# VALIDATING A SET OF EMPIRICALLY WEIGHTED SUSTAINABILITY INDICATORS FOR CONSTRUCTION PRODUCTS

**Shamir Ghumra[1], Jacqui Glass[2], Matthew W. Frost[3], Miles Watkins[4] and Jo Mundy[5]**

[1 4] *Aggregate Industries, Bardon Hall, Markfield, Leicestershire, LE67 9PJ, UK.*
[2 3] *Department of Civil and Building Engineering, Loughborough University, Loughborough, LE11 3TU UK.*
[5] *BRE Global Ltd, Garston, Watford, WD25 9XX, UK.*

Sustainability assessment in UK construction is well established for buildings and civil engineering projects through tools such as the BRE Environmental Assessment Method (BREEAM) and Ceequal (the assessment and awards scheme for improving sustainability in civil engineering and the public realm). Assessment schemes such as these focus on the construction asset and give some consideration to the materials or products used, employing different techniques and varying degrees of guidance. Responsible sourcing seeks to address some of these shortcomings but only addresses the social and environmental aspects of the construction product. There is therefore a clear need for a more holistic approach to the sustainability assessment of construction products and materials. This need should be, in part, fulfilled at a generic level by the publication of BS 8905 "Framework for the assessment of the sustainable use of materials - Guide", but there is a gap in research. A questionnaire survey was developed to collate opinions on a range of sustainability indicators from 35 individuals within a construction product manufacturing organisation. These results were aggregated to derive overall weightings for a series of sustainability indicators. Environmental, social and economic sections are considered equally and weighted indicators are developed within each of these sections, which enhances the robustness of the process used in BS 8905. In general the survey weightings of the environmental indicators were in line with those from leading assessment schemes such as BREEAM, Ceequal and the BES 6001 responsible sourcing standard, thereby validating the survey findings. Such conclusions were not possible for social and economic indicators due to a lack of comparative indicators. The extension of this work could lead to a more holistic approach to the sustainability assessment of construction products and materials.

Keywords: construction products, responsible sourcing, sustainability indicators.

## INTRODUCTION

Sustainability is becoming an ever growing consideration in construction which has been accelerated since the 2008 Strategy for Sustainable Construction from the UK Government (BERR, 2008). This paper presents a review of the leading sustainability assessment schemes and standards currently in use for UK construction projects. The BRE Environmental Assessment Method (BREEAM) has become the most widely used sustainability assessment scheme for non-domestic buildings in the UK. The civil

[1] Shamir.Ghumra@aggregate.com

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infrastructure sector is served by Ceequal (the assessment and awards scheme for improving sustainability in civil engineering and the public realm). However, assessment schemes such as these focus on the construction asset and give little consideration to the materials or products used employing different techniques and varying degrees of guidance. The concept of responsible sourcing has gained momentum in the past two years with the publication of the BRE product standard, BES 6001 (BRE, 2009) and the sector standard from the British Standards Institute (BSI), BS 8902 (BSI, 2009). Responsible sourcing draws more focus on the products used in construction, but largely ignores economic considerations as part of the assessment. Therefore there is a clear need for a more holistic approach to the sustainability assessment of products and materials that make up the finished construction asset. In part this need should be fulfilled at a generic level by the forthcoming publication of BS 8905 "Framework for the assessment of the sustainable use of materials - Guide" (BSI, 2011 forthcoming).

This paper reports on a set of empirically weighted sustainability indicators for construction products and materials that can fit into a standard approach (BS 8905) to help fill the gap identified above. To generate the set of weighted indicators a survey instrument was developed and circulated within a construction product manufacturing business; 35 employees responded which enabled the individual weightings to be aggregated. These weightings were then validated against those already established for similar indicators in the leading assessment schemes and standards outlined above.

This paper presents a review of the current assessment options, presents the proposed indicators with the empirical weightings and then concludes by showing where such work can fit within a holistic sustainability assessment framework based on BS 8905.

## SUSTAINABILITY ASSESSMENT FOR CONSTRUCTION PRODUCTS

This section gives an overview of the key sustainability assessment schemes and standards used in the UK construction sector. BREEAM (Building Research Establishment Environmental Assessment Method) is a widely accepted assessment scheme for non-domestic buildings that is often specified for new build projects and Ceequal is the assessment and awards scheme for improving sustainability in civil engineering and the public realm, which has steadily increased in use for assessing new projects over the past 10 years. These schemes focus on the construction asset, give some limited consideration to the assessment of materials in some elements, but lack a truly holistic environmental, social and economic assessment of the construction products and materials used in construction projects. Responsible sourcing is focused on the construction product and the organisational and supply chain management systems connected with the manufacturing site, e.g. ISO 9001 standard for quality, but largely ignores economic indicators such as life cycle cost or profitability and is currently most often assessed using BES 6001 (BRE, 2009).

