LOWER LONDON ROAD
SUSTAINABLE HOUSING PROJECT

WASTE MINIMISATION IN
CONSTRUCTION

CONTENTS

1 EXECUTIVE SUMMARY

This report presents the findings of a series of waste minimisation audits undertaken at Lower London Road as part of the Sustainable Housing Project. The aim of the audits was to observe waste generation and management on site as a basis for identifying means of reducing both costs and environmental impacts.

The main finding was that waste minimisation opportunities fell into one of three categories:

- Positive Environmental + Positive Financial (Type 1),
- Positive Environmental + Zero Financial (Type 2),
- Positive Environmental + Negative Financial (Type 3);

as described in Table 1.

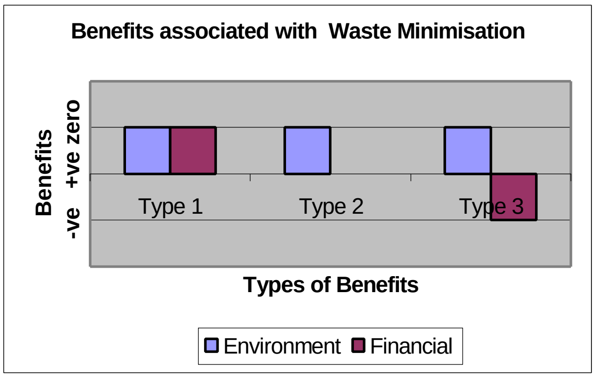

Table 1: Benefits associated with Waste Minimisation

Type (1) waste minimisation opportunities have both environmental and financial benefits, so are most likely to be adopted. However, because of the fiercely competitive nature of the construction sector, the majority of opportunities with any financial benefit have already been adopted, leaving Types (2) and (3). Since it is unlikely that any builder can afford to adopt measures which benefit the environment at a significant economic cost (i.e. a negative financial benefit), the majority of waste minimisation opportunities still available are likely to have no significant economic cost or benefit (Type 2).

Widespread adoption of such measures is only likely to occur if it is either enforced or encouraged. Environmental legislation continues to become ever more pervasive and more effectively enforced, which leaves encouragement as the only remaining avenue to improve the uptake of waste minimisation in the construction sector. We therefore recommend the development of a new standard or good practice guide, such as the one currently under development by CIRIA, to allow builders to demonstrate that they are operating in an environmentally responsible manner. With such a system in place, it will then be up to the general public and the housing market to decide how much they value the environment and what they are prepared to do to reduce the impacts on it from the construction sector.

2 INTRODUCTION

The Lower London Road Sustainable Housing Project was initially conceived with the aim of reducing the environmental impacts of the built environment. To achieve this aim, several principles had to be integrated within the project:

- the environmental impact of different construction methods was compared;
- the embodied energy and toxicity of alternative materials was analysed;
- the operational energy efficiency of the whole building was calculated;
- the waste generated during construction was managed and assessed.

> ***"It was agreed from the outset that a 5% improvement which was duplicated in 20 subsequent projects was twice as good as a 50% improvement which only one developer was brave enough to try again."***

Each stage of the project has been monitored and recorded so that it can be communicated to interested parties. Throughout the project, an important underlying theme has been that the lessons learned and the decisions made should be clear so that they can be applied in future projects. To this end, none of the materials, systems or ideas used in the project represent a dramatic departure from established procedures; they are simply incremental improvements which add up to a significant improvement overall. These incremental improvements were chosen deliberately to encourage widespread uptake of more sustainable housing. It was agreed from the outset that a 5% improvement which was duplicated in 20 subsequent projects was twice as good as a 50% improvement which only one developer was brave enough to try again.

This principle has been continued into the waste minimisation element of the project. Waste minimisation in this context comprises two distinct stages: firstly, the construction method and the detailed choice of materials selected for the development were chosen with minimisation of waste in mind. This included waste from extraction, processing, transport and building, as well as final disposal or recycling. Secondly, the actual process of construction was monitored to assess the main areas where waste arose and to identify ways in which this waste could be reduced. The first stage of waste minimisation is covered predominantly in the materials and design specifications already submitted, although these areas will be discussed in greater detail in the context of this report. The main subject of this report is the minimisation of waste arising during construction.

The construction process itself generates significant quantities of waste: about a fifth of all waste arisings are attributable to the construction sector. This waste is generated at every stage in a normal construction project, from initial winning of resources such as aggregate, through processing, packaging, transport, use on site, repair and disposal.

