ENVIRONMENTAL EVALUATION OF PRECAST CONCRETE ELEMENTS

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ABSTRACT

This paper describes an example of the use of Life Cycle Assessment (LCA) in practice, within the cement- and concrete industries in Sweden.
The production of five different types of precast concrete elements have been studied with the principal aim to establish data for environmental product declarations.
Looking at the environmental load per weight unit, the product containing the least cement and reinforcement is favourable. If functional aspects, such as strength and durability, are taken into account the relationship regarding environmental load between the products is evened out or reversed.
The production of cement is the largest single source regarding environmental load followed by transportation, production of reinforcement steel and the precast plant with approximately equal shares. The key contributors to the environmental impacts are emissions of NOx, CO2 and SO2 and the use of fossil fuels and electricity.

Key words: LCA, environmental assessment, environmental declarations.

1 INTRODUCTION

Growing awareness of environmental problems has created a need for systems for the evaluation of environmental characteristics of products and processes. The most far-reaching tool is Life Cycle Assessment, LCA. The LCA methodology may be used either to map a production process, the production phase of a product ('Cradle to gate'), or the entire Life cycle ('Cradle to grave'), of a product.
In 1993 the cement producers in Finland, Norway and Sweden launched a project with the aim of

- establishing a software tool for LCA of cement and concrete,
- compiling relevant environmental data for cement and concrete production ('Life Cycle Inventory') and
- making some comparative studies on alternative building materials.

With the help of Nordic LCA expertise, reference groups from the building material industry and financial support from Nordic research foundations, the project was finalised in 1997. [1] The LCA tool is presently used for product and process development and to provide data for environmental declarations. This paper describes the LCA of precast concrete elements, cradle to gate.

2 THE LCA TOOL

2.1 General

There are several hazards to be considered when applying LCA and results should be regarded as indicative. Statements concerning environmental advantages for certain materials or products in comparison with other alternatives should be viewed critically. For the internal use, for instance, to control environmental improvement actions, LCA is, however, an effective method.

2.2 The data base

The database developed in the Nordic LCA project [1], contains detailed environmental information on the production of cement in seven different cement plants in Finland, Norway and Sweden. The use of energy and raw materials, emissions to the air and water, land use, waste and environmental effects of transport are recorded. Concrete production is covered in a more general way with the greater detail left for further examination in separate studies such as those described in this paper.

2.3 The software tool

The software used for the inventory is a commercially available programme, 'Life Cycle Inventory Tool' by CIT Ekologik in Gothenburg, Sweden. From this programme, inventory data can be exported to MS Excel for evaluation and analysis.

2.4 LCA - Weighting models

The aim of a weighting model is to make different environmental effects and aspects comparable.

There are several weighting models available. These models are based on different scientific and socio-economical principles and may give varying results. In order for the result not to be too dependent on the choice of model, three different weighting models have been used in these studies. The models used, are: Effect-Category Method or Environmental Theme Method [2], Ecological Scarcity Method (BUWAL) [3], developed in Switzerland and adapted to Swedish conditions and Environmental Priority Strategies (EPS) [4]. Note that weighting models can be adapted to regional conditions. As an example, waste may be given a higher importance in a densely populated country than in a sparsely populated area.

3 LCA ON PRECAST CONCRETE ELEMENTS [5]

3.1 Aim of the study and general remarks

In Sweden, the building industry has taken on the responsibility for providing environmental declarations for all materials and components put on the market. This study has been carried out to establish the necessary environmental data such as emissions and energy use for environmental declarations for precast concrete elements. The inventory data is applicable for a typical Swedish precast concrete production and the results can therefore be regarded as representative for Swedish precast elements. This study has been conducted by the author in co-operation with two of Sweden's leading precasters; Skanska Prefab AB and AB Strängbetong.

3.2 Functional units and data

The functional unit chosen is one kg of a precast concrete element delivered to the building site. Five different material compositions have been studied. See table 1. The product compositions and all other data such as energy use in plant, waste, transport vehicles and transport distances have been chosen to correspond to a normal situation. Data for the production of steel/reinforcement has been taken from one of the case studies in the Nordic LCA project. [6]

Product:	Pipe, block	Hollow core slab	Wall	Beam	High perform.
Concrete	C45, Earth moist	C45, Earth moist	C 35	C 50	C 80
Reinforcement	None	Prestressing	Plain	Prestressing	Prestressing
Other steel	None	None	Some	Some	Some
Plasticizer	Little	Little	Some	More	More

Table 1: Composition of precast concrete type products

3.3 Results

The results used in environmental declarations are grams of emissions and waste, raw material use and energy use per kg concrete product. An evaluation on the basis of weighting models has also been carried out, in order to obtain further environmental information for the internal use within the industry, for instance, for environmental improvements.
Cement is the largest single contributor to the environmental load for precast concrete followed by transportation, where NOx emissions and fossil fuel dominate, the precast plant and production of reinforcement, with roughly equal shares.

