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How to cite:

Ghumra, Shamir; Watkins, Miles; Phillips, Paul; Glass, Jacqui; Frost, Matthew W and Anderson, Jane (2009). Developing a lca-based tool for infrastructure projects. In: Proceedings of 25th Annual Conference of Association of Researchers in Construction Management (Dainty, A.R.J. ed.), ARCOM, pp. 1003–1010.

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Version: Accepted Manuscript

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DEVELOPING A LCA-BASED TOOL FOR INFRASTRUCTURE PROJECTS

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There exists a well established set of tools based on life cycle assessment methodology for buildings. Tools such as the BRE's Environmental Assessment Method (BREEAM) are commonly used and a greater number of clients are specifying a particular rating to be achieved for projects. Whilst the Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL) assesses infrastructure projects across the whole sector it does not specifically take into account the life cycle assessment of the project and, in particular, the materials used. However, recent developments with regard to responsible sourcing may go some way to addressing this gap. For example an organisation's procedures and systems regarding quality, the environment and health & safety can also be assessed through responsible sourcing alongside the impacts of the construction product itself. In the UK however, there is little evidence that a single, unified and overarching framework for project assessments will be developed in the immediate future. Therefore a real and pressing need exists for an easy to use tool for civil engineers that takes into account both the life cycle assessment of the materials used and the environmental impacts these have on infrastructure projects. This research aims to develop such a tool and as such this paper will present an analysis of the drivers and barriers in relation to this development.

Keywords: civil engineering, infrastructure projects, life-cycle assessment, responsible sourcing.

INTRODUCTION

This paper outlines the fundamentals of life cycle assessment (LCA) and the methodology that is used to apply this in the UK Construction sector through one tool in particular the Building Research Establishment (BRE) Green Guide to Specification). The focus on the vertical[2] built environment with particular government legislation and policies, such as the Code for Sustainable Homes (CSH), has created an imbalance and civil infrastructure LCA development has suffered as a result. As such there remains an opportunity to develop a LCA based tool for materials selection in infrastructure projects.

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[2] The vertical built environment is the term given to all buildings regardless of use, this includes both commercial and domestic buildings.

A number of sustainability assessment tools and their development is presented along with more recent developments in relation to responsible sourcing and carbon footprinting. There are a number of organisations working in the area of carbon footprinting and those working in the area of civil infrastructure are identified.

It is important to understand the drivers and barriers in relation to the development of such a tool, these are discussed and presented at the end of the paper.

Life Cycle Assessment Methodology

LCA was initially developed in the late 1960s and 1970s. It has become a recognised and valued tool for the assessment of environmental impacts associated to a wide range of applications from selecting waste treatment methods (Koehler, 2008) to traffic disruption (Huang, 2009) in highway projects. A great deal of LCA work has been done in relation to all aspects of civil infrastructure ranging from mobile communications (Emmenegger, 1998) to roadways (Stripple, 2001). Most assessments are carried out using dedicated software packages by expert practitioners and it remains a relatively specialist field (Ghumra et al, 2009). The term 'Cradle to Grave' approach is often used to define the life cycle in LCA, other definitions of the 'life' include 'Cradle to Cradle' and 'Cradle to Gate'. Pr ocedures of LCA are harmonised in the ISO14040 series which itself sits within the widely applied ISO14000 series of environmental management standards (Ghumra, 2009). The stages of LCA as identified in ISO14040 are shown in Figure 1.

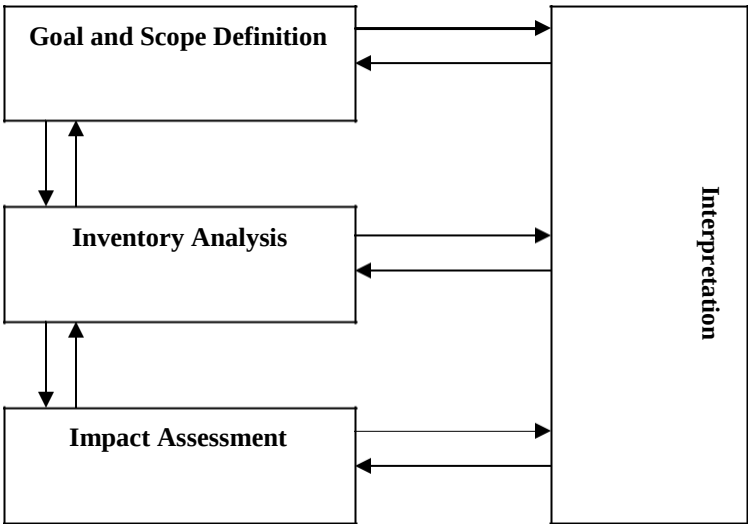

Figure 1. Life Cycle Assessment Framework (based on ISO 14040:1997)

