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DESIGNING TO ENCOURAGE WASTE MINIMISATION IN THE CONSTRUCTION INDUSTRY

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Abstract

The process of waste minimisation through 'designing out waste' is in its infancy. Many barriers and opportunities exist in developing waste minimisation strategies in design. The paper will summarise the initial findings of the authors' recent research. It is intended to stimulate thought into the concept of designing out waste. By outlining the causative factors of waste through design and the principle strategies for waste reduction, the paper highlights the present status of this important subject and question whether adequate emphasis is being put on the initial stages of the waste hierarchy – reduce, reuse, recycle. The paper introduces the various options for waste minimisation in design, including designing for recycling, extended life, disassembly and designing out waste. It concludes by highlighting the links between 'designing out waste' and the future waste management and recycling industries, indicating where opportunities may exist.

1. Introduction

Over 70million¹ tonnes of waste is produced by the construction industry each year. This amounts to 24kg per week for every person in the UK – about four times the rate of household waste production.² The Government's strategy and guidance^{3, 4} suggests we should follow a hierarchical approach to reduce the amount of waste we produce, and to reuse and recycle what waste is produced. However, whilst the reduction of waste forms the highest priority in the waste hierarchy, and contributes towards a sustainable construction industry, its complexity has placed it at the bottom of construction and waste management research agendas.

Many barriers and opportunities exist in developing a strategy of waste reduction in design. The research at Loughborough University, in collaboration with AMEC Construction, is focusing on the systems and techniques which create waste in design, therefore addressing the causative issues and not the problem.

In this paper the concept of 'designing out waste' is explored. In addition, the various merits of several waste minimisation options in design, including 'designing for waste reduction on site', 'designing for recycling', 'extended life' and 'disassembly' are highlighted with examples of industry best practice to date.

2. Research methodology

Increasingly the focus of research is shifting to avoidance of waste on construction sites. Notable research is being undertaken by the Building Research Establishment (BRE) and the Construction Industry Research Information Association (CIRIA). Research methods are not, however, consistent which may lead to erroneous results, particularly if data is intended to be comparative. Research data is often fundamentally based on 'skip analysis' or direct waste analysis (DWA)⁵.

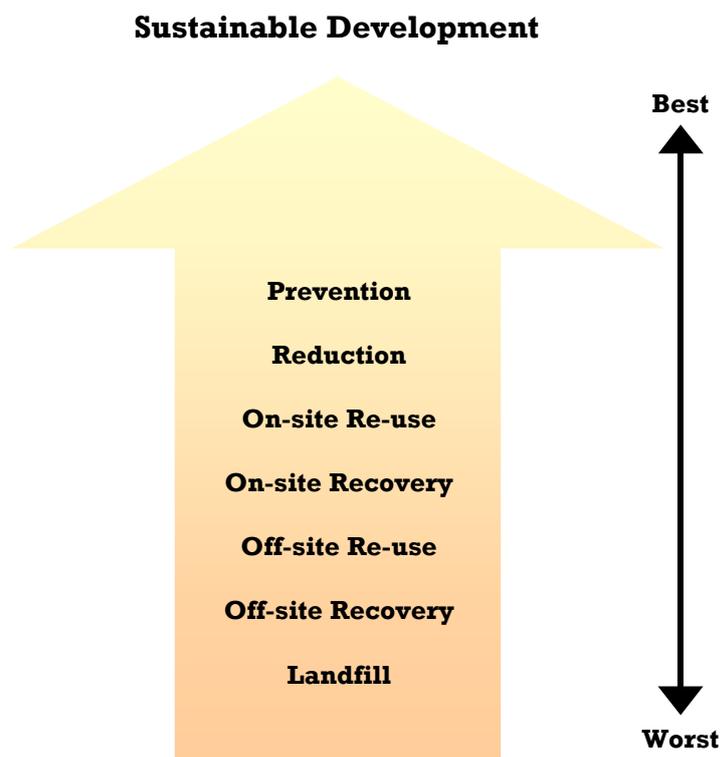
The research reported in this paper involves an ongoing series of waste audits at AMEC Construction sites. The methodology includes discussion, observation and quantitative assessments of the types and distribution of wastes. Primarily, the data is retrieved from site audits, additionally however, procurement inventories are analysed against design drawings to determine materials purchased 'v' as-built projects. The data is then collated to the project plan, and 'historical' information to identify any potential trends in wastes arising. Finally, the data is assessed against each stage of the design process, and questions are raised regarding the potential to reduce waste, particularly on the decisions which create waste.