Due to these shortcomings BSI are developing a new standard BS 8905 "Framework for the assessment of the sustainable use of materials - Guide" to act as a guidance document for those wishing to assess products or materials in a more holistic manner which will support more sustainable decision making in the selection of construction products and materials.

### Sustainability Assessment in BREEAM

BREEAM was developed by the Building Research Establishment (BRE) in 1990 and covers a number of assessment schemes that cover the different requirements of particular building types such as Offices; Industrial; Retail; Prisons; Courts; Education and Healthcare etc. For other, and more unusual building types, a Bespoke BREEAM scheme can be provided. BREEAM awards credits against ten categories (BRE, 2008), these ten category scores are weighted to produce an overall project score on a scale of Pass (30%), Good (45%), Very Good (55%), Excellent (70%) and Outstanding (85%). Sections with particular relevance to this research are (weightings are given in parentheses) Energy (19%), Materials (12.5%), Biodiversity (10%), Transport (8%), Waste (7.5%) and Water (6%); hence, the energy section makes the single largest contribution to BREEAM project sustainability assessment scores.

### Sustainability Assessment in Ceequal

Ceequal is the assessment and awards scheme for improving sustainability in civil engineering and the public realm and was initially launched in 1999. The scheme was developed to enhance the environmental and social performance of civil engineering projects to give clients, designers and contractors an incentive to adopt and improve upon best practise. There are a range of awards available depending on the involvement of the wider project team these being; Whole Project Award; Client & Design Award; Design only Award; Construction only Award, Design and Construct Award.

Ceequal is a points-based system and asks questions over twelve sections, which include (weightings in parentheses) Energy & Carbon (9.5%), Ecology & Biodiversity (8.8%), Water Resources & the Water Environment (8.5%), Material Use (9.4%), Waste Management (8.4%) and Transport (8.1%); here, the materials section is worth less than 10% of the overall project score. The weighting points are embedded within the questions so that the overall score falls into a standard percentage. The four grades of award are Pass (30%), Good (40%), Very Good (60%) and Excellent (75%). Ceequal seeks to have a flexible approach to encompass all civil engineering works, so some of the questions are optional and can be ‘scoped out’ if they are not relevant to the project; there are, however, some basic project questions that are mandatory.

Little academic research has been undertaken specifically relating to Ceequal; trials of the methodology for rail embankments (Campbell-Ledrum & Feris, 2007) and road construction projects (Willetts *et al.*, 2010) represent recent research in this area, but do not question the weightings of the indicators nor do they include an in-depth review of products or materials.

### Responsible Sourcing

The 2008 Strategy for Sustainable Construction from the UK Government (BERR, 2008) contains a number of objectives and targets for the construction industry to achieve by 2012; one of these is that, "25% of construction materials should be from schemes recognised for responsible sourcing". Responsible sourcing is "The promotion and support of responsible practices throughout the supply chain demonstrated by actions and behaviour consistent with responsible sourcing principles" (BRE, 2009). These principles cover a range of issues including ethics, legal compliance and stakeholder engagement (Glass *et al.*, 2011). The construction materials sector has responded to this target in a largely positive manner primarily through the development of two standards. The first being the BRE BES 6001

Framework Standard for the Responsible Sourcing of Construction Products (BRE, 2009) and the second being the BS 8902 Responsible Sourcing standard for Sector Schemes (BSI, 2009). The main difference between these standards is that BES 6001 is focused on an organisation and product and BS 8902 is focused on a sector scheme. Many construction products manufacturers want to realise some degree of competitive advantage in this sphere, hence they have adopted BES 6001.

