

Reuse and Recycling of Construction and Demolition Waste

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1. Introduction

1.1 Background

Since July 2003, Holcim Ltd. (one of the world's leading suppliers of cement, aggregates, ready-mix concrete and asphalt) and the GTZ have established a successful cooperation in the framework of a Public Private Partnership (PPP), supported by the German Ministry for Economic Cooperation and Development (BMZ), and coordinated by the University of Applied Sciences Northwestern Switzerland, with the objective to improve waste management in selected developing countries and increase of resource efficiency in the cement and construction industry.

In the first Phase (PPP1) from 2003 to 2006, GTZ-Holcim were concerned with drawing up internationally acceptable guidelines for the co-processing of waste materials in cement production, which means the substitution of primary fuel (coal, oil) and raw material by high-energy municipal and industrial waste. These guidelines were published in July 2006.

Holcim and GTZ then extended their partnership to 2008 (PPP2) in order to advance the implementation of the guidelines.

The main areas of intervention for the present PPP2 are

- Promotion of co-processing as an integrated part of solid waste management
- Development of concepts showing the potential & significance of (a) reuse of construction and demolition waste, (b) alternative binders and (c) use of cement / concrete in low cost housing for its contribution to sustainable development
- Promoting the dialogue between public authorities and private enterprises,
- Raising awareness and building technical know-how in participating countries.

One of the main components of PPP2, namely the reuse of construction and demolition waste, is the focus of this Report.

1.2 Brief description of the problem to be looked at

Beside municipal and industrial waste, a third waste stream is becoming more and more important in the context of integrated waste and resource management: **construction and demolition waste (CDW)**. The encountered problems stem from the steady increase of construction activities, which leads to increasing amounts of construction waste. In addition, rising conventional production of construction materials increases depletion of raw materials and environmental damage from material production. Since construction often goes along with demolition, and since lifetime spans of buildings in developing countries are comparatively short (e.g. China), waste from demolition also increases. Worldwide demand for construction aggregates is projected to rise close to five percent annually, to over 21 billion tonnes in 2007. Countries like China, India, Indonesia, Thailand, Brazil, Mexico or Turkey will record some of the strongest increases. However, construction materials, such as cement, aggregates or reinforcements, such as steel, have in common that their production is based on the extensive exploitation of natural resources: For example, the high steel demand from the construction sector is one of the major reasons for the steady increase of the world wide exploitation of ore for steel production. Prices for reinforcing steel almost doubled in the past two years. For the production of one tonne of steel, 25 tonnes of raw material have to be exploited resulting in significant negative impacts on natural habitats.

At present part of the construction waste is used as filling and base material in road and building construction, and in most of the cases without following any standards or regulations. The other part of the waste is co-disposed at sanitary / engineered landfills

originally designed for municipal waste, or are dumped uncontrolled along roadsides, or at open spaces. Unsound and illegal disposal practices of CDW caused and still cause contamination of soil, water and air from toxic substances in the waste, such as PCB, asbestos, heavy metals, construction chemicals, etc. However, the real impact of this disposal is hardly known and very little attention is given by national or local authorities to control and regulate this disposal practice.

Although a much higher portion of construction materials could be replaced by re-processed construction waste material, these options are not yet applied in most developing countries, due to lack of knowledge and insufficient regulatory frameworks. In many developing countries, integrated concepts for the reuse of construction and demolition waste (CDW) are missing, resulting in a piling up of these wastes in streets and open places or in the dumping of these wastes at the few sanitary landfills, misusing the very limited available disposal volume.

The purpose of this study is, therefore, to provide a general introduction into the subject of construction and demolition waste and its significance / non-significance in waste concepts in selected developing countries, explaining the disadvantages and risks associated with the uncontrolled re-use of construction waste and the wild dumping at open spaces, and, with the help of case studies, summarizing the technical, financial, social and legal barriers which have been identified as the main reasons for hampering a wider systematic use of CDW in developing countries.

1.3 Methodology of the study

The methodology adopted for these investigations was to review literature and documents from various sources, above all from the web. Only very little information was available as hard copies, while some was obtained through correspondence with experts in different parts of the world.