3. What is waste minimisation

Waste minimisation is any technique which either avoids, eliminates or reduces waste at its source⁶. Many related terms are used to describe waste minimisation in different 'fields' or countries; these include:-

- Waste reduction
- Clean technology
- Pollution prevention/reduction
- Environmental technologies
- Low and non-waste technologies

Figure 1; The Hierarchy of Waste Management



Source; The Hierarchy is originally based on the EU Waste Management Hierarchy⁷.

4. The concept of designing out waste

Designing out waste at the earliest stages of the construction process offers the greatest fundamental opportunities for waste minimisation. The best management approach to waste, particularly hazardous waste, is to manage the process so that there is no waste to manage. This is obviously very difficult, but the concept of 'designing out waste' begins with the question: can the amount of waste being produced be minimised, if not eliminated, totally?

The underlying objective is to eliminate, or at least minimise, waste at every step in the design and construction process, including concept, detail, production information, specification and procurement, first and second tier suppliers, logistics, site planning and construction.

5. Defining waste minimisation

There is a general lack of consensus about the meaning of terms referred to as waste minimisation.

Many definitions and variations of definitions (listed below) exist for waste minimisation and related topics. For the purpose of this paper waste minimisation will be defined as:-

Any technique, process or activity that either avoids, eliminates or reduces waste as its source or allows reuse or recycling of the waste.⁸

5.1 'Eco-design', design for the environment

The design of products which apply environmental criteria aimed at the prevention of waste and emissions and minimisation of their environmental impact, throughout the life cycle of the product.^{9, 10, 11, 12}

5.2 Source reduction

A U.S. concept which closely resembles waste prevention; Municipal solid waste source reduction is the design, manufacture, purchase or use of materials or products (including packaging) to reduce their amount of toxicity before they enter the municipal solid waste stream. Because it is intended to reduce pollution and conserve resources, source reduction should not increase the net amount or toxicity of wastes generated throughout the life of the product.¹³

5.3 Release Reduction

Release reduction refers to any practice that causes a decrease in the cumulative multi-media releases of toxics into the environment.¹⁴

5.4 Dematerialisation

The change in the amount of waste generated per unit of industrial products.¹⁵

5.5 Green Design

Green design consists of two complementary goals. Design for waste prevention avoids the generation of waste in the first place; design for better materials management facilitates the handling of products at the end of their service life.¹⁶

6. Legislation and compliance

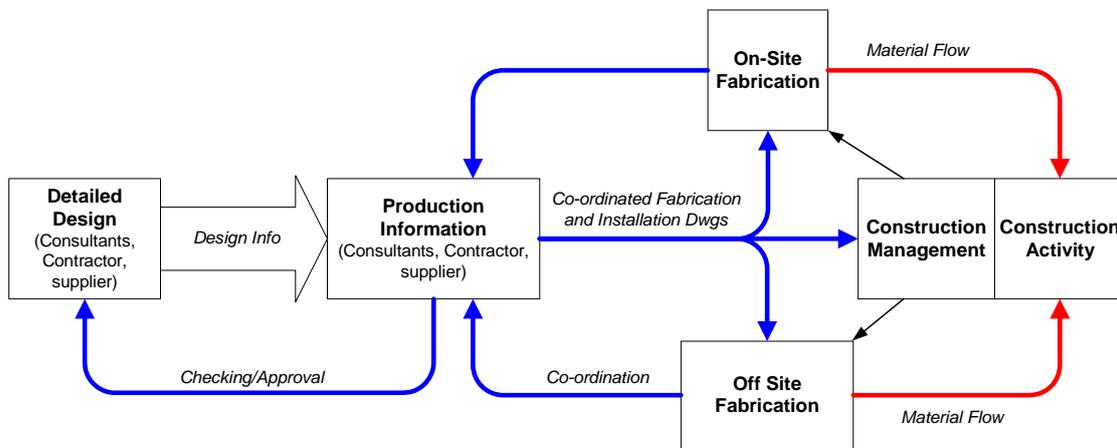
It is inappropriate in this paper to describe the legislative environment pertaining to waste minimisation and designing out waste. However, the fundamental issues related to 'designing out waste' are synonymous with the concepts of Integrated Pollution Control (IPC) which was formerly introduced into UK legislation under Part 1 of the Environmental Protection Act¹⁷ 1990 implemented with effect from 1st April 1991. In addition, the Waste Management Licensing Regs 1994 and the Controlled Waste Regs 1992 provide construction managers with the principal legal framework.

The IPC process using the concept of Best Available Technology Not Entailing Excessive Cost (BATNEEC) establishes procedures which are used to prevent and, only where that is not practicable, to minimise pollution. Therefore, in the confines of this paper, 'designing out waste' could be seen as a process conforming to IPC, whereas disposal to landfill could be seen as an 'end-of-pipe' solution which may not conform to BATNEEC.

