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Construction and Demolition Waste Management – A Review

Markandeya Raju Ponnada[1] and Kameswari P[2]

[1]*Professor, Department of Civil Engineering*
MVGR College of Engineering,
Vizianagaram – 535005, Andhra Pradesh
[2]*Former Post graduate student of Environmental Science*
Centre for Distance learning and Education
Kakatiya Univeristy, Warangal – Telangana State

Abstract

Demolition waste is waste debris from destruction of a construction. Construction industry in India generates about 10-12 million Tons of waste annually. While Retrievable items like bricks, wood, metal, titles are recycled in India, Concrete and masonry waste (>50% of total waste) are not recycled. A defined manual is not available with regulatory authorities for effective management of Construction and Demolition (C & D) waste. Authorities sometimes make rules but often fail in implementing them. This report is expected to be a pilot study towards preparation of such a manual. The objective of this study is to compile relevant literature which will give an insight into demolition waste management strategies of different countries and role of regulatory authorities in demolition waste management. The paper also studies the properties of demolition waste, its hazardous effects and suggests safe recycling/reuse/disposal methods. Based on the study, A C & D Waste management plan was formulated. For effective use of C & D, it essential that the local governing bodies make the submission and implementation of this plan mandatory. This would go a long way in the reduction of Environmental Pollution due to Construction and Demolition waste.

Keywords*: demolition waste; disposal; recycle; reuse; pollution*

1. Introduction

1.1. General

Demolition waste is waste debris from destruction of a building. Certain components of demolition waste such as plasterboard are hazardous once land filled as it is broken down in landfill conditions releasing hydrogen sulfide, a toxic gas. Waste from individual house construction or demolition,

- Find its way into nearby municipal bin/vat/waste storage depots, making the municipal waste heavy
- Degrade quality of municipal waste and makes it difficult for further treatment like composting.
- About 10-20 % finds its way into surface drains, choking them.

Projections for building material requirement of the housing sector indicate a shortage of aggregates upto 55,000 million m^3. Additional 750 million m^3 would be required for achieving the targets of the road sector. Recycling of aggregate material from construction and demolition waste may reduce the demand-supply gap in both these sectors. Government or local authorities should make rules to sort the C & D waste before it is hauled away to landfills or other waste treatment facilities. Hazardous materials may not be moved before the demolition is begun or before the authorities have ascertained that

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safety guidelines and restrictions have been followed for handling and disposal of toxic elements as lead, asbestos or radioactive materials.

1.2. Indian Construction Industry and Wastes Generated

Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million Tons per annum of which waste from Construction Industry accounts for 25%. Construction waste is bulky, heavy and is mostly unsuitable for disposal by incineration or composting. The growing population in the country and requirement of land for other uses has reduced the availability of land for waste disposal. Re-utilization or recycling is an important strategy for management of such waste. Above all, the fast depleting reserves of conventional natural aggregate has necessitated the use of recycling/ re-use technology in order to be able to conserve the conventional natural aggregate for other important works. Apart from mounting problems of waste management, other reasons which support adoption of reuse/ recycling strategy are reduced extraction of raw materials, reduced transportation cost, reduced capital investment on raw materials, improved profits and reduced environmental impact.

1.3. Waste from Construction Industry - Quantum of Wastes - Their Sources and Constituents

Waste is generated at different stages of construction process. During construction activity, excessive cement mix or concrete left after work is over due to rejection/ demolition caused by change in design or wrong workmanship etc. Demolition of Pucca and Semi-Pucca buildings on an average generates 500 and 300 kg/ square meters of waste respectively. Estimated waste generation during construction is 40 to 60 Kg. per sq. m. Waste generation during renovation/ repair work is estimated to be 40 to 50 kg/square meters. Concrete appears in two forms in the waste - Reinforced concrete (Structural elements of building) and foundations (non-reinforced concrete). Excavations produce topsoil, clay, sand, and gravel. This may be either re-used as filler at the same site after completion of excavation work or moved. Large quantum of bricks and masonry mixed with cement, mortar or lime arise as waste during demolition. Stone arises during excavations or by demolition of old buildings. Metal waste is generated during demolition in the form of pipes, conduits, and light sheet material used in ventilation system, wires, and sanitary fittings and as reinforcement in the concrete. Metals are recovered and recycled by re-melting. Timber if in good condition from beams, window frames, doors, partitions and other fittings is reused. However, wood used in construction is often treated with chemicals to prevent Termite infestation and warrants special care during disposal. Other problems associated to wood waste are inclusion of jointing, nails, screws and fixings. Miscellaneous materials that arise as waste include glass, plastic material, paper, etc. Quantities of different constituents of waste that arise from Construction Industry in India are estimated as follows.

1.4. Management of Waste from Construction Industry in India

In general, in India, contractor executes construction project on a labour contract basis or on turnkey basis. Small housing projects are executed by owners and are predominantly executed on labour contract basis and strict supervision is required to control waste generation during construction process. In this construction process waste generation ranges between 5 to 7%. In larger projects, where execution is on turnkey basis or through one’s own team of professionals, material wastage is within 3%.

Table 1. Constituents of Waste that Arise from Construction Industry in India

Constituent	Quantity generated in Million Tonnes
Soil, Sand and Gravel	4.20 to 5.14
Bricks and Masonry	3.60 to 4.40
Concrete	2.40 to 3.67
Metals	0.60 to 0.73
Wood	0.25 to 0.30
Others	0.10 to 0.15

Services of demolition contractor are taken when old building is to be demolished due to deterioration of the building or to make way for construction of a new building. Demolition contractor specialises in planned deconstruction so that recovery of good material can be maximised for re-use. Recovery rate varies from 25% in old buildings to as high as 75% in new buildings. Items recovered during demolition are sold in the market at a discount with respect to price of new material. Sometimes, Woodcarvings and Marble structures are recovered from old buildings, which fetch very good price as Antique piece in Domestic/ Export market. Although the responsibility of removing the waste is primarily of the builder or the owner, it is usually assigned to the demolition contractor. Items that cannot be re-used are disposed off to landfill site. Management of those solid wastes which are sent to the landfill sites from various construction activities is the responsibility of Municipal Bodies or health officers. Hard core material from demolition operation is required for landfill activities to provide daily cover over domestic waste, bulk fill capping, hard standings etc. Some Municipal Corporations require demolition waste for their landfill activities, while others want to minimise it to prolong useful life of landfill sites. However, all respondents are unanimous that in the long run, recycling of waste from construction industry is necessary in view of limited landfill space and increasing quantum of demolition waste. In India Different constituents of waste are not segregated prior to disposal. For the segregation of these wastes, Municipal Authorities incur cost of Rs.60 to Rs.80 per Ton of waste. Presently they are not levying any charges for this waste segregation. Builders/ Owners bear the cost of transportation, which is at present between Rs.250 to Rs.500 per truckload depending on the distance of demolition site from landfill area. Though directives exist for disposal of waste to landfill areas, penal action against violators is practically not taken.
Presently management of waste from construction industry in India comprises of the following elements:

- Re-use of materials salvaged in good condition during demolition.
- All metal items are sent for re-melting through scrap dealers.
- Disposal of other items to low lying sites.

Concrete and masonry constitute more than 50% of waste generated by the Construction Industry. Recycling of this waste by converting it to aggregate offers dual benefit of saving landfill space and reduction in extraction of natural raw material for new construction activity.

Various surveys conducted on reasons for less usage of recycling processes in India have revealed the following

- 70% of respondents have cited Lack of awareness regarding recycling techniques as one of the major reasons for not adopting recycling of waste from Construction Industry.
- 30 % of the respondents have indicated that they are not even aware of recycling possibilities.
- 67% of respondents from user industry have indicated non-availability of recycled product as one reason for not using it.

• The response of industries which had the knowledge and technical know-how of using recycled product indicates that presently, there are no specifications available in the Indian standard codes for the use of recycled material in construction.

2. Literature Survey, Objective and Scope

2.1. The History of Construction Waste Management

Recycling of demolition waste was first carried out after the Second World War in Germany to tackle the problem of disposing large amount of demolition waste caused by the war and simultaneously generate raw material for reconstruction.

Considerable research has been carried out in U.S.A, Japan, U.K, France, Germany, Denmark etc. for recycling concrete, masonry, bricks, bituminous and other constituents of waste from Construction Industry. These studies have demonstrated possibility of using construction waste to substitute new materials of recycling.

