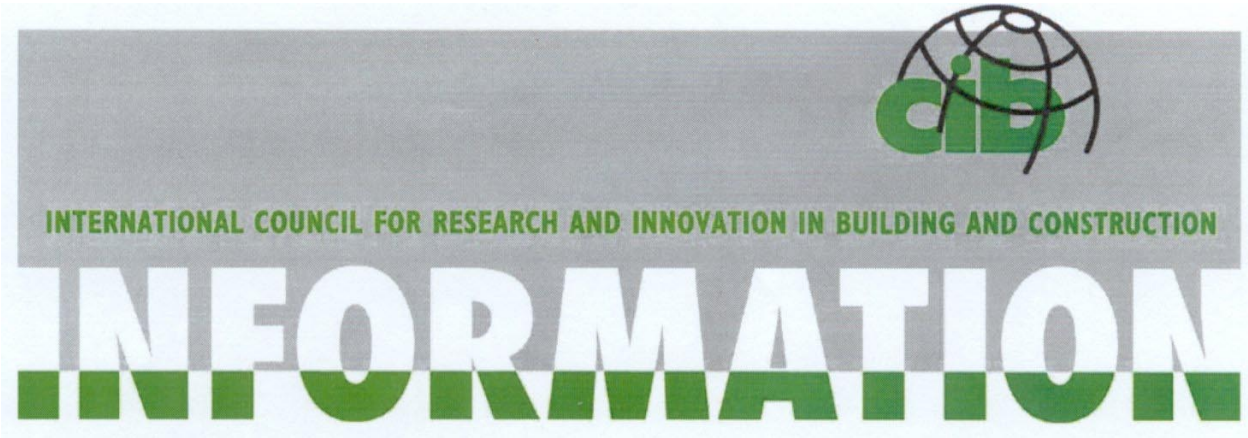

REPORT

Construction Site Waste Management And Minimisation

INTERNATIONAL REPORT

Prepared for:
International Council for Research and Innovation in Building and Construction (CIB)

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Foreword

This study forms part of the outputs of the author's fellowship research project. The author was awarded the prestigious 7th CIB Gyula Sebestyen Young Researcher's Fellowship 2001 by the International Council for Research and Innovation in Building and Construction (CIB). The fellowship was awarded for a research project called **"Realising the full potential of the secondary construction materials market: an eye opener for South Africa".**

The main literature search for this study was conducted at the M.E. Rinker Sr. School of Building Construction, University of Florida, Gainesville, Florida, USA. The study and the preparation of this document were done at CSIR Building and Construction Technology, Pretoria, South Africa.

This study provides a comprehensive summary of the techniques that can currently be applied to improve the management and minimisation of waste on construction sites. The study emphasises the need to prioritise waste management on construction sites. It also promotes waste avoidance before minimisation and minimisation before treatment and disposal. This report consolidates learning from various initiatives that have been implemented around the world and presents it in an innovative yet practical manner for easy comprehension by construction teams.

The report is intended to be an easy reference document for construction industry players including designers, contractors, representative organisations, statutory bodies, government departments and the waste management sector.

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Executive Summary

The construction industry has been found to be one of the most inefficient and wasteful sectors. Internationally, the construction and operation of the built environment has been estimated to account for:

- 12-16% of fresh water consumption;
- 25% of wood harvested;
- 30-40% of energy consumption;
- 40% of virgin materials extracted;
- 20-30% of greenhouse emissions;
- 40% of the total waste stream of countries, 15-30% of which ends up in landfill sites;
- Up to 15% of purchased materials at jobsite ending up as waste.

Construction site waste contributes to the large quantities of construction and demolition (C&D) waste that are generated by the construction industry every year. The waste generated on construction sites has been found to result in two cost factors for the builders, i.e. the cost of transporting and disposing of site waste and the material procurement cost. This can have a negative impact on the profit margin of contractors. Reducing construction site waste can reduce both the cost of raw material purchase and the cost of disposing of the waste created on site. It can also reduce wastage due to inefficiency on site e.g. source separation can reduce the amount of waste resulting from commingled disposal. If planned, waste recovery for reuse and recycling can tremendously reduce the amount of waste that is destined for disposal by landfill. This can also open up secondary resource streams of building materials.

In recent years, the construction industry has realised not only the need to be environmentally responsible but also the benefits of green construction. There is an ongoing campaign to encourage life cycle assessment and costing. There is also a drive to quantify the environmental costs of construction in order to internalise the externalities of construction related activities. Many countries have embarked on programs that promote efficiency in construction in terms of labour, equipment and material use. There is growing advocacy for the purchase and use of recycled content building materials and products. Much effort has been dedicated to developing strategies that focus on construction site waste prevention, reduction, reuse and recycling. In addition, governments have increasingly introduced legislative and incentive instruments that make it more difficult to continue with wasteful jobsite practices. Of particular importance is the documentation of best practices that demonstrate the economic advantage of alternative waste management options for construction sites.

Construction site waste management and minimisation, as presented in this document, has great potential to contribute to construction industry performance improvement as well as solve waste management problems caused by the construction sector. This can be achieved through:

- Waste avoidance on site;
- Waste specification and formalisation in contracts;
- Developing site waste management plans; and
- Using recycled content building materials and products.

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1. Problem statement

Construction site waste contributes to the large quantities of construction and demolition (C&D) waste that are generated by the construction industry every year. It is estimated that on average C&D waste constitutes 15-30% of the total amount of waste that ends up in landfill sites in many countries [1]. At project level, the waste generated on site has been estimated to be about 10% of the materials originally purchased [2]. Many builders realise that many materials that are wasted on the jobsite result in two cost factors i.e. the material procurement cost and the waste disposal cost. Although the waste disposal costs of construction site waste form as little as 0.5% of the total budget of a typical home, contractors realise that this cost can significantly affect their profit since contractors generally operate within a tight 5% profit margin [3].

2. Introduction

Reducing construction site waste can reduce both the cost of raw material purchase and the cost of disposing of the waste created on site. It can also reduce wastage due to inefficiency on site e.g. source separation can reduce the amount of waste resulting from commingled disposal. It is estimated that around 80% of a homebuilder's waste stream is recyclable [3]. If planned, waste recovery for reuse and recycling can tremendously reduce the amount of waste that is destined for disposal by landfill. This can also open up secondary resource streams of building materials. Since building construction is a business, it will be to the advantage of the contractor/builder to adopt waste management methods that reduce liability for jobsite waste. Equally important is the need for the contractor/builder to build a good public image as a "green practitioner". Such an image will give the contractor/builder an edge in business as a preferred service provider.

This document will present practical approaches that can be adopted and used to firstly prevent and secondly manage waste arising from jobsite activities.

3. Definition

Construction site waste can be described as the non-hazardous by-product resulting from activities during new construction and renovation. It is generated during the construction process because of factors such as site preparation, material use, material damage, material non-use, excess procurement and human error. Examples include but are not limited to packaging materials, site clearance, excavation material, building materials such as metals, gypsum, concrete, brick, insulation, wood, plastic, glass, asphalt, composites and site sweepings. Certain types of waste are not included in this definition because of their nature. These materials include hazardous substances such as asbestos and lead, liquid waste such as paint and kerosene, food waste, tyres and containers with residue.

4. Context

The construction industry contributes a significant amount to a country's economy. For instance, the US construction industry accounted for 13% of the GDP in 1993 [4]. The construction industry is however also one of the most inefficient and wasteful sectors. Worldwide the construction and operation of the built environment has been estimated to account for[1]:

- 12-16% of fresh water consumption;
- 25% of wood harvested;
- 30-40% of energy consumption;
- 40% of virgin materials extracted;
- 20-30% of greenhouse emissions;
- 40% of the total waste stream of countries, 15-30% of which ends up in landfill sites;
- Up to 15% of purchased materials at jobsite ending up as waste.

