RECYCLING OF C&D WASTE IN BELGIUM: ONGOING RESEARCH AND RELEVANT DEVELOPMENTS

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Summary

Recycling of Construction and Demolition Waste in Belgium is a well developed industry, with more than 150 companies. The industry successfully evolved and broadened gradually its action field since the beginning of the nineties. This was feasible thanks to a close collaboration with research bodies, certification organizations and regional authorities. The uptake of recycled aggregates in technical specifications and the legal framework for secondary materials played a key role in this.

Currently, a series of research projects are up and running in order to optimize processing and recycling of C&D Waste streams. One of them focuses on the value chain of C&D waste, and involves a rethinking of all steps which lead to waste (i.e. taking into account construction, (selective) demolition, transport and recycling). A more technologically oriented research aims to look for reuse of fine recycled aggregates in sub-floor applications, and recently, the VALRECON project started up and will look for reuse of high quality recycled aggregates in recycled concrete.

At the same time, changes take place in the legislative field, the certification circumstances and even the standards area. Most of these changes offer new opportunities to the industry, but contain at the same time a number of threats.

In this contribution, an overview of research activities and relevant evolutions in other fields will be given. They may offer lessons and ideas for developments in other European countries. More information is available in the long version of this text on DVD.

Keywords: Recycling, C&D Waste, Concrete, Screeds, Research, Belgium, …

1 State of play

1.1 From experiments to a full-grown industrial sector

At the end of the 1970s, the first Belgian research on recycling of construction and demolition waste (C&D Waste) was executed and focussed on the development of the recycling process: from demolition techniques over crushing technology, sieving and sorting processes to the identification of applications for recycled materials. BBRI's former Director-General published back in 1979 as a young researcher his first insights in the matter, stating that ‘it is technically feasible to produce a ‘regular’ concrete with recycled concrete aggregates with a sufficient strength’ [1].

In the following years, the pioneering role of BBRI was transferred from research to real practical applications. Back in the 1980s, when constructing the new Berendrecht lock in the harbour of Antwerp, which is by the way still the largest lock in the world (500 m long, 68m wide and 17m deep), 200,000 tonnes of recycled aggregates originating from the demolition of the existing Zandvliet lock were applied in the new construction’s concrete. The works were supported and monitored by BBRI and BRRC[1] to guarantee the technical quality and have lead to the first industrial scale recycling plant in Belgium in 1986.

Anno 2010, the Belgian recycling sector can be considered as grown up, with in the Flemish region over 150 fixed locations (sorting of mixed C&D Waste, crushing of rubble, sometimes also mixing of lean concrete) and over 40 mobile installations working under quality certification. On the Walloon side, also about 40 recycling centers are active.

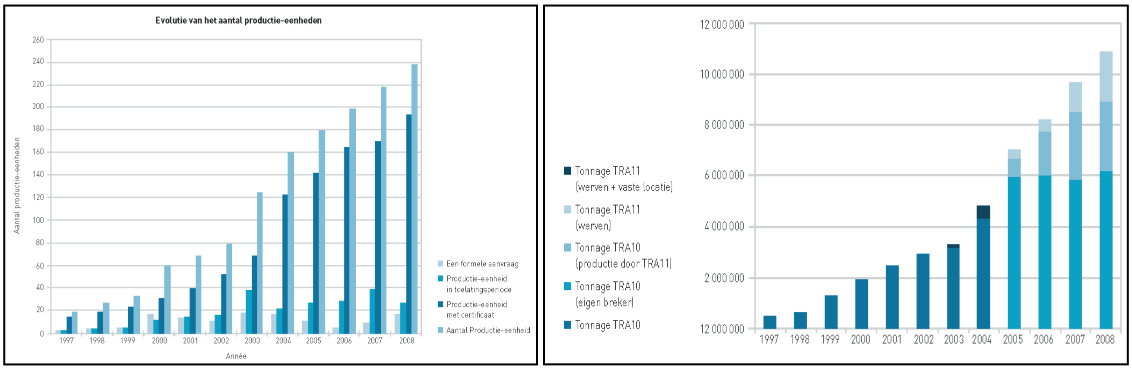

Fig. 1 Evolution of number of production units under COPRO-certification (l.) and total quantity of COPRO-certified recycled aggregates (r.) [2][2]

The recycling industry is processing about 11 million tons of C&D Waste into recycled aggregates in Flanders, which is good for a recycling ratio of over 90% [3]. The Walloon region produces about 4-5 million tons of recycled aggregate. These amounts also include the amount of C&D Waste generated in Brussels (600,000 – 1 million ton). It can be estimated that 90% of the recycled aggregates are used as sub base and base layers in road construction. The other 10% is used in road-like applications on construction sites and about 100,000 to 200,000 tons is nowadays used as aggregate for structural concrete in the private market. This means that less than 1% of the recycled aggregate is used in high-grade applications.

