressive strength

The flexural and compressive strength are two major properties that characterize the mechanical properties of a product. These properties were determined according the standard NBN EN 13892-2: "Methods of test for screed materials: Determination of flexural and compressive strength." [3]

The results show no correlation between the percentage of RACA used in the mix and the flexural strength. See "Figure 2". According to the standard NEN 2741: "In-situ floorings: Quality and execution of cementious screed" [4], the screed should reach a flexural strength between 1 and 7 MPa to be fit for use in houses and offices. This requirement is fulfilled. In accordance with Table 3 of the standard NBN EN 13813 [2], the flexural strength class is designated as "F3".

There is apparently a slight increase of the compressive strength observed in mixtures with a higher percentage of substitution, with the exception of the mixture with 20% replacement, where the compressive strength of the same order of magnitude as that of the mixture with 5% substitution. The results of the compressive strength are shown in "Figure 3".

The variation in the compressive strength is probably not the result of the mixing ratios at which a higher degree of substitution would provide higher compressive strengths. The compressive strength of traditional hand spread screed is rather determined by the compaction of the screed during application and this not controllable.

According to the CSTC – Technical Information 189 [5], the compressive strength may not be less than 8 MPa in-situ placed screeds. The mixtures with 5 % and 20 % do not satisfy this requirement, although Annex A1 of NEN 2741 [4] recommends a compressive strength for screed determined in-situ between 5 and 7 MPa, for use in houses. Here Chap-Yt complies with the standard NEN 2741 and in accordance with Table 2 of the standard NBN EN 13813 [2], the compressive strength class is designated as "C7". For use in offices, the compressive strength should reach 12 to 20 MPa, depending on the application. Chap-Yt does not meet this requirement therefor it can only be used as screed in houses.

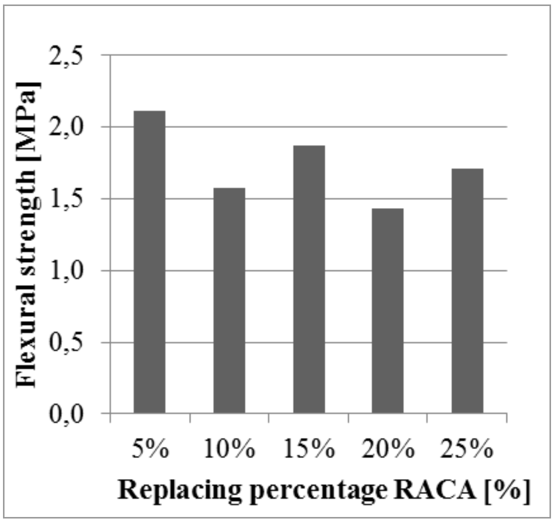


Fig. 2 *Flexural strength of Chap-Yt*

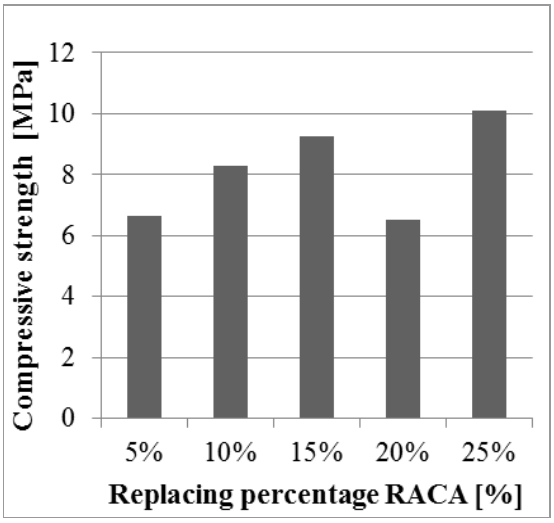


Fig. 3 *Compressive strength of Chap-Yt*

2.4 Resistance to wear

The resistance to wear was determined according to the standard NBN EN 13892-3: Methods of test for screed materials – Part 3: Determination of wear resistance-Böhme (May 2004). [6] It is not required to perform this test, but the results gives an indication if the screed can be used unfinished or if it has to be finished with a firm top layer, e.g. tiles. The tests are run on specimens that were taken out of lager test-samples of the screed. The surface of the specimen is 50 mm² and the loss in thickness and/or in mass is determined. This was done on all mixtures. To be useful without tiling, the loss should not exceed 22mm³/50mm² after 16 cycles of 22 revolutions. This is measured on 9 places on the surface. The results indicate that Chap-Yt-screed is not fit for use without tiling. “Figure 4”.