The South African construction industry has been under recession for more than two decades. Construction related investment declined by about 50% since the late 1970s [5]. The main reason for this trend is said to be the shift from heavy infrastructure projects such as highways, dams, bridges and power stations[2]. Other problems that were experienced during the downward trend of construction output included constraints in the capacity of materials, equipment and competence. Another issue of concern was around the performance of the construction industry i.e. output per unit input. The construction industry, throughout the world, has been found to be generally wasteful. The concept of waste in construction covers labour, materials and equipment aspects. Of particular interest to this document is the issue of material wastage. Material wastage has largely been found to be a result of avoidable practices on site (See section 8 on waste avoidance).

The South African government, in partnership with the private sector and other stakeholders, has embarked on a reform process to regenerate the construction industry and improve its performance. The Construction Industry Development Board (CIDB), a statutory body, was promulgated to be the driver of the national vision of construction industry development [6]. The CIDB will promote enhanced delivery performance to meet the needs of South Africans through best practice, enhance the role of industry in economic and social development through the development of standards, guidelines and regulatory instruments, and provide leadership and partnership with all stakeholders within the construction industry.

Construction site waste management and minimisation, as presented in this document, has a great opportunity to contribute to construction industry performance improvement as well as solve waste management problems caused by the construction sector. This can be achieved through:

- Waste prevention during the design and procurement stages;
- Demand management during construction (waste handling);
- Source control (reduction at the point of generation);
- Waste planning (prioritising waste management on site); and
- Using recycled content materials and products.

[1] Statistics taken from the various sources that are used and referenced throughout this document

[2] Although this was generally the case, there were "booms and busts" of large infrastructure projects such as the Lesotho Highlands Water Project and a number of toll roads.

5. Trends in construction site waste management and minimisation

In recent years, the construction industry has realised not only the need to be environmentally responsible but also the benefits of green construction. There is an ongoing campaign to encourage life cycle assessment and costing. There is also a drive to quantify the environmental costs of construction in order to internalise the externalities of construction related activities. Many countries have embarked on programs that promote efficiency in construction in terms of labour, equipment and material use. There is growing advocacy for the purchase and use of recycled content building materials and products. Much effort has been dedicated to developing strategies that focus on construction site waste prevention, reduction, reuse and recycling. In addition, governments have increasingly introduced legislative and incentive instruments that make it more difficult to continue with wasteful jobsite practices. Of particular importance is the documentation of best practices that demonstrate the economic advantage of alternative waste management options for construction sites.

It has been realised that the client is (or can be) the main driver of waste prevention and green buildings [7]. This is because firstly the client can specify what he/she is prepared to pay or not pay for. Secondly, since the client is likely to be the end user of the building upon completion, details of its performance will be key considerations to him/her. However, in some occasions the client is either unaware or unable to use this ability. This can be because the client does not have a high level of environmental awareness or the designer (architect/engineer) has no experience with green building to help the client make the correct decisions. Designers can play a significant role in green construction, particularly in waste management in this case by designing buildings for waste reduction through doing more with less and by designing buildings to allow for building, component and material reuse and recycling at the building's end of life. However, this can only work if the contractor and his crew firstly understand the designs and secondly have the necessary training and commitment to ensure success.

Many developed countries have realised the need to modify tendering, contracting and construction site processes in order to ensure that waste prevention and management are prioritised on site. Recent innovations include the incorporation of waste specifications in tender documents, the inclusion of model waste management language in contract documents, the demand for waste management plans prior to commencement of construction and the promotion of the purchase and use of recycled content products.

6. Waste specifications for construction sites

Designers are beginning to experience increasing pressure from the client for measures to reduce wastage on the jobsite and ensure environmental buildings. This demand is a result of three factors viz. a need to reduce construction costs, a need to demonstrate environmental responsibility and a need to comply with local waste legislation and reduction goals [8].

One way to ensure that waste management is given priority on construction sites is through the introduction of waste specifications. Waste specifications can be prepared by designers for inclusion in tender documents. These specifications can be written in model specification language to address waste avoidance and minimisation on construction sites[3]. The specifications need to emphasise that the project is looking for alternative waste management techniques to conventional collection and disposal by landfill. The specifications also need to address the following areas [8] and [9]:

- Use of waste reduction techniques during construction;
- Reuse of construction waste material on site;
- Recovery of construction waste material from site for resale and use elsewhere;
- Return of unused construction material to vendors for credit; and
- Recycling of construction waste.

Specifications for waste management can also be incorporated into broader specifications for green construction. Such an approach can ensure that the construction process addresses the question of sustainability not only in terms of waste management but also in terms of issues such as the energy performance of the building, indoor air quality and the use of green materials [8].

In terms of waste management, specifications can be written to address waste avoidance and waste minimisation. Waste avoidance concentrates on the activities that determine whether waste will be created in the first place while waste minimisation concentrates on those activities that determine the amount of generated waste that will end up in landfill sites. Typical actions that can be incorporated into specifications include:

- Compliance with innovative designs;
- Reduced packaging requirements;
- Material return arrangements;
- Waste management plans;
- On site reuse; and
- Use of local recyclers.

Waste specifications are not designed just to make the lives of contractors difficult. On the contrary, they can present an opportunity for contractors to benefit from secondary markets. Table 1 gives some of the advantages of using waste specifications for the client and contractor.

[3] Waste avoidance incorporates waste prevention, demand management and waste reduction, and waste minimisation incorporates waste recovery, reuse and recycling. (See Appendix F)

Advantages of using waste specifications	
Client	Specifications allow the client to: - Evaluate the various provisions to determine if they will or will not add to the project cost. - Demand a comparison of the costs associated with conventional disposal and the alternative option. - Decide whether or not to agree to the projected costs of the alternative option. - Decide whether to receive the revenues generated from waste material sales or allow the contractor to keep them. - Demand a waste management plan from the contractor as part of a bid or prior to project commencement.
Contractor	- Removes concerns relating to a possible competitive disadvantage if a choice to recycle is selected compared to conventional disposal. - Presents an opportunity for the contractor to hold sub-contractors accountable for their waste practices on site and to apportion costs of non-compliance. - The contractor can get a direct benefit from the sale of recovered waste materials. - The contractor can evaluate different reuse and recycling options and select those with the highest returns. - Contractors that prioritise waste management can accumulate credits (where applicable) and become preferred service providers.

Note: Sample model waste specifications are included in Appendix A, adopted directly from [8].

7. Contract language for construction site waste

Designers can go a step further and use the power of a contract document to make sure that waste management gets priority on site. Being a legal and binding document, a contract stipulates required actions and also outlines possible punitive measures in the event of breach of contract. The project contract can be used to:

- Ensure compliance with project plans and goals;
- Ensure participation of the whole project team;
- Delegate responsibility; and
- Distribute liability between the general contractor and his sub-contractors.

Various actions can be implemented on site to ensure that the issues highlighted above are achieved. Compliance with project goals and participation can for instance be achieved by giving clear instructions to all team members on what is expected of them, inserting penalty clauses for non-compliance and by offering incentives for achieving targets [8]. Site waste management is generally effective if there is an individual with overall responsibility. A general contractor or waste management specialist can be appointed to manage the waste management portfolio, delegate responsibility to relevant people and ensure commitment and accountability. Finally, it may be beneficial to distribute liability among sub-contractors for their specific wastes rather than have the general contractor being responsible. Such an approach will encourage sub-contractors to be responsible and more efficient since they will have a stake in the resulting gains or losses due to their waste practice.