The search for information on the web is a virtually endless operation, which produces new and useful information with every session, but primarily from industrialized countries. Useful information on the management of construction and demolition waste (CDW) in developing and emerging countries is extremely limited. Even discussions and correspondence with experts showed that very little information is available on CDW in the developing world, even on the small and scattered activities, which are known to take place. Nevertheless, the three case studies presented in Section 5 do give some idea of the possibilities and constraints of introducing CDW management systems in these countries.

The sections 3.13 on the "Significance of CDW in developing countries", 4.2 "Present trends in CDW management in industrialized countries", 4.6 "Possible applications in developing countries", and 6. "Recommendations for the integration of the subject within the structure of PPP2", result from a subjective analysis and assessment of the information gathered and are open to discussion, as the issues are complex and different investigators will come to different conclusions. It is, however, hoped that this will provide a useful basis for further discussions on the subject and ultimately lead to a sound concept for further action within the PPP2 Programme.

The investigations were conducted by Dipl.-Ing. Architect Kiran Mukerji (Architectural Consultant) and Dipl.-Ing. Architect Christel Sumerauer (GTZ-OE 3140 Bauwesen) between October 2006 and January 2007. Slight revisions and additions were made in October 2007.

2. Overview of Construction and Demolition Waste (CDW)

2.1 Description of CDW

Construction and demolition waste, commonly abbreviated as CDW, can constitute up to 50% of all solid waste generated in a country. It originates from various events, both natural and man-made, and is of a very diverse nature. It can be of mineral or organic origin, inert or hazardous, homogeneous or mixed.

Construction waste occurs on account of building constructions and building renovations, and results from surplus material (excess supplies), damaged or broken material (which is thus unusable), cut-off pieces, processing waste (eg sawdust, metal spoils), dismantled shuttering, used-up tools and accessories, packaging and garbage generated by the people on the construction sites.

Demolition waste can result from natural disasters (earthquakes, hurricanes, tsunamis); wars, civil conflict, vandalism and other man-made events; accidents (impact, explosions, fires, collapse of weak structures); or from the demolition of built structures (including roads, bridges, etc.) for renovation or complete removal or renewal. Every part of the structure, from the roof down to the foundations, and even the surrounding terrain, can be a constituent of demolition waste.

All this CDW has to be removed from the place of origin – in most cases it is considered unusable and is discarded. This has been common practice both in industrialized as well as developing countries for the most part of the 20th century, and in most countries until today.

2.2 Problems of CDW disposal

Since the 1980s, experts in industrialized countries have become increasingly aware of the problems associated with the disposal of CDW. The main problems, which apply to both industrialized and developing countries, can be summarized as follows:

- According to surveys in various parts of the world, CDW constitutes up to 50% of all municipal solid waste (MSW). This is an enormous quantity that has to be managed in some way or other.
- In countries and regions in which CDW reuse or recycling is not practised, this waste is usually deposited in landfills, while only a small percentage is incinerated. As these landfills keep expanding, the land available for productive uses is constantly diminishing, especially in urban areas.
- The environmental problems associated with landfills are immense. Apart from the aesthetic degradation of the area and the destruction of the natural topography and vegetation, landfills can be full of hazardous and toxic substances, which contaminate the ground, the groundwater and the surroundings. Especially when CDW is mixed with MSW, the landfills can also attract undesirable animals and insects that can cause serious health problems to the surrounding population.
- When distances to licensed sanitary landfills are too large, much of the CDW is dumped illegally (also called fly-tipping) at roadsides, in depressions, in rivers, etc. causing serious environmental damage and great costs to remove the waste from there. These costs have to be shouldered by the local authorities and private landowners. The secondary costs include medical treatment costs where health problems arise, lost revenue of legitimate waste management businesses, legal costs of prosecuting fly-tippers, decreasing property values of the areas affected, and the like.

- Disposing of CDW and at the same time producing new materials and components for the construction industry contributes to the depletion of natural resources and increases environmental damage by generating noise, dust, air pollution, higher energy consumption, CO₂ emissions and other negative impacts.