The environmental load distributed by impact source is presented in diagram 1. The emissions of CO2, NOx and SO2 to the air plus the use of fossil fuels are the dominating parameters as in most industrial processes. Note that the different weighting models focus differently

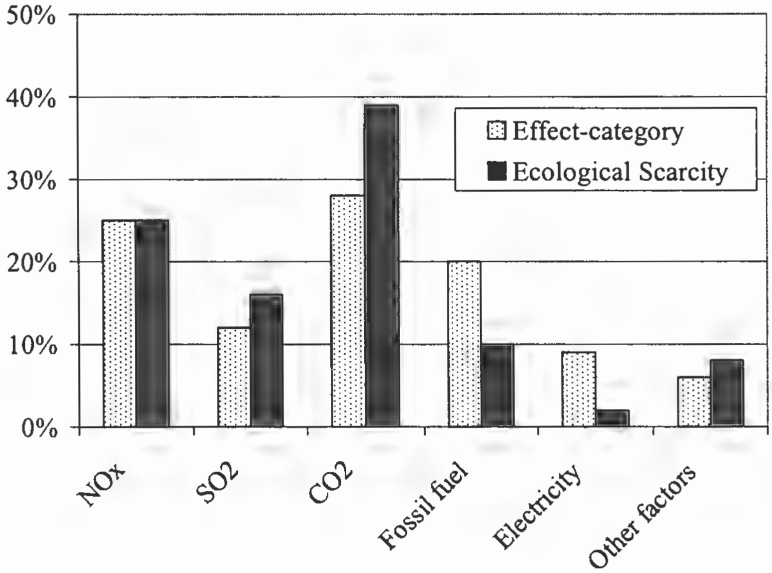

Diagram 1: Distribution of environmental loads for a hollow core slab, according to two different weighting models. Other factors include, for instance, emissions of CO, HC, heavy metals and waste.

3.4 Discussion

More cement and reinforcement used in a product increases the environmental impact. However, if the functional performance is taken into account, regarding, for instance, strength or durability, the relationship may be the other way around. It is very important to keep this in mind and to make designers and buyers aware of the fact that, better performance during the user phase, for instance, with regard to durability, is often many times more important, from the environmental point of view, than differences in the production phase. In diagram 2, simple relationships between environmental loads and technical performance, is displayed. In this case the functional performance is defined as concrete strength.

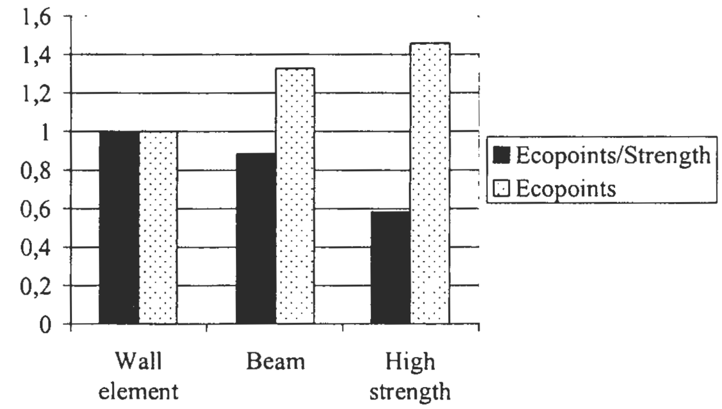

Diagram 2: Environmental load, according to the Effect-category weighting model, of three element types with and without relation to technical function.

When comparing different structural material such as concrete, steel and timber it is even more crucial to identify a comparable functional performance. Steel and timber, in most cases, need special fire protection and often treatment for durability, which of course must be taken into account, in the case the environmental performance of the different materials is compared.
Regardless of functional performance, the focus on environmentally friendly cement production is obvious, and there are several ways to obtain that.
The transports for materials and in particular for the finished product also have a relatively large impact. Environmental improvement of vehicles and possibilities of railway transportation are some factors worth considering.
Concrete waste material from the production process could be washed or crushed and reused as aggregates or filling material. The choice of recycling method should be made primarily to avoid any excessive transportation and the overall environmental impact of this will then be negligible. Because of the great environmental impact of steel production greater attention must be paid to the recycling of waste steel material.

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