Second International Conference Buildings and the Environment, June 1997, Paris

ENVIRONMENTAL PROFILES OF CONSTRUCTION MATERIALS, COMPONENTS AND BUILDINGS

Suzy Edwards Building Research Establishment, Watford WD2 7JR, UK

How should environmental profiles be used for construction materials? An environmental profile is a graphical presentation of environmental burdens. The concept may be used to present the results from a number of different stages within an LCA. The most effective use of profiles for materials and products in buildings has yet to be established; whether they should present raw data or data which have been interpreted and to what stage in the life of the material they should be applied. They can be used to assess the effects of extraction, processing and manufacture of a material until the factory gate, but their suitability to show the burdens created over the life of the material in the building is less certain. The challenge is to design profiles that allow architects and their clients to make the most informed choices when designing or refurbishing a building. The approach that BRE is taking to develop profiles which may be used in the best interests of the client and the promotion of sustainable construction is discussed.

1 INTRODUCTION

The success of assessment methodologies for buildings such as BREEAM[1], which focus on the sustainability of the whole building, have highlighted the need for reliable, comprehensive information about the materials used in their construction.

Building materials present particular challenges for quantifying their environmental impacts:

- Their impacts within the building depend on a wide number of variables; e.g. workmanship, occupancy rates, local environment.
- Every building uses a unique assembly of materials, products and components.
- Buildings have a long life and therefore maintenance regimes and disposal and re-use options for particular components are difficult to predict.
- Building materials use large quantities of extracted resources that affect landscape and biodiversity, highly complex impacts to quantify.

Guidance is constantly sought from BRE by building clients such as housing associations, local authorities and large commercial organisations, who wish to

— 165 —

10621

provide a straight forward, independent lead to the specifiers for their buildings in choosing the 'most environmentally friendly' materials.

1.2 Environmental Profiles Partners in Technology Project

BRE has begun a three year Partners in Technology project, designed to collect data about the environmental impacts of different construction materials and components over the whole of their life, using the technique of life cycle assessment (LCA). Twenty-four industry trade organisations are contributing and it is anticipated that this project will provide an accepted method for gathering and presenting environmental information which will enable clients, designers and specifiers to make informed decisions at the design stage.

The members of ISO Technical Committee 207 are working to produce international standards for environmental assessment procedures, including the conduct of LCA and the presentation of information by environmental labelling [2]. Recently, work has begun in TC 207/SC3 to standardise the presentation of environmental burdens in a way that has been compared to nutritional information displayed on food products. An example of this approach is shown in figure 1 below. BRE is working to ensure that the development of a standard will include the particular requirements of materials and products used in construction. Together with the construction materials industry, BRE still has to resolve a number of issues in order to achieve the creation of a useful environmental profile and this paper discusses some of the most important of these.

Figure 1. Example of a possible format for an Environmental Profile



2. APPLICATION OF PROFILES

The most fundamental issue for environmental profiles of construction materials is the choice of where in the life of a material a profile can be applied.

A number of options exist, because guidance needs to be available for different stages in the design process, when designers choose:

- 1) the concept for the whole building
- 2) elements (such as partition walls, roofs)
- 3) individual products

2.1 Profile for the whole building design

At any of the stages, 1) to 3), the designer can make a difference to the environmental performance of the building, but at the initial design stage the differences can be more profound, with the ability to influence the total mass of each of the materials the building will require. Each element in a building is interdependent upon the others; for example, the choice of walling may result in a requirement for deeper foundations, flooring beams will be part of specific systems and thus design options may have different knock-on effects for the environmental impact of the whole design.

2.2 Profile for the level at which designers make choices: Building elements

Profiles for an element allow designers to choose between materials at a sophisticated level and include issues such as factory-finish versus on-site preparation. For 1m² masonry wall, the profile will include normalised "per tonne" information on bricks, mortar, wall ties and insulation. Maintenance and replacement impacts over the life of a building can be applied to elements.

2.3 Profile for individual materials

a) for the products from individual manufacturing plants

This would theoretically allow the client to choose the most "environmentally friendly " product from the range on the market. It has the advantage of distinguishing between manufacturing processes which have differing impacts on the environment, such as the wet and dry processes for the manufacture of cement, and could act as an internal driver for sector improvement. It allows the most environmentally clean products to be recognised as such, rather than hidden within average figures.

There are several disadvantages to this approach. Whilst it does make it possible to compare "best" and "worse" products from one material type with the "best" and "worst" from another material type, it does not allow alternative products for comparable functions to be compared easily since the range of performance for the material type has not been standardised/averaged. More

- 167 ---

importantly, "best and worse" is a rather simplistic approach for certain building materials.