Note: Sample model contract language for construction site waste management is included in Appendix B, adopted directly from [9].

8. Waste Avoidance

8.1 Definition

Waste avoidance refers to activities that focus on ensuring that waste is not created to begin with. It is by far the most economical approach to dealing with waste compared to minimisation and disposal. Increasingly, international debate is beginning to question the whole notion of waste. One such debate is the perception that waste is a man made creation that does not have to exist. It is a creation that has for long been accepted to be a cost of development. Research by resource efficiency protagonists such as Young reveals that consumption and production have over the years, resulted in increased quantities of generated waste [10]. It then follows that human action has the ability to eliminate waste and transcend to waste avoidance if there is awareness, commitment, accountability and liability.

The concept of waste avoidance can be represented with three components viz. waste prevention, waste demand management and waste reduction (see waste hierarchy in Appendix F).

8.2 Waste prevention

Waste prevention concentrates on site practice that can determine whether or not waste will be created prior to or during construction site activity. As the saying goes, the best way to manage waste is not to create it at all. The biggest opportunity to impact on waste generation through prevention principles is at:
Design – through design for waste reduction i.e. doing more with less, and design with consideration for reuse and recycling at the end of life of a structure.
Operations – through clear communication of designs to the project team to avoid unnecessary waste through errors and redos.
Procurement – through the engagement of suppliers to encourage a reduction in packaging waste, the use of reusable containers and through "take back" agreements for unused materials.

8.3 Demand management

Waste demand management concentrates on site practices that rely on the human element. Many jobsite waste problems are a result of avoidable practices. Some of the key human interfaces that can avoid waste generation include:
Material delivery – care when loading, transporting and off loading materials.
Material storage – safe storage, covered storage where necessary and storage away from jobsite activities.
Material use – doing more with less, material storage for reuse elsewhere.
Project team – communication, commitment from staff, training and reduced human error.
Buying recycled – reduced demand of virgin material production, redirection of waste to extended use applications.

8.4 Waste reduction

Waste reduction concentrates on site practices that determine the amount of generated waste that will ultimately be disposed by landfill. If some amount of waste is inevitably generated on site, the next opportunity is to reduce the amount of waste destined for landfill to an

absolute minimum. This is best achieved through source control as the waste is being generated on site. This requires 100% contribution from the generators. Source control is achieved through:
Separation at source – selective and separate disposal of generated waste for reuse, recycling and garbage disposal.
On-site reuse – closure of materials flow loop internally on site instead of externally in the waste stream.

Note: A detailed table of the sources and causes of construction site waste is included in Appendix C, adopted directly from [11]. This table contains useful findings that can be used in future planning of jobsite waste prevention programs.

9. Waste management plans

9.1 Definition

A waste management plan can be described as a construction project related plan that gives provisions for the prevention, separation, salvage, reuse, recycling and disposal of C&D waste. The ultimate goal of a waste management plan is to reduce the amount of C&D waste destined for landfill to an absolute minimum. A waste management plan encourages resource efficiency and helps internalise the environmental externalities related to building construction.

A waste management plan presents an opportunity for a building owner and his team to demonstrate responsibility toward the environment by using a green approach to construction. Furthermore, the plan helps the building contractor identify opportunities from waste rather than to have to deal with it as a daily problem on site. Most importantly, a waste management plan encourages the client team to demand, help develop and comply with waste reduction targets for the project and also serves as a guideline for the contractor's waste management activities on site.

9.2 Elements of a waste management plan

Project planning is very important because it allows the opportunity to define a problem, assess possible solutions, proceed to implement the final option and make provision for evaluation at the end. It is unthinkable to commence a construction project without going through this process. For the same reason, waste management on construction sites should be planned before construction activities begin (in order to avoid dealing with waste as a problem).

A waste management plan does not have to be complicated, in fact it need not even be a long document. It simply needs to be concise, comprehensive and practical for easy interpretation and implementation on site. A good waste management plan will contain the following components:

- Goals;
- Waste audit;
- Waste disposal options;
- Waste handling requirements;
- Transportation requirements; and an
- Economic assessment.

9.2.1 Setting goals

Before conducting any detailed planning for waste management on site, the client team should make a commitment to waste prevention and waste redirection from landfill to reuse and recycling applications. This should be followed by realistic quantitative targets for waste reduction[4]. Realistic targets can be based on previous projects of similar nature, targets set by environmental rating systems that reward waste reduction with credit points and financial considerations (advised by market conditions).

[4] Overall waste target and possibly material specific targets as well

9.2.2 Waste Audit

For the contractor to be able to determine the best approach to deal with jobsite waste, he needs to collect information relating to the waste that will be generated on site. This information will be useful for waste planning. Such information is generally required before the waste is actually generated on site although on site waste audits can also be conducted to capture useful information for future projects and to update waste estimates for the current project.

A waste audit can basically be divided into two activities viz. a waste analysis and a waste assessment.

Waste analysis

A waste stream analysis will determine the types and quantities of waste that will be generated in the project. The analysis will also determine the stages of construction where specific wastes will be generated. There are two methods of conducting a waste stream analysis [9]. The first involves collecting actual data from project sites to determine the types of materials being discarded. The second uses information from previous projects. Both methods characterise wastes that are generated on the jobsite, and can help identify suitable waste reduction options.

Collecting data from the jobsite during construction can take several forms. Information can be extracted from purchase records, waste bin inspections and detailed waste analyses of selected sample waste bins [9]. Secondary analysis from previous experience on the other hand includes extracting waste generation rates, using purchase records and using waste disposal records for similar projects [12]. In cases where information is not readily available, other sources that can be used for quantity estimates include engineering estimates, and typical waste composition figures for construction sites.

Waste assessment

A waste assessment will use the information collected in the waste analysis to determine the site-specific waste characteristics. The assessment will help characterise waste by type, amount, method of generation and time of generation. It will also identify the construction activities that generate large quantities of waste. This information will inform the contractor on which waste reduction options he needs to focus his efforts.

Waste analysis and assessment information can be captured in a simple spreadsheet. It can be arranged in a manner that will easily show the types of envisaged waste materials, the expected quantities, recyclability, activity and time of generation, and a possible recycling option.

Note: A sample waste analysis and assessment spreadsheet is included in Appendix D.

9.2.3 Waste disposal options

Having assessed all the waste that will be generated on site, it is now possible to explore the various end-scenarios. It is useful to have knowledge of the types of materials that are reusable and recyclable, the conditions of acceptance in the respective markets, secondary market conditions in your area and the location and types of waste disposal sites.

Reusable materials

- Some materials can be accepted for reuse applications if they satisfy certain criteria. e.g. dimensions, level of contamination and quality.
- Typical places to approach with reusable materials include suppliers, secondary material outlets and renovators.
- If available, obtain a published list of locally accepted reusable materials.
- Reusable waste can be sold at a site sale or auction.
- Useful waste material can also be donated to charity organisation.

Recyclable materials

- Find a list of which materials are recycled in the locality of the project.
- Locate the companies that recycle these waste materials.
- Useful sources of such information include registers of recyclers, waste material exchanges and waste information systems that are either administered by government waste departments or by research institutions that specialise in waste management.
- Sometimes unconventional methods of searching for information may yield the best results, particularly for the not so popular recyclable materials such as insulation material and carpet padding.
- Establish market prices for specific waste materials.