1.2 The establishment of a solid framework

The research and demonstration work helped to introduce recycling practices in the construction industry. An important role was also played by the authorities, in developing a framework of technical specifications for recycling applications.

One of the main barriers for expansion of the sector in the 1990’s was indeed the lack of technical prescriptions. Thanks to a collective initiative, i.e. the set-up of a working

[1] Belgian Road Research Centre

[2] Besides COPRO, also CERTIPRO functions as a certification organisation for recycled aggregates. Currently 4 important recycling plants dispose of the QUAREA certificate for their products.

group of LIN[3] - 'Hergebruik van Afvalstoffen' (Reuse of waste materials), several specific technical specifications for government projects were drafted, allowing amongst others the use of secondary aggregates in road construction applications. This resulted in the uptake of technical prescriptions for recycled aggregates in the Standard Specifications for Road Constructions (SB250) in the Flemish region by 1996 [4].

Also in the Walloon region, initiatives were supported by the government in order to start up the recycling industry. With the input of the Walloon government, the organisation TraDeCoWall[4] was founded in 1991 in order to start recycling C&D Waste, to identify practical and reliable solutions for the management of waste originating from building and demolition sites and to develop valorisation options for those wastes. This initiative was later on also supported by the publication of Walloon technical specifications for public road works in which recycling was permitted in some areas (by MET, now in SPW[5]).

Besides the technical aspects, also the aspects of environmental protection were covered by authority initiatives. Following the Waste Decree of 1994, OVAM[6] was responsible for the definition of the Strategic Waste Management Plan in 1995, in which the ambition of a 75% recycling rate of C&D Waste in Flanders by the year 2000 was defined. In 1997, the first version of VLAREA[7] regulation was published. The VLAREA regulates the administrative and environmental hygiene requirements (leaching, ...) for C&D Waste in order to be allowed for reuse in or as –amongst others- building materials. The VLAREA also implied a quality control and certification scheme for recycled aggregates, and was in this field the first legislation in Europe. In those days, the "COPRO" certification scheme emerged and allowed for the marketing of certified recycled aggregates.

Back in 1993, high grade applications such as recycled concrete with recycled aggregates were heavily debated. A LIN working group even prepared technical specifications for "recycled concrete" [5], but notwithstanding the earlier positive demonstrations by BBRI, the market and government bodies were still reluctant. At the time the specifications were not approved.

1.3 A comparison with other countries

The Belgian situation sketched above, shows that there is a well established framework and recycling practice, where up to 85-90% of C&D Waste is recycled. This is one of the better recycling rates in Europe, together with the Netherlands, Germany and Denmark [3].

This high success rate in Belgium is explained by the need for recycling on the one hand, since disposing non-final and recyclable waste is no longer accepted. A secondary aspect is that the Flemish part (the North) of Belgium has only limited access to virgin aggregates (and is reducing gradually the quarrying of sand and gravel in the Meuse). The Southern part, the Walloon region, has more quarries and produces therefore important amounts of crushed natural aggregates. Comparison with other countries learns that the need for recycling in The Netherlands is even higher, whereas the urge to use recycled

[3] LIN stands for the Department Environment and Infrastructure of the Flemish Community, now known as the Department Mobility and Public Works (MOW).
[4] Société Coopérative pour le TRAitement des DEchets de COnstruction en WALLonie
[5] MET =Ministère Wallon de l'Equipement et des Transports, Walloon Ministry of Infrastructure and Transport, SPW= Service Public de Wallonie
[6] Openbare Afvalstoffenmaatschappij voor het Vlaamse Gewest – Public Waste Agency of Flanders
[7] VLAREA stands for the Flemish Regulation for Prevention and Management of Waste

aggregates in Germany, Denmark, Norway or France is less, since there are many natural resources available.

On the other hand, the (micro-)economic conditions for recycling (cost/benefit) are beneficial in a densely populated country as Belgium. The produced C&D Waste can be processed to qualitative recycled aggregates in a mobile plant on site (no transport costs) or in a fixed recycling centre nearby (small transport distances). The recycled aggregate is in a lot of cases competitive with virgin aggregates. However, due to a large, and sometimes illegal, competition in the (Flemish) recycling sector, the profit margins on the recycling process are rather limited. This also prohibits further investments in the production of a higher quality product that can be used in concrete, together with the uncertainty of a steady inflow of concrete waste.