Bricks provide a good example. They are made from different types of clays occurring regionally around the UK. In some areas the clay contains oil, which reduces the amount of energy required for firing and therefore influences the total amount of energy required for manufacturing the bricks. The oil bearing clays require less fuel to fire at the correct temperature, because the oil contributes to the heating. This oil adds to the environmental burden of the brick by the quantity of carbon dioxide produced, but is not included in the embodied energy of the product. The regional clays cause greater differences in environmental burdens for a given type of brick than exist between the various types of brick manufactured in the UK.

In the cement industry, conversion from the wet to the dry manufacturing process represents a massive capital investment which can only be competitively achieved when the present process equipment is replaced. In both these cases, comparisons between best and worse products within the sector are likely to be of little help as a driver for environmental improvement in industries which are already making major improvements in energy efficiency.

b) for a generic product, e.g. cement.

This is better for designers at the early stages of design because the general impacts of the product, calculated from proportional data from the industry as a whole, are available to allow them to make decisions before final specifications are made. The disadvantage is that best manufacturing practice is not rewarded. Such a profile could also be displayed on products and could form the basis of a sectoral benchmarking scheme, when used in association with information about specific products.

2.4 Initial Design Estimator

BRE is working, funded by the Department of Environment, to produce an "Initial Design Estimator". The aim of the work is to provide designers with a software program containing a range of specifications for elements commonly used in office buildings, currently being developed by BRE and Davis, Langdon & Everest Ltd. The program will contain information on the environmental impacts of the specifications, caused by their production to the factory gate, their maintenance values and replacement requirements. This work was initially focused on energy and has now widened to include other impacts. Designers will be able to enter their initial ideas for office designs by choosing the closest elements from the specifications available; the program will then produce an environmental profile for the whole building. From the profile generated for the whole building, designers will be able to see the consequences of varying the options within their designs.

2.5 The BRE Approach

Having taken into consideration the factors for and against the different levels at which profiles may be applied, BRE considers that a hierarchy of information should be provided for construction materials, components and buildings. Decisions on the types of building material to use can only be made accurately when considered in association with the design of the building and the implications of certain choices for other materials. Design options should be made explicit and summed over the whole life of the building.

A whole design concept such as that on which the estimator is based is essential and represents the top of the hierarchy.

At the bottom of the hierarchy, is information about generic building materials and components on a "per tonne" basis. An output of the Environmetal profiles project will be a collection of such information in a UK National Database. The information will be accessible, but it is intended that it should be used most accurately as part of the Estimator and not as the basis for comparisons between individual materials and components.

In the middle of the hierarchy stands the desire of the manufacturers to label their products and use the environmental attributes of their products for marketing purposes. This idea cannot provide clients with the same level of information as the Estimator, but the profiles can use the same data that will be fed into this tool. The choice to produce product specific or generic profiles remains open. Manufacturers can use the same methods of data collection and analysis to obtain satisfactory, comparable data for individual products as are used to produce generic data for the UK National Database and Estimator tool. The initial products in the Database will be chosen on the basis of the specifications input to the Estimator.

To generate profiles for manufacturers on a comparable basis, "per tonne" data must be generated, as is currently provided for life cycle costing. For certain products this will have be converted into functional units. This unit will be based upon the standard of 'service' provided by the component in a building, such as burning time for a fire door, or thermal performance of insulation material and the anticipated life of the product compared to that of a building, typically set at sixty years. In the first instance, it may be necessary to limit component environmental profiles to a presentation of the 'initial impacts' from extraction, processing and manufacture, adding in use and diposal effects next.

--- 169 ---

With regard to data collected, it is clear that two sets of data will have to be calculated for the separate purposes of the Profiles and Estimator projects. The product profiles will be used for marketing purposes. This requires an average value which is based on UK production, while the Estimator requires values based upon actual usage in the UK and which therefore include the impacts resulting from imports.

3. ENVIRONMENTAL PROFILES: GENERAL ISSUES

3.1 Data Gathering

It is clear that if the profiles are to be used for comparative purposes, clear rules must be applied to the process of their creation. Such rules have been set for LCA comparative studies:

Clearly defined boundaries in the data collection Allocation rules for co-production and scrap material inputs Common conversion figures

The mechanisms for classification and characterisation must also be explicit. There will be significant hurdles to overcome to include the concepts of uncertainty, risk and hazard in the profiles. If it is decided that interpretation is required, then a common list of indices must be prepared on which to compare all the building materials and products. This is likely to be modified as the data is collected. As LCA techniques have advanced, it has become clear that the choice of boundaries and allocation rules may produce very different outcomes and that in order to establish a level playing field between materials producers all data must be gathered together using the same methodology. This is the aim of the BRE Environmental Profiles project. A great deal of time and money has already been expended in gathering data by many sectors of the industry however, and in such cases this data must be accepted and moulded to fit the methodology where necessary.