The first version of the BES 6001 standard was launched in October 2008 with an updated version being released in mid 2009. There are two parts to the assessment; the first seeks to assess the organisational management alongside the supply chain management from a quality, environmental and health & safety standards perspective whereas the second part addresses the social and environmental impacts of the products' manufacture, which are:

- Greenhouse gas emissions (7 points, 18%)
- Resource use (7 points, 18%)
- Waste management (4 points, 10%)
- Water extraction (4 points, 10%)
- Life cycle assessment (LCA) (5 points, 13%)
- Transport impacts (4 points, 10%)
- Employment & Skills (4 points, 10%)
- Community Engagement (4 points, 10%)

The list above shows the maximum number of points available for each issue and the relative worth of that score in relation to a total of 39 points for the entire social and environmental section. Points are awarded on a sliding scale (e.g. for water extraction 1 point is awarded if a site has a policy and metrics regarding water extraction; 2 points are awarded if there are objectives and targets to manage the water used; 3 points are awarded if this information is communicated to stakeholders and the maximum 4 points are awarded if the information communicated to stakeholders is externally verified). Organisations can be rated as Pass, Good, Very Good or Excellent against BES 6001.

**BS 8905**

The BS 8905 standard "Framework for the assessment of the sustainable use of materials - Guide" being developed by BSI seeks to provide a set of guidance and signposts to existing standards and procedures to formulate a more holistic sustainability assessment of materials.

The standard itself is not intended to be used as a source of certification (BSI, 2011 forthcoming), rather it encourages the involvement of stakeholders to prioritise sustainability criteria to form the basis of an assessment. A range of environmental, social and economic indicators are identified in BS 8905, but no weighting system is prescribed, so there is a need to extend the responsible sourcing approach to create a more holistic sustainability assessment framework.

BS 8905 (BSI, 2011 forthcoming) consists of three main phases, the first of which is the scoping phase and a key part of this is "a list of prioritised parameters for each aspect of sustainability". Therefore the approach herein is adopting, in part, the procedure for sustainability assessment detailed in BS 8905; all of the indicators identified above are from the perspective of a construction product or the factory that manufactures that product. The responsible sourcing indicators in particular will act as a useful barometer when comparing the weightings from a company survey (see next section) to existing standards and practice. So, based on the BS 8905 approach, research has been undertaken to identify, weight and compare selected sustainability indicators for construction products, as described in the following sections.

## SELECTED SUSTAINABILITY INDICATORS

There are clear similarities between the sustainability issues cited within assessment schemes such as BREEAM, Ceequal and BES 6001. Therefore it can be argued that sustainability indicators based on these schemes and standards should form the basis for any application of the BS 8905 framework (BSI, 2011 forthcoming).

Table 1 identifies specific environmental, social and economic indicators; it is based on previous research, reported elsewhere (Ghumra *et al.*, 2011a; Ghumra *et al.*, 2011b), from which a number of appropriate economic indicators were notably drawn (these were based on a series of 25 semi-structured interviews with stakeholders from the construction sector including designers, clients and contractors).

*Table 1: Selected sustainability indicators for construction products*

| Environmental Indicators | Social Indicators | Economic Indicators |
|---|---|---|
| Life Cycle Assessment/Carbon footprinting | Durability/Longevity | Profit Margin |
| Water (embodied in product) | Product Properties | Life Cycle Cost |
| Waste (to landfill) | Mode of Delivery | Internal Supply of Materials |
| Biodiversity | Employment & Skills | Operational Equipment Efficiency |
| Recycled/Secondary Content | Community Engagement | |

Having identified the key indicators a form of weighting is required, as described in the next section.

## PARTICIPANTS' WEIGHTING OF THE INDICATORS

This section of the paper explains the methodology of the weighting process and the calculations undertaken to arrive at the final weightings of the indicators that will be used as part of a holistic sustainability assessment framework.

An on-line survey was developed as the mechanism for collating data which was distributed via e-mail to the central services function at a leading construction materials supplier in the UK. As the potential sustainability assessment framework will be used primarily by the company as an internal, benchmarking tool, it was only necessary to involve company staff at this stage. Key central management teams including marketing, sustainability, communications, estates and human resources were targeted (a total of 86 people), and 35 responses were collated over a three week period, which represents a useable response rate of approximately 40%.

There were three main questions in the survey, one for environmental indicators, one for social indicators and one for the economic indicators. The individual indicators shown in Table 1 were assigned to their respective group and participants were asked to weight each indicator between 10% and 90% at 10% intervals, within each question (i.e. 100% would be divided between the indicators in each question). The weighted average of these responses (based on the frequency of response at a particular weighting level) were calculated to derive indicator weightings.

## SURVEY RESULTS

This section presents the results from the company survey in their raw form and gives the number of participants who selected a particular weighting level for the environmental, social and economic questions (Tables 2 to 4). Weighted averages were taken for each indicator to arrive at the final weighting for each indicator; this is presented at the end of the section (Table 5) alongside the corresponding weightings in BREEAM, Ceequal and BES 6001 to indicate how these indicators are weighted in the respective schemes and standards.