A significant portion of these arisings can be designed out of a project with careful selection of materials. For example, a steel frame building generates waste from ore mining, processing, transport and smelting before the foundations are laid but a timber frame building carries a lesser environmental burden. However, it is important to give careful consideration to such decisions and to avoid sweeping assumptions. If the steel is manufactured from scrap, as a large proportion is, then there is a net reduction in waste (although there is still a considerable energy burden) and timber sourced from unsustainable forestry practices can have a dramatic detrimental effect on biodiversity. For any particular material, there is often a wide variation in the environmental impact of production by different manufacturers. It may therefore be necessary to assess the environmental performance of a number of potential suppliers.

2.1 Supplier Environmental Questionnaire

This first stage of waste minimisation has been undertaken firstly through the assessment of design and materials options as set out in the relevant specifications (previously submitted to DETR and posted on the sustainable construction web site). Once these materials had been selected (on a generic basis, e.g. timber, plasterboard), an Environmental Questionnaire was sent to each potential supplier to assess the environmental aspects of their production processes. A copy of this questionnaire is attached as Appendix 1.

The questionnaire is designed to cover those aspects of producing a building material that can have a detrimental impact on the environment. This includes the materials used in its manufacture and the manufacturing process itself; the first section covers accreditation to internationally recognised environmental management systems, such as ISO14001 and EMAS. If a company has gone through all the procedures required to gain accreditation to one of these standards, it is a reasonable assumption that they have their principal environmental impacts under control, with structured plans in place to reduce environmental impacts on a continuous basis.

Environmental Management Systems are based on the premise of identifying significant environmental impacts and putting in place the procedures, reporting structures and management framework required to continually reduce them and monitor this reduction. Accreditation to a recognised environmental management standard requires that the system must be verified by certified independent auditors, ensuring an impartial view. Potential suppliers were also questioned about their performance against relevant environmental legislation, such as IPC authorisations, trade effluent etc. and whether they had previously undertaken any environmental projects.

Certain chemicals are universally viewed as being unacceptable for use in any environmentally friendly product. These include red list and black list substances such as DDT and dioxins. Where any of these substances are used, the product in question would not be considered for inclusion in the project.

2.2 Local Suppliers

Waste and environmental pollution from transport of materials to the construction site can be minimised by specifying local producers wherever possible. This also makes it simpler to check up on the environmental performance of suppliers and provides a useful incentive for prospective suppliers to demonstrate their environmental credentials, as their products may then be specified for subsequent sustainable construction projects in the area.

Wherever possible, local suppliers were given preference for this project, particularly for the main components of the building, such as the timber frame and blockwork. Local suppliers were also used for services such as recycling and waste disposal.

The environmental impacts of transport are well known, including atmospheric emissions, road building, pollution from runoff etc. As a rule of thumb, running an articulated lorry for 100 miles generates about one tonne of carbon dioxide, about the same amount as would be emitted by a small, highly efficient flat in a year. Lower London Road comprises 95 flats and has a design life of 100 years, which equates to a carbon dioxide output over the design life of the building of around 10,000 tonnes, equivalent to about one million miles of road freight transport.

For this development, an estimated average of seven articulated lorries per day made deliveries to the site, each of which had made a round trip averaging 60 miles. The total build time for the development is about eighteen months, during which the builders were working a five day week. This rough calculation shows that about 175,000 vehicle miles were attributable to the development, not including transport of materials to local depots and transport of waste materials off the site. Once these have also been added, the impact on the environment from transport, at least in terms of global warming, comes to about 2,500 tonnes of CO_2, or almost one quarter that of the development during its entire design life.

> *"the impact on the environment from transport comes to almost one quarter that of the development during its entire design life."*

It should be borne in mind that this is a particularly efficient development, in terms of the energy required to operate it. None of the flats had an SAP rating below 95 during the initial stages of the design, following which further developments, such as the introduction of heat recovery ventilation in every flat, should have raised SAP ratings throughout the scheme to the maximum 100. However, the extended design life should be set against this increase in fuel efficiency: Lower London Road is about 40-50% more efficient than a standard development but is designed for a period 66% longer than the standard specification. This means that the environmental consequences of transporting material to the site should be a smaller proportion of the overall impact, compared to a standard development. However, we have also taken steps in this project to ensure that local materials were used wherever possible, so by taking this into account the benefits are likely to be greater than the calculation would imply.

The message that this calculation should send to future developers is that the implications of transporting materials to and from the site should not be underestimated. The implications of using locally produced materials go much further than simply supporting the local economy. The reduction in environmental impacts from transport alone are likely to be comparable to those that can be achieved through detailed assessment of the building design and construction processes.

