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Sustainable Design and Maintenance of Concrete Structures

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Summary

Concrete is an environment-friendly material. Approximately 85-90% of concrete comes from natural resources, which normally are available in extensive amounts. Concrete is durable and may, if the structure needs to be demolished, be recycled as aggregates in new concrete. The sustainability of concrete structures may be further improved by minimising the use of resources, i.e. by using more environment-friendly constituent materials without having to compromise on durability and by optimising the structural design with regard to both utilisation of load bearing capacity and to service life.

Keywords: Sustainable, environment-friendly, life cycle inventory, concrete, design, maintenance, repair

1. Introduction

This paper is based on two development projects, one on structural design and one on maintenance and repair. The projects are part of a four year contract, initiated in the second part of 1998. The contract is called "Resource Saving Concrete Structures" (colloquially "Green Concrete").

The evaluation of selected structural designs as well as methods for maintenance and repair will include life cycle inventories (LCI). For the evaluation, requirements to acceptable combinations of measurable values will be set up. Based on structural calculations amounts of materials for the various structural designs will be determined and used to estimate the design related environmental loading, and - including information about the service life and the need for maintenance - to estimate the operation and maintenance related environmental loading.

2. Structural Design

The purpose is to develop structural designs which

- Minimise the environmental effects from the construction of concrete structures
- Optimise - and increase - the use of environment-friendly concrete types

Motorway bridges have been selected as the type of structure to be dealt with. The project constitutes the following activities:

- Identification of significant technical, environmental, and financial factors
- Proposal of alternative structural designs
- Evaluation of selected structural designs with regard to
 - constructability and durability
 - environmental effects
 - structural and financial effects
- Preparation of catalogues on
 - environment-friendly structural designs
 - structural designs for environment-friendly concrete

As part of the contract, a "demo-bridge" will be constructed. It is roadway bridge, and it will be designed according to the Danish rules and regulations for loads and dimensions. The purpose of evaluating alternative bridge designs and alternative design details is to:

- Minimise the amount of materials by
 - changing the design (increase the degree of utilisation of the load bearing capacity)
 - using alternative materials, e.g. concrete with very high compressive and tensile strengths (compact reinforced concrete (CRC [2]))
- Maximise the service life
- Substitute the currently used materials by more environmental-friendly materials
- Increase the use of prefabricated structural elements (optimised production)

3. Operation and Maintenance

Concrete structures in aggressive and extra aggressive environmental exposure, e.g. bridges in marine environment or exposed to de-icing salt, require maintenance, whereas concrete structures in passive environmental exposure have merely no need for maintenance. Based on this the following concrete types and structural elements have been selected for evaluation of maintenance requirements, both with regard to financial and environmental considerations:

- Type of structure
 - typical motorway bridge in concrete
- Type of concrete
 - concrete for aggressive environmental exposure
 - concrete for extra aggressive environmental exposure
- Structural elements:
 - columns
 - edge beams
 - bridge deck (with and without water proofing membrane).

To estimate of the environmental loading during the operation and maintenance phase, the impact of normal maintenance activities as well as repair activities will be considered. During the coming two years, information about the durability of environment-friendly concrete types and the environmental impact and service life of remedial measures will be collected. Based on the outcome of the life cycle inventories, suitable maintenance and repair methods will be proposed.