Work on recycling of aggregates has been done at Central Building Research Institute (CBRI), Roorkee, and Central Road Research Institute (CRRI), New Delhi. The study report stresses the importance of recycling construction waste, creating awareness about the problem of waste management and the availability of technologies for recycling. According to a study commissioned by Technology Information, Forecasting and Assessment Council (TIFAC), 70% of the construction industry is not aware of recycling techniques. The study recommends establishment of quality standards for recycled aggregate materials and recycled aggregate concrete. This would help in setting up a target product quality for producers and assure the user of a minimum quality requirement, thus encouraging him to use it.

2.2. Review of Recycling Operations in other Countries

Recycling of waste from Construction Industry is carried out in U.K, France, Denmark, Germany, U.S.A, Japan, *etc*. The proportion of different constituents varies from country to country depending upon the material used for construction and the building technology.

The salient features of recycling operations in different countries can be summarized as follows:

The Regulatory framework in Denmark has significantly helped it to improve recycling of waste from Construction Industry. Before demolition of the building, the owner of the structure has to apply for permission by filling in detailed form in which he has to identify each constituent and estimate the quantity likely to arise. Simultaneously, he has to define the disposal strategy. He has to also identify the waste carrier and environmental problems anticipated during waste disposal along with methodology to control it. After demolition takes place, different materials have to be transported separately. Otherwise it attracts a price penalty or even refusal for movement of material. The disposal of waste to landfill is taxed at high rates, while there is no tax on material sent to recycling. Netherlands has developed specifications covering recycled material to be used as aggregate in concrete. Dutch Government has imposed stiff charge on disposal of waste to landfill sites. This charge has risen by seven times since 1988.The technology adopted in Denmark is simple and labour intensive, while the plants in Germany incorporate number of machines.

2.3. Objective and Scope of Study

The objective of this study is to study the properties of demolition waste, its hazardous effects and suggest safe recycling/reuse/disposal methods.

The Scope of the work is limited to collection of literature on demolition waste management which includes properties of demolition waste, its hazardous effects and suggest safe recycling/reuse/disposal methods.

The scope of this work is also

- To study demolition waste management strategies of different countries
- To study the role of regulatory authorities in demolition waste management
- To suggest improved methods of recycling/reuse/disposal of demolition waste
- To suggest the modifications required in regulations in vogue for demolition waste disposal

2.4. Method of Approach for Achieving the Objective

Collect literature from internet and journals
Visit local regulatory authorities and enquire about the strategies adopted
Visit a major site where demolition is going on
Study the methodologies adopted by them and verify with norms of regulatory authority
Suggest improved methods of recycling/reuse/disposal of demolition waste
Suggest the modifications required in regulations in vogue for demolition waste disposal

The following aspects are going to be studied.

Classification of various major and minor components of demolition waste
Properties of various major and minor components of demolition waste
Methods of sorting, collection, transportation and storage of demolition waste
Recycling and reuse of various components of demolition waste
Need for safe methods of disposing demolition waste
Planning and management aspects
Institutional and regulatory aspects

3. Recycling Construction and Demolition Wastes

3.1. Introduction

Architects, engineers, specification writers, and contractors have an interest in and understand the goals of job site recycling of Demolition waste but are not familiar with its practicalities. Without this familiarity, it's difficult to piece together how recycling works into overall project management, or to counter the concerns of those who object to job site recycling on the basis of cost, complexity, unreliability, or other factors. This chapter is intended to provide the information to understand and address those objections, and lay the foundation for successful recycling from any new construction, renovation or demolition project.

3.2. Necessity of Recycling Demolition Waste

"Sustainable building" has become a global catchphrase. In architects' offices and on construction sites around the world there is increasing emphasis on reducing the environmental impacts of renovation and new construction. C&D recycling is among the most visible commitments a developer can make to sustainable building, visible to every worker on the site and to every passerby. In providing materials to local vendors and processors, job site recycling creates employment and economic activity that help sustain local economies. And perhaps most important, on a lifecycle basis, recycling produces usable materials at much less environmental cost than materials from primary sources. That is, in addition to conserving raw materials, recycling conserves energy and water, and reduces the production of greenhouse emissions and other pollutants. On and off the

job site, recycling is one of the most significant commitments that can be made to sustainable building. So for many reasons - environmental, economic, practical and environmental compliance - job site recycling is, and should be, at the center of sustainable building. Further, recycling is only one of several ways to conserve resources and materials in construction and renovation. For every material that can be re-used in a job, recycling isn't even necessary. This is true for source reduction - using less material in the first place, using less packaging, or using materials more efficiently (thereby eliminating waste). And finally, use recycled or recycled-content products. Recycling falls apart if there are no markets for the materials that are diverted from the waste stream and the best way to assure strong markets is to specify the use of recycled products wherever possible.

Basics of Construction and Demolition Recycling

The reasons to recycle construction and demolition (C&D) wastes are simple but compelling:

1. Construction and demolition wastes are one of the largest waste streams in the country.

2. Almost all job site wastes are recyclable.

3. It costs less - usually much less - to recycle job site wastes than to throw them away.

Almost all Job Site Wastes Are Recyclable. This waste stream is also very large. Waste that's generated during construction of a new building is more than that produced by occupants of that building during one to two years of occupancy. There is hardly a single waste material from a job site that cannot be recycled: Some of the waste materials from demolition site that can be recycled are as follows.

Table 2. Waste Materials from Demolition Site that can be Recycled

Architectural salvage	**Non-Ferrous Metals**	**Land clearing residuals**
Doors and door frames	Wiring/conduit	Trees, stumps, brush
Windows and frames	Plumbing (pipes, fixtures)	Soil
Millwork	HVAC (ductwork, motors)	**Ferrous Metals**
Furniture and Furnishings	**Asphalt**	Structural steel
Office furniture	**Aggregate**	Steel framing members
Partition systems	Concrete (with & without rebar)	**Porcelain fixtures**
Medical/lab equipment	Brick	**Ceiling tiles**
Reception/casual furniture	Concrete block	**Gypsum Wallboard**
Lockers/athletic equipment	**Wood**	**Roofing**
Carpeting	Dimensional lumber	Shingles
Broadloom	Panels (plywood, OSB, MDF)	Commercial membrane
Carpet tiles	Engineered beams (glu-lam, etc.)	Wood, metal, slate

In total, from almost any job site, 90% to 95% of all waste materials can be recycled.

There are some materials that aren't on this list, because markets remain undeveloped or contamination makes them difficult to recycle - for example, fiberglass and foam insulation, painted or papered gypsum wallboard. And some renovation or demolition job sites contain hazardous or special waste materials that need to be managed as such (lead-painted wood or plaster, asbestos floor tiles or siding). In almost all cases, the cost of recycling is lower than the cost of throwing materials away. However, day in and day out,

for the architect, owner, and contractor, recycling makes economic sense. This is a critical point. If recycling costs more than disposal, then there will always be a very good reason NOT to recycle. But if recycling is cost-competitive or less expensive than disposal, then recycling should be considered as part of every job. In the worst case, the cost to recycle is not much more than half the cost of disposal. When you sum these costs across almost any construction project, the savings often amount to tens of Lakhs of Rupees. Even if materials cannot be separated for recycling, recycling still costs no more than disposal.

A rough comparison of cost for recycling of mixed debris and the cost of disposal reveals that there is great advantage, on the side of recycling. 75% to 90% of the mixed debris gets sorted out, recovered, and used again. The economic benefits of recycling are highest if waste materials can be separated from each other and recycled individually. This is called "Source separation." Source separation means separating different recyclable materials at the job site. That is, workers keep metals separate from wood and wood separate from concrete, and so on, and place each material into a different container. These containers are then transported to different markets. Commingled recycling is the alternative to source separation. Commingled recycling means placing all recyclable materials into a single container, which is then transported to a processing facility, where different materials are separated by hand or by automated equipment. Source separation and commingled recycling have distinct advantages and disadvantages.

Table 3. Advantages and Disadvantages of Source Separation Vs Commingled Recycling

Recycling Method	Advantages	Disadvantages
Source Separation	• Higher recycling rates • Lower recycling costs • Often working at site is safer	• Multiple containers at site. Workers must separate the materials. Complex logistics. More information to Manage
Commingled Recycling	• Only one or two containers at site. No need of workers at site. Easier logistics. less information to manage	• Lower recycling rates. Higher recycling costs

The biggest tradeoff between source separation and commingled recycling is complexity vs. economics.