2.3 Design for disassembly

One of the principal sources of waste from the construction sector is the demolition of existing buildings. In recent years this has reduced somewhat with the introduction of the landfill tax; however, the material is still being produced, it is just being disposed of in more imaginative ways. Landscaping and acoustic bunds are more popular than ever and there is a noticeable tendency for buildings to be somewhat higher than they used to be.

This problem is the same as that faced by many other manufacturing sectors, which are now looking to the techniques of “cleaner design” to improve the environmental performance of their products. Design for disassembly and recycling means making products that can be taken apart easily for subsequent recycling and parts reuse. For example, Kodak’s ‘disposal’ cameras snap apart, allowing 87% of the parts (by weight) to be reused or recycled. Unfortunately, the economic costs associated with physically taking apart products to get at valuable components and materials often exceeds the value of the materials. Reducing the time (and thus cost) of disassembly might reverse this balance. Thus in the longer term design for disassembly should act as a driver for recycling and reuse.

Waste arising from the demolition of buildings is not generated until the end of their useful design life. Since the design life for Lower London Road has been extended to 100 years, this meant second guessing what environmental legislation will be in place in the next century. Obviously, it is not possible to be certain about this, however by extrapolating recent trends it is possible to make some predictions with reasonable confidence. One such trend in environmental legislation is the requirement for manufacturers to take on responsibility for the whole life of their products. This is beginning to be seen in some sectors, such as electronics, car batteries, tyres etc. As we expect the pressure on finite environmental resources to continue growing, we can also expect this legislation to be extended to other sectors. We have therefore set out to make it easier to dismantle and recycle the building at the end of its life.

In the context of Lower London Road, design for disassembly meant avoiding composite materials which are more difficult to separate and recycle and deliberately favouring materials which are easily recyclable, like steel for railings, timber for the main construction and even PVC for drainage, plumbing etc. Wherever possible, we have tried to avoid mixing materials, so that the eventual dismantling and recycling of the building a simplified.

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3 WASTE MINIMISATION DURING CONSTRUCTION

The reduction of environmental impacts from the construction process itself requires an additional level of control over all aspects of construction. One useful way of addressing these issues is to consider the construction project in exactly the same way as any other manufacturing or production process and to apply the principles of waste minimisation on this basis. A typical waste minimisation project of this sort would consider the inputs, processes and outputs of the production process, as well as any utility inputs such as energy, water etc. One difficulty with applying these principles to construction is that each project is unique, which can lead to problems when assessing the effectiveness of a waste minimisation approach. However, if the right measures and benchmarks are chosen, it should be possible to overcome these difficulties.

3.1 Barriers to Waste Minimisation

A further difference between traditional industrial waste minimisation and the application of the same principles to construction is that the final data for a development, in terms of materials used, waste generated etc. are not available until the development is complete. This means that any cost saving measures identified in one project can only be applied in the next project. Since no two construction projects are exactly alike, the application of waste minimisation to the construction process is therefore not as precise as it is in an industrial context.

For waste minimisation in construction to be widely adopted, it is necessary to answer definitively one simple question: is it worth it? For example, if you are in charge of a building project with a budget of £1million and you suspect that you can save 2-3% of this cost through waste minimisation, you obviously have £20-30,000 to spend on waste minimisation. If you add up the total cost of segregating, double handling, measuring and managing raw materials, energy, fuels and waste and maybe having a general labourer on site to keep things tidy and it comes to less than the amount you stand to save, then it is worthwhile. The difficulty faced by developers in deciding whether or not to pursue waste minimisation is that the value of neither figure is known: for a given project, it cannot be stated at the outset how much can be saved or how much it will cost to save it.

This leaves developers in the situation we see at the moment: any cost saving measures which are apparently effective will be used and those that may seem a bit more far-fetched may be tried but will not be adopted unless they are clearly working. This principle applies to waste minimisation throughout the design and construction of a project. At Lower London Road, for example, a decision was taken early on in the design stage of the project to use cellulose insulation. This material has the same insulating properties as the traditional rockwool and, although it costs considerably more (around £7 per square metre compared to about £2.50), it is considered to be more environmentally friendly because it is made from waste material and has a very low embodied energy.