A third aspect in the success of recycling is policy and standardisation, which can translate itself into levies on virgin aggregates, setting recycling targets (cfr. new Waste Framework Directive of the EU), stimulating the use of recycled aggregates in public works (Green Public Procurement, demonstration projects, technical reference documents) and the establishment of a normative framework. For recycling into concrete, this is considered as one of the main barriers in Belgium. Until recently there were no documents describing or prescribing the allowance of recycled aggregates in structural concrete, whereas in other countries with a high recycling rate (The Netherlands, Germany, Austria, ...) this framework exists and the standards for Aggregates for concrete and Concrete itself either have integrated specifications for recycled aggregate in the text, or have technical reference documents stating the possibilities and limitations towards the use of recycled aggregate into concrete [6].

1.4 New & remaining challenges

A study by VITO for OVAM [7] investigated over 100 aggregates samples on environmental soundness. Results showed that 11% passed one or more thresholds for composition (organic substances) or leaching (heavy metals, inorganic substances). Recycled aggregates are as a consequence still regarded as waste with inherent environmental risks and problems. Extra efforts are clearly needed to optimise the environmental and technical quality of recycled aggregate.

A research track, funded by the Grindfonds[8], followed now is the possibility for 'whole chain management' where, on a project basis, the (high-value) quality of the recycled aggregate is guaranteed, by acting at the source (demolition). Also in the field of legislation and quality control, the 'chain management' track is pursued.

Confidence is also what lacks when it comes to using recycled aggregates in structural concrete. Further work is to be done to prove the possible use of RCA in certain concrete applications, and thus obtaining a high value use for RCA, and to transfer this knowledge towards SMEs and the entire recycling sector. Such type of research is currently funded by IWT[9] in the TETRA-programme, which stands for Technology Transfer.

[8] The 'Grindfonds' is a fund, fed by the levies on the gravel quarrying in the province of Limburg, and strives to stimulate the research for gravel substitutes and supports commercialization activities.

[9] Agentschap voor Innovatie door Wetenschap & Technology – Flemish agency for innovation through science & technology

Within the TETRA-programme, also the remaining problem of recycling the fine fraction, the recycled sand, is tackled. New applications, such as screeds, are investigated in cooperation with the recycling sector.

These different research efforts are highligthed below, in relation to the initiatives taken on normative and policy level.

2 The value chain

2.1 New Flemish legislation on waste management & recycling

In 2009, a new version of the Flemish legislation on waste management and recycling, VLAREA, was published. For C&D Waste the existing framework on environmental characterization was enlarged with two important concepts [8].

2.1.1 Total or Whole Chain management

First of all, VLAREA introduces the chain management concept by stating the following: "*The list of environmental parameters to verify is limited to heavy metals (As, Cd, Cr, Cu, Hg, Pb, Ni, Zn), extractable organohalogens (EOX), mineral oil and PAHs, on the condition that the recycled aggregates (except asphalt) comes from a recycling centre, subjected to a management system, approved by OVAM*" [8]. This management system is at the moment being elaborated by the sector representatives and will contain the principle of 'chain management'. This means that a distinction will be made between suspicious and unsuspicious C&D Waste at the acceptance at the recycling centre, based on the origin of the waste. When the rubble has been selectively demolished, no problems are to be expected. In the other cases, the waste will be treated as suspicious and will need further analysis and processing steps. Other aspects in the Chain Management System are adapted frequencies of testing, based on a statistical approach and the responsibility of each actor in the recycling chain.

2.1.2 Waste inventory before demolition

In order to allow for a correct price setting and a correct follow-up of (dangerous) waste streams, the VLAREA imposes since May 2009 that "*for buildings with a (partially) different function than housing, and an enclosed volume over 1000 m³, a waste inventory for demolition has to be drawn up, before awarding the work to a contractor, by an architect or another expert. The owner of the urban development or building permit (in most cases the client) is responsible for this. The inventory should list all waste fractions that will come from the building, their type (hazardous, inert, ...), appearance and presence in the building and quantity.*" [8] This means that for industrial buildings (but also schools, shops, ...) of a certain dimension, a pre-demolition assessment must be executed to list all hazardous and other waste fractions. Based on the listed materials, the demolition contractors can define their price offer based upon the same information, which should allow for a more fair competition in the market and a better follow-up of hazardous waste throughout the chain.