Source separation is more complex because workers must separate waste materials before they throw them away, there are more containers on site, and there are more markets and haulers to work with and keep track of.

But in most cases, source separation is economically more advantageous than commingled recycling:

• Source separation produces materials that are ready to go directly to market; there is no need to pay a processor to sort materials.

• Source separated materials are generally of higher quality, with fewer contaminants, so they're worth more in recycling markets.

On balance, source separation is generally preferable to commingled recycling. It costs less, and recycling rates are typically higher. Complexity is usually not much of an issue. It's no harder for workers to toss different materials into different containers than to throw them out mixed together. Being smaller, containers for source separated materials can often be placed close to work areas, so that source separation actually takes less time and effort than carrying wastes to a central container for mixed debris. Nor does source separation imply that every material will be separated all of the time. There will always be a mixed debris container on site, and there will be some materials that are always disposed or recycled as mixed debris. Some materials will also be source-separated during one phase of a job, but handled as mixed debris at other times. For example, in a wood-framed building, wood would generally be source-separated while the structure is framed.

But when the project moves on and the only wood waste is an odd pallet or pieces of blocking, these will be handled as mixed debris.

There are some jobs where commingled recycling is the only option possible, because of site limitations, job size, or schedule. In these cases the goal is to identify the commingled processor who can achieve the best combination of price and recycling rate. But where it's feasible, source separation should be considered the best recycling option.

The basics of source separation are easy: each recyclable material should be segregated as it is generated, and placed in the appropriate container. A few additional rules make source separation work smoothly:

Keep as few containers as possible on site at any time. Containers take up space, and having too many containers increases the possibility of confusion and contamination. In general, aim to have one container on site for mixed debris, and one or two additional containers for the specific wastes generated during each phase of the job.

Match containers to the material. A wood container, for example, will typically hold 30 or 40 cubic yards. But scrap metal from wiring and plumbing may need only a 2- or 4-yard container. For something like concrete, you may have a lot of material, but container size may be limited by the weight that can be hauled over the road. Site layout and access also play a role in container selection. Place containers close to work locations. An advantage of source separation is that it doesn't rely on one big central container for all wastes. Smaller containers can often be placed close to the work. Also look for opportunities to use intermediate containers like hampers or rolling hoppers that can be placed right next to the work, and then wheeled to a larger waste container at the end of the shift. Again, there may be surprising savings in labor and convenience.

What makes source separation work is the fact that it's matched to the phase of the job. You only have on site the containers needed at a particular time for the specific wastes being generated. You collect, haul, and market these materials. When the job moves on, you recycle different materials, in different containers, and generally to different markets. It takes a little energy and thought to do this, but in most cases the financial savings and the advantage in recycling rates are more than worth it.

Good planning is the single most important part of construction waste management. Like anything else in construction, recycling is straightforward if you have a good blueprint, but becomes much more difficult and expensive if it's an add-on. Good planning allows you to identify all recyclable materials and know how you're going to manage them before the job starts. Good planning addresses how each waste material will be handled, what containers will be used and when they'll be on site, and where each material will be marketed. Good planning allows you to assess the costs and benefits of recycling and decide which materials to source separate, which to recycle as commingled debris, and which to discard as trash. Good planning covers communications, training, and troubleshooting, and lays out tracking and reporting procedures for documentation. The Waste Management Plan is the document that lays out the start-to- finish strategy for job site recycling. It is prepared directly from the drawings and specifications for the job, and a good plan will closely follow these documents.

The Waste Management Plan should

- Estimate types and quantities of C&D wastes generated during each phase of the Job;
- Identify how each waste will be managed and marketed;
- Provide an estimate of the overall job recycling rate;
- Lay out plans for training, meetings, and other communications related to job-site waste management;
- Provide troubleshooting instructions and contact information.

All of this can (and should) be done before you break ground, so that recycling is incorporated seamlessly into overall performance of the job. It's best if the Waste

Management Plan is written and signed off on by all parties (owner, architect, and contractor) a month or more before groundbreaking or the first day of demolition.

Demolition and Renovation

Demolition and renovation projects are different from new construction, and often need some extra planning. For example, compared to new construction, demolition and renovation projects often involve

• Much larger quantities of waste (often the entire building);
• Many high-value wastes, for example, furniture and furnishings, architectural salvage and valuable commodities such as nonferrous metals;
• Wastes that are difficult to separate and recycle (like painted gypsum wallboard, insulation, and shingles), and wastes that may be contaminated with hazardous materials.
• Automated demolition equipment like cranes and grapples, which don't lend themselves to the separation of one material from another.
• Tight and inflexible schedules; project value is in the new construction, while demolition is perceived simply as a cost, with the goal to finish as quickly and cheaply as possible.

In addition, some amount of recycling is already ingrained in the demolition industry. Demolition contractors have been segregating wastes for many years, either to capture revenue (*e.g.*, wiring, structural steel), or to reduce disposal costs (*e.g.*, concrete, brick). This is both good and bad. It's good because demolition contractors are already aware of and practice some recycling. It can be bad when a demolition contractor thinks he knows all there is to know about recycling, and balks at suggestions to go beyond customary procedures. Contractors who are generating revenues from recycling may also be reluctant to relinquish this income, as they may if a Waste Management Plan clearly identifies these materials and revenue streams. Given these considerations, an on-site audit before work begins is a critical part of recycling from demolition or renovation. This is not necessary in new construction, where recycling can be planned entirely from drawings and specifications. A team that includes the architect, contractor, and recycler should get on site to confirm what materials will be removed and how they will be handled (hand disassembly, removal by crane, *etc.*). Often it will be good to bring along a salvage specialist, who can identify opportunities to remove architectural materials such as flooring, doors and windows. High-value commodities like wiring, nonferrous metals, suspended ceilings and the like should also be catalogued, and plans made for their recovery separate from other wastes. The on-site audit also provides an opportunity to identify and resolve any conflicts between recycling and operations - and more specifically, any potential conflicts between the owner, architect, and contractor, whose goals and priorities at this stage may not be completely in alignment.

3.3. Barriers and Response (Objection To Job Site Recycling)

Almost every day, somewhere in India, an owner, architect, or contractor is proposing to recycle construction and demolition wastes. And almost every day, someone else is throwing up a barrier to recycling. Unless the proponent can address each barrier, recycling will often be abandoned before it's tried. Or worse, it will be forced on an unwilling participant who will, with or without actual malice, find a way to torpedo the effort. It's far better to address the barriers up front, with real information, than let them stand in the way, or linger and taint the whole recycling effort.

Some of the barriers that can linger and taint the whole recycling effort are as follows.

Recycling will Slow Down the Job

The perception that recycling will slow down the job is almost never true. Recycling asks

workers to work a little bit smarter, not any harder or longer. Recycling containers are matched to the specific wastes being generated during different phases of the project, and they should be clearly labeled, so there's not a question of having to choose which container to use for which waste. Because they're often smaller than the big roll off boxes used for mixed debris, many recycling containers can be placed closer to the work locations where wastes are generated. Far from slowing down the job, recycling often saves time and effort.

(There's also a safety connection. Because recyclable wastes are usually put into containers as soon as they're generated - not left on the ground to be picked up as mixed debris - recycling generally makes for a cleaner and safer job site.) In addition, recycling is a morale booster. Recycling gets strong support from contractor and subcontractor work crews. This means that they give extra effort to make recycling work, and enhances the overall tone on the work site, which makes the work go smoother and quicker. Logistics and service are other reasons which suggest that recycling might slow down the job. Again, this is not true. The key is to integrate recycling with other job site activities, so that the right containers are on site for each phase of the job, and containers flow smoothly onto and away from the site as wastes are generated. If this is done, there's no reason that recycling a half dozen different materials will take any more time than throwing everything away into a single dumpster.

There's no Room on Site to Recycle

This, too, is almost never true. A key to successful recycling is to match containers to wastes, both in time and size. So it's not necessary to have five or six containers on site. Instead, containers are matched to each phase of the job, and are swapped in or out so that only one to three containers are on location at any time, matched to specific wastes being generated. Also, because recycling containers are often smaller than mixed debris containers, there can be more flexibility in setting them out on the site, so that a recycling container can often be shoe-horned in where a larger mixed debris container would not fit. If site constraints absolutely preclude source separation, sorting wastes off site is an option, although one that will add labor and other expense. And mixed debris recycling, with recycling rates of 75+% should be possible on any jobsite.