However, this assessment of the pros and cons of using this material overlooks the effect that it has on the programming of a building project. When using rockwool, the external walls are completed, the insulation material is inserted and the internal facing is skinned with plasterboard. This is an efficient, dry process and builders are used to it. With cellulose insulation, the external wall must be finished, then the whole apartment cleaned out before the insulation can be applied. Cellulose is then blown into the space between the studs and rolled flat; excess material is picked up off the floor and replaced in the container (which is why the floor has to be cleaned beforehand). Once the insulation is in place, the internal wall skin can be put up and the apartment then has to be cleaned again. Although this process would not normally be considered in assessing the costs and benefits of this material, the implications for labour costs, and scheduling are significant.

This is just one example of the hidden costs of changing the accepted approach to building, which goes some way to explaining the reluctance of builders to try out new ideas. It is obviously more efficient to have a number of general waste skips dotted around a site, which workers can just throw anything into, rather than having specific segregated skips and asking people to spend most of their working day walking across the site with pieces of wood. It is against this background that waste minimisation must be promoted and it will only be accepted if there is a clear financial argument in its favour.

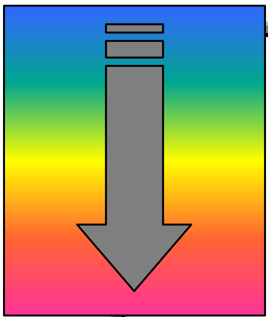
4 CONSTRUCTION PROCESS

The following sections set out the main elements of the construction process at Lower London Road and provide commentary on waste generated in these areas, with pointers toward reducing waste and the associated impact on the environment.

4.1 Site Preparation

The selection of a contaminated (or brownfield) site is a desirable prerequisite of sustainable development. Greenfield developments use a finite resource and effectively prevent it from being used economically for any other purpose. In environmental terms there is a spectrum of land quality which descends from pristine wilderness through cultivated agricultural land and developed areas to heavily contaminated sites. Economically, there is a similar spectrum, although in this case, land suitable for housing has the highest value, then industrial land, agriculture, forestry etc. Similarly in terms of its social value, different types of land are worth more to the societies that live on them. In all cases, contaminated land has the lowest value; it is also far easier to convert a land type from a higher value to a lower value: pristine wilderness is practically impossible to recreate and it is usually economically impractical to regenerate agricultural or forestry land once it has been used for any other purpose.

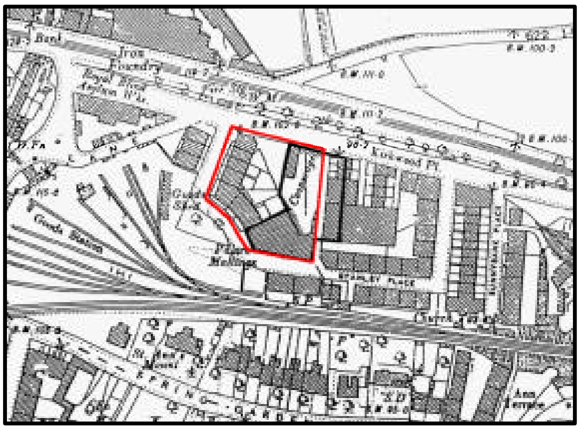
Table 2.1 Land Use



Social	Environmental	Economic
Residential	Wilderness	Residential
Recreational	Agricultural	Commercial
Commercial	Forestry	Recreational
Agricultural	Recreational	Agricultural
Wilderness	Residential	Forestry
Forestry	Commercial	Wilderness
Contaminated	Contaminated	Contaminated

Given that a development is to be built on contaminated land, there are a range of remediation options available. Mainly for economic reasons, the most popular form of remediation in the United Kingdom is so-called “dig and dump” where the most heavily contaminated material on the site is identified (usually by chemical analysis), removed and disposed of to landfill. In terms of waste minimisation, this process has its pros and cons: although it restores land to a higher value, it does so at the expense of landfill capacity. The contamination is not treated as such, merely moved elsewhere.

Alternative treatment technologies are typically more expensive and more time consuming, although in environmental terms they are often preferable. Within the constraints of a development project, cost and timescale are two of the most important considerations, which means that more environmentally friendly treatment technologies tend to be applied only in high profile public sector projects. Depending on the nature and extent of the contamination involved, these techniques can treat the soil on-site to remove the contaminated material or, in the case of some organic contaminants, actually destroy it.



In the case of Lower London Road, the site was formerly used for a number of industrial purposes, including the cooperage shown in this plan of 1896. Other uses included a bottling plant and a perambulator factory. In addition, the site is adjacent to the railway lines and sidings, all of which have the potential to cause contamination.

