TNO | Knowledge for business

Closed Cycle Construction

To closed material cycles for concrete and masonry in construction

In the Netherlands a new concept is currently being developed for the separation and reuse of Construction and Demolition Waste (C&D waste). For concrete and masonry rubble this concept aims for the recovery of the original constituents (clay bricks, gravel, sand and cement stone). With this the material cycle is completely closed. That's why the concept is called Closed Cycle Construction.

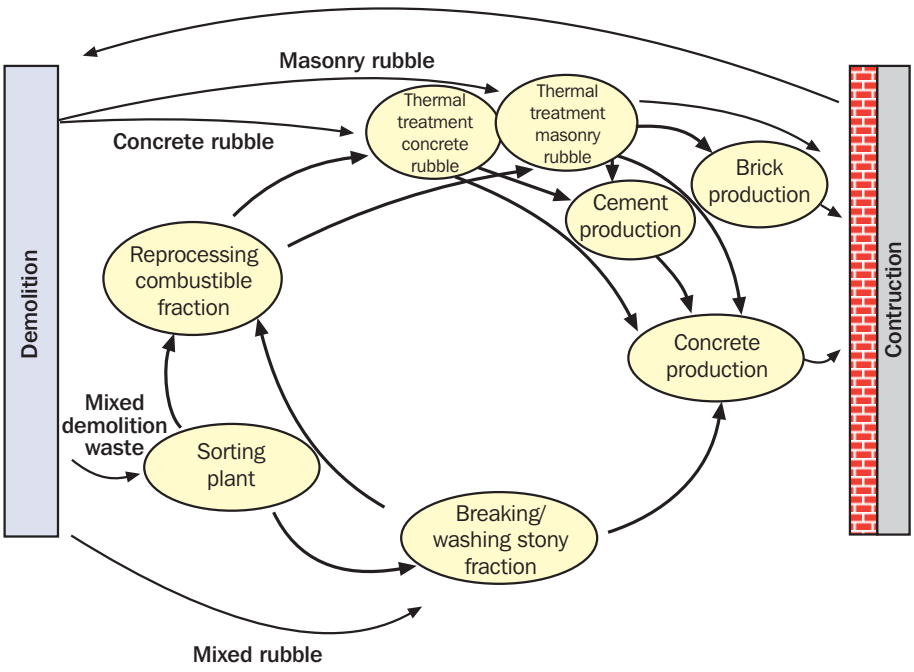
In the Netherlands, C&D waste is already being reused to a large extent (approximately 90%). Especially the stony fraction is crushed and reused as a road base material. Nevertheless, 1.5 million tons are still being disposed of in landfills on a yearly basis. Furthermore, nearly all the material that is reused goes into one segment of the market (road construction). This market is expected to decrease, whereas the production of C&D waste will increase. New high grade products and new outlets would increase the sales potential.

Closed Cycle Construction

Besides this waste disposal issue, also the raw materials supply is an important issue in the construction sector in the Netherlands. Especially gravel, concrete and masonry sand, and marl are getting scarce. All this calls for new technologies, enabling the reuse of C&D waste on the original quality level (again as concrete or masonry). Therefore the Closed Cycle Construction concept (in Dutch referred to as Kringbouw) has been developed, on the basis of investigations of TNO. In short, this means that after deconstruction / demolition of a building concrete rubble, masonry debris and mixed stony rubble are separated and treated individually, gaining products (clay bricks) and minerals (gravel, aggregates, sand and cement stone) that can be reused as raw materials for the manufacture of new construction products. This actually closes the material cycles for concrete and masonry. That's why the concept is called Closed Cycle Construction.

Unit operations in the new concept

Thermal treatment of specific C&D waste fractions constitutes the heart of the Closed Cycle Construction process. As visualised overleaf, four different C&D waste streams are distinctly processed, namely clean concrete rubble, clean masonry debris, mixed rubble and mixed C&D waste (also including wood, plastic, plasterboard, glass, etc).
For concrete, this new technology involves a rotary kiln in which the uncontaminated concrete rubble is thermally treated at a temperature of about 700 °C to dehydrate the cement stone. The concrete rubble pieces disintegrate and the original components (gravel, sand and cement stone) are set free, and can be reused for the production of new concrete.
For masonry debris, the new technology consists of a three-step process. In the first step, the large pieces of debris are thermally treated at a temperature of about 500 °C, to set free the majority of the original ceramic bricks. These whole bricks can be used for restoration purposes or for the construction of buildings in an old fashioned appearance. Subsequently, the remaining pieces of brick and mortar are physically separated. In the third step, the remaining ceramic fraction is crushed and reused as one of the raw materials for the production of new ceramic bricks.
To be able to process the entire supply of C&D waste, the above mentioned processes have to be implemented in an overall process. This overall process also includes process steps for the treatment of mixed C&D waste. The mixed C&D waste streams are separated and decontaminated. For this purpose several dry density separation techniques are being developed. The quality of the stony fraction is improved to a level that it can be re-used as an aggregate in concrete.
For unsorted demolition waste advanced detection and separation techniques are being developed, to sort out contaminants like gypsum and hazardous materials. The



remaining material is divided into a heavy (stony) fraction and a light (combustible) fraction. The combustible fraction (wood, plastic, paper, bituminous roofing material) is cleaned up and prepared as a fuel for the thermal process steps.

Benefits of Closed Cycle Construction are:

- The material cycles for concrete and masonry are closed, within their own chain.
- High-grade raw materials are recovered for the production of new concrete and ceramic bricks. This means higher profits for the C&D waste treatment industry, and less excavation of primary materials.
- Utilising the combustible fraction of demolition waste as a fuel doubles the environmental profit. The amount of waste to be disposed of is reduced, and the amount of fuel that is required for the thermal treatment of concrete and masonry rubble is also reduced.
- Re-use of the recovered cement stone fraction in the production of new cement (as replacement of part of the Portland cement clinker) leads to less excavation of marl, and less carbon dioxide emissions.

The initiators

The concept Closed Cycle Construction was invented by TNO, with input from industrial parties. A consortium of TNO and ten companies took the initiative to further develop and elaborate the concept. Almost all links of the chain presented in the figure above are represented in the consortium. The following companies are involved with, between brackets, the activity in the project they are involved in:

- Oranje Demontage (selective demolition and separation at the source);
- Van Gansewinkel (collection, logistics, sorting and secondary fuels);
- Bentum Recycling Centrale (thermal treatment of concrete rubble, breaking and treatment of the stony fraction of C&D waste);
- Theo Pouw (breaking and treatment of the stony fraction and clean up of the fines);
- Twee"R"beheer (breaking and treatment of the stony fraction);
- ENCI (reuse of the cement stone fraction in cement production);
- Mebin (production of fluid concrete);
- Holcim (production of prefab concrete construction parts);
- Den Boer Beton (production of precast concrete paving elements);
- Wienerberger Bricks (thermal treatment of masonry debris and production of new ceramic bricks).

Pilot- and demonstration project

In the years 2001 – 2002 the feasibility of the Closed Cycle Construction concept has been investigated. The results were promising to such an extent that the consortium decided in 2003 to test the process in a follow-up project on a pilot scale. From this three years lasting and 2 million euro's costing research programme it must become clear whether the process works in practice or not. In this project fundamental laboratory research (by TNO and TUDelft) goes hand in hand with verification / demonstration on a pilot scale (by the industrial parties).

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