2.1.3 Chain management in a projectwise approach: from pre-demolition assessment to high value recycled aggregates

A research project, funded by the Grindfonds and executed by BBRI and Enviro-Challenge, aims at demonstrating the benefits and possibilities of a rigorously applied chain management in a demolition and construction project. Work has been performed on pre-demolition assessment methodology and knowledge, controlled demolition, quality assurance and technical reference documents for application of the recycled aggregates. Several case studies are executed, in which the different steps of the chain are followed and demonstrated. One of them, the Dossche case, is illustrated in the following paragraphs.

The Dossche case relates to an ancient cattle fodder production plant dating from the 1960s and situated in Heusden-Zolder. It consists of 2 large towers, connected by a bridge and flanked by several hangars for storage and a large building with silos.

Fig. 2 An overview of the ancient cattle food factory 'Dossche' in Heusden-Zolder.

Both BBRI and Enviro-Challenge were partners of the European IRMA-project (Integrated Decontamination and Rehabilitation of Buildings, Structures and Materials in Urban Renewal) dealing with contamination in buildings and management of recycling in large-scale urban demolition and construction projects. An important result of the IRMA-project was a methodology for identifying contaminants (asbestos, PCBs, PAHs, mineral oil, other chemical substances) in buildings to be demolished. It includes a pre-demolition assessment in 4 steps [9]:

1. historic records of the building: what materials were used, were there any incidents, what activities took place in and around the building
2. site visit: a verification on site is an absolute prerequisite in order to verify the suspicions identified in phase 1 and to visually assess the condition of the building and identify other possible contaminations.
3. sampling and testing: some contaminants (PCBs) might be invisible, some contaminations might be severe, others might be only superficial or even not relevant. Sampling and chemical testing are necessary at that moment, eg. to check the penetration depth of mineral oil in a concrete floor.
4. establishing a plan for selective demolition to produce a clean, uncontaminated fraction as large as possible and a limited, contaminated part that is kept apart to avoid contamination of the recyclable rubble.

Applying this methodology on the Dossche case learned that, from a historic point of view, the following contaminations could be expected:

- tar containing roofing materials on all roofs
- oil tanks present
- asbestos could be present in all types of applications (packagings, insulation, panels, ...)

An extra asset in the pre-demolition assessment was the presence of an ancient employee of the factory during the site visit. This helped to identify following potential hazards:
- transformers, possibly containing PCB-oils (see Fig. 3)
- fire incidents on the plant (in the silos)
- large mineral oil spills in the garage space (see Fig. 3)
- contamination of surfaces by the chemical products used in the production process (enrichment of metals & minerals)

Fig. 3 Contamination of the garage with mineral oil (l.) and with PCBs in the transformer space (r.)

In order to ascertain the presence or absence of contaminants, several cores were drilled and the concentration of hazardous components in the concrete layers was examined. The results showed that certain spots were in fact severely contaminated by mineral oil and PCBs. PAHs and heavy metals were tested as well, but apparently these components didn't form hazards or risks.

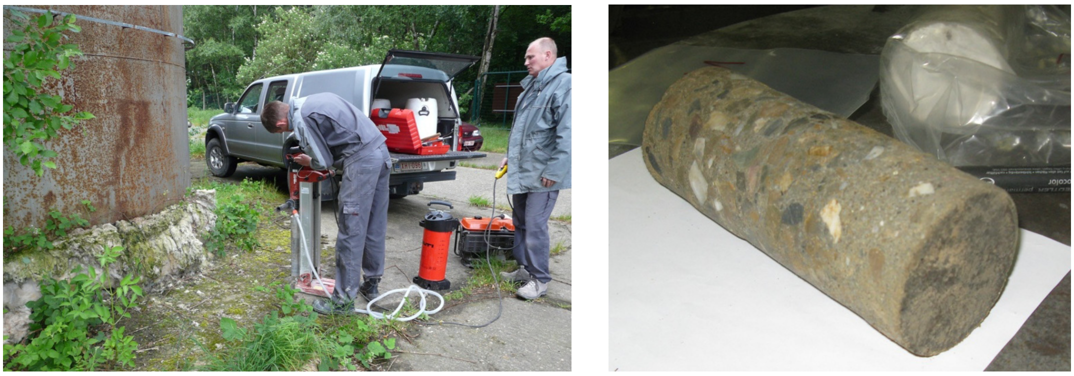

Fig. 4 Drilling cores to analyse the concrete slabs on presence of contamination

Also in other case studies the same approach was followed: contaminants were identified, or suspected hot spots were cleared as 'non-hazardous'. This projectwise approach shows the benefits of pre-demolition assessment: instead of evacuating all waste as potentially 'hazardous', the dangerous substances are well defined and can be separately processed, without contaminating the valuable and recyclable (concrete) waste.