Unwanted waste

- Accept that site activity will inevitably still generate a certain amount of unusable and unwanted waste that is good only for disposal by landfill.
- Find out what types of waste disposal sites are there, i.e. municipal waste sites, C&D waste sites, garden and C&D waste sites etc.
- Determine the requirements for acceptance e.g. commingled or clean separated waste.
- Determine the location and distance to these sites.
- Determine the tipping fees charged by each.

Hazardous waste

- Find out about all the relevant local regulations relating to the handling and disposal of hazardous waste.
- Find local hazardous waste removal contractors.
- Determine the location and distance to the designated hazardous waste disposal sites.
- Determine the tipping fees charged by each.

9.2.4 Waste handling requirements

In order to have efficient waste management on the jobsite, consideration should be given to how the waste will be handled to maximise recovery. Since the most effective waste reduction strategy is source control, 100% participation from the construction crew is important. Before the crew can participate, it is important that they are made aware of the waste plan, they need to be trained on waste handling methods and they need to be involved in the process.

The project team needs to appoint an individual that will be responsible for the overall waste management activity. This can be the general contractor or a waste management specialist. This individual can appoint and train one or two waste management leaders that will be responsible for the day-to-day running of jobsite waste activities and feedback to the waste manager.

Some of the actions the waste team will have to take include the following:

- Decide on whether to implement a "time based" waste recycling system at the jobface or dedicate "a recycling centre" on site.
- In case of the former, plan the system and determine container sizes, number and location and coordinate details of container collection.
- In case of the latter, design and layout the recycling centre on site.
- Determine security, staff and facility requirements for the recycling centre.
- Clearly mark all items in the recycling centre to avoid confusion, contamination and abuse.
- Plan for the collection of waste from the jobface to the recycling centre.
- Ensure adequate and sufficient containers to allow for effective waste separation, storage, collection and transport to the recycling centre and to the final destination.
- Train the labour crew to distinguish between reusable and recyclable materials, how to avoid contamination and where to store reusables, recyclables and unwanted waste.
- Co-ordinate waste collection to avoid the collection of half-empty or overflowing containers.

9.2.5 Transportation requirements

Consider options available to collect and transport reusable, recyclable and unwanted waste away from the construction site. There are four basic methods that can be used [13], namely:

- Commercial hauling - This method involves contracting with waste or recycling service providers to place collection containers on-site, collect and transport the full containers to waste or recycling facilities. This strategy works well on projects where large quantities of materials are generated, such as on demolition sites, big housing projects and on commercial projects. Some recyclers offer smaller waste containers or containers with several compartments for small-scale projects such as home improvements.
- Self-hauling - This method is often preferred for residential construction and remodelling. Recyclable materials are collected on-site in piles or temporary containers and taken to recycling facilities using the contractor's own vehicles. This method is effective for materials generated in small quantities.
- Cleanup services - A construction clean-up service that offers waste removal and recycling services all in one. The clean-up crew comes on-site and picks up recyclables and garbage that are collected in piles or containers. The materials are then

taken to the most appropriate recycling or disposal facility. Such services can offer job-site recycling consultations as well.

- Commingled recycling – The last option in the order of preference, commingled recycling programs collect containers of mixed recyclables or mixed garbage and recyclables, and separate them at material recovery facilities. This option is convenient for cramped sites, but the cost saving is limited (high pre-recycling costs) and recycling rates may be lower than for other options.

When assessing the above options, contact the service providers in your area and request details on the sizes of their containers, and their rental and collection cost estimates.

9.2.6 Economic considerations

The information in sections 9.2.2 to 9.2.5 will help in deciding which of the waste materials are economical to reuse and recycle and which are not. The main criteria that are used to decide between extended use applications and landfill disposal are the cost implications of each option and the anticipated returns. Landfill disposal generally depends on local tipping fees and the associated transport costs while extended use applications depend on recycling costs and market conditions.

The cost analysis can be conducted in a simple spreadsheet. For all the identified reusable and recyclable materials, use the estimated quantities (from the waste audit), container sizes and rental estimates (transportation requirements) and tipping fees/rebates (disposal options) to calculate the total cost of each possible option. Calculate the estimated disposal cost for all other unwanted wastes. For all the reusable and recyclable options, calculate the cost of landfilling the same amount of waste and compare with the above totals to determine the savings or additional costs.

The results of the cost analysis can be used in conjunction with the waste goals that were set in section 9.2.1 to decide which materials to reuse, recycle and landfill. It may be cost effective to only recycle one or two of the waste materials generated by the project or it might be worthwhile to institute a full-fledged recycling program [13].

Note: Sample worksheets for waste analysis and recycling analysis are included in Appendix E, adopted directly from [13] and [14].

9.3 Support

In order for waste management to be successful on construction projects, it needs to be afforded the same priority and status as safety for instance. Its program can even be incorporated into the safety program, to simplify things. Either way, the waste program should have a strong element of training in order to allow for maximum participation from the contractors and their labour crews. Training can take the form of general awareness training for all members of the construction team and detailed waste management training for the selected waste team. Regular meetings need to be held to give feedback on progress, achievements and possibly to award outstanding performance. The construction site should have adequate signs and information relating to waste reduction goals, waste management procedures, who to contact for assistance, performance to date and outstanding achievers.

9.4 Plan implementation

One key determining factor of the success of a waste management plan is its implementability. It is good to develop strategies that are guided by the ideals that we would like to reach in the construction industry, however at project level our contribution towards these ideals should be through achievable goals using practical methods. Furthermore, some plans may not be cost effective to implement. It may thus be better to begin on a small scale and increase the effort as the learning curve flattens out.

The following actions will be necessary when implementing a site waste management plan [13].

Appointment of waste manager

To ensure commitment, operational efficiency and accountability, the waste management function should be assigned to one individual. The waste manager should be given power to:

- Select his waste team;
- With the help of his team instruct, oversee, record and feedback on day-to-day waste practice;
- Delegate responsibility to sub-contractors where necessary; and
- Coordinate with suppliers, service providers and sub-contractors to prioritise waste prevention and salvage on site.

Distribution of information

The contractor must distribute the waste management plan to the client team, his crew and to all subcontractors that come to site. The contractor needs to communicate information relating to activities that might be a source of confusion, for example:

- If applicable, how the “time-based” waste recycling system will work.
- If applicable, identify the designated area for a “recycling centre” on site and explain how it will work.
- Give details of how day-to-day findings will be fed back into site activities to improve waste practice.
- Describe what constitutes contamination and what steps will be taken to ensure it does not manifest itself on site.

Waste handling

The construction site should be clearly laid out with sufficient instructions for waste management. Provision should be made for easy and convenient jobface waste separation and storage, smooth and timely separate collection and effective use of the recycling centre. The facilities dedicated for the waste program should be kept clean at all times. Finally, all hazardous waste should be treated as a separate waste stream, clearly marked and stored in isolation for collection.

9.5 Monitoring and evaluation

The waste team must select effective feedback mechanisms to make sure that problems are dealt with timeously, that processes can be improved while the project is running and to prevent the repetition of similar mistakes in future projects.

Some of the available approaches include:

- Day-to-day site inspection and data capture with overnight feedback to enable corrective action the next day.
- Ongoing monitoring of site activities with regular progress reports detailing quantities of generated waste, quantities redirected to extended use applications and quantities of unwanted waste. Along with these quantities, should come the associated expenses/income of each option. All expenses/income should be accompanied by proof e.g. receipts, invoices etc.
- Post project evaluation with details on project finances, successes and lessons learnt.

9.6 Education

The construction team will be in a better position to participate if it has knowledge on waste management and green construction. The contractor needs to organise a waste training program (a basic awareness course for all and a detailed waste management course for the waste team). As indicated earlier, it might be easier to incorporate such training into the safety-training program. The contractor can also mandate sub-contractors to train their crews in waste management by including clauses in contract documents.

