

BPEOs FOR C&D WASTE

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ABSTRACT

C&D (construction and demolition) waste materials represent an important feedstock in the re-use, recycling and recovery of arisings essential to an industry seeking improved levels of efficiency. Waste management requires to be examined in terms of environmental impact assessment and economic cost, as well as social-safeguard legislative considerations. The construction industry requires help to determine practical, yet environmentally-conscious options to manage residue. Material salvage, low-level and high-level recycling, landfill and, incineration for energy recovery represent general disposal routes. The work described* provides stakeholders with a way to compare waste-management alternatives by cost and environmental impact in easily identifiable units. Empirical analysis of disposal options for a representative waste stream is discussed to illustrate a way to guide industry in its waste management. The work presented here recalls September discussion

KEYWORDS: C&D-waste-management, Environmental-impact, economic-impact

INTRODUCTION

To recognise the full potential of construction and demolition (C&D) waste-arisings as a building resource, improved guidance is needed. Localised virgin-aggregates levies and landfill restrictions, together with modern recycling techniques can process almost all demolished material and this will exert pressure on C&D waste re-use and recycling rates (Whyte et al. 2005). Legislators need objective decision-making processes for waste management to allow analyses of best practicable environmental options (BPEOs). Guidance in assessing disposal-routes in BPEO terms can improve confidence in the environmental credentials of a preferred option, identify savings in disposal and transportation costs, generate revenue from the arisings feedstock and reduce the demand for increasingly scarce primary materials (SEPA 2000). As a guide to busy practitioners the construction industry has much to gain from an easy-to-use BPEO waste management system.

Information already exists detailing the environmental impact of building materials processing and manufacturing techniques. Empirical comparisons are now possible to allow informed decisions regarding re-use and recycling. Life-cycle assessment and the resultant easy-to-use BPEO guide described below assists the decision-making process greatly. To illustrate the application of the BPEO guide masonry and concrete arisings are assessed; the best practical environmental option from a range of disposal alternatives is identified. A possible framework for waste management in Western Australia is assessed through this paper highlights which examines the need to categorise demolition waste, establish for each category the full range of waste disposal alternatives, and then assist stakeholders to choose the best option.

* This paper recalls work presented by Whyte et-al, at the Waste & Recycle 2008 Conference: the heat is on no time to waste, Fremantle Esplanade WA Aus, 9-13 Sept 2008

CATEGORISATION & EIA

National waste plans use BPEOs to underpin environmental legislation and, direct waste management solutions to balance environmental, financial and social variables. Current guidance concentrates on municipal waste management. No BPEOs deal specifically with the waste-arising generated by construction and demolition, although regulators acknowledge that work is required to devise and implement appropriate waste management schemes and establish accurate measurement data. [SEPA, 2003]. Establishing a BPEO for any waste stream requires a baseline of material generated, decision criteria for disposal, and then a means to define, appraise, shortlist and consequently choose an optimum waste management option. The research described presents a methodology to establish BPEOs for the materials and products of C&D waste.

CATEGORISATION OF CONSTITUENTS, DISPOSAL

Waste as a result of depletion is composed chiefly of concrete rubble and masonry and, to a lesser extent, asphalt and soil with the remainder a mix of products composed of glass, gypsum, timber, plastic and metal. The construction and demolition waste stream is said to constitute a quarter of the European community's controlled waste arisings and has been divided, by the European Waste Catalogue, into more than two dozen waste coding sub-categories [2000/532/EC]. These divisions indicate the level of sorting, reuse and recycling possible. Managing the constituents of demolition waste falls under the main options of salvage and re-use, low-level processing as fill and the like, high-level processing as feedstock for reconstituted building products, incineration for energy recovery and, landfill. Costs also represent a major determinant in the uptake and utilisation of demolition arisings by industry. In addition whilst the technical expertise exists to utilise demolition waste arisings as new building products, it must be recognised that consumer confidence in secondary materials and transportation issues must be addressed.

