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CHALLENGES TO THE DEVELOPMENT OF PRODUCT CATEGORY RULES AND ENVIRONMENTAL PRODUCT DECLARATIONS FOR THE U.S. CONCRETE INDUSTRY

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ABSTRACT:

Unlike other developed nations, the United States is just beginning to use environmental product declarations (EPDs) for environmentally preferable purchasing. Many industries and companies are rushing to develop EPDs and product category rules (PCRs). The concrete industry is no exception. But difficulties have arisen due to lack of standardization of life-cycle stages, functional units, environmental impact categories, data quality, and allocation. This paper will discuss these challenges for the U.S. concrete industry related to development of PCRs and EPDs.

Keywords: allocation, data quality, development, environmental product declaration, EPD, impact categories, PCRs, product category rules

1. INTRODUCTION

The use of environmental product declarations (EPDs) is a new trend in environmentally preferable purchasing in the United States. There is urgency surrounding the development of EPDs and product category rules (PCRs) because public entities (such as departments of transportation in several states and universities) as well as private interest groups, have already embarked on, or announced initiatives to, develop EPDs and PCRs for various construction materials, including concrete. Industries competing with concrete in the United States, such as the wood and steel industries, are also developing PCRs and EPDs.

In addition, the sixth public comment version of LEED Building Design and Construction (under development for release in 2013) awarded points for use of Type III EPDs for non-structural as well as structural products.

2. PRODUCT CATEGORY RULES AND ENVIRONMENTAL PRODUCT DECLARATIONS

2.1 Product Category Rules

PCRs standardize data collection and reporting of environmental impacts of products in a specified category (functional unit). They also provide the requirements for developing Type III EPDs, including the information related to performing life-cycle inventory (LCI) or life-cycle assessment (LCA). Generally, a separate PCR is developed for each major functional unit of a product.

Most PCRs require LCAs and LCIs to follow the guidelines proposed by the International Organization for Standardization in ISO 14040, *Environmental Management - Life Cycle Assessment - Principles and Framework* [1] and ISO 14044, *Environmental Management - Life Cycle Assessment – Requirements and Guidelines* [2] as a baseline. Figure 1 shows the elementary flows (inputs and outputs) and life cycle stages of a building.

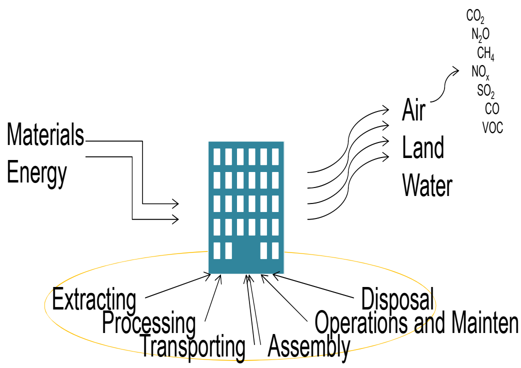

Fig.1 Elementary flows for LCA

2.2 Environmental Product Declarations

There are three types of EPDs according to ISO. The three types of EPDs are shown in Table 1. The major difference among EPD type is whether the EPD is peer-reviewed by a third party, and whether it is based on LCA.

(1) Type I

Type I EPDs are created by using ISO standard 14024 [3]. The label created using this ISO standard focuses on multiple discrete criteria such as the amount of recycled content included or the amount of renewable energy used to create a product. This information is volunteered by the product manufacturer and although not calculated through LCA methods, it is verified by a third-party, independent verifier.

(2) Type II

Type II labels are also self-declared by the product manufacturer and are based on a single, discrete criterion such as recycled content, or whether the product is degradable or reusable. Type II EPDs are created by using ISO standard 14021 [4].

(3) Type III

Type III EPDs are created by using ISO standard 14025 [5]. These labels are based on LCI and LCA according to ISO standards and the applicable set of PCRs for the product category. Type III labels are the most rigorous in terms of verification because the PCRs is third-party verified, the data must be independently verified, and the EPD itself is verified.

Table 1 Environmental Product Declaration Types

Type	ISO Standard	Third-Party Reviewed	LCA Based
I	14024	Yes	No
II	14021	No	No
III	14025	Yes	Yes

During development of a Type III EPD, an LCA is performed according to a PCR. The LCA accounts for all environmental inputs and outputs related to the boundary set by the PCR, including raw materials used, energy consumed, waste created, and emissions to air, soil (solid waste), and water.

3. CHALLENGES FOR CONCRETE PCR AND EPD DEVELOPMENT

While PCRs and EPDs have been used in Europe for some time, their use in the United States has been limited. PCRs for cementitious and concrete based products manufactured in the U.S. are beginning to be developed. Through development of these rules, lack of consensus in a few areas have revealed areas that could benefit from more research.

These include the stages of the life cycle inventory (LCI) to be included and definition of functional unit, relevant environmental impact indicators, data quality requirements, and allocation rules (especially for recycled content or by-products).