9.7 Motivation

Education may equip the project team with the required knowledge to participate effectively in waste management, but can it guarantee participation? This is an obvious concern of any participative process. One mechanism that can be used to improve the chances of participation is motivation. Some of the motivational mechanisms that can be used include:

- Management style – the waste manager should always appear positive, full of courage and hope. Workers look up to management, particularly in times of change and new initiatives.
- Innovation – the contractor should implement things such as slogans, team building items such as stickers and uniform, and spotlights on outstanding team members.
- Sharing successes – the construction site should have signposts with information on achievements to date. The contractor should hold regular meetings to acknowledge team and individual effort.
- Incentives – the contractor should organise inexpensive rewards such as caps and T-shirts, good parking spots and vouchers to deserving team members.

Note: A sample waste management plan is included in Appendix F.

10. Material specific reuse and recycling

A large proportion of the waste produced on construction sites is recoverable for reuse and recycling. This however depends on site practice and whether waste management has been prioritised or not. While it is possible to reuse and /or recycle many of the waste materials generated on site, the feasibility will depend on the market conditions for each type of material. Material reuse can take a number of forms i.e.:

- The *high value use* of materials in a similar application e.g. secondary use of a window frame, or in a different application e.g. the use of secondary bricks for paving; and
- The *low value use* of materials in a similar application e.g. the use of a crushed concrete road surface as a road sub layer or in a different application e.g. the use of wood off-cuts as shutters.

In terms of recycling, metals have the highest recycling rate. Plastics, glass, cardboard and paper have mature industries that can readily absorb salvaged materials. Asphalt recycling is also a relatively mature industry, perhaps with the exception of asphalt roof shingle recycling that still has a small market in some areas. Concrete, brick and masonry (building rubble) recycling is perfectly feasible but may still not be extensive in some areas. Gypsum and carpet padding recycling have relatively smaller markets.

Some of the issues that need to be considered during the planning of material specific reuse and recycling include:

- Providing a central (convenient), yet separate, storage facility for reusable waste on site;
- Providing for the separate storage of recyclables on site;
- Estimating the quantities of each type of material that will be generated on site;
- Determining recycling opportunities for various waste materials in the locality of the project;
- Determining associated costs relating to waste container rental, waste transportation and waste disposal fees; and
- Training the labour crew on waste management.

Material specific considerations [9] and [13]:

Wood

Wood generated on construction sites is generally reusable and recyclable. All off-cuts and damaged wood should be kept clean and stored centrally in a safe place. The construction crew should be encouraged to check the storage area before using new wood sections. Recyclers generally accept wood waste that is untreated. Nails are generally not a problem as they can be removed manually prior to recycling or with a magnet during recycling. Key considerations for wood recycling include recycling disposal fees/rebates, transport and landfill costs as these will vary by region. Some of the applications for salvaged wood include on site applications such as use in shuttering, partitioning of storage containers etc.; recycling into furniture, mulch and animal bedding.

Metal

All metals ferrous and non-ferrous that are generated on site can be recycled. Metal recycling industries have been around for a very long time. Metals can be recycled to 100% of their original state i.e. with no loss of quality. Recyclers generally pay a rebate for the disposal of scrap metal in their site, but rates will differ according to region.

Concrete, bricks and masonry

Building rubble generated on site is easily reusable and recyclable. It is important to keep waste materials separate and ensure that contaminants are minimal. Rubble can be reused on or off site for applications such as site levelling, backfill and landscaping and landfill engineering. Rubble can also be recycled on or off site either separately i.e. concrete recycling or mixed i.e. rubble recycling to produce recycled aggregates. Recycling plants vary in size (i.e. from about 300 to above 1000 tons/day) and type (i.e. stationery or mobile). Some of the applications of recycled aggregates include road construction, foundations and recycled aggregate concrete (RAC).

Asphalt

Asphalt concrete used for road applications consists of the asphalt binder and aggregates and is recyclable. Asphalt recycling can take three forms namely:

- Cold planing, which is a cold in-situ form of asphalt reclamation and recycling
- Hot recycling of recovered asphalt at a central recycling plant
- Hot-in-place recycling, which involves the heating of a pavement layer to allow for its recovery and recycling on site

Asphalt roof shingles consist of a felt mat saturated in asphalt, small rock granules and a stabilizer. Recycled asphalt can be used in new road surface construction and in road sub layers.

Gypsum drywall

Drywall is used extensively in new construction for inner wall finishing, partitioning and in the ceiling. It is estimated to account for up to 15% of the waste of residential new construction and up to 30% of the waste of commercial new construction. It consists of a gypsum core covered with paper. Gypsum recycling is possible, but it is a very delicate process. Recyclers only accept untreated gypsum, preferably with no contaminants, because the quality of recycled gypsum depends heavily on the level of contamination (often the paper cover itself creates problems during recycling). Gypsum can be recycled for use in new gypsum drywall, cement manufacture, soil conditioning applications, manure treatment and in the drying of sludge.

11. Recycled content materials and products

Recycled content materials and products (RCMPs) contribute to the closure of the flow of materials in construction. Through the use of such materials, construction projects can get closer to resource efficiency. RCMPs contain secondary/recycled materials, the actual amount of which is determined by the standards and specifications that are applicable to specific materials. RCMPs can be divided into two main types i.e. pre-consumer RCMPs that are produced from the by-products of industrial processes such as manufacturing and post-consumer RCMPs that are produced from waste products that are generated by consumers. Many of the RCMPs have been tested, approved and certificated for use in construction related applications around the world.

The use of RCMPs has benefits such as:

- Closing the loop of materials flow in construction thereby contributing to resource efficiency.
- Absorbing the waste material that is diverted from landfill sites.
- Feeding end-markets of secondary construction materials.
- Expanding secondary industries thus creating opportunities for employment and SMME development.
- Conserving the embodied energy of secondary materials.

The use of RCMPs in construction depends on the support of stakeholders such as the project team, standards generating bodies and local authorities. Useful strategies that can be used to promote the use of RCMPs include the launch of public sector driven “buy recycled campaigns”, the development of “ Recycled Material Development Zones” to support secondary industries, the development of green construction information systems and leadership by example through the implementation of demonstration projects and policies to use RCMPs in public and private sector construction projects.

12. Conclusions

There has been increasing pressure to come up with processes that reduce wastage on the jobsite and ensure the yield of environmental buildings. This demand is a result of factors such as a need to reduce the cost of construction, a need to demonstrate environmental responsibility and a need to comply with strict local waste legislation and goals. Governments and construction industries around the world have responded by introducing innovations such as:

- Construction site waste specifications;
- Model contract waste management language;
- Construction site waste avoidance strategies;
- Construction waste management plans; and
- Buying and using recycled content materials and products.

Improving construction site waste management can contribute to the overall improvement of the performance of the construction industry. It will also bring us a step closer to achieving sustainability in construction. The benefits of construction site waste management include:

- The reduction of the generation of avoidable waste on site.
- Preventing site waste from entering the national waste stream and redirecting potential waste from landfills to reuse and recycling applications.
- A reduction in C&D waste transportation and disposal costs.
- Reduced material procurement costs as a result of reduced site wastage and the use of on site secondary materials.
- Protection of the contractor's (already narrow) profit margin.
- Improvement of site efficiency and performance.

13. References

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APPENDIX A

Appendix A: Model waste specifications

Adopted directly from: Triangle J Council of Governments Publication
Title: *WasteSpec: Model specifications for construction waste reduction, reuse and recycling*, by Triangle J Council of Governments, NC, USA July 1995.