3 Recycling C&D Waste in screeds

In order to overcome the future shortage of natural sand caused by extraction restrictions, an alternative to importing sand, is the replacement of natural sand by fine recycled aggregates. Since sand is the main ingredient in screeds used in sub-floorings, research projects were set up to determine the amount of recycled concrete aggregate (RCA) and mixed aggregate (RMA) that can replace sand in screed mixtures. In doing so a solution could be found for the left-over sand-fraction of recycled aggregates. In the following paragraphs results of these ongoing research projects are presented.

3.1 Properties of the recycled aggregates used

The properties of different kinds of fine recycled aggregates were analysed, compared to natural sands. The figure below shows the grading of the different tested sand types. The other sand characteristics are summarized in table 1.

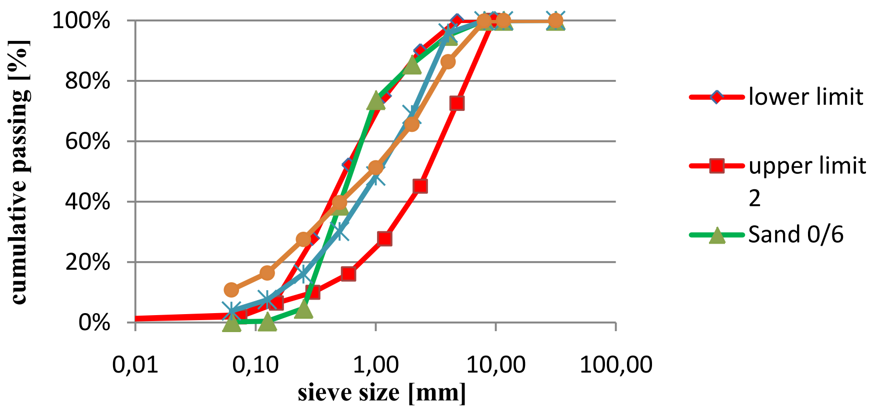

Fig. 5 Grading of the fine recycled aggregates under study

Tab. 1 Properties of the fine recycled aggregates according to PTV 401

Aggregate	Fines < 63µm (% m/m)	Sand equi-valent	Class. PTV401	Absolute density (kg/m³)	Water absorption (%)	Organic content
Sand 'C' 0/4	0,2	97,0	A	2538	3,32	none
Mixed RA A 0/4	3,8	67,8	A	2417	14,6	low
Concrete RA A 0/4	8,9	81,4	A	2371	7,2	none
Mixed RA B 0/4	10,8	50,1	B	2338	11,4	low
Mixed RA D 0/6.3	8,8	43,9	C	2518	12,0	higher

The results show that recycled mixed aggregates contain more fines and clay-like particles. The absolute density of recycled aggregates is apparently slightly lower than the density of natural sand 'C'. As expected, water-absorption of recycled aggregates is higher than for natural aggregates and this is even more so for recycled mixed aggregates. The higher porosity of recycled aggregates and the presence of masonry particles, which are more porous than concrete, explain this. As a result of this, the water-demand will be higher for mixtures with recycled aggregates.

3.2 Designing a screed mixture and applying it on site

The selected fractions – natural sand 0/4, fine recycled concrete aggregates 0/4 and fine recycled mixed aggregates - were used in a mixture design. The aim was to obtain a traditional hand-spread sand cement screed with a compression strength of 15 N/mm² and an optimized recycled content.

The amount of recycled aggregate replacing natural sand was increased with steps of 10% up to 80%. In all mixtures the cement dosage was kept on 220 kg/m³. Test results show (see Fig. 6 and Fig. 7) that up to 65% of fine recycled concrete aggregates (RCA) can be put into the mixtures and up to 45% of fine recycled mixed aggregates (RMA). Results illustrate that the compression strength of the mix even increased while adding recycled sand.

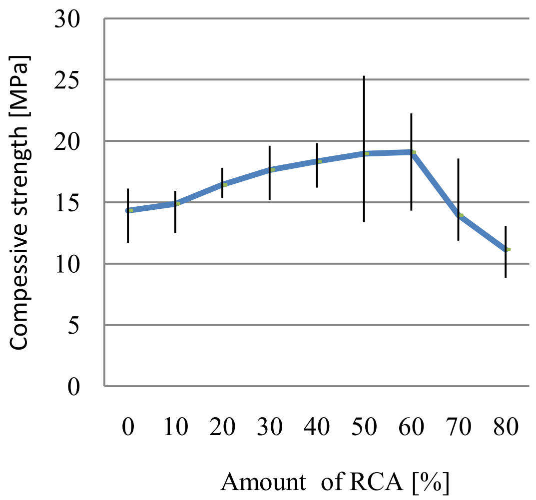

Fig. 6 Compressive strength in function of replacement percentage (RCA 0/4)