Fiscal controls and regulations can encourage demolition waste re-use and recycling, particularly in projects in the public sector. Contract conditions and design specifications that are sympathetic towards recyclates, such as using recycled aggregates as permitted constituents for applications in the Specification for Highway Works, should continue to increase the uptake of recyclable materials [Collins, 2001]. The industry must go beyond a simplistic identification of the opportunities and perceived benefits in the use of demolition waste and seek an objective comparison of the range of disposal options available. Waste management methodologies to identify BPEOs for demolition arisings require consideration of the environmental impact, cost and legislation of all practical alternatives. Quantifying materials alongside energy used and pollutants generated, assist choice of the best practicable environmental option to address waste-arisings, where BPEOs stem from a like-for-like comparison of options. Variables are assessed in terms of the constituent resources and energy associated with product inputs, as well as the pollution and waste from product outputs.

Life-cycle assessment (LCA) provides a basis on which to compare the environmental impacts of building materials and products where manufacture, supply, use and decommissioning are traced. LCA requires the identification and quantification of the energy and raw materials used and emissions and wastes consequently released, the assessment and evaluation of potential impacts and, an assessment of opportunities to bring about environmental improvements.

LCA in WA

Biswas (2008) notes that a LCA conducted locally assessed the environmental implications of one tonne of building construction waste sent to landfill in Western Australia (2008). The analyses of embodied energy and environmental impact was conducted finding that for one tonne of construction waste the embodied energy was found to be 3,486 MJ, with a carbon footprint of 737Mt CO₂ equivalent, with a breakdown of embodied energy by construction waste sub-category finding

that bricks account for half (53%) of building waste's total embodied energy. Of the embodied energy (MJ) and carbon footprints (CO₂ equ-) of the sub-categories making-up one tonne of residential construction waste sent to landfill, bricks have the largest sub-category carbon footprint, contributing 78% of the total (made-up of 1890 MJ of embodied energy and 577 kg carbon footprint CO₂ equivalent). Of environmental impacts from the generation of one tonne of building waste, global warming has the most significant impact, which can however be reduced by recycling activities. When recycled, materials such as bricks, concrete and metal (accounting for 60% of the construction waste arisings), can reduce photochemical oxidation by 7.8%, reduce water scarcity by 11.4% and, reduce solid waste generation by 82.4% and, reduce global warming by 4%. This is already occurring with large WA manufacturer Midland Brick recycling, since 2006, 22,482 tonnes of off-site waste.

BPEO FOR C&D WASTE

Life-cycle assessment although comprehensive can be cumbersome for the construction industry. Given difficulties in making judgements about the benefits of different materials and their effect on environmental impact comparison categories, a simplified system of score-ranking or weighting environmental impacts, allows data to be much more accessible, albeit subjectively. Weightings from expert consensus can be prepared for the environmental impact categories. [Dickie and Howard, 2000; Howard et al., 1999]. Environmental impact expressed in terms of a single reductionist unit can assist comprehension greatly; *Low Ecopoint* values indicate a lesser environmental impact so that, a simple comparison of two alternatives identifies a lower ecopoint value as a preferred option. (Whyte, John & Biswas 2008)

The methodology here to predict and subsequently compare the environmental impact of the range of waste disposal options builds upon both primary and secondary research in the application of environmental life-cycle analysis techniques for plant utilisation, material production and emissions. Environmental assessment data is presented in the form of *Ecopoints*, cost data is calculated in unit-rate cost-per-tonne and, a checklist of social safeguard legislation is identified.

Rubble/Concrete

Waste concrete and masonry material disposal options include on-site and off-site reuse and re-processing, off-site salvage for plinths and the like, and higher level use. Aggregates of crushed rock, sand and gravel are essential in the provision of materials for construction projects. Quarrying or marine-dredging remain a primary source although, in many countries, secondary recycled aggregates present an attractive and technologically viable alternative to quarry products. On-site use of the processed inert rubble as low level bulk fill is common, with reclamation and retail of cleaned (cement/mortar-free) stone, brick, block, tile, slate, beam, column and mouldings possible. Higher level recycling (sorting, crushing and combining of the arisings) as RCA (recycled concrete aggregate of 95-100% crushed concrete), and RA (recycled and secondary aggregates of 0-94% crushed concrete) present opportunities for material use in construction.

