Prioritizing perspectives for action for greening the concrete chain

Quickscan-based cost curve for 16 options selected by the CSR Concrete network

Summary
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Summary

This study is part of the process agreed to under the Concrete Green Deal concluded in October 2011 between the Dutch ministries of Economic Affairs and Infrastructure & Environment and 24 companies and 7 trade associations in the concrete supply chain cooperating in the CSR Concrete Network, an informal collaboration under the flag of CSR Netherlands, an organisation promoting Corporate Social Responsibility. The Dutch roads and waterways authority 'Rijkswaterstaat' (an agency of the Ministry of Infrastructure & Environment) has contributed as a member of the CSR Concrete Network by commissioning this study.

The CSR Concrete Network has already taken intitial steps to improve the environmental footprint of the concrete chain, but further improvements are deemed desirable in the medium term (from 2020 onwards) and against this background 16 'greening options' were selected.

The review study on the 'Environmental impact of concrete use in Dutch construction'(CE Delft, 2013), encompassing the full range of environmental impacts of the concrete chain, showed there is a high degree of correlation between these various impacts and CO_2 emissions. In the present follow-up study it was therefore decided to evaluate the greening options on the basis of CO_2 reduction potential and the abatement costs per metric ton avoided CO_2 emissions. The greening options are summarized below in Table 1.

The aim of this project is to provide a rough estimate of the cost curve for 16 options with potential for further greening the concrete chain in the medum term. CE Delft has ensured that the data provided were critically evaluated and used in a consistent and coherent manner to calculate the CO_2 reduction potential and CO_2 abatement costs.

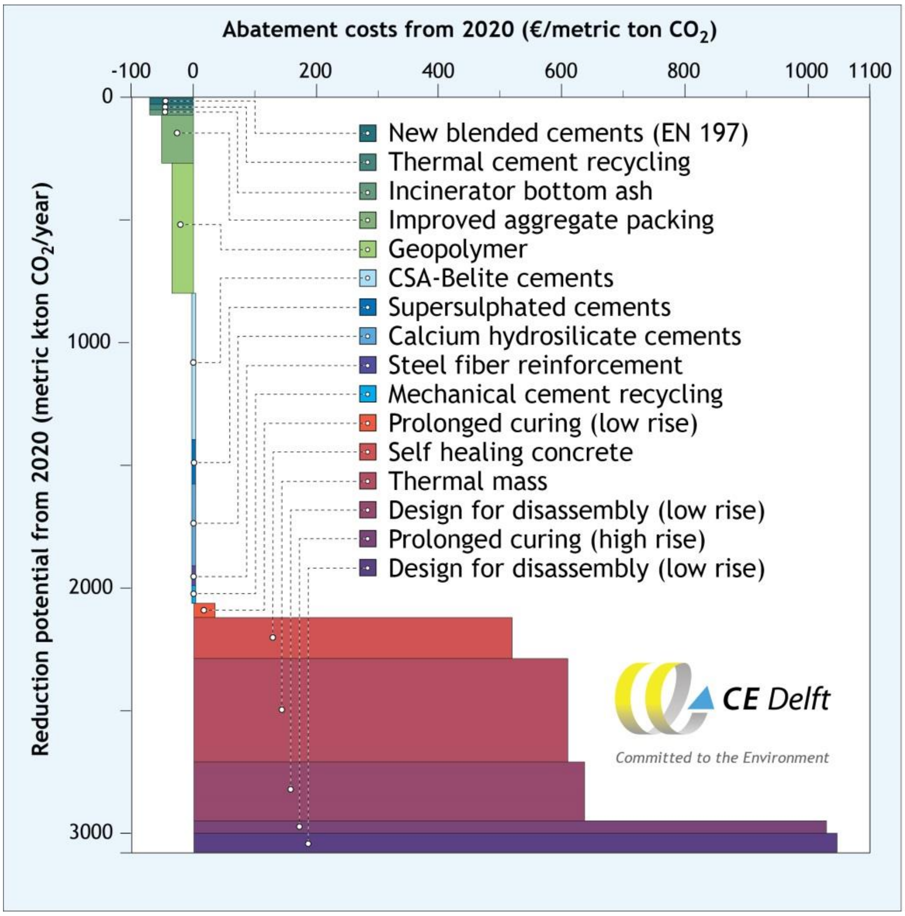
Table 1 Synopsis of 16 options for medium-term greening of the concrete chain