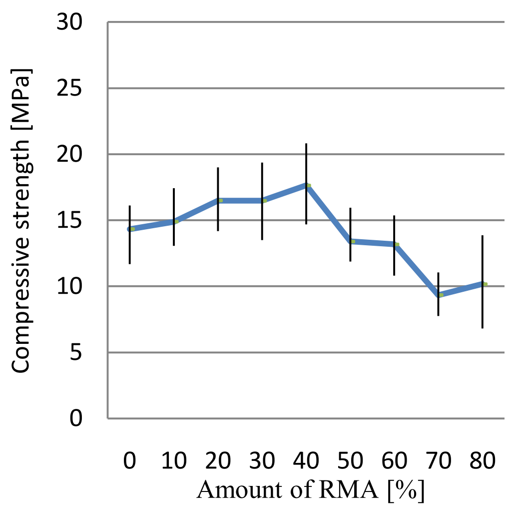

Fig. 7 Compressive strength in function of replacement percentage (RMA 0/7)

However, not only compression strength is an important parameter. Also workability and finishing properties proved to be very relevant in a series of in situ tests. As illustrated in Fig. 8, 200 m² of subflooring was put in place with 6 different mixtures. The used mixtures are the ones mentioned in the table 2 (0%, 30% replaced by RCA 0/4, 30% replaced by RMA 0/4) with a cement dosage of respectively 220 and 250 kg/m³.

Tab. 2 Shrinkage of different mixtures

Mixture composition	Measured shrinkage in situ
100% sand	0,5 mm/m
70% sand + 30% RCA 0/4	0,8 mm/m
70% sand + 30% RMA 0/4	0,9 mm/m

The subflooring was put into place by labourers who are familiar with the technique of spreading out traditional earth-dry screed mixtures. Based upon their input using more than

30% recycled aggregates in the mixtures appeared unrealistic as smoothening and finishing the surface of subflooring became too difficult with higher replacement percentages.

As recycled aggregates tend to have more fines than natural sand, using too much of these recycled aggregates results in a smooth, dense mixture which is more difficult to spread out. At the same time enclosing large air-bubbles becomes highly probable and wet places could appear on the fresh finished surface. With coarser sands the replacement percentage could be increased up to 50%, but the experienced contractor clearly didn't like this because of the finishing problems.

The drying shrinkage tends to be somewhat higher when using mixtures with 30% recycled aggregates compared to a natural mix. In results of measured shrinkage in situ are compared. In all cases the drying shrinkage ended at 35 days and no visible cracks appeared.

Fig. 8 Full scale test with modified sand-cement-screeds for subflooring

3.3 Conclusion

The results of the laboratory tests and the tests in situ prove that it is possible to use 30% of fine recycled aggregates as a substitute for sand in traditional sand-cement-screeds for sub-floorings. Substituting 30% of natural sand by by recycled aggregates may be an interesting contribution to implementing the cradle-to-cradle principles in sustainable construction.

4 VALRECON: Recycling C&D Waste in concrete

4.1 The Belgian standard for concrete allowing recycled aggregates and the VALRECON objectives

Neighbouring countries (Germany, The Netherlands) allow more for the use of recycled aggregates in concrete, compared to the existing Belgian situation. However, the Belgian draft annex prNBN B15-001:2010 to the European standard for concrete, EN 206-1, envisages allowing for 20%v replacement of coarse virgin aggregates by RCA in concrete for interior applications with a strength class up to C25/30. The new NBN B15-001 will also define quality requirements for the recycled aggregate itself (i.e. specific fit-for-use requirements), such as limits for granular size, composition (constituents), resistance to fragmentation, density and water absorption.

The VALRECON project , executed in close cooperation with the recycling and concrete sector, tries to go further by tackling the image problem of RCA that still exists and by proving that it is possible to produce concrete in the strength classes C20/25 and C25/30 while replacing 50% or even 100% of the coarse aggregates by coarse RCA. In its approach VALRECON studies also if it is possible to use very high replacement percentages in specific situations where lower strength or durability demands are valid.

4.2 Quality of Recycled aggregates

Prior to making concrete with RCA, the properties of the RCA are determined, evaluated and related to the state-of-the-art in crushing and sorting technology and the technical and environmental requirements. According to the standard NBN EN 933-5:1998 and its amendment NBN EN 933-5/A1:2004 the percentage of crushed and broken surfaces is determined. Preliminary results in **Fig. 9** show that the RCA under study have more round aggregates in the midsized zone between 8 and 18 than in the finer or even the larger aggregates. In principle the midsized fraction 8/20 will deliver a better workability of the fresh concrete.

