VALORIZATION OF CONSTRUCTION AND DEMOLITION WASTE, A ROUTE TO CIRCULAR ECONOMY: THE VALDEM PROJECT VALORISATION DES DÉCHETS DE CONSTRUCTION ET DE DÉMOLITION, UNE VOIE VERS L'ÉCONOMIE CIRCULAIRE : LE PROJET VALDEM

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INTRODUCTION

From resource prospective, building and construction sector is responsible for more than third of global resource consumption, and its generation of solid waste is estimated to be 40% of the total waste volume. At European level, construction and demolition waste is the largest waste stream representing one third of waste produced in EU. Therefore, the resource efficiency and management is crucial in building construction.

A very significant part of the construction and demolition waste (CDW) is not recycled today. In addition, a very limited part is used as a recycled content in the construction and building products and materials. This lack is mainly due to heterogeneity and dispersion of waste flows, decreasing efficiency and economic viability of recycling. To address this issue, VALDEM project (funded by Interreg FWVL European Fund) aims to overcome barriers to increase up-cycling applications. The project focuses its activities in North of France, Flanders and Walloon regions (Belgium), and stands out from usual approaches by its cross-border view of circular economy.

VALDEM aims, on the one hand, to optimize buildings end of life management by developing new deconstruction, sorting and recycling processes to produce uniform and accessible material flows. On the other hand, the project aims at increasing recycling and generating high quality secondary materials (concrete and other flows) to be used in future buildings within an up-cycling prospective. Finally, it aims at validating the solutions from technical, scientific, economic and environmental point of view.

The environmental evaluation, based on life cycle assessment (LCA), consists of identifying hotspots and key aspects to prioritize the efforts of different economic actors. As a first step, an LCA meta-analysis is conducted to provide an environmental picture for different potential activities within the scope of the project. As a next step, a comparative LCA is conducted to assess the environmental benefits and impacts of different solutions proposed in the framework of the project in a decision making context. It also helps to limit the impact transfer and to generate the maximum value for all the stakeholders. Finally, results will be transferred to main actors (recycling operators, buildings contractors, product manufacturers …) in the three regions in order to consolidate future key aspects to eco-design a building in light of circular economy.

DATA COLLECTION

The starting point of the project is the realization of an inventory of available waste within the sorting facilities. Some fractions of the waste have already their application or valorization route, but the direct contact with the sorting park managers highlights that other ones are problematic and, at this time, have no market. It concerns essentially the fine and mixed fractions (concrete-brick-plaster-soil). PhD thesis students and research centres investigate different ways to separate them and develop (new) applications.

LCA OF CONCRETE BLOCKS INCLUDING RECYCLED AGGREGATES

Goal and scope

While waiting for the Valdem technical partners results, the LCA team (WP3-A4) used the results of another research project, CONREPAD (BEWARE fellowships), where some Valdem operators were involved (ULiège - GeMME). The theme is the recycling of waste concrete blocks manufactured by the PREFER company (Belgium), and in particular the substitution of natural aggregates (NA) by crushed waste blocks as recycled concrete aggregates (RCA).

The goal of this comparative LCA is to evaluate the impact of the recycling process of the block waste, and to assess the influence of their integration in the making of the blocks in substitution of the NA, in comparison with to the "business as usual" process (NA only).

The CONREPAD study determined that the integration of 30% of RCA did not alter the mechanical properties of the blocks and was therefore conceivable.

The functional unit of the LCA is 1 m^3 of concrete blocks.

The system boundaries for the blocks with natural aggregate only, called NA blocks (B_RCA0) include the production of the block and the landfill of the waste (Figure *1*).

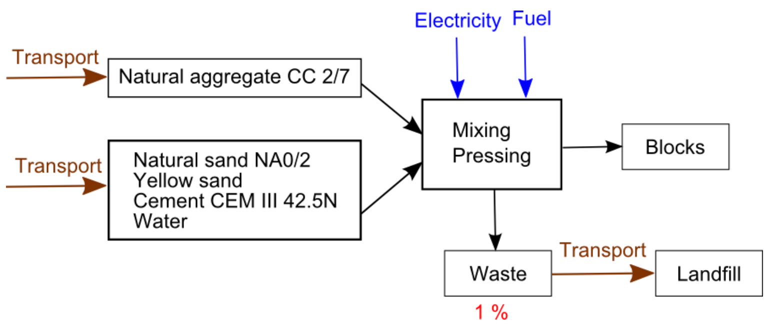


Figure 1: System boundaries for the production of 0% substitution blocks – B_RCA0 (NA only)

The system boundaries for the blocks with 30% of RCA (B_RCA30) include the production of the block, the recycling process of waste (crushing with a mobile crusher, sorting), the valorization of the 2/6.3 fraction in the concrete blocks, the benefit of internal recycling in other products of PREFER of the larger fractions (in substitution of NA – expansion of the system boundaries), and the landfill of the ultimate waste (fine fraction 0/2) (Figure *2*).