3.1 Life Cycle Stages and Functional Unit

EPDs should include environmental impacts for all life cycle stages for which the product has environmental impacts. For a product that has a simple or easily defined use (such as carpet, which is usually only used as a floor covering), including all environmental impacts from all life cycle stages is relatively straightforward. However, for a product that can be used for many purposes (such as concrete), it is more difficult.

In the American Center for Life Cycle Assessment's (ACLCA's) document "Guidance for Product Category Rule Program Developers" [6], it stresses the importance of defining a function in terms of "the primary social benefit the product provides." This is not easily accomplished for concrete that can be used in a slab; as a beam, column, foundation, or other structural member; for walls; for sidewalks; or for many other uses. BS EN 15804 [7] defines functional unit as "quantified performance of a product system for use as a reference unit."

As an example, a PCR written for cast-in-place concrete is not automatically applicable to precast concrete or concrete masonry units. Many environmental impacts related to cast-in-place concrete occur on the construction site. Formwork for cast-in-place concrete is erected on-site, and reinforcement and reinforcement chairs are installed at the site.

Alternatively, precast concrete has unique plant manufacturing processes and precast products leave the manufacturing facility after being cured and including reinforcement, insulation, or other hardware. A sample of a precast concrete wall is shown in Figure 2.

Fig.2 Precast Concrete Wall. Photo courtesy of Portland Cement Association

Concrete masonry units have different constituent materials than ready-mix concrete. They also have different processes including placing the mix in the mold, curing, and storing in the plant, and they use different standards, metrics, and declared units. A typical concrete masonry unit wall is shown in Figure 3.

Fig.3 Concrete Masonry Unit Wall. Photo courtesy of Portland Cement Association

According to BS EN 15804 [7], the life cycle stages are designated as:

- A1-A3: Product stage
- A4-A5: Construction process stage
- B1-B5: Use stage (related to building fabric)
- B6-B7: Use stage (related to building operation)
- C1-C4: End-of-life stage

These stages are also shown in Table 2.

Table 2 Life-cycle Information Modules

Stage	ISO Standard	Third-Party Reviewed
A1	Product	Raw material extraction
A2	Product	Transport
A3	Product	Manufacturing
A4	Construction	Transport
A5	Construction	Installation
B1	Use	Use or Application
B2	Use	Maintenance
B3	Use	Repair
B4	Use	Replacement
B5	Use	Refurbishment
B6	Use	Operational Energy
B7	Use	Operational Water
C1	End-of-Life	Deconstruction
C2	End-of-Life	Transport
C3	End-of-Life	Waste Processing
C4	End-of-Life	Disposal
D	Benefit	Reuse, Recovery, Recycling

When considering the various uses of concrete—whether ready-mixed, precast, or formed into concrete masonry units—it seems clear that a business-to-business PCR would need to be developed for only the production, construction, and end-of-life stages. This would be considered an informational module EPD.

Although not to be used for comparative assertions, there is concern in the concrete industry that these EPDs would be used for product selection. Disregarding the use phase eliminates consideration of thermal mass, sound reduction, fire resistance, service life, and other benefits of concrete.

For end-product PCRs, the functional unit of the concrete assembly should be taken into account. In these cases, the PCR for a wall, for example, would specify how to take into account these benefits of concrete. For example, an EPD for a specific wall thickness and concrete mix could specify the fire resistance, sound transmission class (STC), and a metric for thermal mass.

3.2 Environmental Impact Categories

Often times codes, standards, and rating systems list a minimum amount of impact categories yet ISO 14040 series standards require all relevant impacts be included. Many materials have significant impacts in impact categories that do not meet the common shorter lists.

The most common impact categories required are listed here as items 1-5 (these are also included in BS EN 15804). All impact categories are listed in Table 3. In addition to these, energy use, and occasionally materials use, are reported in an EPD.

(1) Global Warming Potential

According to the UN, global warming potential is "an index representing the combined effect of the differing times greenhouse gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation." This impact category has received much attention and is commonly included in PCRs and EPDs.

The metric generally used is for a 100-year time horizon. Emissions to air for methane, nitrous oxide, and carbon dioxide are converted to equivalent carbon dioxide emissions. This metric is preferable to a metric of only carbon dioxide emissions. Also, when using such a simplified metric, it is more accurate to call it global warming potential than climate change.

An EPD is required to list all significant impacts. An EPD of only global warming potential contains only a single attribute and is *not* a valid EPD. Unfortunately these are beginning to emerge in the market place because this impact is one of the easiest to calculate.

(2) Formation of Tropospheric Ozone

This environmental impact category relates to the formation of ground-level ozone [8]. Ground-level ozone is commonly attributed to negative human health effects. This category is also commonly included and reported in PCRs and EPDs.

(3) Acidification

Acidification related has received media attention and is largely tied to sulfur dioxide and nitrogen oxides resulting from fossil fuel combustion that pollutes water or soil [8]. It also is an impact category that is frequently included in PCRs and reported in EPDs.

(4) Eutrophication

Eutrophication is largely caused by run-off of nitrates and phosphates and is largely tied to the amount of chemical run-off that causes increases in algae growth and reduction of oxygen [8]. This impact category is frequently included in PCRs and reported in EPDs.