With all these Containers and Materials, Recycling is way too Complicated

It is not more complicated than having one big container for all job site wastes. Recycling requires intelligent up-front planning, most of which is already done as part of overall project management. The waste management plan tracks the flow of the project, matching the work that's being done as the project moves from phase to phase. When the framers are working, it's time for a wood box. When the wiring, plumbing, and HVAC are being installed, it's time for a metal box. When gypsum wallboard is being installed, it's time for a wallboard box. If you've planned the job well from the construction side, you've already done most of the work required to recycle.

But how do i know all these Service Providers will be Reliable?

Until the mid-1990s, this was a good question. There were many fewer recycling markets, and only a few haulers who made C&D recycling a priority. But this situation has changed rapidly, thanks to the basic laws of supply and demand. As more owners, architects, and contractors have begun to ask for recycling services, more service providers have entered the market, and to survive they've had to offer efficient and reliable service. Now, it's no different than choosing any other subcontractor. Confirm references from past work; look for size, flexibility and stability; do a basic background check; and make sure you have a dedicated contact who's accountable for each job. If you do this, reliability shouldn't be a question.

We have no Contract Language for Recycling

C&D recycling starts with a good specification that clearly states recycling goals, materials to be recycled, and planning, reporting, and recordkeeping requirements. As with every other jobsite activity, a good specification provides the foundation for a smooth work flow, without confusion or misunderstanding. Recycling shouldn't be an afterthought or add-on. Just a couple of years ago, a lot of C&D recycling specs had to be written from scratch; there just weren't many examples to go by. But now there are a lot of good samples to choose from, that fit just about every recycling situation and specification format. Many model specifications are available over the web.

Recycling Costs too Much

After everything is said and done, this is the biggest reservation that owners, architects, and contractors express about recycling. It's also one of the easiest to disprove. Throughout India, the cost to transport and landfill C&D wastes is much less than the cost of recycling. Although exact pricing varies with markets and transportation lanes, the financial information is clear and compelling for almost every material in the C&D waste stream, recycling is much less expensive than disposal. And for the highest volume materials in C&D, recycling is less expensive by a factor of two, three, or four. In a worst case scenario - a tough site, a tight schedule, a waste stream that has to be recycled largely as mixed debris - it's safe to state that recycling will cost no more than disposal. In almost all other cases, recycling will be much less costly, with savings that often run into tens of Lakhs of Rupees, even after all costs for planning, training, recordkeeping, and reporting are factored in.

I'll never get Subcontractors to go along

Subs respond to the same cues as anyone else: clear priorities, clear instruction, clear procedures, financial penalties and incentives. Two things are most important:

1. Management-level interaction: Make sure that subs' managers and supervisors understand that recycling is important and that deviation from specified procedures will be penalized. Again, clear up-front specifications and unambiguous contract language are critical.
2. Training: Recycling training should be provided at every crew shift, and should cover materials to be recycled, recycling procedures, recycling containers (location, identification, *etc.*), and where to go with questions. It's particularly important to reach subcontractor supervisors, so that they can provide instruction to individual workers as they come onto the site from day to day. Subs and their workers understand the environmental importance of recycling, and tend to be supportive. Their concerns are predictable: "It will slow us down." "It will cost us." "It's complicated." As long as procedures are clear and these concerns are answered, compliance with recycling requirements should not be an issue.

This is a Union Job. The Union won't Cooperate, and the Labor Cost will be too High

In almost all cases, the reverse will be true. Unions and their workers understand the environmental benefits of jobsite recycling, and see a commitment to recycling as a commitment to caring by the owner and contractor. Union employees are often the most enthusiastic supporters of recycling. As noted elsewhere, there's no reason to expect that recycling will add significant labor time or cost into the job, and in many cases recycling can save some time in waste management. Recycling also promotes a neater, safer, and more productive jobsite. Again, these are factors that will encourage union support, not the reverse. It is important to bring union representatives into the planning process and solicit their input and comment on waste management and recycling. After all, the workers on the

jobsite are where the rubber meets the road, and they more than anyone else have to integrate recycling into the job flow. Getting their early involvement and support is an important step.

3.4. The Waste Management Plan

The Waste Management Plan is the cornerstone for successful C&D recycling. It is a comprehensive document that provides all of the information needed by any individual on site to understand and achieve the waste management goals for the project. The Waste Management Plan should be started as early in the project as possible, well before groundbreaking or the beginning of demolition. This allows time for all parties to participate in developing the plan, allows contractors and subcontractors to integrate recycling into their setup and work plans, and assures that training can be provided to supervisors and workers. If there will be issues like space for recycling containers or internal handling of recyclables (*e.g.*, using hampers or self-dumping hoppers), these definitely should be addressed in the Plan well in advance of groundbreaking. The Waste Management Plan is also a living document, used as a day-to-day reference just like blueprints and specifications. This fact cannot be overemphasized. Handling procedures or markets may change during the course of a job; these changes should be noted in modifications to the plan. As waste materials move from the site you will gather information on waste and recycling tonnages and costs. These should be matched against initial projections, variances should be analyzed, and a running recycling rate should be calculated. This last is critical. If you're looking for certification, you need to track progress toward this goal (and take steps if it looks like you're running low). And you should publicize the recycling rate to laborers and trades; it's a good way to help boost morale, and keep workers striving to achieve your recycling goals.

The Waste Management Plan should specify who is responsible for acquiring and storing this information, where information will be stored (*e.g.*, on site, by the architect, by the contractor), who is responsible for using the information to produce operating and financial reports, and how information will be transferred from one party to another. A few waste streams need special consideration.

3.5. Construction and Demolition Waste Management Background

The purpose of these Guidelines is to promote an integrated approach to construction and demolition (C&D) waste management, throughout the duration of a project. They are designed to promote sustainable development, environmental protection and optimum use of resources. The Guidelines provide guidance on the preparation of Detailed Project report on Construction and Demolition Waste management.

Management Plans for certain classes of project, which exceed specified threshold limits. The requirement for such Plans extends equally to both public and private sector developments. They provide clients, developers, designers, practitioners, contractors, sub-contractors and competent authorities with an agreed basis for determining the adequacy of C&D Waste Management Plans.

Construction and demolition waste is defined as waste which arises from construction, renovation and demolition activities etc. Also included within the definition are surplus and damaged products and materials arising in the course of construction work or used temporarily during the course of on-site activities.

Landfill has been the traditional disposal mechanism for C&D waste, but in accordance with the waste management hierarchy and having regard to the resource value of the discarded materials and the current exhaustive pressures on landfill space, recycling must take over as the main management route for this waste stream. The recycling of C&D waste has been recommended in all of the Regional Waste Management Plans, which the local authorities are now implementing, with many setting a target of about 80% recycling

of C&D waste. Further it is likely that there could be a remarkable increase in the quantity of C&D due to increased infrastructure and housing development and improved reporting.

This latest estimate is based on compilations of local authority collection permit reports.

In relation to C&D waste which excludes soil and stones, it is estimated that only 69% undergoes recovery/disposal.

There is every need for an Agency to carry out detailed research accurately assess construction and demolition. Prudent and proper management of this waste stream will be required in order to significantly improve the recycling rates of core construction and demolition waste materials other than soil and stones.

This pattern of higher C&D waste arising is reflected throughout the world. The recycling of C&D waste is essential in order to reduce our dependency on finite natural resources such as geological and energy reserves. While recycling of such material has the added benefit of controlling the extent of waste disposal and reducing overall transportation costs, prevention is the most desirable approach to waste management, since the elimination of waste removes the need for subsequent handling, transportation and treatment of discarded materials.