7. Mapping wastes arising in the construction process

To map wastes arising in the construction process a model is needed as a framework for identifying the stages and the participants involved. Whilst many models of the design/construction process exist, the following model provides a basic framework for discussion of the issues.

The design construction process



Source: Austin, S., Baldwin, A., Hammond, J. & Waskett, P.¹⁸

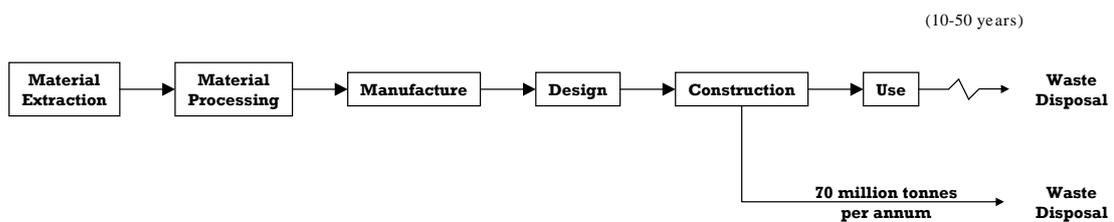
The diagram will highlight material/waste flows and illustrate the dominant causes of waste arising.

8. The causative factors of waste

Determining the causative factors of construction waste in commercial and industrial buildings, which are almost always designed individually for client requirements, is not straightforward. Other sectors, including housing, retail and civils all have the advantage of a degree of generic design which allows waste benchmarking on a m² or m³ basis. The process of design and designing out waste, should however have similarities regardless of whether the end of product is reproduced on a 'blueprint' basis or not.

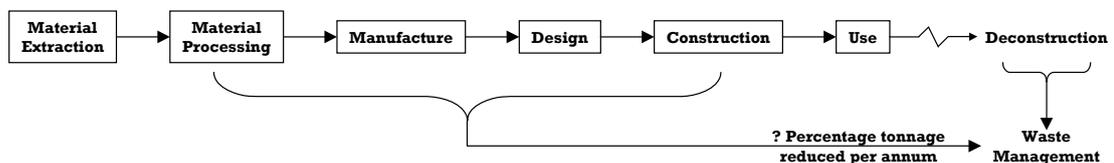
A building design, or product design, is a process of synthesis in which decisions are made which affect cost, performance, buildability, safety and wastes arising. Generally buildings are developed without regard for the environment and particularly no regard for waste minimisation. This approach is outlined in below.

'Traditional' Stages of Product/Construction Life Cycle



Decisions are made at each stage of the design process including concept, detail and construction which create wastes. The concept of 'designing out waste' addresses each decision throughout the process and attempts to influence actions to reduce waste.

Designing to Encourage Waste Minimisation



The sphere of influence of the designer and/or the construction manager will be dictated by the contract, which in turn is ultimately led by the Client. Contractual arrangements which are based on Design, Manage and Construct (DMC) contracts have the advantage that designers and Construction Managers can form 'in-house' working groups to focus the design teams efforts on reducing wastes.

A recent waste management research study, undertaken by the authors, of a three-phase pharmaceutical development has highlighted ease of communication within the design and construct process as an important waste minimisation factor. The first phase of the contract involved a brickwork, labour and materials package which inevitably creates high volumes of wastes. On phase II, more consideration eventually equated to less waste. Working with the contractors, several site practices were changed, particularly handling and logistics; it appeared many of the waste issues equated directly with logistics and site layout. This information, based on discussion, observation and quantitative data gathering was fed back to the design team for Phase III. Presently, the design team is working with the Client to alleviate the majority of building envelope wastes through changing to an alternative cladding material.

This approach is not universal in its successful application. Often common wastes arise from a number of work packages, for example, timber. This creates difficulty in identifying the source work package of the waste and hence analysing the decisions behind why the waste occurred.

9. Addressing the causative factors of waste

The following list broadly summarises 'designing out waste' methodologies. The focus of wastes reduction can be both short and long term.

- Use of prefabrication and off-site prefabrication
- Standard component/bespoke design
- Realistic component size, capacity and specification
- Minimising temporary works
- Optimising design lives
- Allowing specification of recycled materials in design
- Designing for recycling and ease of disassembly
- Identify building products which create waste
- Poor communication

Many "quick wins" can be achieved to reduce wastes through improving the design process in terms of communication. Better briefing from inception to construction will reduce wasted effort and wasted materials, particularly avoiding design variations.

Whichever waste minimisation practice is employed it is beneficial if priority waste streams are identified. The priority will be dictated by the project, for example, 'high volume low value' wastes would dominate civils, whilst 'high value low volume' are more likely on construction sites.