A contaminated land site investigation was undertaken at Lower London Road. This revealed that a certain amount of contaminated material was present on-site as a result of previous uses, which had to be removed and disposed of to landfill. However, the amount of material removed in this way was relatively small. There was a delay of a number of years between remediation of the site and its preparation for development. During this time a large amount of fly tipping took place and the site became heavily overgrown. By the time development of the site began, it was necessary to remove some material which had been deposited on the site and this too was sent to landfill. However, in general the site required additional material to be brought on to make up levels for the development.

At this time the builders, Harts, were also undertaking a substantial development at the Caledonian Distillery site, which is about one mile away across town. Development of this site required the demolition of existing industrial buildings, which generated a large amount of clean inert rubble. Rather than disposing of this material to landfill, we applied to SEPA for a temporary waste carriage licence to transport the material to Lower London Road, where it was used to make up the levels of the site as required. This process avoided the unnecessary generation of waste material at the Caledonian Distillery site and removed the requirement for any additional material to be brought on to the Lower London Road site, thus realising a double environmental benefit.

On the subject of ground contamination, it is also worth considering activities during construction and the impact they may have on the environmental quality of the finished development. One example of this is this storage and use of diesel fuel for trucks, forklifts, cement mixers etc.. Ideally, all such potentially contaminating materials should be stored on bunds to prevent spillage which would result in contamination of the soil. This contamination would obviously not be picked up by a site investigation, since it would occur subsequently. The consequences for residents, for the environment and for the liability of the developer would therefore be unknown.

4.2 Foundations and Groundworks

Once the site had been prepared, the next stage of the development was to install the foundations and ground works. By this stage the foundation design had already been fixed; a system of piling and ground beams, with occasional floor slabs where required, was designed with two main aims in mind: to minimise environmental impacts and to last for 100 years. This foundation design used the minimum amount of material required for the purpose. It also relied heavily on fabrication off site under controlled conditions. This meant not only that the quality of the materials was assured but also that the generation of waste was minimised, both on and off site.

The first major audit of waste generation at the site was undertaken at this stage, however it was discovered that very little waste was generated in this process. At subsequent stages of the construction of foundations and ground works, there was greater scope for the generation of waste through careless use of rebar (concrete reinforcement bars). However, inspection of practices on-site revealed that rebar was carefully segregated into different sizes and diameters, used wherever it was practical and recycled where it was not.

Another aspect of the groundworks construction which we felt warranted particular attention was the use of shuttering for pouring concrete. On the basis of previous waste minimisation studies we had researched, we expected to find considerable waste in this part of the building process. This has been reported particularly in Japan, where endangered tropical hardwoods have been used for concrete shuttering and then disposed of after a single use. The use of shuttering at Lower London Road could not have been more different. Materials used were obviously fairly low grade temperate softwoods and each piece of shuttering was used several times. Once it had been used once, each piece would be removed and stored, then re-used until the groundworks for the whole development were complete. Once this stage of the development had been completed, the shuttering, which was heavily contaminated with concrete, was sent for recycling.

4.3 Timber Frame

The timber frame was pre fabricated by Walker Timber at their nearby facility in Bo'ness. An environmental audit of this facility revealed a very efficient operation: any waste generated was chipped and transport is to the Caberboard factory in Stirling. There it was used in the manufacture of oriented strand board, much of which was used in the manufacture of timber frame kits.

Once delivered on site, little waste is generated in the erection of the timber kit. A certain amount of off cuts and other small pieces of wood were found in the timber skip but the quantity of material produced was small, particularly compared to the size of the kit. This waste material was all segregated and sent for recycling.

One issue which came to light during the construction of the timber kit concerned the weight off the wall panels. Since these had been increased to accommodate the extra insulation required, they were considerably heavier than those for a standard timber kit. Although at 150 mm the walls sections could still be handled manually, if they were any thicker a crane might be required to manoeuvre them around the site. As environmental concerns become ever more important and insulation levels rise, the implications of this trend for the programming of timber frame building operations may become significant.

4.4 Blockwork

It is often considered that blockwork must represent an area of significant waste in construction projects, as damaged blocks are easily identifiable in skips. However, this is something of an oversimplification of the real situation. Blockwork can be separated into three main components: substructure, outer leaf and cosmetic blocks.

Substructure blocks are denser than other blocks used in building, as they have to withstand the weight of the whole building on top of them. They also tend to be used in applications where walls of several block thicknesses are required, which means that more of this type of block may be used than would be expected. These blocks are not seen in the finished building, so it is not important that they should look presentable and scratched or chipped blocks can still be used. It is also possible at this stage of the construction process to “lose” waste blocks in fill material within substructure walls, so even if blocks are wasted at this stage, they may not find their way into waste skips.