The weighting results of the environmental indicators are shown in Table 2. The water and biodiversity indicators show similar outcomes with the concentration of participants selecting lower importance weightings. LCA/Carbon footprinting is clearly the issue that the majority of participants felt were the most significant. Waste and recycled/secondary content have at least 70% of the weighting outcomes at 30% or below but still have a large spread of outcomes across the full range.

*Table 2: Environmental indicators weighting results*

| Environmental Indicators | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% |
|---|---|---|---|---|---|---|---|---|---|
| LCA Carbon Footprinting | 7 | 3 | 10 | 4 | 2 | 6 | 1 | 1 | 1 |
| Water | 19 | 9 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| Waste | 6 | 10 | 9 | 3 | 1 | 2 | 2 | 1 | 0 |
| Biodiversity | 20 | 3 | 4 | 1 | 1 | 2 | 1 | 0 | 0 |
| Recycled/Secondary Content | 11 | 12 | 3 | 4 | 1 | 1 | 1 | 1 | 1 |

The weighting results of the social indicators are shown in Table 3. Overall there does not seem to be a clear issue that has been weighted consistently highly. Durability/ longevity has a range of weightings and along with community engagement is the only issue to have a single instance at 90%. Product properties and mode of delivery both have over half of the responses at 20% or below. Employment and skills has a similarly low weighting concentration below the 30% level.

*Table 3: Social indicators weighting results*

| Social Indicators | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% |
|---|---|---|---|---|---|---|---|---|---|
| Durability/Longevity | 3 | 9 | 11 | 3 | 3 | 1 | 2 | 0 | 1 |
| Product Properties | 12 | 10 | 3 | 3 | 2 | 1 | 1 | 0 | 0 |
| Mode of Delivery | 11 | 15 | 2 | 1 | 2 | 0 | 0 | 2 | 0 |
| Employment & Skills | 9 | 8 | 10 | 2 | 1 | 0 | 2 | 2 | 0 |
| Community Engagement | 11 | 9 | 5 | 1 | 2 | 1 | 0 | 2 | 1 |

*Table 4: Economic indicators weighting results*

| Economic Indicators | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% |
|---|---|---|---|---|---|---|---|---|---|
| Profit Margin | 2 | 4 | 13 | 4 | 4 | 6 | 1 | 0 | 1 |
| Life Cycle Cost | 4 | 8 | 9 | 6 | 3 | 2 | 1 | 0 | 2 |
| Internal supply of materials | 11 | 12 | 5 | 0 | 1 | 2 | 1 | 0 | 1 |
| Equipment Efficiency | 7 | 17 | 4 | 0 | 1 | 0 | 1 | 1 | 2 |

The weighting results of the economic indicators are shown in Table 4. Profit margin and life cycle cost appear to have a greater number of weightings at 30% or over. Eighty percent of the cumulative responses are achieved at the 50% level for profit margin, at the 40% level for life cycle cost and at the 30% level for the remaining two indicators. Weightings for these indicators will generally be higher than the environmental or social indicators (as there are four indicators as opposed to five).

Table 5 shows the overall weightings of the survey indicators against the corresponding weightings from BREEAM, Ceequal and BES 6001. This has been done at a section level, e.g. durability and longevity appear in the materials sections of BREEAM and Ceequal and the entire materials section is weighted at 12.5% and 9.4% respectively, taking the weighting of the individual question would have made relative comparisons impossible. The purpose of Table 5 is not to draw comparisons between the absolute values of the weightings for each indicator, but to understand the relative positioning of the indicators to one another to validate the weightings of the survey indicators. The schemes and standards have different scopes and terms of reference; hence it would be unwise to extrapolate specific numerical similarities or differences on this basis.

*Table 5: Environmental, Social and Economic weightings*

| | Weighting % | | | |
|---|---|---|---|---|
| Indicators | Survey | BREEAM | Ceequal | BES 6001 |
| LCA / Carbon Footprinting | 27.3 | 19.0 | 9.5 | 31 |
| Water | 14.6 | 6.0 | 8.5 | 10 |
| Waste | 22.7 | 7.5 | 8.4 | 10 |
| Biodiversity | 15.3 | 10.0 | 8.8 | 18 |
| Recycled/Secondary Content | 20.1 | 12.5 | 9.4 | 18 |
| Durability/Longevity | 24.3 | 12.5 | 9.4 | - |
| Product Properties | 17.3 | - | - | - |
| Mode of Delivery | 17.0 | 8.0 | 8.1 | 10 |
| Employment & Skills | 21.0 | - | - | 10 |
| Community Engagement | 20.3 | - | 7.4 | 10 |
| Profit Margin | 30.8 | - | - | - |
| Life Cycle Cost | 27.7 | - | 9.4 | - |
| Internal supply of materials | 19.8 | - | - | - |
| Equipment Efficiency | 21.7 | - | - | - |