3.2 Level of detail

An environmental profile may be defined as a presentation of environmental burdens, summed over the life of the product. It may include the resources used in production and a list of the emissions to air, water and soil. The level of detail at which this information is most usefully, and feasibly, presented is open to debate. A profile visually displays the results of an LCA and thus the options of detail available may be related to the four stages of life cycle assessment studies. [2]. These include inventory, interpretation (classification and characterisation) and valuation, as illustrated below in Table 1.

Table 1. Four stages of L	CA
---------------------------	----

LCA Stage	Profile Information
Inventory: Collecting data values for	eg. 1)CO ₂ : 3 tonnes/year
resources used and emissions	2)CH ₄ : 2 tonnes/year
produced.Breadth determined by the	3)SO ₂ : 1.5 tonnes/year
chosen goal and scope of the LCA	4)NO ₂ : 3.5 tonnes/year
Classification: Grouping the data	e.g.1)&2): Global Warming Gases
into Impact Assessment categories	3)&4): Acid Gases
Characterisation: Ascribing a value	e.g.:
to the impacts generated by the	Global Warming Potential (GWP)
product, often taking a common	(greenhouse gas to CO ₂ equivalents)
emission as a reference value.	Acidification Potential
Valuation: ranking, weighting or prioritising of different categories.	e.g. Eco-points. (3)
prioritioning of anteronit outogeneou	

It is possible to create profiles from the data generated at each of the stages shown above, and it is clear from the table that the more the data is 'interpreted', the shorter the profile will be and clients will have less to understand. However, the more the data has been processed the less transparent it is to those reading it. At each level of interpretation, the client has to accept the judgement of the scientific community. The challenge is to produce a system which adequately displays the varying impacts of different construction materials but which can still be interpreted and used by the majority of designers and specifiers. For the majority of clients in the construction industry this unlikely to present many problems and indeed they would welcome this. The pace of design projects means that the professionals and their clients appear to be content to receive general reassurance that the products in the designs they are creating are 'friendly' to the environment and non-toxic to man. Such claims are reinforced if made with the approval of a third party. Some clients however, do have environmental priorities of their own which they seek to satisfy and it would appear that more research is needed to investigate the preferences of the customer.

3.3 Interpretation of Inventory Data

Although clients probably prefer easily digestible information, which has been interpreted, this presents technical problems to the practitioner. At the present time, there is international political acceptance of the methods devised for calculating Global Warming Potential and Ozone Depletion Potential. For the other categories of impact that should be considered in a profile for construction materials, methodologies for characterisation of the impact are being developed and are gaining acceptance in different countries but no international consensus has yet been achieved. Categories requiring such work are illustrated in Box 1 below. Work in the area of classification is more

- 171 ---

advanced, and there are commonly agreed, albeit incomplete, lists of existing chemicals in Europe, concerning eco- and human toxicity.

Box 1: Impact Categories
Abiotic resources
Biotic resources
Acidification
Eutrophication
Photochemical oxidant formation
(smog)
Human toxicity(to include
considerations of daily intake and
observable effect levels)
Ecotoxicity
Landuse

A number of more subjective, qualitative areas of impact also apply to profiles for building materials, such as visual amenity. Site related impacts such as noise, dust and odour may be important if there are sensitive receptors in the vicinity, but are also difficult to present in a meaningful way.

4. CONCLUSION

The discussion above has illustrated the technical issues to be considered and reveals the enormous amount of work to be undertaken before a consensus can be reached on what an environmental profile should be and reliable data is available to create them. Many of the problems are common to products from any sector and research has been on-going in many of these areas for some time. It is unfortunate that some of the issues which are most relevant to construction materials, such as land use, are the least developed. In the longer term, it looks likely that the most accurate information will be available to architects in the form of profiles for a whole design, based on partly classified inventory data. In the short term, reliable profiles will be made available for material and product choices made in "quick -fix" situations.

REFERENCES

1. BREEAM New offices. Version 1/93. An Environmetal Assessment for New Office Designs. CRC Ltd, London

2. ISO 14040. June 1996, Life Cycle Assessment - principles and framework. Public consultation document.

3. The Eco-indicator 95, Final Report. NOH report 9523. PRJ Consultants, Amersfoort, the Netherlands.