The absolute density of the RCA is determined according to the standard NBN EN 1097-6:2000 (+ AC:2002 + A1:2006). **Fig. 10** shows a lower density for the finer fraction.

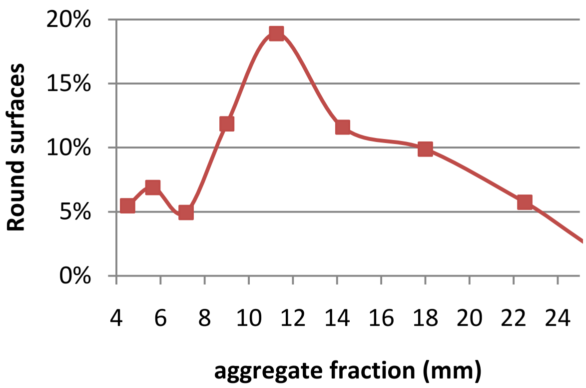

Fig. 9 Round surface per aggregate fraction

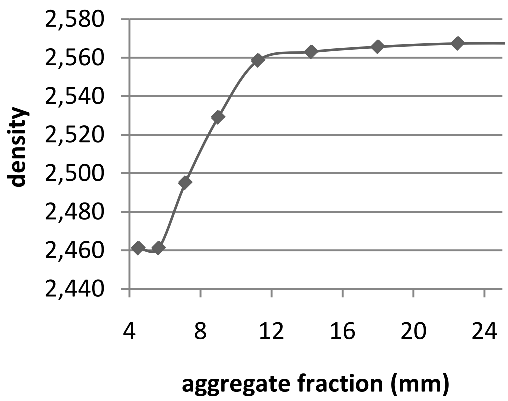

Fig. 10 Relation between density and RCA size

The first results of the identification and classification of the components present in RCA according to NBN EN 933-11:2009 show that the finest fraction contains more contaminants like organic and other non-inert material (**Fig. 11**).. Above 8 mm the presence of these unwanted components is much lower and the stony fraction is nearly 100%. In all cases the RCA respond to the requirements of NBN EN 12620:2008.

A high water absorption will influence the need for water, the workability and indirectly the mechanical properties of the concrete. Therefore, the water absorption of the RCA is determined according to NBN EN 1097-6:2000. As expected, the water absorption is higher for finer particles than for larger ones. This research confirms again that limiting the fine fraction in RCA is a sensible thing to do: water absorption problems, workability uncertainty and the presence of contaminant particles are avoided.