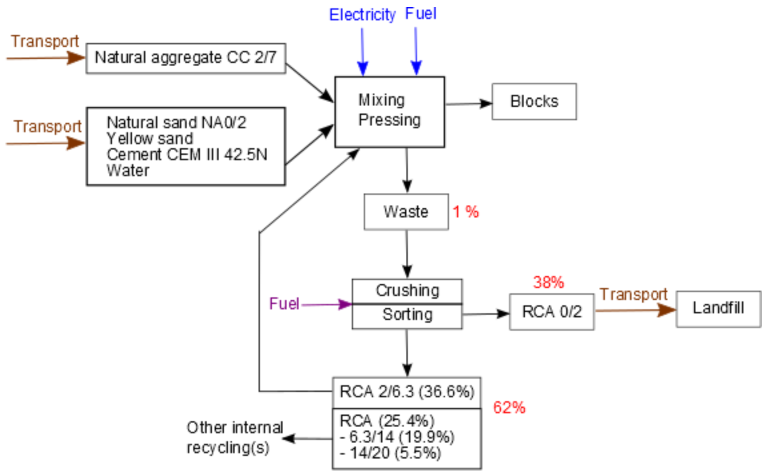


Figure 2: System boundaries for the production 30% RCA blocks (B_RCA30)

Life cycle inventory

Inventory data are primary data from the CONREPAD results, including composition of blocks, raw materials and their source, landfill distances, crushing and sorting of waste by a mobile crusher. Mixing and pressing of the blocks is derived from existing process in the database and adapted to the Belgian case.

Impact assessment and interpretation of results

Ecoinvent database (3.4, November 2017) [1] is used for the modelling of the scenarios.

Impact assessment are evaluated in Simapro 8.5.0 software (2018) (Pré-Consultants, NL), with ILCD 2011 Midpoint+ (1.10) method [2], as recommended by the Joint Research Centre of the European Commission, and in accordance with the ISO 14040:2006 [3] and ISO 14044:2006 [4] standards.

The considered impact categories are Climate change, Ozone depletion, Particulate matter, Photochemical ozone formation, Acidification, Terrestrial eutrophication, Freshwater eutrophication, Marine eutrophication, Land use, and Mineral, fossil and renewable resource depletion.

Since the amount of waste is very low (only 1% of the production), the blocks incorporating recycled aggregates can only represent a very small part of PREFER production (only 3%). A mixed production is modelled to correspond to a real situation where PREFER ensures the supply of all its clients with both the blocks using its waste and NA blocks (mix of B_RCA0 and B_RCA30).