The boundary setting (Goal and Scope) is the first stage of the LCA process, the functional unit (e.g. m^2 of product) is agreed upon and the inventory is analysed before the impacts are assessed. There is an ongoing aspect of interpretation that makes LCA an iterative process to allow the review of the process model at each stage.

LCA has been used and developed in the BRE environmental profiles methodology which forms the basis of the 'Green Guide to Specification' (Anderson et al, 2009).

SUSTAINABILITY ASSESSMENT TOOLS AND THEIR DEVELOPMENT

This section reviews tools currently available for the assessment of conventional construction materials/projects. The BRE was part of UK Government until 1997 and is now run as a trust (BRE, 2007). The BRE has been at the forefront of sustainability in the built environment since its conception over 80 years ago. The BRE's 'Green Guide to Specification' (Anderson et al, 2009) and the Green Guide On-line (BRE, 2007) are LCA based tools using the BRE Environmental profiles methodology (BRE, 2007) for materials selection for building construction. The success of these tools is due to general market uptake and through their integration into policy frameworks such as the CSH and the BREEAM (BRE Environmental Assessment Method) suite of products. No other tool in the UK has the coverage and wide usage of the Green Guide, it is not without imperfections but few would argue that it has raised the profile and increased awareness of materials selection for buildings in the UK. The Green Guide to Specification works on the basis that a building has walls, a roof and a floor and hence the basic elements can be simplified and grouped together making it applicable to most buildings. Civil infrastructure is inherently diverse and can encompass utilities, highways, waterways, sewers, runways and communication networks it is therefore much more complex to underpin these types of projects within broad material groupings. The materials used may well be similar but the application and use of the material or product can vary significantly.

The Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL) is a UK based tool focussed solely on infrastructure projects. Ceequal was developed to meet the needs of all infrastructure projects and was a collaborative effort from a number of private and commercial organisations (CEEQUAL, 2008). Ceequal is run as an independent organisation with directors and verifiers working for Ceequal on a contract basis. The Ceequal manual is fundamentally different to BREEAM as there are questions that can be 'scoped out' as it is appreciated that the infrastructure sector is very diverse and not all projects can conform to the same rules. Ceequal is not based on any life cycle methodology, but is versatile enough in its approach to tackle any type of infrastructure project and does include questions that promote the benefits of LCA of infrastructure projects. The most recent version of Ceequal (Version 4, November 2008) has expanded the materials section and has a greater emphasis on energy than previous versions. Ceequal currently represents the best foundation for any potential LCA based tool for infrastructure.

The Leadership in Energy and Environmental Design (LEED) tool (USGBC, 2009) was developed by the US Green Building Council, and has similar schemes in place outside of the USA (AIA, 2008) whereas BREEAM is UK based, but has extended to overseas markets such as the Netherlands and Canada (Haapio, 2008) The LEED scheme is similar to BREEAM as they both cover a range of credits including

materials. BREEAM can only be used for buildings but LEED can be applied to infrastructure projects; another significant difference is that the current version of LEED (version 2) does not use LCA as part of the materials assessment whereas BREEAM does.

These respective sustainability tools are well established and recognised, a number of other initiatives have been developed more recently.