(5) Ozone Depletion

According to the U.S. EPA, "A chemical destruction of the stratospheric ozone layer beyond natural reactions. Stratospheric ozone is constantly being created and destroyed through natural cycles. Various ozone-depleting substances (ODS), however, accelerate the destruction processes, resulting in lower than normal ozone levels" [8]. This impact category is also regularly included in PCRs and reported in EPDs.

(6) Toxicity

Because this environmental impact category is more complicated to calculate, it is frequently absent from PCR requirements. This has been the case with PCR development in the U.S. as well. This category includes human health effects as well as ecotoxicity.

Toxicity has a lower profile in the U.S. than historically due to the effectiveness of the Clean Air and Water Acts and other legislation. However, toxicity has profound effect on human and species health.

Toxicity can be significant for materials imported into the U.S., and are relevant impact categories in ISO 14044, thus should be included in all EPDs.

(7) Land Use, Biodiversity, and Habitat Alteration

Environmental impacts related to land use, biodiversity, and habitat alteration are important to include when determining the full environmental impact of a product or process and should be included in PCRs and EPDs. Biodiversity, land use, and habitat alteration impacts can be significant for biobased materials and materials imported into the U.S., and are considered relevant impact categories in ISO 14044, thus should be included in all EPDs.

Table 3 Environmental Impact Categories

Impact Category	Commonly Used?
Global Warming Potential	Yes
Formation of Tropospheric Ozone	Yes
Acidification	Yes
Eutrophication	Yes
Ozone Depletion	Yes
Toxicity	No
Land use, biodiversity, and habitat alteration	No

3.3 Data Quality

Because one of the primary goals of PCRs is to create process clarity, rules related to data and modeling are critical. The ACLCA document [6] requires that the PCR developer ensure data transparency for evaluation by the PCR reviewer such that the reviewer can determine whether the data is primary, secondary, or tertiary; technosphere or ecosphere flow data; measured or calculated; and for the temporal period specified.

After a thorough literature search, no precedent could be found for including variability in an EPD except one instance in a draft PCR. Per BS EN 15804 [7], range and variability need only be reported if significant. According to BS EN 15804 Section 7.1i, "in the case where an EPD is declared as an average environmental performance for a number of products a statement to that effect shall be included in the declaration together with a description of the range/variability of the LCIA results if significant."

Because EPDs will eventually be developed to compare products with the same functional unit (for example, walls) and not just materials, it is important that PCRs for all industries are consistent and not more stringent or penalizing for one industry compared to another.

It is the goal of data quality requirements to facilitate verification by the LCA peer reviewers. The BS EN 15804 guidelines have the same general requirements for data availability for verification purposes as the ACLCA. Namely, the LCA practitioner must provide:

- Analysis of material and energy flows related to cut-off rules
- Description of unit processes
- List of LCA software and data sets used
- Life cycle impact assessment results per unit process and per plant/product
- Calculations for end-of-life scenarios and allocation procedures

3.4 Allocation Rules

In general, allocation is clearly covered in ISO 14044 clause 4.3.4 and the requirements of 6.7.1 through 6.7.3. The allocation of upstream profiles of fly ash and slag cement is considered controversial by some other industries, most notably the steel and power generation industries. Figure 4 shows supplementary cementitious materials (SCMs) used in concrete. Fly ash, slag cement, and silica fume are recovered materials from industrial processes.

Fig.4 Supplementary cementitious materials. From left to right, fly ash (Class C), metakaolin (calcined clay), silica fume, fly ash (Class F), slag cement, and calcined shale. Photo courtesy of the Portland Cement Association.

BS EN 15804 recommends the polluter pays principle, which states "processes of waste processing shall be assigned to the product system that generates the waste until the end-of-waste state is reached."

Similarly, the WBCSD cement sustainability initiative [9] states, "CO_2 emissions associated with the production of clinker- or cement-substituting mineral components (MIC) shall not be considered an indirect emission of the cement industry if these emissions are the result of another industrial process. This applies, in particular, to slag produced by the steel industry, and to fly ash produced by power plants."

This would mean that only the materials, energy, and emissions from processing and transporting these materials from the point of the industrial process to their use in the cement or concrete plant needs to be determined. This would apply to the recovered materials commonly used as SCMs: fly ash, slag cement, and silica fume. It would also apply to recovered or recycled aggregates used in concrete.

4. CONCLUSIONS

Public entities and private interest groups are encouraging the use of EPDs for environmentally preferable purchasing in the United States. This paper presented challenges for the U.S. concrete industry related to development of PCRs and EPDs. Challenges include:

(1) Certain PCR categories—such as life-cycle stages, impact categories, data quality, and allocation rules—could benefit from more research
(2) The functional unit for a product that serves many functions is difficult to define.
(3) To focus on all the life cycle impacts of a product, research in areas related to ecotoxicity, human toxicity, land use, biodiversity, and habitat alteration is needed.
(4) Data should be transparent and verifiable. Other requirements about data quality are beyond the control of the LCA practitioner.
(5) Allocation rules included in ISO 14044 and BS En 15804 should be followed as standard practice.

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