Outer leaf blocks are usually finished in render, so again it is not essential for them to look good. This means that there is more scope for using damaged blocks which might otherwise have to be discarded and for including broken or cut blocks. Only where manufactured stone or similar cosmetic materials are used is it important for the final appearance to be good. In these cases, more care is required to ensure that materials do not have to be discarded simply for cosmetic reasons.

4.5 Insulation and Plasterboard

Blown cellulose thermal insulation was used at Lower London Road for its improved environmental performance. Although the use of this material caused programming delays and represented an additional cost, no waste was generated because the material is supplied in bulk and any that is spilled during the application process is re-used.

Plasterboard waste was collected in a separate skip for recycling. As with other aspects of the building, like the timber frame, the re-use of plasterboard off-cuts comes down to an economic decision: is it worthwhile for workers to take off-cuts to a dedicated storage area, then return to that area whenever they need a small piece of board? Given the cost of plasterboard purchased in bulk and the cost of labour, the answer is often no. Section 5.4, Labour and Material Costs, covers this issue in greater detail.

4.6 Mortar and Render

Very little waste was generated in this area once the materials had been prepared on site, although a small amount of waste was generated from poor storage of bulk raw materials such as sand and cement. This is covered in greater detail in Section 5.1 below.

5 WASTE MINIMISATION

5.1 Storage and Handling

An important aspect of waste minimisation is the availability of space for correct storage, handling and segregation of both raw materials and waste. At early stages of the Lower London Road development, waste minimisation was undertaken to the highest standards, with neat piles of materials, segregated wastes, recycling skips etc. However, as the development progressed and space became increasingly restricted, waste minimisation activities began to infringe on the normal operation of building works.

Obviously, construction work must take priority over waste minimisation: if the development is not built on time and to budget there will be no waste to minimise or money to save. However, the fact that space will almost inevitably become increasingly restricted as the development grows means that there will usually be more potential for waste minimisation at the earlier stages.

Once materials are delivered to the site, proper storage and handling are essential to reduce loss or damage caused by exposure to rain, mud and forklifts. For instance, bags of cement need to be covered in plastic for protection from moisture; bricks and blocks must be stacked carefully so they will not be damaged by passing forklifts and trucks and timber must be covered and kept off the ground. In other words, not only is it necessary for materials to be stored where they will be secured and protected, they also need to be stored in a configuration that prevents damage to the structure or the finish.

5.2 Planning Delivery

With space at a premium it is important wherever possible to plan the delivery of materials to the site to avoid damage to materials and the unnecessary generation of waste. A typical example of this is the delivery of bulk materials such as gravel, sand etc. These are particularly prone to being spread around the site by forklifts etc., which is plainly a waste of good quality raw materials. The alternatives to this practice are either to provide sufficient space and insist that workers take due care with these materials, or to provide materials in packaged form which can be stacked and used as required. However, the calculation which builders need to be able to do in this case is to assess whether either of these options is cost-effective.

If there is not sufficient space on site for the storage of bulk raw materials then provision will have to be made for storage of these materials adjacent to the site. This is likely to represent an additional expense, on top of which the additional time spent by workers in going to and from the store must also be paid for. If materials are supplied in packaged form, they are not only more expensive (often considerably so) but there is also the problem of generating and disposing of packaging waste. In practice, it is not thought to be cost-effective to pursue either of these options, so small amount of waste from this source is, for the time being, inevitable.

As space becomes ever more restricted it becomes increasingly important to maintain standards of general house keeping around the site. Proper storage of raw materials and segregation of waste is essential if unnecessary damage and incorrect disposal are to be avoided. At the early stages of the development it is relatively easy to store materials as there is plenty of space, however in the latter stages of development it may be more worthwhile to employ a general labourer to keep the site tidy. It is particularly at this stage of the development that the pressures of completing the contract on time and to budget are most acute. It is also at this stage that the widest variety of materials are present on site and there is the greatest potential for the generation of waste.

Ordering unnecessarily large quantities of material promotes careless material handling and use, inefficient utilisation, and generation of waste in the form of both scrap and unused materials. It encourages the wasteful use of supplies, since subcontractors and workers will be less inclined to use up scrap and re-use cut-offs if they know that they can simply cut a piece of wood or plasterboard the size they need from a new board or sheet of extra material. The presence of excess material also contributes to the severe space pressures on construction sites.