RECENT DEVELOPMENTS IN SUSTAINABILITY ASSESSMENT

The BRE launched a Responsible Sourcing standard in the UK last November in the form of the BES 6001 Framework (BRE, 2008). This has partly arisen due to the prominence of certification schemes for timber such as the Forestry Stewardship Council (FSC) which meant that other construction materials such as concrete and steel were disadvantaged in schemes such as BREEAM where credits are available for responsible sourcing. The BES 6001 framework seeks to address this imbalance and other sectors such as precast concrete have based their own sector schemes on this. The framework looks at an organisation's procedures and systems regarding quality, the environment and health & safety. The inclusion of the standard into BREEAM and the CSH is expected when these respective schemes are reviewed in late 2009. This inclusion will give organisations further incentive to become recognised as a responsible source in addition to the ISO 14001 and ISO 9001 standards that many companies operate.

Carbon footprinting has been around for many years, recent work by Finkbeiner (2009) presents a good account of the current developments in Carbon footprinting, but it is only in the last three years that Carbon footprinting has become a marketing tool alongside the environmental benefits associated with it. The Carbon Trust has developed the publicly available specification (PAS 2050) and has been working with a number of leading organisations in the UK to implement this methodology into (primarily) consumer facing brands. Figure 2 shows the standard Carbon Footprinting label that accompanies many products, whilst this information is useful it does appear simplistic and no indication is given against an 'average'.

Figure 2. Carbon Footprint Label, (Sinden, 2009)

There is a lack of true comparability between products and processes and a perception that any more detailed explanation of the methodology would render the carbon footprint too complex for the average UK consumer. Practitioners of full life cycle studies that examine other impacts (as well as climate change) are increasingly finding Carbon footprinting too simplistic and ask questions whether 'Carbon' can really be perceived as the panacea of sustainability. The International Organisation for Standardisation (ISO) are working on an international standard for Carbon footprinting, this work is headed under ISO 14067. The World Business Council for Sustainable Development (WBCSD) is working with the World Resource Institute (WRI) to develop the 'Product and Supply Chain Initiative', this work stems from the Green House Gas Protocol Initiative (Brown, 2009). These organisations have representatives on various working groups to ensure collaboration; this greater level of dialogue can add a great deal of expertise and refinement but simultaneously can delay the launch of drafts and standards. Carbon footprinting is very much a buzz word as is 'offsetting' and being Carbon 'neutral', if the ultimate effect of Carbon footprinting reduces the impacts of Carbon in the environment it can only be commended. However it then falls on others who are more professed in the wider impacts of LCA to raise concerns if reducing the Carbon footprint could subsequently have a negative impact on another environmental category.

Industry bodies and trade organisations are not excluded from the focus on Carbon and the Highways Agency, Transport Research Laboratory and Mineral Products Association are currently working on a Carbon calculator for asphalt materials. It is important to keep abreast of these developments as the need for a full LCA of materials will go beyond Carbon and give clients and engineers more information about the relative impacts of climate change and other environmental impact categories. The first stage of approaching UK infrastructure would inevitably mean looking at highways as roads represent the largest sector of UK infrastructure by output (£) (ONS, 2009). By learning from projects, such as the Carbon calculator, the drivers for a LCA based tool may change over time and barriers that were not previously recognised may appear.

DRIVERS & BARRIERS

The ongoing focus on Carbon may well change to water in the coming years (Forston, 2008) where industry and suppliers may be required to monitor water consumption by type more accurately and demonstrate purification and re-use practices. The UK Infrastructure sector is gaining knowledge on LCA and more fundamentally many organisations are beginning to adopt true life cycle thinking. It is because of this changing paradigm that a fuller more encompassing LCA of all impacts (not just carbon and climate change) should be used and accepted by engineers and clients alike.

The BRE Green Guide to Specification is now in its fourth edition (Anderson et al, 2009) and includes a breakdown of the rating for each impact category, more

transparency and refinement of the assumptions will mean that the Green Guide will become better with each new version, organisations are invited to engage with the BRE to develop the Green Guide. This iterative approach has been a key part of the success of the Green Guide and is an aspect that any tool for infrastructure projects should aim to include. A tool for infrastructure based on the principles of the BRE Environmental Profiles methodology could benefit from such an association but, as highlighted earlier in this paper, such a tool would also be susceptible to the same criticisms.

The principal stakeholders for this work are outlined in Table 1 and have already been contacted and shown interest in this work. Collectively these represent the main groups involved in the uptake of such a tool and can therefore be considered to be proponents for such a tool.