Waste concrete rubble processing to obtain a usable aggregate material, requires levels similar to virgin-material processing, crushing and stock-piling [DETR, 1998]. The energy requirement for the production of crushed rock for construction is 15.4 kWh/t, with sand and gravel production requiring 10 kWh/t. Transportation and maintaining stock-piles, using a standard 15-tonne lorry to move 1 tonne of aggregate over 1km, requires 0.014 kg of diesel. Energy rates generally find that 1 tonne of diesel used in moving-plant is equivalent to 11,600 kWh of energy, and that one tonne of diesel is equivalent to 11,889 kWh of energy in the production of fine aggregate, with one tonne of diesel equivalent to 12,667 kWh of energy in the production of crushed rock [Dhir, Dyer et al 2004]. Emission factors for diesel-fuel and electricity generation required to crush igneous rock/stone, as well as emissions for static diesel engines used in the production of fine aggregate, and also diesel

fuel emission factors for moving aggregates over 1 km, are available from the National Atmospheric Emissions Inventory in the United Kingdom [NAEI 2001]. Industry can better appreciate this easy-data through an adoption of *Ecopoints*.

Ecopoints environmental-impact-values related to the production of one tonne of primary sand for construction purposes; the processing of 1 tonne of igneous rock; and, the environmental impact associated with the movement of 1 tonne of each material can be developed and are summarised below in Table 1. Raw material processing is examined alongside a summary of the impact values for the production of secondary aggregates from residual rubble waste arisings. The choice of the recyclates over raw-material is justified easily and empirically, given that lower Ecopoint values represent lower environmental impacts and a preferable production of building materials using waste arisings.

Variable	ECOPOINTS impact per tonne	
	Recycled material	Raw material
Transport	0.228	0.228
rock (crushed) production	0.019	0.619
finer/sand production	0.411	0.611

**TABLE 1
SAND/ ROCK PRODUCTION & TRANSPORT IMPACTS**

Whyte [et al 2005] conducted a cost analysis to assess processing of concrete and masonry waste arisings, finding that the cost to get rid of inert demolition material to landfill is 5.28/t (GB-Pounds £) to supply and deliver new virgin aggregates is 11.10(GB-Pounds £), all-in preparation of recycled aggregates for feedstock is 7.22/t (GB-Pounds £), an extra-over transportation fee is 1.60/t/24km (GB-Pounds £), the costs to supply and deliver new bricks is 68/t (GB-Pounds £), with salvaged bricks costing 52/t (GB-Pounds £), and, the general cost to salvage and prepare used masonry products is 3.65/t (GB-Pounds £) . The choice of the recycled material over raw-material is justified given the availability of local facilities to collect and recycling.

Table 2 below describes concrete/masonry waste disposal options alongside respective Ecopoint values, and costs per tonne. A rating of 1 signifies the most desirable BPEO and a rating of 5 signifies the least desirable option. The rankings tabulated for both environment and cost variables assist in the determination of BPEO best practicable environmental option for concrete waste.

Alternatives	RANK		VARIABLE	
	COST	ENVIRONMENTAL	<i>Ecopoint</i>	<i>cost/t (GB-Pounds £)</i>
Re-use/ salvage : on-site	1	1	<i>nominal</i>	<i>3.65</i>
Re-use/ salvage: off-site	3	3	<i>11.187</i>	<i>6.50</i>
recycling material : on-site	2	2	<i>0.868</i>	<i>7.22</i>
Recycling material : off-site	5	5	<i>11.826</i>	<i>8.82</i>
Raw material installation & landfill of C&D waste	4	4	<i>11.806</i>	<i>16.38</i>

**TABLE 2:
RANK (BPEO) FOR CONCRETE: COST AND ENVIRONMENTAL IMPACT**

Cost analysis finds product salvage and re-use near to the site of origin, followed by on-site material recycling and utilisation, to be the most cost-effective waste management technique (where facilities exist, off-site material recycling is less expensive than landfill plus virgin material supply). In environmental terms, after product salvage and re-use locally, on-site crushing and material recycling as low-level-fill gives the next most theoretically desirable environmental impact

compared with other options. Off-site product salvage provides a desirable BPEO depending on the nature of the product involved, whilst material recycling off-site is found to be comparable to the combined environmental impact(s) of landfill coupled with the supply of replacement with primary material.

SUMMARY

Product salvage, re-use locally and on-site material recycling are also found to present cost-effective C&D waste management options. Life cycle assessment of one tonne of building waste in Western Australia demonstrates the potential value of recycling construction waste to lower environmental impact. Building upon cost data and LCA analysis, the BPEO methodology presented above allows an easy weighting-&-ranking of waste-management-alternatives for use by construction industry decision makers.

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