Steering on Environmental Cost Indicator (MKI) of concrete can negatively affect its quality and life time performance

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Steering on Environmental Cost Indicator (MKI) of concrete can negatively affect its quality and life time performance

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CONTRIBUTION

The technical (service) lifespan of concrete is a crucial element in the construction sector, where the quality of the concrete mix and execution technology plays a decisive role in the performance throughout the entire functional life of structures. This presentation explores the importance of a well-designed concrete mix and how it contributes to the sustainability (overall environmental impact) and longevity of structures. We will examine the influence of reducing the environmental impact of concrete, resistance to environmental exposure conditions, and maintenance needs of concrete structures. By providing insights into the relationships between mix composition and lifespan performance, we emphasize the necessity of careful material selection and precise execution technology as the foundation for sustainable construction practices. The presentation will offer practical recommendations for improving the technical lifespan and reducing the environmental impact of concrete by focusing on the quality of the concrete mix and execution technology.

Background information:

With the Raw Materials Agreement and the Construction Transition Agenda, the Dutch government aims to establish agreements that contribute to achieving the objectives of the Concrete Agreement. The government intends for all public procurement to be circular by 2030. From 2023 onwards, the government will initiate that tenders at the national, provincial, and municipal levels must be circular, unless this is not (fully) feasible.

As part of the climate-neutral and ircular Infrastructure Strategy (KCI), six major infrastructure asset owners namely: Rijkswaterstaat, ProRail, the provinces of North Brabant and North Holland, and the cities of Amsterdam and The Hague, will establish minimum sustainability requirements starting from 1st of July 2023 (Duurzame-infra, 2023 [1]). These requirements are presented in the table below. It is expected that other provinces, municipalities, and water boards will follow soon (Duurzame-infra, 2023 [2]).

Table 1: Maximum environmental cost values (MKI) for ready-mix concrete in accordance with KCI (MKI in €/m3).

	Final*	Maximum environmental cost indicator (MKI) in % starting from 2021**		
	2021	2024	2027	2030
C12/15	16	94%	87,9%	81,6%
C20/25	20,4	94%	87,9%	81,6%
C30/37	20,5	94%	87,9%	81,6%
C35/45	21,2	94%	87,9%	81,6%
C45/55	21,6	94%	87,9%	81,6%
C55/67	21,8	94%	87,9%	81,6%

Table 1 is based on the Concrete Agreement:

*Final values from the "Contract Requirements and Award Criteria Concrete Agreement 2011" version of June 5, 2021.

** MKI values in % (compared to 2021) from "Note on Declining MKI" version of May 18, 2021 (Note: this is a document from the Concrete Agreement but not approved by the Concrete Agreement board).

***The environmental costs (MKI) values for ready-mix concrete mentioned in table 1 are not indexed according to the new released national cPCR for cement.

Focusing solely on low environmental impact, circularity and/or alternative (secondary) materials carries risks in terms of unexpected decrease in (service)lifespan and (increased) maintenance costs of structures throughout their service life.

Currently, standards provide a deemed-to-satisfy approach, which is based on known and traditional (raw)materials and difficult to harmonize with current sustainability goals. However, for structural safety and long-lasting resistance (durability) of structures, the performance of the materials is governing. Especially for innovative materials, it makes sense to invest in a performance based approach to safe guard structural safety and durability requirements. In addition to the concrete mixture (deemed to satisfy approach), the execution and hardening phases are essential for the concrete properties in practice, as schematically shown in Figure 1. The impact of execution on structural safety, service life, and maintenance is not considered in the deemed to satisfy approach. A performance-based approach, in which the realized properties are validated, would address this gap. This approach can also be more beneficial for clients, as it provides a more reliable verification of the performance of the built structure. This is applicable to concrete based on both traditional cement, alternative binders and (secondary) materials.

Another consequence of the deemed-to-satisfy approach is that quality control in the current standards and certification is mostly based on the strength class of concrete hardened in the laboratory (labcrete). The holistic impact of individual raw material optimization and the drive to make individual materials more sustainable, as the impact of execution stage of concrete on site is not directly considered. The difference between properties of concrete hardened in the laboratory and concrete made in practice (realcrete) is thus generally not measured. As a result, quality optimizations from an execution standpoint, which could maximize the concrete properties in practice cannot be implemented. This introduces a risk of failure costs or unmonitored changes during execution. Particularly for alternative materials, there is no framework to measure the difference between labcrete and realcrete, which is crucial to optimize the execution method.