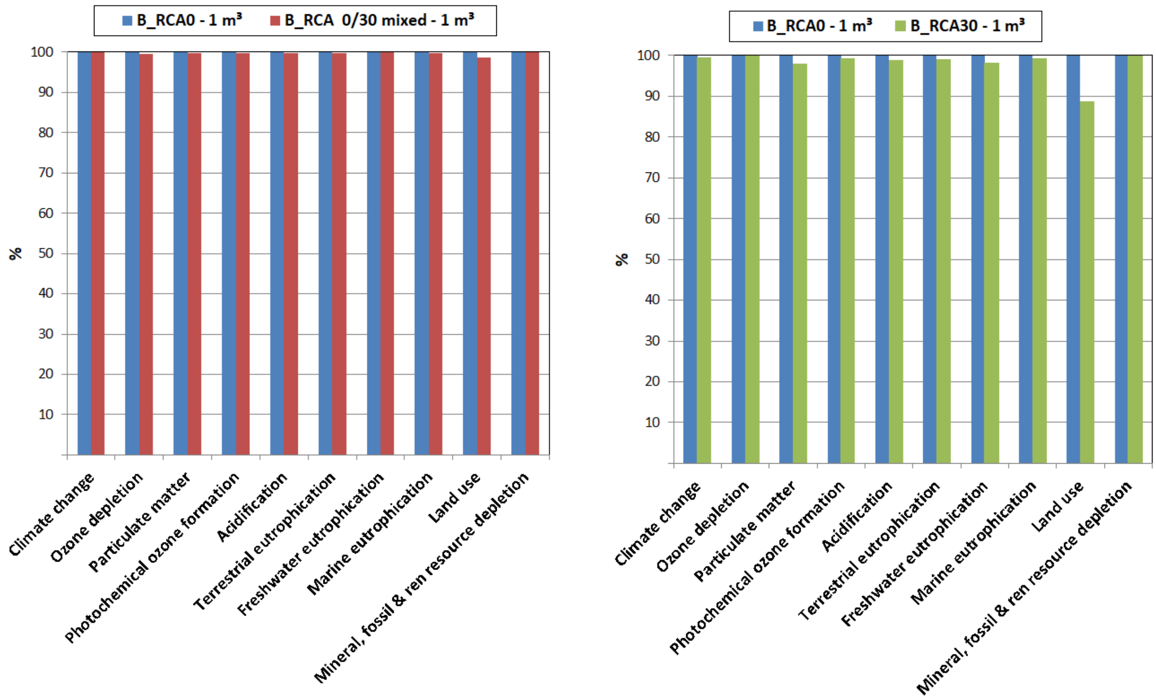
The comparative LCA of NA blocks (B_RCA0) and of the mixed production (mix of B_RCA0 and B_RCA30) does not show significant differences in any impact category (Figure *3*(a)). The reason is that part of the blocks including RCA represent only a very small part of the total production of Prefer (3%).

Moreover, the cement is the most impacting element in all categories, except Land use.

Natural aggregates have no impact in the Mineral resource depletion category because there is no characterisation factor associated with the "gravel" in ILCD method (nor in any other one). This absence is linked to the history of the development of the characterization method for this category, which initially was based on scarcity of a number of substances considered to be potentially critical, and where "gravel" was not included [5].

However, NA has a rather large impact in Land use category, which explains the fact that even a small substitution of NA can bring a gain in this category.

An improvement can be considered since there is the potential to complete the input of internal waste blocks by recycled aggregates coming from the sorting centre of Eloy Construction (situated at Richopré quarry, Chanxhe), and visited previously in the framework of Valdem. If the entire production of concrete blocks of PREFER incorporates 30% of RCA from Richopré, a gain of about 11.5% can be measured for the "Land Use" indicator (Figure *3* (b)).



(a) (b)

Figure 3: Comparison of the impacts of the production of 1 m³ of concrete blocks with NA only (B_RCA0 – reference scenario) (in blue) and (a) the production of 1 m³ of mixed production including 0% and 30% of RCA (B_RCA0 and B_RCA30) (in red); (b) the production of 1 m³ of B_RCA30 (alternative scenario with import of external RCA) (in green) – Characterization ILCD 2011 Midpoint+ (1.01)

CONCLUSIONS

The results of this study show a way to up-cycle aggregates from production waste and/or CDW, which could be proposed to the company PREFER.

Life cycle assessment of the production of blocks including the RCA from the waste blocks does not show significant gain in any impact category because of the very low available amount of waste (1%). The internal production of RCA 2/7 added in B_RCA30 blocks can only substitute 3% of the global production of Prefer. An alternative scenario, based on the import of external RCA 2/7 from a nearby CDW sorting site, shows however a potential gain in all categories, especially in the Land use category (up to 11.5%) if the total production of blocks consists of B_RCA30.

Globally, and in a circular economy perspective, substitution of NA with RCA recycled from waste blocks, combined with external import of RCA, is an interesting development route to improve the environmental impact of the concrete blocks of Prefer.

This study also highlights the fact that there is no characterization factor for natural aggregates ("gravel") in the category of Depletion of mineral resources in any method. As a result, the potential benefits of their substitution for recycled aggregates will be systematically underestimated if this aspect of avoidance of the consumption of a natural resource cannot be taken into account, especially in the context of the valorization of CDW.

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KEYWORDS

Life cycle assessment, Recycled concrete aggregates, Concrete blocks, Circular economy