While good progress has been made in pursuit of the Government targets for the recycling of construction and demolition waste, progress has been largely achieved through the use of C&D waste for engineering works at landfill sites and in land reclamation activities. The performance achieved in the prevention of waste on site developments as well as the preparation and use of suitable C&D waste derived aggregates in construction works has been limited to date. Many permitted facilities are conditioned to accept only soil and stones in the land reclamation activity and it is essential to ensure that other categories of C&D waste materials which are unsuitable for the purposes of land reclamation are not deposited at these sites in contravention of permit conditions. Furthermore, it should be an objective to ensure that the resource of C&D waste is employed in the most beneficial manner practicable through optimal reuse and recycling activities. Construction projects, even with good prevention practices, will generate significant quantities of waste on a once-off basis. The identification and provision of facilities for the reception of such waste araisings should be integrated into the project planning and design processes. The preparation of a Project C&D Waste Management Plan should begin in the early stages of project development to facilitate suitable arrangements for the proper and orderly management of the wastes and surpluses that are liable to arise in the course of the development works.

3.6. Waste Management Policy and Legislation

There is every need for a The Waste Management Act (WMA) and associated regulations to create a sense of responsibility for the management of waste. Under the waste management regulatory code, an authorization must be made to be required to carry out any waste related activity. The WMA should set out the following provisions:

- specific authorizations are needed for both the collection of waste and its recovery/disposal;
- imposes a general obligation on any person/contractor (other than a local authority) to obtain a waste collection permit, where they are engaged in the collection of waste on a commercial basis.
- generally those of low volume C&D which are perceived to pose a low risk to the environment, do not need a waste license and instead require a permit from a local authority or a Certificate of Registration from local authority. It is essential that the conditions attached by competent authorities to these authorisations are fully complied with by licensees and permit holders.

- the requirement for the preparation and submission of Annual Environmental Reports in respect of activities undertaken by authorised operators should be rigorously applied.
- it is imperative that all haulers engaged by site developers for the removal of waste material from site and each facility used for the consignment of C&D waste possess the requisite authorisations and are compliantly adhering to the conditions imposed on their permits and licenses.

These proposals attempt to resolve a number of issues raised by construction industry stakeholders and have the objective, where feasible, of making authorisation applications for reuse and recycling of C&D waste-related activities a more attractive proposition for developers.

Proposed Amendments Include:

- a reduction in the time allowed for local authorities to acknowledge receipt of a valid application and the period within which the application must be determined;
- a requirement for applicants to provide details of traffic management systems; and
- a proposed maximum threshold per annum in respect of a "Certificate of Registration" for the recovery of C&D waste for land reclamation.

3.7. Purpose of Guidelines

The Guidelines contained in this report are intended to:

- promote a coherent, integrated approach, whereby the management of construction and demolition waste is given due consideration throughout the duration of a project;
- outline the manner in which clients, planners, designers, contractors, sub-contractors and suppliers reduce C&D waste and improve the manner in which any waste generated is managed;
- provide designers, developers, practitioners and competent authorities with an agreed basis for determining the adequacy of Construction and Demolition Waste Management Plans; and
- provide both general and specific guidance in relation to the preparation of satisfactory Project Construction and Demolition Waste Management Plans for certain classes of projects which exceed a specified threshold size.

3.8. Methodology

Best Practice

The management of C&D waste should reflect the waste management hierarchy, with waste prevention and minimization being the first priority succeeded by reuse and recycling. During site clearance and reconstruction works, there are numerous opportunities for the beneficial reuse and recycling of the demolition materials. The subsequent use of recycled materials in reconstruction works also reduces the quantities of waste which ultimately needs to be consigned to landfill sites.

Prevention of Waste

The primary effort therefore should be to engage in waste prevention and reduce the amount of waste generated in the first place i.e. minimize the resources needed to do the job. Prevention is financially advantageous as it reduces the purchase of construction materials and obviates the need to remove wastes from site. It is important to emphasize the potential for certain purchasing procedures to contribute to a reduction in excessive material wastage on site.

Examples include:

- ensuring materials are ordered on an "as needed" basis to prevent over supply to site;
- purchasing coverings, paneling or other materials in shape, dimensions and form that minimises the creation of excessive scrap waste on site;
- ensuring correct storage and handling of construction materials to minimise generation of damaged materials/waste *e.g.*, keeping deliveries packaged until they are ready to be used;
- ensuring correct sequencing of operations; and
- assigning individual responsibility (through appropriate contractual arrangements) to sub-contractors for the purchase of raw materials and for the management of wastes arising from their activities, thereby ensuring that available resources are not expended in an extravagant manner at the expense of the main contractor.
- Renovation which retains and repairs existing structural and decorative elements, with the introduction only where necessary of new items, contributes greatly to a reduction in C&D waste arisings. In the case of protected structures, demolition is permitted only in exceptional circumstances. Designers and developers should consult the concerned Department of Environment/Local Government for advice on procedures relating to the development, demolition and architectural salvage of protected structures.

Reuse of Waste

Material that is generated should be reused on site or salvaged for subsequent reuse to the greatest extent possible and disposal should only be considered as a last resort. Initiatives should be put in place to maximize the efficient use/reuse of materials. Excavated spoil/topsoil can be carefully set aside and used as landscaping material in the completed development.

Innovative initiatives to avoid the need for disposal should be investigated:

- architectural features should ideally be reused in refurbishment of retained structures on the same site;
- the warehousing of salvaged material can facilitate its reuse on future projects; and
- “Architectural salvage sales" can allow the public to acquire material resources that have been removed from decommissioned buildings.

Recycling of Waste

There are a number of established markets available for the beneficial use of C&D waste:

Waste timber can be

- recycled as shuttering or hoarding, or sent for reprocessing as medium density fiber board;
- waste concrete can be utilized as fill material for roads or in the manufacture of new concrete when arising at source; and
- in addition, the technology for the segregation and recovery of stone, for example, is well established, readily accessible and there is a large reuse market for aggregates as fill for roads and other construction projects. Bitumen and Asphalt can also be recycled in roads projects.

3.9. Overall Management of C&D Waste

Waste minimization, reuse and recycling can best be managed operationally by nominating a "C&D Waste Manager" to take responsibility for all aspects of waste management at the different stages of the Project. This C&D Waste Manager may well be a number of different individuals over the life-cycle of the Project, but in general is

intended to be a reliable person chosen from within the Planning/Design/Contracting Team, who is technically competent and appropriately trained, who takes the responsibility to ensure that the objectives and measures within the Project Waste Management Plan are delivered and who is assigned the requisite authority to secure achievement of this purpose. Specifically, the function of the C&D Waste Manager will be to communicate effectively with colleagues in relation to the aims and objectives for waste management on the Project. The primary responsibility for delivery of the objectives of the Waste Management Plan will fall upon the C&D Waste Manager designated at the demolition /construction stage. A key objective for the C&D Waste Manager should be to maintain accurate records on the quantities of waste/surpluses arising and the real cost (including purchase) associated with waste generation and management. The preparation, application and documentation of a Project Waste Management Plan should enable contractors, designers and competent authorities - to learn from the systematic implementation and assessment of best practice, particularly through the recording of summary information on performance outcomes.

3.10. Guidelines on Content of Plans

Thresholds

It is best practice to address C&D waste management issues within the project planning, or pre-contract stage, as this allows optimum scope for waste prevention and recycling aspects in the subsequent phases of the scheme. Initial formulation of the approach to be adopted in the management of C&D waste should therefore commence at the pre-planning or conceptual stage. Indeed, this general approach is important since the optimum C&D waste management solutions may have broader impacts on the surrounding area, which may need to be addressed in a planning context - for example the alteration of the topographical profile of the development site or the creation of particular traffic movement patterns. Designers should provide the Client at an early stage with clear advice in relation to the prevailing policy, legislation and best practice in C&D waste management.

By securing agreement from the Client on the implementation of environmentally sound management of C&D waste at the outset of the project, this commitment can be imposed on all construction industry stakeholders over the entire duration of the project. Developers of projects with significant potential for the generation of C&D waste can best address the associated issues and the application of best practice through the preparation of a Project C&D Waste Management Plan. It is entirely appropriate that the essential requirement to prepare such a Plan extends equally to both public and private sector developments.

In particular, Project C&D Waste Management Plans should be prepared for projects in excess of any of the following thresholds-

- New residential development of 10 houses or more;
- New developments including institutional, educational, health and other public facilities, with an aggregate floor area in excess of 1,250 m^2;
- Demolition/renovation/refurbishment projects generating in excess of 100 m^3 of C&D waste;
- Projects producing in excess of 500m^3 of waste

4. Observations and Discussions

4.1. The Waste Management Plan

The Waste Management Plan is the cornerstone for successful C&D recycling. It is a comprehensive document that provides all of the information needed by any individual on site to understand and achieve the waste management goals for the project.