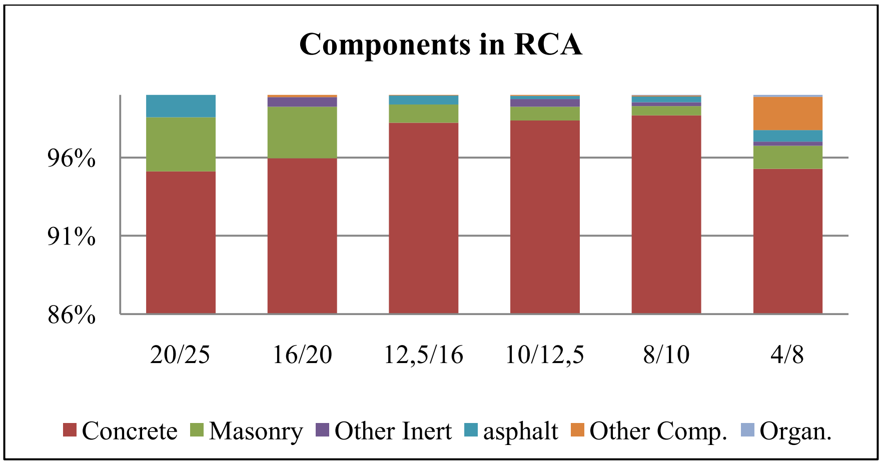

Fig. 11 Composition of RCA

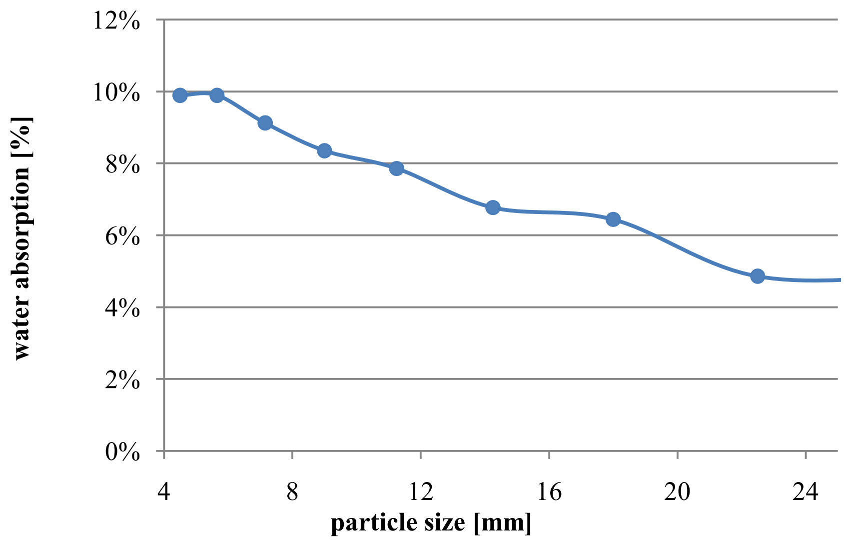

Fig. 12 Water absorption of RCA

4.3 Concrete mixes with high volume replacement: first results

The VALRECON research program focuses on the technical aspects of the mix design of concrete for strength classes C20/25 and C25/30. Given the nature of TETRA-projects and the required practical outcome of the research for the companies cooperating and financially contributing, the research work is ‘industry oriented’. Concrete mixes are designed with a constant workability and aggregates used have a commonly applied grading 8/20. The aim of the research is to aim for a 100% replacement in concretes C20/25 and C25/30 for EE2 environment class according to NBN B15-001 or classes X0, XC1, XC2, XC3 and XF1 according to EN 206-1.

Based upon this context, the slump was set at S3, the W/C-ratio is limited to a maximum of 0.55 and the minimal amount of cement is 300kg. To meet the workability demands, the amount of cement was slightly increased together with the water demand. In a second step water reducing additives were added to the mixture and the effect of the dosage was examined.

The preliminary results indicate that it is feasible to produce concrete mixtures in strength class C25/30 with 100% replacement of the coarse natural aggregates by recycled concrete aggregates 8/20. Figure 13 shows the results of 6 different mixes where the aim was to reach for a compression strength of 25 MPa on cylinders. The preliminary tests were clearly not always successful, but one has to take into account that only a limited number of parameters were studied. The amount of coarse RCA was kept constant to a level of 41% [M/M] of the total mass of the mixture and the workability was kept constant on S3.

Table 3 illustrates clearly the impact of the use of water-reducing admixtures: using water reducing admixtures allows to reach the required consistency without endangering the compressive strength.

Tab. 3 Concrete compositions with 100% RCA 8/20

Mixture n°	Cement-dosage [kg/m³]	Water-reducing admixture [%]	W/C-ratio [%]	Compression strength [Mpa]
1	270.4	1.58	44	30.8
2	272.0	0	56	21.7
3	322.0	1	36	33.6
4	306.7	0	52	25.6
5	275.5	0	61	19.4
6	287.3	1	46	22.3

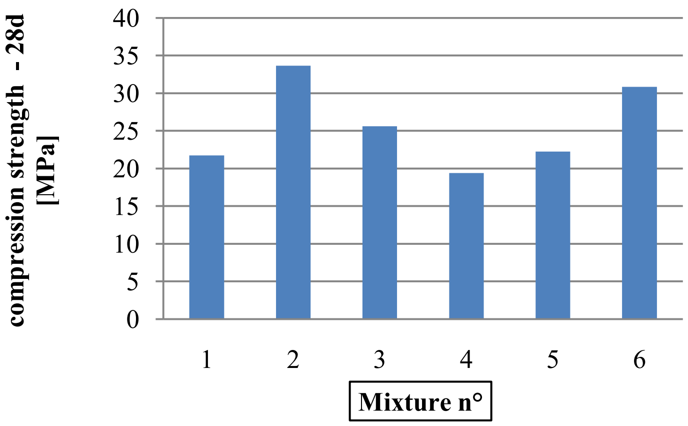

Fig. 13 Compression strength on cylinders at 28 days

5 Conclusions

Belgium has a well established C&D Waste recycling practice, delivering high quality end products that are mainly applied in road constructions and in bound and hydraulically-bound applications. Improvements can still be made, on the one hand in terms of environmental quality, which is supported by new legislation and research on chain management and pre-demolition assessment.

On the other hand, also new and more ambitious technical recycling solutions (fines in screeds, coarse aggregates in concrete) are being developed in cooperation with the sector.

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