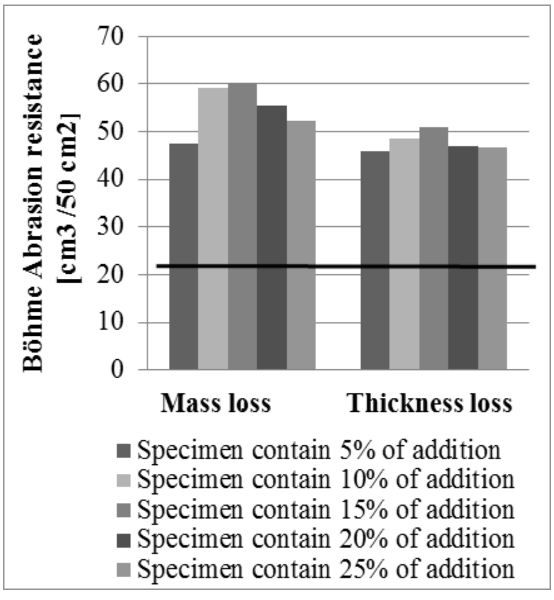


Fig. 4 *Böhme wear resistance*

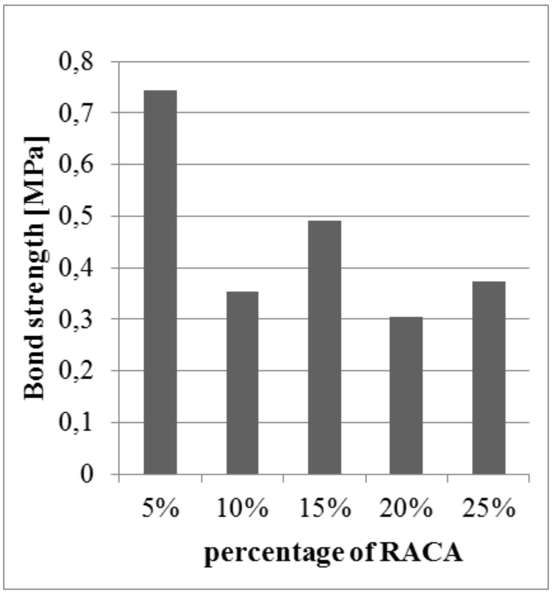


Fig. 5 *Bond strength*

2.5 Bond strength

The bond strength was determined according to the standard NBN EN 13892-8: Methods of test for screed materials – Part 8: Determination of bond strength. [7] This European Standard specifies a method for determining the bond strength between a screed and a standard substrate for specimens made from cementitious screed, calcium sulphate screed, magnesite screed and synthetic resin screed material. The bond strength is determined by applying a pull off test on a circular cross section with a diameter of 50 mm which is glued with an epoxy resin on a test area of the same size. The test area is made by coring through the screed. Tensile stress is applied by a direct load perpendicular to the bond area. The bond strength is calculated as the quotient between the failure load and the test area.

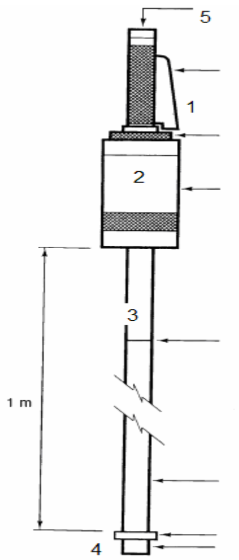
The type of the failure was always cohesive failure in the screed, indicating that there is no problem in terms of bond on the surface. The finishing of the floor with tiles can be done by using cementitious tile adhesive. The variations in the test results are probably due non-homogeneous compaction screed, which is inherent to the method of applying the screed. See “Figure 5” on previous page.

