BRÝR Í HRINGRÁSARHAGKERFI

VERKEFNI FYRIR RANNSÓKNARSJÓÐ VEGAGERÐARINNAR

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This project provides information on how bridges can be assessed with a view to them being a part of a circular economy. The principles of circular economy are outlined and methods for transferring these principles to bridge design introduced. There is a clear requirement to push circular economy higher up the agenda in the construction industry as the principles (eliminate waste and pollution, re-use and longevity, and protecting nature) go hand-in-hand with the required drive for improved sustainability of structures, including bridges.

The Netherlands are world leaders when it comes to the circular economy and have set noteworthy targets for the national economy in terms of circularity and material consumption. Rijkswaterstaat, the executive agency of the Ministry of Infrastructure and Water Management, is working from a clearly defined agenda, using systematic indicators for circularity assessment of structures and calculating the environmental cost of the use of different construction materials. Such assessment is done with a view to improving performance with respect to three goals (protecting material resources, protecting the environment and protecting existing value) that identify very clearly with the principles of circular economy.

As a case study, within this research a comparison between steel and concrete footbridge alternatives at a given location in Mo i Rana, Norway, has been conducted. The comparison is done based on the methodology used by Rijkswaterstaat in the Netherlands, and the tool that has been applied has been developed with a view to support that methodology.

In the circularity assessment of the two bridge alternatives, two indicators are calculated.

- The Material Circularity Indicator (MCI) evaluates performance with respect to the key goal of protecting material resources. It is calculated as a function of the proportion of primary versus secondary material used at the construction stage as well as the proportion of materials that continue to the next cycle versus the material that is lost at end-of-life.
- The Environmental Cost Indicator (ECI). This indicator unites relevant environmental impacts into a single environmental cost and has been developed to encourage the market to develop and offer alternatives of improved circularity. The calculated cost is ‘shadow cost’ that can be used in tender evaluation or to serve as a threshold in tenders.

The assessment uses quantities from the steel footbridge as built, and concrete bridge quantities from the pre-design, as bridge type selection was undertaken as part of the pre-design process. Each material used for the bridges was defined in terms its sources (Primary Renewable, Primary Virgin,

Secondary Reused and Secondary Recycled) and the assumptions for the end-of-life potential (Reusable, Recyclable, Energy recovery, Landfill).

The results indicate a slightly higher circularity of the steel bridge with respect to the protection of material resources goal, mostly due it being a lighter bridge and recycling challenges associated with curved concrete elements cast in-situ.

In terms of Environmental cost, the concrete bridge however performs better than the steel footbridge. Using unit shadow prices for environmental impact categories from the Dutch Nationale Milieudatabase, the total environmental cost for a 100-year service life, excluding end-of-life benefits is €26,400 and €16,600 for the steel and concrete footbridge alternatives respectively.

This circularity assessment has informed on how circularity can be improved. Measures include requiring the use of steel with high recycling content and considering future re-use in the design of components such as columns and parapets. The indication from the assessment is that a higher unit shadow prices would have to be used for the environmental costs to significantly influencing choice of bridge alternatives, even if they were somehow transformed to actual costs.

A 'Circular Design Framework for Bridges' has been drawn up. It builds on a Circular Buildings Toolkit by adopting the same design strategies. The framework consists of 42 design actions aimed at improving bridge circularity. The actions have been prioritised, and it is the view of the authors that those that should be implemented immediately are:

- Implementing circular design strategies by using a checklist of circular design actions.
- Make Life Cycle Cost Assessment mandatory for bridges, for comparison of bridge alternatives in concept studies and pre-design.
- Include relevant circular economy information in BIM modes that are produced in design and used by owner during the service life.
- Make Life Cycle Assessments mandatory for bridges, and establish, legislate and work with carbon emission targets.

To follow-up to this research project, it is proposed that next year's work will be on:

- Formulation of the circular design actions checklist and the appropriate 'check' criteria for each action in the list.
- Defining in more detailed terms how Environmental Costs can be used in procurement.

Close dialogue with bridge owners is required for the follow up to the research.