The Waste Management Plan should be started as early in the project as possible, well before groundbreaking or the beginning of demolition. This allows time for all parties to participate in developing the plan, allows contractors and subcontractors to integrate recycling into their setup and work plans, and assures that training can be provided to supervisors and workers. If there will be issues like space for recycling containers or internal handling of recyclables (*e.g.*, using hampers or self-dumping hoppers), these definitely should be addressed in the Plan well in advance of groundbreaking.

The Waste Management Plan is also a living document, used as a day-to-day reference just like blueprints and specifications. This fact cannot be overemphasized. Handling procedures or markets may change during the course of a job; these changes should be noted in modifications to the plan. As waste materials move from the site you will gather information on waste and recycling tonnages and costs.

These should be matched against initial projections, variances should be analyzed, and a running recycling rate should be calculated. This last is critical. If you're looking for certification, you need to track progress toward this goal (and take steps if it looks like you're running low). And you should publicize the recycling rate to laborers and trades; it's a good way to help boost morale, and keep workers striving to achieve your recycling goals.

The Waste Management Plan should include the following information, laid out in clearly identified sections.

Section 1: CONTACT INFORMATION

Contacts for all persons with responsibility for waste management, including, at a minimum, architect, general contractor (project manager and site supervisor), and waste management specialist (if one is engaged for the project). Also, in some cases, owner's representative, waste hauler(s), and key subcontractors (*e.g.*, demolition subcontractor).

Section 2: GOALS

This is a critical - if brief - section and should be placed front and center. It states in concise but explicit terms the waste management goals for the project. For example, "This project will recycle, reuse, or salvage at least 75% of the waste generated on site". Important sub-goals should also be stated clearly, such as, "Documentation of all wastes leaving the site shall be maintained by the site supervisor, including wastes removed from the site by subcontractors." The Goals section makes clear, to all who read it, the importance of waste reduction and recycling, specific goals, and the most important activities and responsibilities that support achievement of these goals.

Section 3: TRAINING

It's important that all contractor and subcontractor employees receive training in jobsite recycling procedures. They are the individuals who will place wastes in either the right (that is, the recycling) or the wrong (the trash) container. The training section of the Waste Management Plan lays out the procedures to assure that all workers and supervisors receive training, and outlines the contents of training. Typically, training will be keyed to three events:

Section 4: COMMUNICATIONS AND TROUBLESHOOTING

It's important that all contractor and subcontractor employees receive training in jobsite recycling procedures. They are the individuals who will place wastes in either the right (that is, the recycling) or the wrong (the trash) container. The training section of the Waste Management Plan lays out the procedures to assure that all workers and supervisors receive training, and outlines the contents of training. Typically, training will be keyed to three events:

Crew shifts.

When the job moves to a new phase with a new set of subcontractors on site, training should be provided to subcontractor supervisors and personnel. Whenever possible, training should be provided directly to all laborers. If not, the responsibility of subcontractor supervisors to provide training should be made clear, and they should be required to document that training has been provided to their crews.

New subcontractor on site.

Every time a new subcontractor comes on site, the subcontractor's supervisors and key staff should be trained in jobsite recycling procedures, including communications, troubleshooting, and penalties.

Weekly meetings.

Weekly construction project meetings should include a recycling "freshener", including updates on recycling rates, notes of any changes in recycling procedures, troubleshooting, and time for questions and answers. Communications includes:

Meetings:

At what meetings will waste management and recycling be discussed? What is their schedule? Who will attend? What information will be discussed? Typically recycling is addressed in most pre-construction meetings and in meetings at subcontractor changeover or the introduction of a new subcontractor. Some contractors, owners, or architects ask for a recycling update at all weekly meetings. In general, recycling meetings can be keyed to the complexity and phase of the job. A complex job (or any job in a complex or rapidly changing phase) may require frequent attention to recycling in jobsite meetings. A smaller or simpler job, or any job in the middle of a long, stable phase of construction, may require only infrequent discussion of recycling.

Questions and Decision-making.

The communications section also specifies who is responsible for decisions related to recycling, the chain of command for such decisions, and who should be contacted with recycling questions as they arise.

Troubleshooting.

Like any process during construction, recycling can encounter problems - a container in the wrong location, a missed pickup, an engine block in the wood dumpster. The troubleshooting section specifies the steps to be taken and individuals to be contacted in the event of such situations. Most important is that persons using the plan - the site supervisor and key subcontractor personnel - know what steps to take (generally, "STOP") and whom to call if an unexpected problem comes up.

Section 5: REPORTING AND RECORDKEEPING

Section 6: WASTE IDENTIFICATION, MANAGEMENT, AND MARKETING

It's impossible to prove the value of waste reduction and recycling - either financially or environmentally - without good documentation. This means
(1) a comprehensive and verifiable record (by weight) of all materials that leave the site, either as trash or recyclables;
(2) documentation of where these materials have been sent; and
(3) information on the costs of hauling and disposing of all wastes and recyclables.
The Waste Management Plan needs to spell out procedures to collect and manage this information. Four items are critical.
1. Weight slips:
Obtained from haulers or end markets, for each container that leaves the site.
2. Documentation of recycling (or disposal):
Obtained from all end markets (in many cases, weight slips are adequate to provide this documentation).
3. Transportation invoices:
Obtained from haulers or markets (in cases where transportation is provided by the market).
4. Recycling/disposal invoices/receipts:

Obtained from end markets.

The Waste Management Plan should specify who is responsible for acquiring and storing this information, where information will be stored (*e.g.*, on site, by the architect, by the contractor), who is responsible for using the information to produce operating and financial reports (including documentation), and how information will be transferred from one party to another. A few waste streams need special consideration.

The Waste Management Plan should include instruction on how documentation of these wastes should be handled:

- Furniture and furnishings: These typically aren't recorded by weight. Conversion from a piece count to a weight estimate is required.
- Equipment that is resold: Items that are sold or donated to secondary markets are rarely weighed. These may include, for example, chillers, air conditioning or ventilation units, kitchen equipment or industrial machinery. Again, a reasonable weight estimate is required.
- Items recycled by subcontractors: Many scrap metals have significant market value, and subcontractors are used to carrying them off on their own. Contractors who may do this include plumbers, electricians, HVAC contractors, and roofers. It's not necessary to interfere with this practice; simply require that subcontractors report on the materials they take off site. (Unless there's a lot of tonnage involved, you don't have to require weight slips; subcontractors' estimates are sufficient.) This section is the core of the Waste Management Plan. Material by material, it catalogues what will be generated as waste from project start to finish, how each material will be handled (source-separated recycling, commingled recycling, or disposal), and where each material will be marketed (or disposed of).

The section can be less or more comprehensive. A simple project that generates only a few waste materials may need only a few lines of information. A 400,000 square foot renovation may have 20 pages of detail. The aim is to assure that anyone who comes on site and generates a waste can find that waste in the plan and find out what to do with it.

For each waste, the management plan should include the following information:

Material:

Described in enough detail so that each waste material can be identified without ambiguity. It's critical that the roster of materials is comprehensive; if you omit a significant waste stream, it may cause confusion on the job site, and may seriously affect your ultimate recycling rate and waste management costs. It's most important to list separately all materials that will be handled differently or will be sent to different markets. For example, if all metals will be placed in a single container and marketed together, it may be sufficient to list "Metals" in the plan, with the accompanying information that any and all metals are to be treated in the same way. But if, for example, ferrous and nonferrous metals are to be separated and marketed independently, the waste management plan should specify this separation and independent handling procedures.

Procedure:

How will materials be handled? Many jobs may have only three categories:
(1) source-separated recycling; (2) commingled recycling; and (3) disposal as waste.
Other categories (not necessarily a comprehensive list) include recovery as salvage (*e.g.*, furniture and furnishings), on-site or off-site grinding (*e.g.*, land clearing debris) or crushing (*e.g.*, concrete), or on-site stockpiling (*e.g.*, soils).

Market:

This field lists the specific organization that will receive each recycled material. No waste is recycled until it's marketed, and no material should be targeted for recycling until

(a) a market has been identified,
(b) you've confirmed that the market will accept the material, and
(c) confirmed that you can meet the market specification for the material.
Don't fill in the "Market" until you've made these checks.