Excess purchases also increase the risk of material being lost, damaged, or stolen. This risk can be reduced through proper coordination between contractors and suppliers to arrange just-in-time deliveries. The less material that is kept on site, the less there is to lose, damage, or steal. And once materials are delivered, security measures need to be taken to prevent theft.

5.3 Packaging Waste

Construction materials do not tend to be over burdened with packaging, however particularly towards the later stages of the development when a wide variety of different materials, fittings etc. are present on site, this can be a problem. Packaging materials are made from a wide range of materials, including several different plastics, cardboard, wooden pallets etc. They therefore tend to be disposed of in the general waste skip, rather than being segregated for recycling. In comparison to the amount of waste generated by the construction process itself, waste from packaging is not considered significant. Nonetheless, it can be reduced and even avoided by careful selection of materials.

As discussed above, the purchase of bulk raw materials is favoured on financial grounds. In terms of the disposal of packaging waste these materials would also be favoured from environmental point of view. Therefore, although the use of bulk materials leads to the generation of a certain percentage of waste, the generation of packaging waste is completely avoided.

The Producer Responsibility Obligations (Packaging Waste) Regulations 1997 (as amended) made under the Environment Act 1995, constitute the UK's compliance with the EC directive on packaging and packaging waste (94/62/EEC). They place a legal obligation on those in the packaging chain to recover and recycle a certain amount of packaging from the waste stream. Although these regulations do not apply to a construction company which is simply the end user of packaging, the implications of their introduction throughout the packaging chain will mean a reduction in packaging from now on.

Another implication of the introduction of Packaging Waste Regulations is the extension of producer responsibility onto the site. In Germany, it is already common practice for suppliers to remove their own packaging materials and take appropriate measures to dispose of or recycle them. Already in the UK, purchasers are within their rights to insist that packaging material should be taken back, although it is still rare to see people unpacking everything at the supermarket checkout. However, in the context of a large construction project, the purchasing power of the developer should be more than adequate to achieve this aim, if the supplier wants to win the contract.

5.4 Labour Costs and Material Costs

The issue of high labour costs relative to materials is notable in the construction industry and may be the single largest barrier to waste prevention. When contractors talk about waste prevention strategies, their main concern is that deconstruction and reuse of materials will incur labour costs in excess of the value of the materials salvaged.

An example of this principle in action relates to the design of blockwork on all Harts jobs. Great care is taken to ensure that all dimensions of each building are a whole multiple of the dimensions of the bricks or blocks which are used. This means that bricklayers do not waste time cutting blocks when they should be laying them and it also reduces the generation of waste off-cuts from blocks. A relatively simple detail which can be included in just about any development therefore leads to an increase in efficiency as well as a reduction in waste generation.

In terms of sustainability, it is usually considered to be better practice for employers to retain their workers on a permanent basis, as this gives the employees greater stability and allows the both parties to gain from additional benefits such as training etc. Permanent employment of this kind is rare in the construction sector, where workers are normally employed on a contract basis for the duration of the job. In this respect, Harts are an exception as the majority of their staff are employed on a permanent basis. However, at least anecdotally, it is arguable whether this represents an overall benefit for all parties concerned. During several site audit visits it was noticeable that contractors and permanent employees had quite different priorities. For example, on the same day, contract bricklayers were seen hard at work while permanent employees could not work because it was too wet. Contractors are paid by the job, so it was to their advantage to keep working, whereas retained staff are paid by the day, so it is to their advantage if the job takes longer.

6 CONCLUSIONS

The whole issue of waste minimisation in construction can be summarised in four words: "is it worth it?" Purely from an environmental perspective, the answer is obviously yes but construction is a fiercely competitive business and everything has to bear economic scrutiny or it will not be adopted. On top of this, the construction business is notoriously conservative, so it is not enough for waste minimisation simply to add up; for it to be widely adopted, it must give its proponents a clear competitive advantage.

The most effective way of persuading companies to adopt environmentally friendly measures is if they simultaneously save money. Without this financial advantage, there is often insufficient motive to outweigh the additional resources required to adopt these measures, even if these resources are only a bit of manpower and another skip.

Waste minimisation audits often start from the premise that the company or activity in question is not being operated in an efficient manner, either from an economic or an environmental point of view. Environmentally, this is often not too far wide of the mark, as few companies exist solely to carry on their business in an environmentally friendly manner. Economically however, this premise usually only applies to aspects of a company's operations that are considered to be additional to its core business. In a manufacturing company, this category would include areas such as utilities (water, energy and fuels), effluent and waste disposal, all of which are incidental to the main business of making product.