CONSTRUCTION WASTE MANAGEMENT

THIS SECTION HAS BEEN INTRODUCED TO DEAL SPECIFICALLY WITH CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT.

DEPENDING ON THE SIZE AND COMPLEXITY OF THE PROJECT, YOU MAY INCORPORATE ALL CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT INFORMATION AND REQUIREMENTS INTO A SINGLE, STAND ALONE SECTION - CONSTRUCTION WASTE MANAGEMENT,

OR

YOU MAY DISTRIBUTE CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT INFORMATION AND REQUIREMENTS THROUGHOUT RELATED DOCUMENTS AND SECTIONS OF THE PROJECT MANUAL FOLLOWING THE EXAMPLE USED IN THIS WASTESPEC. LIST ALL RELATED SECTIONS.

IF YOU DID NOT SPECIFY AN ALTERNATE IN ORDER TO DETERMINE RECYCLING COST INFORMATION, THE DRAFT WASTE MANAGEMENT PLAN OUTLINED IN THIS SECTION SHOULD BE USED TO ESTIMATE THE COST OF RECYCLING.

EDIT TO SUIT PROJECT AND LOCATION. DELETE OR EDIT REFERENCES TO WASTE DISPOSAL IN OTHER SECTIONS THAT CONFLICT WITH THE PROVISIONS OF THIS SECTION.

PART 1 - GENERAL

REQUIREMENTS INCLUDED IN THIS SECTION

[EDIT LIST BELOW TO SUIT PROJECT.]

A. Waste Management Goals.
B. Waste Management Plan.
C. Management Plan Implementation.
D. Special Programs.

WASTE MANAGEMENT GOALS

-$ A. The Owner has established that this Project shall generate the least

amount of waste possible and that processes that ensure the generation of as little waste as possible due to error, poor planning, breakage, mishandling, contamination, or other factors shall be employed.

-$ B. Of the inevitable waste that is generated, as many of the waste materials as economically feasible shall be reused, salvaged, or recycled. Waste disposal in landfills shall be minimized. [REFER TO DEFINITIONS SECTION FOR TERMS USED IN THIS SECTION.] [FOR PURPOSES OF THIS SECTION, THE FOLLOWING DEFINITIONS APPLY: REUSE, SALVAGE, RECYCLE, RETURN.]

[EDIT STATEMENTS ABOVE ACCORDING TO WHETHER THIS SECTION IS INTEGRATED INTO THE SPECIFICATION OR WHETHER IT IS USED AS A STAND-ALONE SECTION.

+$ C. With regard to these goals the Contractor shall develop, for the Architect's review, a Waste Management Plan for this Project.

WASTE MANAGEMENT PLAN

+$ A. Draft Waste Management Plan: Within [SPECIFY TIME FRAME] [10 CALENDAR DAYS] after receipt of Notice of Award of Bid, or prior to any waste removal, whichever occurs sooner, the Contractor shall submit to the Owner and Architect a Draft Waste Management Plan.

[SEE APPENDIX F FOR A SAMPLE WASTE MANAGEMENT PLAN WHICH CAN BE APPENDED TO PROJECT SPECIFICATIONS.]

The Draft Plan shall contain the following:

1. Analysis of the proposed jobsite waste to be generated, including types and quantities.

2. Landfill options: The name of the landfill(s) where trash will be disposed of, the applicable landfill tipping fee(s), and the projected cost of disposing of all Project waste in the landfill(s).

3. Alternatives to Landfilling: A list of each material proposed to be salvaged, reused, or recycled during the course of the Project, the proposed local market for each material, and the estimated net cost savings or additional costs resulting from separating and recycling (versus landfilling) each material. "Net" means that the following have been subtracted from the cost of separating and recycling: (a) revenue from the sale of recycled or salvaged materials and (b) landfill tipping fees saved due to diversion of materials from the landfill. The list of these materials is to include, at minimum, the following

materials:

[LIST BELOW MATERIALS APPLICABLE TO PROJECT AND LOCATION. THE LIST OF MATERIALS SHOULD INCLUDE AT MINIMUM THE MATERIALS LISTED IN (a) THROUGH (i) BELOW. ADD OTHER MATERIALS RELEVANT TO LOCAL AREA. EXAMPLES MAY INCLUDE DRYWALL; PLASTIC BUCKETS; CARPET AND CARPET PAD TRIM; PAINT; ASPHALT ROOFING SHINGLES; VINYL SIDING; PLASTIC SHEETING; AND RIGID FOAM INSULATION.]

a. Cardboard.
b. Clean dimensional wood.
c. Beverage containers.
d. Land clearing debris.
e. Concrete.
f. Bricks.
g. Concrete Masonry Units (CMU).
h. Asphalt.
i. Metals from banding, stud trim, ductwork, piping, rebar, roofing, other trim, steel, iron, galvanized sheet steel, stainless steel, aluminum, copper, zinc, lead, brass, and bronze.

-$ B. Resources for Development of Waste Management Plan: The following sources may be useful in developing the Draft Waste Management Plan:

[EDIT LIST OF RECYCLING RESOURCES BELOW TO SUIT PROJECT. REFER TO APPENDICES A, B, C, AND D OF THIS WASTESPEC FOR RESOURCES YOU CAN USE TO DEVELOP RECYCLING WORKSHEETS AND LIST OF LOCAL MARKETS SPECIFIC TO YOUR PROJECT.]

1. Recycling Haulers and Markets: [APPENDIX _____] [THE ATTACHED LIST] contains local haulers and markets for recyclable materials. This list is provided for information only and is not necessarily comprehensive; other haulers and markets are acceptable. For more information, contact the [STATE] [COUNTY] [RECYCLING DEPARTMENT] [LISTED IN APPENDIX _____] [AT PHONE NUMBER _____.]

2. Recycling Economics Information: [APPENDIX ___] [THE ATTACHED FORMS] contain information that may be useful in estimating the costs or savings or recycling options.

+$ C. Final Waste Management Plan: Once the Owner has determined which of the recycling options addressed in the draft Waste Management Plan are acceptable, the Contractor shall submit, within [SPECIFY TIME FRAME] [10 CALENDAR DAYS] a Final Waste Management Plan.

[SEE APPENDIX F FOR A SAMPLE WASTE MANAGEMENT PLAN WHICH CAN BE APPENDED TO PROJECT SPECIFICATIONS.]

The Final Waste Management Plan shall contain the following:

1. Analysis of the proposed jobsite waste to be generated, including types and quantities.

2. Landfill options: The name of the landfill(s) where trash will be disposed of, the applicable landfill tipping fee(s), and the projected cost of disposing of all Project waste in the landfill(s).

3. Alternatives to Landfilling: A list of the waste materials from the Project that will be separated for reuse, salvage, or recycling.

4. Meetings: A description of the regular meetings to be held to address waste management. Refer to Section 01200 - Project Meetings.

5. Materials Handling Procedures: A description of the means by which any waste materials identified in item (3) above will be protected from contamination, and a description of the means to be employed in recycling the above materials consistent with requirements for acceptance by designated facilities.

6. Transportation: A description of the means of transportation of the recyclable materials (whether materials will be site-separated and self-hauled to designated centers, or whether mixed materials will be collected by a waste hauler and removed from the site) and destination of materials.

WASTE MANAGEMENT PLAN IMPLEMENTATION

+$ A. Manager: The Contractor shall designate an on-site party (or parties) responsible for instructing workers and overseeing and documenting results of the Waste Management Plan for the Project.