Estimated Quantity:

As the plan is developed, quantities of each waste should be estimated and recorded as an aid in planning container number and size, estimating the project recycling rate, and estimating waste management costs.

Section 7: RECYCLING RATE ESTIMATE

This calculation encapsulates your estimates of the total quantities of materials recycled and the total disposed. The recycling rate is simply the total quantity recycled divided by the sum of the quantity recycled plus the quantity thrown away. When the plan is first developed, this will be an estimate, used to forecast an ultimate recycling rate and to assess changes in waste management procedures that will affect this rate. As the project moves along, it becomes a living record used to track progress toward recycling goals. If the rate runs below projections, use the results documented in the plan to find out why, and (particularly if you need a certification) use the plan to evaluate alternatives to increase the rate.

Section 8: COST/BENEFIT ASSESSMENT

As noted elsewhere, it's a rare project where recycling is undertaken for strictly environmental reasons. Recycling needs to be justified financially, as well as environmentally. This section of the plan - typically a worksheet - is where you make this justification. As you develop the plan and identify markets, you'll be able to estimate

recycling costs, material by material, for transportation (including containers) and management. You should simultaneously estimate the cost to dispose of materials as wastes (transportation plus tipping fee), so that you can compare the cost of recycling versus disposal. Once again, these are estimates that should be updated with real information as the project moves ahead, so you can compare actual against budgeted waste management costs, and keep a running track of the savings for recycling compared to disposal. This is another good morale builder for workers on site, as well as a nice Good News item for contractor management, architect, and owner.

4.2. Things to do before Demolition Begins

Demolition and construction site preparation, are critical elements of any successful project. Unexpected delays and costs associated with encountering unexpected factors can be critical. Uncovering hazardous materials or utility obstructions can risk project timelines and overall success. Surprises can also mean the difference between project profit and loss.

With any demolition project, there are many issues to resolve before demolition can actually begin. Robinette, with more than thirty years of demolition management, understands what needs to be done and does it. We will work with your project team to pre-plan actions necessary to eliminate problems.

PRE-DEMOLITION ACTIVITIES

Complete Site Check for Hazardous Materials

Obtain proper permits and approvals Materials found after demolition begins can slow or completely halt demolition work while removal takes place. Hazards may include; lead based paint, asbestos, PCB light ballasts, mercury in switch gears and thermostats, oil tanks, contaminated soils, *etc*. Offering a single source solution Robinette has an environmental division that can address these issues prior to the onset of demolition activities.

Project permits can be complex including local, state and EPA oversight. General building permits may allow for demolition without additional demolition permits. EPA and local Government permits should have a mandatory 10-day notification period. You cannot start a total building/structural removal job without waiting 10 days from initial notification! The contractor should have a strong working relationship with these authorities and should be able to obtain permits with a minimum of delay.

Things to do before Demolition Begin

Explore asset and resource recovery of items normally left for demolition disposal. Prepare a clear and complete scope of work and discuss it in detail with the demolition contractor prior to starting work. Ensure that you receive guaranteed legal disposal of all demolition materials. Mark, cut and cap all utilities and communication lines to demolition area this action can result in double savings by reducing the cost of demolition service and bringing in cash for salvaged items. There are many companies that will pay you to remove your unwanted items but who don’t do demolition work. This is an excellent way to productively fill a ten-day waiting period in total or structural demolition. Coordination and communication between your demolition contractor and with his on-site supervisor is critical. We recommend that a final review of the project plan be completed on the first day of the job. Demand that your demolition contractor work in coordination with local landfills or recycling centers to dispose of onsite materials properly. Verify that your contractor complies with mandated resource recovery provisions for disposed project materials.

Failure to adequately prepare at this stage can slow or halt demolition and can result in damage to existing property and service disruptions. It is critical to notify all utility companies. Our field personnel work closely with on-site management to insure that existing utilities remain operational and free of damage.

Insist that the demolition contractor you hire has a comprehensive safety program in place and uses it!

Many contractors have beautiful manuals but provide little or no training to their employees. While the services of a safe company can be slightly more expensive on the surface, the potential costs to you from even one incident, or work stoppage far outweighs this apparent expense.

Project coordination, communication, and planning will ensure success. The contractor should have the experience, resources and partnerships in place to provide an effective demolition solution. Offering the close single source coordination of four operating divisions, he should allow you to hold one organization responsible. Our commitment to success eliminates the finger pointing so often encountered with competitors.

Based on the study made as part of this project and the discussions submitted in this project, a Template for waste management plan is formulated in APPENDIX-A.

5. Summary and Conclusions

Practical Application and use of the Project

There is no defined manual framed by regulatory authorities for management of C & D Waste. This work is expected to be a pilot study towards preparation of such a manual. It also suggests improved methods of recycling/reuse/disposal of demolition waste and modifications required in regulations in vogue for demolition waste disposal.

1. Construction and Demolition Waste (C&D) is characterised by large variation range of composition as well as physical properties.
2. Main field of application of C&D: Unbounded systems like fills and embankments.
3. Reuse of concrete C&D, as secondary aggregates requires incorporation of liberation techniques into the processing.
4. Advanced liberation techniques like the treatment by high-performance sonic impulses results in clear quality improvement.
5. Reuse of masonry C&D in construction requires technologies, which improve quality and homogeneity.
6. Experiments show feasibility of masonry C&D as raw material for manufacturing of lightweight granulates.
7. Properties of the lightweight granulates are rather constant or at least equal
8. Waste wood can be used for shuttering.
9. For effective use of C&D, A waste management Plan is essential and it should be insisted by local governing bodies for better future.

It is expected that if the local governing development authorities make the submission and implementation of the C & D Waste management plan formulated in APPENDIX-A, then it would go a long way in the reduction of Environmental Pollution due to Construction and Demolition waste.

Future Scope of Research

Methods for Examination of product quality and uniformity have to be developed.

Comparative studies about the energy demand can be made for different alternatives of waste utilisation.

APPENDIX – A

CONSTRUCTION & DEMOLITION WASTE MANAGEMENT PLAN – A SAMPLE TEMPLATE

Basic Information
Project Name:
Address:
Name of the Contractor:
Address:
Phone/Mobile No.:
E-mail:
Description of Project:
The project consists of the _____ (development/redevelopment etc.) of a _____ (housing/commercial/institutional/roads/water/waste water etc) scheme on a _____ (Greenfield/infill/redevelopment/brown field etc) site. The project is situated at _____ in the administrative area of _____. The site of the works is located approximately_____ (meters/kilometers) from _____ (town/village/main road etc.) and access will be via the _____ (local/regional/national) road. The work will generally consist of the demolition of _____ (m^3) of _____ and the construction of _____ (no.of m2) of _____ (houses/offices/institutional/roads etc).
In the course of the project, it is estimated that the following quantities of C&D wastes/material surpluses will arise:

Table A1. Estimated C&D Waste Arising on Site

C&D WASTE MATERIAL	QUANTITY (TONNES)
Clay and stones	
Concrete	
Masonry	
Wood	
Packaging	
Hazardous Materials	
Other waste Materials	
Total Arising	

Proposals for Minimisation, Reuse and Recycling of C&D Waste
C&D waste will arise on the project mainly from _____ (excavation/demolition) and _____ (unavoidable construction waste/material surpluses/damaged materials). The _____ (purchasing Manager etc.) shall ensure that materials are ordered so that the quantity delivered, the timing of the delivery and the storage is not conducive in the creation of unnecessary waste.
Excavated clay will be carefully stored in segregated piles on site for taking a decision on subsequent reuse/removed from site for direct beneficial use elsewhere). Concrete waste will be _____(source segregated/collected in receptacles with mixed C&D waste materials, for subsequent separation and recovery at a remote facility).

Masonry and wood will be _____ (source segregated/collected in receptacles with mixed C&D waste materials, for subsequent separation and recovery at a remote facility). Packaging will be _____(source segregated for recycling or return to suppliers). Hazardous wastes will be _____(identified, removed and kept separate from other C&D waste materials in order to avoid further contamination). Other C&D waste materials will be _____(collected in receptacles with mixed C&D waste materials, for subsequent separation and disposal at a remote facility).
Excavation clay, C&D waste and derived aggregates are considered suitable for certain on-site construction applications. It is proposed that the following quantities, corresponding to all C&D waste arisings from the project, will be used within the works;
It is anticipated that waste materials _____(will/will not) have to be moved off site. It _____(is/is not) the intention to engage specialist waste service contractors, who will possess the requisite authorisations, for the collection and movement of waste off-site, and to bring the material to a facility which currently (holds/does not hold) a _____(Waste License/Waste permit/Certificate of Registration). Accordingly, it will be necessary to arrange the following waste authorisations specifically for the project.