Category	Greening option	Explanation
Changes in concrete composition	Improved aggregate packing	Optimisation of aggregate packing
	New blended cements (EN 197)	Broadening of permitted raw materials for cement under European standard
	CSA-Belite cements	Use of calcium sulpho-aluminate cements
	Supersulphated cements	Use of supersulphated cements
	Calcium hydrosilicate cements	Use of new calcium hydrosilicate cements
	Geopolymers	Use of alkaline-activated materials as cement
Reuse/ recycling	Design for disassembly	Construction using standard units that can be disassembled
	Mechanical cement recycling	Mechanical cement recycling via ‘smart crushing’ and/or ADR
	Thermal cement recycling	Thermal cement recycling via so-called ‘kringbouw’ concept
	Incinerator bottom ash	Use of incinerator bottom ash as filler with binding potential
Alternative reinforcement method	Steel-fibre reinforcement	Use of steel fibres instead of traditional reinforcement in poured concrete
Changes to construction process	Prolonged curing	Longer curing time for poured concrete by changing construction planning
	Overdimensioning	Reducing overdimensioning in design phase
Extension of building lifetime	Flexible construction	Longer lifetime through flexible design
	Self-healing concrete	Self-healing concrete with calcium carbonate-producing bacteria
User phase	Thermal mass	Thermal mass combined with heat pump and heat/cold storage, augmenting EPC requirement

The cost curve plots technical CO_2 emission reduction potential for 2020 against CO_2 abatement costs. The former is the CO_2 emission reduction that can be achieved by around 2020 if all parties embark today on an all-out effort to implement these greening options and there is no problem with funding. Calculation of the technical reduction potential is based on emission reductions already proven on lab or pilot scale, implying that all the procedures required for large-scale market introduction can be implemented by 2020. The abatement costs of a given option are the costs incurred in using it to avoid emission of one metric ton of CO_2 (expressed in euro per tonne CO_2). The cost curve is shown in Figure 1.

As the figure shows, the total more or less cost-effective reduction potential totals around 2 million tonnes CO_2/y. Up to 1 million tonnes there are five measures that are purely positive in economic terms. Between 1 and 2 million tonnes there are numerous measures that are slightly less or more than cost-neutral. These are all options relating in one way or another to changes in concrete composition, such as ‘geopolymers’, ‘calcium hydrosilicate cements’ and ‘CSA-belite cements’ as well as the options ‘thermal and mechanical cement recycling’, ‘incinerator bottom ash’ and ‘steel-fibre reinforcement’. In terms of reduction potential there is substantial synergy between many of these measures, however. All-in all, the combined reduction potential is 1,300 ktonne/year, over one-third of the overall carbon footprint of the concrete chain (3,700 ktonne/y) (CE Delft, 2013). If only the cost-effective measures are implemented, the figure becomes a little less than 1,100 ktonne/y. This means that if the maximum reduction potential of all the cited greening options is indeed achieved, a route is opened to significantly reducing the aggregate footprint of the concrete chain.

Figure 1 Cost curve for greening options in the Dutch concrete chain (2020)



Several remarks are in order:

1. The figures used for the abatement costs and reduction potential are conservative estimates. The data presented in the cost curve are valid only in the range in which the application is proven (as detailed in Appendix B). The option 'cement recycling', for example, may well prove to have far greater potential once it is demonstrated that recycled cement can be utilized on a large scale as a decarbonisation-free[1] raw material for CSA-belite cement, say. In that case the combined reduction potential of the greening option 'CSA-belite cement' rises threefold, boosting the overall reduction potential to over 2,000 ktonne/y.
2. Abatement costs have been calculated on the basis of today's technology. During initial discussion of the results it was already clear that by considering the options in this way parties were inspired to look for alternative procedures that will probably turn out to be cheaper, as with the option 'design for disassembly', for example. The potential for using recycled cement will in all likelihood also prove to be far greater than assumed here, as development advances.
3. Abatement costs are highly sensitive to small changes in the amount of CO_2 that can be saved per tonne of cement or concrete. Minor variations in assumptions can sometimes lead to major changes in abatement costs,

[1] In production of Portland cement clinker CO_2 is usually driven off from the main raw material, limestone (in the Netherlands generally the tuffaceous chalk of Maastricht), a process known as decarbonisation. Reducing decarbonisation by employing raw materials from which no CO_2 is driven off is an effective means of cutting CO_2 emissions.

particularly when the CO_2 cuts per tonne of concrete are only limited.

4. The option ‘thermal mass’ is an energy-efficient and comfortable means of heating and cooling buildings, which is also borne out by the cost curve. It should be appreciated, though, that the energy savings achieved are entirely feasible *without* concrete. In contrast to all the other options considered, the reduction potential of ‘thermal mass’ cannot be allocated directly to the concrete. We therefore recommend that this be seen as a systemic option for low-energy buildings rather than as an option for greening the concrete chain. If ‘thermal mass’ is included on equal footing in the comparison, the overall reduction potential becomes almost 1,600 ktonne/y (40% of the aggregate CO_2 emissions of the concrete chain).

For the options ‘reducing overdimensioning in the design phase’ and ‘longer lifetime through flexible design’ there proved to be insufficient quantitative data available for inclusion in the cost curve. Given that these measures impinge on a substantial fraction of national concrete use, further investigation of the reduction potential they represent may provide a valuable addition to the present study. The results of the Stutech/Stufib studies, to be published later this year, may well yield sufficient points of departure for taking to hand calculations of the abatement costs and reduction potential of these two options.