## DISCUSSION

This section presents a discussion of the company survey results in the context of existing sustainability assessment schemes and standards. The role of responsible sourcing is discussed as it represents an established framework that could be developed into a more holistic sustainability assessment standard for construction products with clear links to accepted sustainability assessment tools. The selected sustainability indicators could be developed further to provide an assessment framework for construction products, but more research would need to be carried out for such a development which is beyond the scope of this paper.

Generally it can be seen that the results of the company survey map well to similar indicators used within the assessment tools for environmental issues showing broad data validity. When all of the indicators are ranked on the basis of their respective weightings LCA Carbon footprinting (compared to Energy section weightings) is the most highly-weighted issue from all sources, the least highly-weighted issue is that of water, which would be ranked fourth or fifth in all the standards/schemes and recycled/secondary content is generally second or third in the rankings. The waste indicator appears to be more significant to the survey participants than in the schemes/standards. Overall this indicates that the survey weightings for environmental issues are valid and do reflect the weightings used in existing assessment tools.

For the social indicators there are no complete sets of comparable indicators for all of the survey weightings. However the Durability/Longevity indicator does appear to be the most significant. Transport, employment & skills and community engagement are equally weighted in BES 6001, broadly similarly to the survey weightings, at least for the last two of these indicators. Transport (mode of delivery) appears to be more of a concern for the survey respondents than in the BES 6001 standard which was perhaps due to the nature of the company as a manufacturing business and hence a degree of participant bias may be the reason for such a difference. For the economic indicators in this survey life cycle cost was the only economic issue mentioned in any other assessment scheme. Further correlations for economic indicators are difficult to make due to the lack of comparable indicators. This supports the position that sustainability assessments for construction lacks focus on the economics of construction products and materials; it is however acknowledged that the accountancy system present in most organisations will have a thorough understanding on the economic implications of material production and use, but may ignore life cycle costs.

In summary, the weightings of environmental indicators embedded in the BES 6001 standard for responsible sourcing represent the closest match to the survey weightings, however comparisons for social indicators are difficult and there are no economic indicators to make comparisons against at all. BES 6001 could potentially be revised to explore a more structured approach to the economic aspect of the product assessment. This work could help to inform subsequent revisions of BES 6001 by considering the inclusion of the economic indicators outlined previously including life cycle cost. As part of the application of the process suggested in BS 8905 (BSI, 2011 forthcoming), the selected sustainability indicators could be developed into a framework for the sustainability assessment of construction products and materials as an extension to this research. This might allow the construction products manufacturer to have a structured approach for the sustainability profiling of its products, to identify areas for improvement, reduce environmental and social impacts and improve the market position of its products and materials.

## CONCLUSION

Sustainability has taken an increasingly significant role in construction projects in the past few years primarily driven by the uptake of sustainability assessment schemes such as BREEAM and Ceequal. However, assessment schemes such as these focus on the construction asset and give little consideration to the materials or products used. Responsible sourcing has gained momentum in the past two years with the publication of the BRE standard BES 6001 (BRE, 2009) which draws more focus on the products used in construction. Therefore there is a clear need for a more holistic approach to the sustainability assessment of products and materials. In part this need has been fulfilled at a generic level by the forthcoming publication of BS 8905 "Framework for the assessment of the sustainable use of materials - Guide" (BSI, 2011 forthcoming).

The purpose of this research was to adopt the holistic approach outlined in BS 8905 and build on existing standards. A survey was developed comprising of a list of environmental, social and economic indicators which were based on the existing sustainability schemes and standards and supported by previous research. The survey participants weighted the individual indicators grouped as environmental, social or economic issues. The results were aggregated by frequency of response to arrive at a final weighting of all the indicators. Generally it was seen that the results of the company survey mapped well to existing assessment tools, showing validity of the weightings of the survey results for environmental issues, but such comparisons were not possible for social and economic indicators due to a lack of comparable indicators. Further work arising from this study could include revising the BES 6001 standard to include a more structured approach to the economic aspect of the product assessment and developing a framework for the sustainability assessment of construction products and materials based on BS 8905.

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