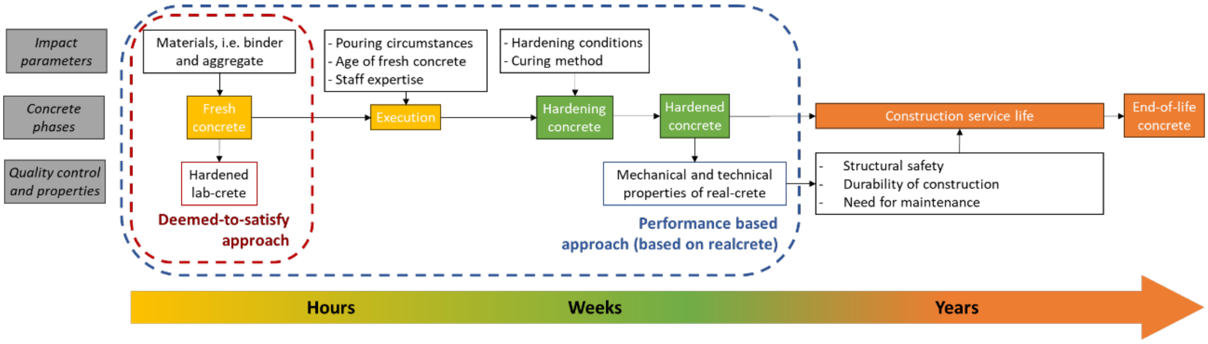

Figure 1: Different stages of the concrete service life in view of deemed-to-satisfy and performance based approach (after J. van Oosten).

IMPLEMENTATION

Bringing research insights or practical solutions into practice in the field of concrete technology faces several challenges. One major challenge is the current reliance on a "deemed-to-satisfy" approach, which focuses on standard materials and lab-tested conditions that may not accurately reflect real-world performance ("labcrete" vs. "realcrete"), resulting in higher maintenance costs. This creates a gap between the predicted durability and actual performance of concrete structures, especially when innovative or sustainable materials are used. Additionally, focusing solely on minimizing environmental impact or circularity can inadvertently compromise the service life and increase maintenance costs if structural safety and durability are not properly validated.

To implement innovative solutions successfully, a performance-based approach is needed. This would involve validating the actual properties of concrete during execution and in real-life conditions, ensuring that both structural safety and durability requirements are met. Such an approach would allow for better quality control and optimization, not only of the concrete mix but also of the execution process, helping to reduce risks and failure costs while aligning with sustainability goals.

DISCUSSION

Concluding Statement: Achieving both sustainability and long-term durability in concrete structures requires moving beyond traditional "deemed-to-satisfy" standards. A performance-based approach, which validates the actual properties of concrete after the execution phase, is crucial for aligning long term environmental goals with structural integrity (i.e. service life requirements) and acceptable maintenance costs.

Open Question: How can we effectively implement a performance-based approach across the construction industry, ensuring sustainability, structural integrity and low maintenace without increasing costs?

Concluding Statement: The gap between "labcrete" and "realcrete" properties presents a significant challenge in optimizing concrete performance in practice. Validating execution quality and real-world conditions is essential to minimize risks of failure and maximize material efficiency.

Open Question: What frameworks or tools can be developed to accurately measure and bridge the gap between lab-tested concrete properties and real-world performance?

Concluding Statement: Circularity and the use of alternative materials in concrete carry risks of unexpected reductions in service life and increased maintenance costs. A careful balance between innovation and performance validation is necessary to ensure long-term success.

Open Question: What are the best strategies to ensure that the introduction of alternative materials does not compromise the durability and longevity of concrete structures?

Concluding Statement: Execution and hardening phases are critical but often overlooked aspects of concrete performance. A more thorough validation process during these stages could greatly improve the sustainability and lifespan of structures.

Open Question: How can we integrate execution quality into the current regulatory and certification frameworks to ensure that concrete structures meet sustainability and durability standards?

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