3 BRE screed field test

Chap-Yt screed has been used in a test case in a house in Zoersel, Province Antwerp in Flanders. It was applied on the second and third floor. About 170 m² Chap-Yt screed was put in place. The screed in this test case has been assessed to see if it was adequately compacted to withstand loads on the floor in service. This was done through a drop testing with the BRE Screed tester. At the time of the tests, the screed was 28 days old. The selected spots for the test where chosen at 1,5m distance from each other and from the walls. The screed is classified in three classes, according to the imprint after dropping a weight of 4 kilos on an anvil from a height of 1 meter. Measurements were taken on the second floor in the living room, the kitchen and the sleeping room, and on the third floor in the living room, the kitchen and two sleeping rooms. In total 26 points were tested. The mean value for the BRE screed test was 2,093 mm imprint, with a maximum of 2,79 mm and a minimum of 1,04 mm. Conclusion: in all rooms Chap-Yt screed meets the requirements for use in Class A. See “Table 4”.

Tab. 4 *BRE Screed test – Classes for Use*

BRE Screed Test	
Drop test with 4 kg from 1m high Maximum imprint at 28d [mm]	Suitable for use in
Class A : 3 mm	heavy use: hospitals, industry
Class B : 4 mm	medium use: public places, corridors, main elevator, lobby, canteens, restaurants, offices,,,
Class C : 5 mm	light use: small office, waiting room, housing



1 release
2 drop weight
3 guide rod – 1m
4 anvil – 500 mm²
5 level

Fig. 6 *BRE Screed Tester*

Fig. 7 *Chap-Yt screed put in place*

4 Sustainability aspects

Aerated concrete is one of the elements that can be found in the composition of demolition waste. Due to its poor mechanical properties, aerated concrete is unwanted in the stony fraction of demolition rubble that is to be recycled as aggregate for use in concrete. At this moment no valid recycling technology has been developed for used aerated concrete. By using recycled aerated concrete as an aggregate in screed mixtures to replace up to 25 % of sand in conventional cementitious screed mixes, a sustainable solution is found for this waste problem. Since these screed mixes are used in indoor applications, no problems are caused by leaching of sulphates into the ground. Test results show that the level of leached sulphates (844 mg/kg DS) is far beneath the maximum level (2200 mg/kg DS in VLAREA).

Aerated concrete is considered to be a problem waste fraction. Each year 92000 tons of aerated concrete waste is being produced in Flanders. [1] This amount of waste is expected to grow in years to come. The waste is collected at recycling centres, on demolition sites but a large-scale organized collecting system for aerated concrete has not been set up yet.

There is a need for applications within which this fraction of construction and demolition waste can be recycled, and preferably in as high as possible applications so that a direct or good market can be generated for aerated concrete waste.

Some dealers of construction materials distribute big bags to collect aerated concrete waste at the construction site. These quantities are limited. The producers recycled a limited amount of their own processing waste as sand fraction into aerated concrete products.

5 Conclusions

Results of tests for determination of the mechanical properties of Chap-Yt indicate that this kind of screed composition consisting of sand, cement and up to 25 % of recycled aerated concrete, can be used as a traditional screed for flooring compared to ordinary hand-spread sand-cement screed. Laboratory tests show that this kind of screed can be used in houses but they aren't fit for use in places where a lot of heavy traffic passes, like in hospitals. However, the BRE screed tests that were carried out on a test case in a real application indicated that this kind of screed mix can be well compacted so that it is fit for use in class A applications like hospitals and industry. From the results of the resistance to wear, determined with the Böhme wear test, it becomes clear that this screed has to be finished with a solid floor covering like tiles.

Hand spread ordinary sand-cement screeds are widely used in a lot of house building projects. The screed composition with recycled aerated concrete, Chap-Yt, is a good alternative screed composition that contributes to finding a solution for a fraction of construction and demolition waste that otherwise is difficult to be recycled. With this application for recycled aerated concrete, a step forward was made toward a sustainable materials management and closing the loop.

References

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