[DEPENDING ON THE SIZE AND COMPLEXITY OF THE PROJECT, YOU MAY EITHER DESIGNATE A FULL TIME CONSTRUCTION WASTE MANAGER OR ASSIGN RESPONSIBILITY TO THE JOB SUPERVISOR OR APPROPRIATE PERSONNEL.]

+$ B. Distribution: The Contractor shall distribute copies of the Waste Management Plan to the Job Site Foreman, each Subcontractor, the Owner, and the Architect.

+$ C. Instruction: The Contractor shall provide on-site instruction of appropriate separation, handling, and recycling, salvage, reuse,

and return methods to be used by all parties at the appropriate stages of the Project.

+$ D. Separation facilities: The Contractor shall lay out and label a specific area to facilitate separation of materials for potential recycling, salvage, reuse, and return. Recycling and waste bin areas are to be kept neat and clean and clearly marked in order to avoid contamination of materials.

+$ E. Hazardous wastes: Hazardous wastes shall be separated, stored, and disposed of according to local regulations.

+$ F. Application for Progress Payments: The Contractor shall submit with each Application for Progress Payment a Summary of Waste Generated by the Project. Failure to submit this information shall render the Application for Payment incomplete and shall delay Progress Payment. The Summary shall be submitted on a form acceptable to the Owner [SEE APPENDIX ____] and shall contain the following information:

1. The amount (in tons or cubic yards) of material landfilled from the Project, the identity of the landfill, the total amount of tipping fees paid at the landfill, and the total disposal cost. Include manifests, weight tickets, receipt, and invoices.

2. For each material recycled, reused, or salvaged from the Project, the amount (in tons or cubic yards), the date removed from the jobsite, the receiving party, the transportation cost, the amount of any money paid or received for the recycled or salvaged material, and the net total cost or savings of salvage or recycling each material. Attach manifests, weight tickets, receipts, and invoices.

SPECIAL PROGRAMS

-$ A. The Contractor shall be responsible for final implementation of programs involving tax credits or rebates or similar incentives related to recycling, if applicable to the Project. Revenues or other savings obtained for recycling or returns shall accrue to the [CONTRACTOR] [OWNER].

1. Applicable programs are the following:
[LIST APPLICABLE PROGRAMS HERE.]

2. The Contractor is responsible for obtaining information packets relevant to all of the above-listed programs prior to starting work on the Project.

B. The Contractor shall document work methods, recycled materials, [LIST OTHER] that qualify for tax credits, rebates, and other

savings under each of the above-listed programs.

– END OF SECTION –

APPENDIX B

Appendix B: Model waste management contract language

Adopted directly from: Masters Dissertation
Title: *Advanced construction and demolition waste management for Florida Builders*, by Vleck Rudi E, ME Rinker School of Building Construction, University of Florida, Gainesville, Florida, June 2001.

I. Description

A. The owner desires that this project generate the least amount of waste possible and that processes that ensure the generation of as little waste as possible due to error, poor planning, breakage, mishandling, contamination, or other factors be employed.

B. Of the inevitable waste that is generated, as many of the waste materials as economically feasible shall be salvaged, reused or recycled. This is mandatory wherever practicable.

C. With these goals the contractor shall develop a waste management plan for this project.

II. Waste management

A. Plan

1. Required sections

Within fourteen working days after receipt of notice to proceed, or prior to waste removal on site, whichever occurs first, the contractor shall submit three copies of the draft waste management plan to the architect and owner: The plan should contain the following sections:

a) A list of each material proposed to be salvaged, reused, recycled and disposed of a s garbage
b) Estimated quantities for each waste stream
c) Separation requirements
d) On-site storage method for each waste stream
e) Transportation method for each waste stream
f) Destination of each waste stream
g) Estimated disposal fee or rebate of each material

2. Materials

The list of materials should at a minimum, include:

a) Cardboard
b) Carpet
c) Clean dimensional wood
d) Site clearance
e) Concrete, bricks and masonry
f) Asphalt
g) Metals
h) Gypsum
i) Excavation soil
j) Glass
k) Wood

3. Additional information

Include the names of each subcontractor who will transport non-hazardous or hazardous waste from the construction site and the name of the receiving facility that will accept waste for disposal.

B. Resources

A sample waste management plan and waste management plan forms are attached as part of this document. In addition, the contractor may request specific technical assistance or referrals from resources that include:

a) A Recycling coordinator
b) Engineering and Architectural services
c) A sustainable buildings specialist
d) A solid waste management office
e) Department of environmental affairs

C. Review and Approval

The draft waste management plan will be submitted to the Architect for review and approval with one copy going to the owner. The Architect will check the following:

a) That all materials that may be economically recycled are listed.
b) That the haulers, recyclers and waste disposal facilities that are listed cover general waste, recyclable waste and hazardous waste.

Upon completion, the Architect submits his comments and when satisfied with the contractor's response, the plan is approved.

D. Reporting

The contractor shall submit monthly progress reports that summarise waste practice on site. The reports shall be submitted in a format acceptable to the owner and shall contain:

a) Details of all materials that were salvaged, reused and recycled form the project
b) Details of all the materials that were disposed of in landfill sited from the project

APPENDIX C

Appendix C: Sources and causes of construction site waste

Adopted directly from: Proceedings of the 2nd Southern African Conference on Sustainable Development in the Built Environment
Title: *Construction material waste source evaluation*, by Ekanayake LL and Ofori G, Department of Building, National University of Singapore, Singapore, 2000.

Table C1: Sources and causes of construction site waste

Design	Operational	Material handling	Procurement
Lack of attention paid to dimensional coordination of products Changes made to the design while construction is in progress Designer's inexperience in method and sequence of construction Lack of attention paid to standard sizes available on the market Designer's unfamiliarity with alternative products Complexity of detailing in the Drawings Lack of information in the drawings Errors in contract documents Incomplete contract documents at commencement of project Selection of low quality products	Errors by tradespersons or laborers Accidents due to negligence Damage to work done caused by subsequent trades Use of incorrect material, thus requiring replacement Required quantity unclear due to improper planning Delays in passing of information to the contractor on types and sizes of products to be used Equipment malfunctioning Inclement weather	Damages during transportation Inappropriate storage leading to damage or deterioration Materials supplied in loose form Use of whatever material which are close to working place Unfriendly attitudes of project team and Laborers Theft	Ordering errors (e.g. ordering significantly more or less) Lack of possibilities to order small quantities Purchased products that do not comply with specification

APPENDIX D

Appendix D: Sample waste analysis and assessment sheet

Waste Audit Information

(Insert project specific information e.g. project name, main contractor, main sub-contractors, date etc.)

Waste analysis and assessment sheet

Container Type*	Description	Volume (m3)	Weight (Tons)	% Full
Unwanted waste				
Reusable metal				
Reusable wood				
Reusable drywall				
Reusable plastic				
Reusable bricks				
Wood recycling				
Metal recycling				
Cardboard recycling				
Drywall recycling				
Rubble recycling				

Comments

* If there is more than one type of each container, add them to the list.

(This analysis will give an indication of the type and amount of C&D waste that is generated on site per day/hour/week and this can be used to give a projected figure of expected waste quantities)

(Indicate which of the containers will be used in a detailed waste audit)

Container type	Unwanted waste		Unwanted waste		Reuse containers		Recycling containers	
Waste materials	Reusables		Recyclables		Contamination		Contamination	
	Vol/Tons*	%	Vol/Tons	%	Vol/Tons	%	Vol/Tons	%
Metal								
Wood								
Gypsum								
Concrete								

Bricks								
Masonry								
Asphalt								
Masonry								
Cardboard								
Total misplaced								
Comments								
* Give quantities in terms of volume or tonnage								
(This information will give indication of the type of materials that are generated in large quantities on site, where they are disposed of and where focus should be made)								
(Describe possible reuse and recycling options)								

APPENDIX E

Appendix E: Sample worksheets for waste analysis and recycling analysis

Adopted directly from: The King County Website
Title: C*onstruction Works News Gram*,
http://splash.metrokc.gov/swd/bizprog/sus_build/newsgram6.htm

And from: NAHB Research Centre Publication
Title: *Construction waste management handbook: Homestead Habitat for Humanity Jordan Commons*, prepared by the NAHB Research Centre for Homestead Habitat for Humanity, USA, May 1996.