Conversely, from an economic perspective at least, the main activities of a successful manufacturing industry are usually very efficient. If they are not, the company will lose out to more efficient competitors. On the basis of this waste minimisation programme and other construction experience, this would appear to be very much the case with the construction sector. Material, construction and waste disposal costs appear to be kept to a minimum, within the constraints of each working site.

Against this background of financial parsimony, it is unlikely that the waste minimisation approach will identify many measures which can be adapted to both environmental and economic advantage. This leaves measures which have an environmental benefit and minimal additional cost (measures with a significant extra cost can effectively be ignored). Adoption of these measures requires a commitment to environmental improvement from builders and others involved in the construction process. For this commitment to become widespread it will need either to be enforced or rewarded. Increasingly stringent environmental regulations mean that the stick is steadily being applied but the carrot is so far missing.

There can be a small financial and marketing advantage to paying particular attention to the environmental aspects of building design but as yet there appears to be no similar advantage to taking particular care in the construction process. Environmental standards such as BREEAM take no account of the construction process which, as this audit shows, may be ignoring a significant portion of the environmental impacts of construction. Development of an appropriate standard or good practice document, perhaps by BRE or NHBC, would be one way of improving adoption of waste minimisation in construction.

Appendix 1

SUPPLIERS ENVIRONMENTAL QUESTIONNAIRE

WREN & BELL

Materials Questionnaire

1 COMPANY DETAILS

Company Name: «Company»

Address: «Address1» «Address2» «PostalCode»	Tel.
	Fax.
	e-mail

Products proposed for use in this development:
«Product»

2 PERSONNEL

Managing Director:

Contact: *(usually person with overall responsibility for environmental matters)*	Position:

3 ACCREDITATION

Please tick and enclose evidence if your company has any of the following:

ISO 14001		ISO 9000	
EMAS		Other Quality Management System	
Other Environmental Management System		Investors In People	
Environmental Policy Statement		SA 8000	

4 LEGISLATION

Please tick and enclose evidence if your company operates any of the following:

IPC Authorisation		COSHH	
APC Authorisation		CHIP	
Trade Effluent Discharge Consent		CIMAH	
Duty of Care		Others?	
Packaging Waste Regulations			

5 PERFORMANCE

Please tick if your company has undertaken any of the following:

Environmental Audit		Environmental Impact Review	
Waste Minimisation Programme		Supplier Monitoring	
Energy Audit		Life Cycle Assessment	

6 MATERIALS

Please list the main raw materials used in manufacture of the products referred to in (1) above:

7	PROCESS
	Please outline the main steps of the production process:

8	WASTE AND BY-PRODUCT
	Please describe the main waste materials generated:
	What is the fate of these materials?
	Is a usable by-product made? *(Please describe if so)*

9	PACKAGING
	Please describe the nature and quantity of packaging materials used:

10 HAZARDOUS MATERIALS

Please tick any of the following materials that are used in your production process:

"drins"		endosulfan		organotin compounds	
1,2-dichloroethane		fenitrothion		PBBs	
ammonia		fluorides		PCBs	
asbestos		Formaldehyde		PCP compounds	
atrazine		furans		persistent mineral oils	
azinphos-methyl		HCFCs		persistent synthetic materials	
biocides		HCH		pesticides	
cadmium		hexachlorobenzene		phthalates	
carbon tetrachloride		hexachlorobutadiene		PVC	
carcinogens		malathion		radioactive materials	
CFCs		mercury		simazine	
cyanides		nitrites		solvents (VOCs)	
DDT		oestrogenic compounds		trichlorobenzene	
dichlorvos		organohalogen compounds		trichloroethylene	
dioxins		organophosporus compounds		trifluralin	

Other hazardous materials?

11	ENVIRONMENTAL IMPACTS
	Please outline the contribution made by your manufacturing process to the following:
	Emissions to atmosphere:
	Energy consumption:
	Discharges to sewer:
	Discharges to surface waters:
	Land contamination (e.g. spillages, land use and landfill use)
12	TRANSPORT
	Please outline the main methods of transport used for:
	Supply of materials
	Distribution of product
13	EVIRONMENTAL BENEFITS
	Please outline the main environmental benefits of your products, particularly in relation to alternatives:
14	ADDITIONAL INFORMATION
	Please include any additional information in support of your responses and any comments:
	Please also attach any information pertaining to the performance of your products.