Table A2. Proposals for Beneficial Use/Management of C&D Material Surpluses/Deficits and Waste Arising on and off the Project

C&D Waste Type Proposed Use	Clay and stones (Tonnes)	Concrete (Tonnes)	Masonry (Tonnes)	Totals (Tonnes)
Earthworks				
General Fill/Hardcore				
Pipe Bedding				
Selected Trench Backfill				
Fill to structures				
Beneath Paths Structure				
Beneath Road Structure				
Offsite Use				
TOTAL				

Table A3. Specific Waste Authorizations necessary for the Scheme

Authorization Type	Specific Need for project (Yes/No)
Waste License	
Waste Permit	
Waste Collection Permit	
Tran frontier Shipment Notification	
Movement of Hazardous waste form	

Demolition Procedures
The demolition works shall be undertaken in a manner which maximises the potential for recycling, including source segregating waste where appropriate. Activities shall be carried out in the following sequence:

Table A4. Sequence of Demolition Activity

Demolition Activity Sequence	General Description
Disconnection of services	Shutoff of Electricity, Gas, water etc
Inventory of Hazardous wastes	e.g. Asbestos etc.
Removal of Abandoned Furniture/Equipment	e.g. Furniture/white Goods
Removal of Asbestos/Hazardous Materials	e.g. Application of H&S Procedures
Removal of Fixtures	e.g. Fitted Presses etc.
Removal of Timber	e.g. Removal of Floors, Trusses, Rafters
Demolition of structure shell	Manual or Mechanical Demolition
Source segregation of Material Fractions	Separation into Designated Material Fractions
Transport of Material from site to Treatment Facilities	e.g. C&D waste Recycling Facility
Transport of Material from site to controlled disposal sites	e.g. Inertised Hazardous Landfill site
Site preparation/Restoration	e.g. Hard standing, Landscaping

Assignment of Responsibilities

A _____ (site engineer/Manager/Assistant Manager etc.) shall be designated as the C&D Waste Manager and have overall responsibility for the implementation of project C&D Waste Management Plan. The C&D Waste Manager will be assigned the authority to instruct all site personnel to comply with the specific, provisions of the plan. At the operational level, a _____(Ganger etc.) from the main contractor and _____(appropriate personnel) from each sub-contractor on the site shall be assigned the direct responsibility to ensure that the discrete operations stated in the project C&D Waste Management plan are performed on an on-going basis.

Training

Copies of the Project C&D Waste Management plan will be made available to all relevant personnel on site. All site personnel and sub-contractors will be instructed about the objectives of the project C&D Waste Management plan and informed of the responsibilities which fall upon them as a consequence of its provisions. Where source segregation, selective demolition and material reuse techniques apply, each member of staff will be given instructions on how to comply with the Project C&D Waste Management plan. Posters will be designed to reinforce the key messages within the project C&D Waste Management plan and will be displayed prominently for the benefit of site staff.

Waste Auditing

The C&D Waste Manager shall arrange for full details of all arisings, movements and treatment of construction and demolition waste discards to be recorded during the construction stage of the project. Each consignment of C&D Waste taken from site will be subject to documentation, which will conform to Table A4 and ensure full traceability of the material to its final destination. Details of the inputs of materials to the construction site and the outputs of wastage arisings from the project will be investigated and recorded in a Waste Audit, which will identify the amount, nature and composition of the waste generated on the site. The Waste Audit will examine the way in which the waste is produced and will provide a commentary highlighting how management policies and practices may inherently contribute to the production of construction and demolition waste. The measured waste quantities will be used to quantify the costs of management and disposal in a Waste Audit Report, which will also record lessons learned from these experiences which can be applied to future projects. The total cost of C&D waste

management will be measured and will take account of the purchase cost of materials (including imported soil), handling costs, storage costs, transportation costs, revenue from sales, disposal costs etc. Costs will be calculated for management of a range of C&D waste materials, using format shown in Table A5.

Table A5. Details to be included within Transportation Dockets

Detail	Particulars
Name of project of origin	e.g. New Harbour, Motorway
Material being Transported	e.g. Soil, Demolition Concrete, Crushed Asphalt etc.
Quantity of material	e.g.20.50 Tonnes
Date of Material Movement	e.g.01/01/2007
Name of carrier	e.g. Authorized Carriers Ltd.
Destination of Material	e.g. Newtown Residential and Office Development
Proposed Use	e.g. Use as Hardcore in Dwelling Floors

Table A6. Standard Record Form for Costs of C&D Waste Management (sample related to Soil-separate record forms should be compiled in respect of each waste material)

Material	Estimated Quantities & costs (Tonnes & Rs.)
SOIL	
Quantity of waste soil (Tonnes)	
Purchase cost i.e. Import costs (Rs.)	
Materials Handling costs (Rs.)	
Material Storage costs (Rs.)	
Material Transportation costs (Rs.)	
Revenue from Material sales (Rs.)	
Material Disposal costs (Rs.)	
Material Treatment Costs (Rs.)	
Total Waste Soil Management Costs (Rs.)	
Unit Waste Soil Management Costs (Rs.)	

Final details of the quantities and types of C&D Waste arisings from the project will be forwarded to _____(Local governing authority *etc*.,)

Figures

Figure 1. Wood Separated from Demolition Waste

Figure 2. Construction and Demolition Waste Disposal by Land Filling

Figure 3(a). Construction and Demolition Waste – Source Separated

Figure 3(b). Construction and Demolition Waste – Source Separated

References

[1] A. Mueller, "Determination of the composition of C&D recycled aggregates", Bauhaus Universität Weimar, Chair of Mineral Processing of Building Materials and Reuse Couydrastr. 7, D-99421, Weimar, Germany E-mail: anette-m.mueller@bauing.uni-weimar.de1.
[2] http://www.environmentdesignguide.com.au/pages//content/cas--case-studies/cas-50- australian-ethical-investment-headquarters-6-star-green-star-office-refurbishment-canberra.php.
[3] www.tjcog.dst.nc.us/cdwaste.htm#wastespec Source/author: Triangle J Council of Governments (NC).
[4] www.ciwmb.ca.gov/ConDemo/Specs/ Source/author: California Integrated Waste Management Board.www.wbdg.org/design/index.php?cn=4.3.4&cx=0 Source/Author: Whole Building Design Guide.
[5] www.epa.gov/rtp/new-bldg/environmental/s_01690.htm Source/author: U.S. Environmental Protection Agency.
[6] www.stopwaste.org/fsbuild.html Source/author: Alameda County Waste Management Authority.

Authors

Markandeya Raju Ponnada was born on 25-08-1979 at TUNI of Andhra Pradesh in INDIA. He did his B.Tech in Civil Engineering from Nagarjuna University during 1997-2001 and M.E in Structures from Andhra University during 2001-2003. He was awarded Ph.D by JNTU Hyderabad for his work under the Guidance of Dr.V.Ravindra, Professor of Civil Engineering, JNTU Kakinada in the area of Prestressed steel beams in 2009. He has more than 34 publications in various National and International Journals and Conferences. He has more than 14 years of teaching experience during which he taught subjects like Finite Element Method, Applied Mechanics, Design of Steel Structures, Industrial Structures, Highway Engineering and Prestressed Concrete to Undergraduate and Post graduate Students. He is presently Working as an Associate Professor and Head of the Department of Civil Engineering, MVGR College of Engineering, Vizianagaram, Andhra Pradesh, INDIA. He has considerable expertise in STAAD.Pro and his areas of interest are Properties of Concrete, Analysis and Design of Pre-stressed Structures and Computer Applications in Structural Engineering. He has guided more than 25 B.Tech projects, 6 M.Tech dissertations and is presently guiding a one student for his Ph.D. He has vast experience in various consultancy assignments particularly in the area of Multi-storey buildings and Composite bridges.

Mrs. Kameswari P completed her graduation in Applied Chemistry from Andhra University and Post-graduation in Environmental Science from Kakatiya University. She has a couple of years of experience as a teacher in reputed High School.