11. **The effects of designing out waste on the waste management industry**

The following table provides a summary of the potential impacts of a 'changing' construction industry on the waste management sector. The summary highlights how changes in design philosophies could create a need for change within waste management.

Designing out waste issue	Effect on the waste management industry
Increasing the recyclability of designs so buildings 'can be recycled'!	= Increased infrastructure in place to recover and recycle products
Reducing levels of hazardous materials specified	= Reduced requirement for hazardous waste landfills etc.
Increasing standardisation	= Reduced number of waste streams increasing the opportunity for effective waste segregation on site
Increasing specification of recycled materials	= Requirement for waste managers to close the 'recycling loop'
Supply chain 'take-back' requirements	= Reduced requirement for wastes management.
Use of prefabrication	= Dominant, segregated waste streams at the factory
Standard components leading to re-manufacturing of old components	= Supply chain 'take-back' requirements
Minimising design variations 'mistakes'	= Reduced requirement for waste management

12. Conclusions

Increasingly design and construction companies are demanding services and procedures which are safe and 'environmentally friendly'; this will include waste avoidance as a primary focus.

By promoting the focus of waste (and of other detrimental environmental issues) within the design phases of product and building development, the emphasis of addressing waste avoidance will shift from 'a site issue' to 'a design issue'. This, in turn, will require stakeholders within the design and construction process to develop closer ties with waste managers who can demonstrate innovative solutions to wastes reduction and recycling, as opposed to waste disposal.

Many different waste minimisation concepts exist, all of which have similar objectives. Designing out waste is one such concept which will become more dominant. This is likely to be driven by economic, public and legislative pressures.

The approach will allow waste managers and designers an opportunity to reduce waste holistically as opposed to the traditional independent approaches which have, in the past, created 'end of pipe' solutions which often do not end up at the best overall solution.

REFERENCES

- ¹ Govt Statistical Service (1998) Digest of Environmental Statistics No. 20, Government Statistical Service
- ² CIRIA (1999) Waste Minimisation & Recycling in Construction; Boardroom Handbook. CIRIA
- ³ Department of Environment, Transport & the Regions (1998). Opportunities for change: consultation paper on a UK strategy for sustainable construction. HMSO.
- ⁴ DOE (1995). Making waste work – a waste strategy for England and Wales. DOE, HMSO.
- ⁵ Brunner, P.H. & Ernst, W.R. (1986) Alternative Methods for the Analysis of Municipal Solid Wastes. Waste Management & Research 4, 147-160
- ⁶ Crittenden, B., Kolaczowski.S. (1995) Waste Minimisation A Practical Guide. IChemE
- ⁷ EU (1997) EU Waste Management Hierarchy; Second Environmental Action Programme
- ⁸ Crittenden & Kolaczowski (1992)
- ⁹ Weenen, J.C. Van, & Duifj, GAP: First NOH European Conference Design for the Environment, 21-23 Sept 1992, Nonspeed, the Netherlands
- ¹⁰ Weenan, J.C. Van, Bakker, C.A., & Keijser, I.U. de: Ecodesign. An Exploration of the Environment in Product Design. IDES, Uni. of Amsterdam, 1992
- ¹¹ Keoleian, G.A., Menery, D., & Curran, M.A.: A Life Cycle Approach to Product System Design. In: Pollution Prevention Review, Summer 1993, pp 293-306
- ¹² Hopfenbeck, W, & Jasch, C.,: 'O' design. Umwellorientierte Produktpolitik. Ven. Moderne Industrie, 1995
- ¹³ World Wildlife Fund and The Conservation Foundation: Getting at the Source. Strategies for Reducing Municipal Solid Waste. The Final Report of the Strategies for Source Reduction Steering committee Washington, D.C., 1991, p.x.
- ¹⁴ Hearne, S.A. Aucott.M. (1991) Source Reduction Versus Release Reduction: Why the TRI cannot measure Pollution Prevention. Pollution Prevention Review. Winter 1991-92
- ¹⁵ Herman, R., Ardekani, S.A., Ausubel, J.H. (1989) Technology and the Environment; Dematerialisation. Pp 50-69, Washington, D.C. Nationala Academy Press
- ¹⁶ U.S. Congress, Office of Tech. Assess. (1989) Facing America's Trash: What Next for Municipal Solid Waste, OTA 0-424 (Washington, D.C.: US Govt Printing Office)
- ¹⁷ Environmental Protection Act (199). HMSO, London
- ¹⁸ Austin, S., Baldwin, A., Hammond, J. & Waskett, P. Application of the Analytical Design Planning Technique in the Project Process. Submitted to CEC Conference, VTT, Finaldn, 1999