Project Waste Analysis Worksheet

Material	Quantity	Recyclable? Reusable?	Possible Recycling Method

Table E2: Recycling Economics Projection Table for Self- Hauling

Recycling Economics Worksheet

Self-hauling

Cost of Recycling

Material	Tons or Yards	Tip Fee	Subtotal 1	# Loads	Hours Per Load	Labour rate and/or truck costs per hour	Subtotal 2	Total Cost
		$ -	$ -			$ -	$ -	$ -
		$ -	$ -			$ -	$ -	$ -
		$ -	$ -			$ -	$ -	$ -
		$ -	$ -			$ -	$ -	$ -
		$ -	$ -			$ -	$ -	$ -
		$ -	$ -			$ -	$ -	$ -
		$ -	$ -			$ -	$ -	$ -
		$ -	$ -			$ -	$ -	$ -
		$ -	$ -			$ -	$ -	$ -
Totals			$ -				$ -	$ -

Cost of Not Recycling

Material	Tons or Yards	Tip Fee	Subtotal 1	# Loads	Hours Per Load	Labour rate and/or truck costs per hour	Subtotal 2	Total Cost
Garbage		$ -	$ -			$ -	$ -	$ -

Savings or Cost of Recycling

Cost of Not Recycling	Cost of Recycling	**Total Savings**
$ -	$ -	**$ -**

Table E3: Recycling Economics Projection Table for a Commercial Hauler

Recycling Economics Worksheet

Commercial Hauler

Cost of Recycling

Material	Tons or Yards	Tip Fee	Sub Total 1	# Loads	Hauling Fee	Sub Total 2	# of months	Container Rental	Sub Total 3	Total Cost
			$ -		$ -	$ -		$ -	$ -	$ -
			$ -		$ -	$ -		$ -	$ -	$ -
			$ -		$ -	$ -		$ -	$ -	$ -
			$ -		$ -	$ -		$ -	$ -	$ -
			$ -		$ -	$ -			$ -	$ -
			$ -		$ -	$ -			$ -	$ -
			$ -		$ -	$ -			$ -	$ -
			$ -		$ -	$ -			$ -	$ -
			$ -		$ -	$ -			$ -	$ -
Totals			$ -			$ -			$ -	$ -

Cost of Not Recycling

Material	Tons or Yards	Tip Fee	Sub Total 1	# Loads	Hauling Fee	Sub Total 2	# of Months	Container Rental	Sub Total 3	Total Cost
Garbage		$ -	$ -		$ -	$ -		$ -	$ -	$ -

Savings or Cost of Recycling

Cost of Not Recycling	Cost of Recycling	Total Savings
$ -	$ -	**$ -**

Recycling Economics Worksheet

Table E4: Cost Projections Table for Waste Disposal/ Materials Recovery for Recycling

Waste Material	Q'ty (Tons)	Requirements (Container rental or self-haul)	Contact (Potential service provider)	Recycling Rate (-) Cost (+) Premium	Disposal Rate R/ton or R/m3	Cost (-) / Premium (+) Recycling (R)	Cost Disposal (R)	Net Premium - Recycling (R)
Metals								
Wood Reuse								
Wood Recycle								
Cardboard								
Drywall								
Recyclable Containers (all aluminium)								
Unrecoverable Construction Waste								
MSW Disposal								
TOTAL								

APPENDIX F

Appendix F: Sample waste management plan

Name of Project	Intuthuko Shopping Mall
Location	Empangeni
Starting date	04/2002
Short Description	Demolition of an old community centre and construction of a shopping centre and associated infrastructure i.e. roads, parking area and taxi rank.
Main Contractor	Inkunzi emnyama construction and civil works
Responsibility for waste	Independent waste consultant

Description

- This project shall generate the least amount of waste possible by properly planning material procurement (ordering, transportation and delivery), ensuring proper material handling and storage to reduce the avoidable generation of wastage (i.e. broken and damaged materials) and reusing potential waste materials on site wherever possible. Of the inevitable waste that is generated, as many of the waste materials as economically feasible shall be recovered and sorted for donation, reuse elsewhere or stored separately for recycling.
- Table F1 below identifies all the waste materials that will be generated on this project. It gives a breakdown of the waste materials by type and quantity. It also describes the end-of-life option selected for each material and the associated handling procedures.
- Waste avoidance is given first priority, followed by waste minimisation (see figure F1). These shall be discussed at the beginning of every safety meeting (or waste management meeting where it exists). As each new subcontractor comes on site, the "waste manager" or "recycling coordinator" will present him/her with a copy of the waste management plan and provide a tour of the waste management areas on site, including the recycling centre if applicable. The subcontractor will be expected to ensure that all of his/her crewmembers comply with the waste management plan. All waste containers will be clearly labelled (i.e. unwanted waste, and specific reusable and recyclable waste).
- The construction site shall be clearly signposted with information relating to waste management including directions to waste containers and the recycling centre, waste collection intervals, waste management targets and progress on site, acceptable and unacceptable site waste practice and outstanding performers among others.

Waste management plan

Table F1: Waste management plan

Material	Qty	End-of-life option	Handling procedure
Demolition (in cases where an existing structure had to be removed)			
Concrete (from shell of building)	300 tons	Recycled – concrete crusher and reused as fill	Break up and store separately
Wood (from roof-frame)	10 tons	Recycled (Name?)	Clean and store in clean wood container

Asphalt (from parking lot)	100 tons	Recycled – crushed and reused in new parking lot	Store separately
Corrugated iron (from roof)	50 m2	Sold – housing market	Store in reusable metal container
Other waste	60 tons	Unwanted waste – to be landfilled	Store in unwanted waste container
New Construction			
Concrete	10 tons	Recycled – concrete crusher (Name?)	Store separately
Clean wood scrap	60 tons	Reused on site and recycled by wood recycler (Name?)	Clean and store in clean wood container
Gypsum drywall	50 tons	Recycled (Name?)	Store in separate covered container
Scrap metal	13 tons	Recycled (Name?)	Store in scrap metal container
Electrical and plumbing metal wastes		Subcontractor responsibility, reports required	Separate and store in specific container of vehicle for recycling
Carpet padding		Subcontractor responsibility, reports required	Separate and store in specific container of vehicle for recycling
Insulation material		Subcontractor responsibility, reports required	Separate and store in specific container of vehicle for recycling
Other wastes	20 tons	Unwanted waste – to be landfilled	Store in unwanted waste container

Note: Waste characterisation done according to waste audit presented in Appendix D and waste economics done according to worksheet in Appendix E.

Figure F1: Waste management hierarchy

Waste Management Hierarchy		
Waste Avoidance	Prevention (cleaner production)	Most Desirable
	Demand management (human behaviour & lifestyle)	
	Reduction (source control)	
Waste Minimisation	Recovery (salvage)	
	Reuse (immediate use)	
	Recycling (reprocessing)	
	Composting (biological reprocessing)	
Waste Treatment	Incineration: Energy recovery	
	Incineration: Volume reduction	
	Chemical treatment (neutralisation)	Least Desirable
Waste Disposal	Landfill	