Table 1: Principal Stakeholder Organisations

CEEQUAL	Highways Agency	Environment Agency
CIRIA	British Precast	Britpave
Institute of Asphalt Technology	Transport Research Laboratory	Civil Engineers Contractors Association
Construction Products Association	Building Research Establishment	Minerals Products Association
Surrey University	Scott Wilson	BAM Nuttall
Balfour Beatty	Jacobs	County Surveyors Society
Nottingham University	Institution of Civil Engineers	Loughborough University

The BRE environmental profiles methodology has been mentioned as one LCA model, there are many others which could be used to refine existing models or be taken in isolation. The ongoing EcoLanes project (EcoLanes, 2009) is using four different LCA models in different European countries to investigate the impacts of using recycled tyres and roller compacted concrete in road surfacing materials. The EcoLanes project aims to reduce construction time and costs of such pavements and to also reduce the amount of energy consumed in road construction projects. The EcoLanes project is focussed on specific additives and fibres in the surfacing material and the impacts associated to this, the models could be used to further enhance a LCA for materials selection for road construction projects however this may widen the scope to beyond the UK. Other countries tend to favour concrete surfacing for roads whereas in the UK asphalt surfacing is preferred, existing concrete surfaced roads are due to be replaced with asphalt (Highways Agency, 2000). The local parameters and culture of respective countries would also need to be taken into account and this could further hinder the development of such a tool if the geographic boundary is too wide.

LCA methodologies have been improved but further international standardisation such as a single index (Roy, 2009) would give a greater degree of comparison. The LCA methodology will be the most important aspect to the development of a tool as the

data to conduct the assessment would need to be collected with the model in mind. The quality and consistency of the data is another potential barrier to the uptake of a tool, if the data collection stage is considered too onerous or complicated then fewer organisations are likely to get involved. Trade-offs may have to be made between generic assumptions for road construction and specific proprietary products that may have particular environmental benefits; short-term barriers to developing a LCA based tool for road construction in particular could include the following:

- Consideration of the impacts of texture or skid resistance of a road surface on the pavement.
- Accounting for repair and maintenance for in the in-use phase of the life cycle.
- Impact allocation of by-products such as Pulverised Fly Ash.
- Treatment and modelling of traffic disruption to a re-surfacing project.
- Sensitivities to particular material components such as recycled asphalt planings.

Questions such as these present challenges that need further work and consultation to answer, but such difficult questions should not prevent this research from being carried out. Indeed, it is because of the very complex nature of the problem that the need for an infrastructure LCA tool still exists in 2009.

CONCLUSION

The LCA methodology will form a key part of the initial work, the BRE Environmental profiles methodology may form the basis of this LCA tool but other models will need to be investigated. Not only must the model be robust and comply with the relevant ISO standards but will need to have been tested and used in the construction sector with a degree of success.

Other more specific sustainability tools in the areas of responsible sourcing and Carbon footprinting could act as catalysts for the acceptance for a full LCA tool, conversely users may feel ‘tool fatigue’ which coul d be counter productive.

The focus on 'Carbon' as an indicator may act as abarrier to the development of a tool that seeks to take into account all environmental impacts. The criticisms of the BRE 'Green Guide' and environmental profiles methodology may also prevent wide acceptance of this work, however a greater degree of transparency may go some way to overcome this. The identified need for a LCA based tool for infrastructure projects will be the main driver for this work. The availability of numerous LCA models will facilitate the development of a tool without the need to derive an entirely new model.

The proposed Green Guide to Infrastructure will therefore seek to establish a sound method that is transparent and easy to use for highways (pavement construction) and then seek to develop this further into other areas of infrastructure. This paper forms part of the preliminary work to establish the drivers and barriers for such a tool to be developed.

A range of research techniques will be employed in the course of the research including:

• Communicating with stakeholders and other associated organisations;

• Application of the BRE Environmental Profiles Met hodology and database to civil infrastructure scenarios;

• Development of the concept for new tools specific to civil infrastructure;

• Forging links and cooperation with existing market tools and methods such as CEEQUAL.

The first stage of the research will involve conducting semi-structured interviews with specialists at the organisations presented in Table 1, by engaging with these individuals the framework and boundaries can be established to develop a LCA based tool for materials selection in infrastructure projects.

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