In many developing countries the problems associated with CDW disposal are even more serious, because

- there is far less awareness about the problems and their effects than in industrialized countries,
- the lack of legislation and enforcement mechanisms encourage fly-tipping,
- the lack of funds and the lack of technical equipment are largely the reason why illegal dumps are not cleared,
- scavengers who collect resalable material from these dumps have often suffered serious injuries, or have even been buried under collapsing landfills.

2.3 Avoiding CDW disposal

In view of the problems of CDW disposal described above, there is an urgent need to avoid CDW disposal, or at least reduce it to the lowest possible level, and instead to reuse and recycle as much as possible.

The advantages are:

- Up to 50% of MSW landfills is reduced, so that the landfills can be used up to twice as long if no CDW were deposited there.
- Less space being required for landfills provides more space for productive uses.
- The negative environmental impact of waste disposal is greatly reduced by inflicting less harm on the landscape, flora and fauna, and thus retaining the aesthetical appeal of the location; by avoiding harmful emissions into the air or the leaching of toxic substances into the groundwater, and thus contributing to a healthier environment.
- Illegal fly-tipping is reduced to a minimum, minimising the resulting environmental damage and high costs it causes.
- Less natural resources are depleted for the production of new building materials and components, thus avoiding further environmental damage.

2.4 Recycling or reuse of CDW

The increasing problems associated with CDW have led to a complete rethinking in some of the industrialized countries. The current tendency in several industrialized countries is to view wastes as resources or by-products, which become new products that can be used for a variety of useful purposes.

Recycling and reusing old building materials is not new – just a few examples: In ancient Rome and Greece, stone columns and capitals were frequently dismantled from old buildings and reused in new ones. Many of the old mosques and palaces in Cairo were erected with stone blocks that had been removed from the outer surface of the great Pyramids of Gizeh.

Around the world, earth houses have repeatedly been demolished and rebuilt using the same earth and wooden beams. After World War II, most reconstruction work in Europe was carried out with demolition waste. However, with the rapid increase of built up space and the increasingly complicated constructions, the recovery and reuse of material from dismantled structures was not given importance anymore, and almost all the CDW was dumped (legally or illegally) on landfill sites, very often mixed with municipal solid waste (MSW).

The increasing awareness of the problems of disposal of CDW, as described above, ultimately gave rise to the development of new concepts for dealing with CDW. The concepts have different names, such as

- Waste Management Hierarchy, with the highest to lowest priority being: Avoidance, Reduction, Reuse, Recycling, Recovery, Disposal.
- 3 Rs: Reduce, Reuse, Recycle. There has recently been a proposal to add a 4th R: "Recover" (Ref. 7.1).
- Integrated Solid Waste Management (ISWM), which integrates the three dimensions of urban waste management and sanitation, namely, (1) the STAKEHOLDERS, (2) the waste ELEMENTS and (3) the sustainability ASPECTS of development processes.
- Waste Reduction and Purchasing Policy (WRAPP), which propogates the WRAPP Loop: Buy – Use – Recover – Remake.

The common aim of all such concepts is to view waste as a valuable resource, and consequently to introduce mechanisms to maximise the reuse of materials that were previously rejected and discarded. While the previous Life Cycle Analysis (LCA) was expressed as "cradle-to-grave" (representing a one-way flow of materials from extraction, manufacture and use to landfill disposal), the concept is moving towards "cradle-to-cradle" (indicating a circular flow of materials from "birth-to-rebirth").

2.5 Types of CDW and their uses

The first prerequisite for the reuse and recycling of CDW is to separate the fractions as best possible. In order to do so, it is important to categorize the various components of CDW. Each country deals with waste differently and consequently each one follows a different list of CDW fractions, depending on its national building codes and building practice.

In order to achieve more uniformity amongst its member countries, the European Union has prepared the European Waste Catalogue (EWC). It classifies waste materials and categorises them according to what they are and how they were produced. The first EWC was published in 1994 and was slightly revised in 2002.

The EWC 2002 is divided into twenty main chapters, most of which are industry-based, but some of which are based on materials and processes. The official document has 32 pages and each chapter has a two-digit code between 01 and 20 (CDW has the code 17). Each individual waste has a six-figure code, the first two of which being those of the chapter (eg 17 for CDW). Hazardous wastes are identified by an asterisk (*) at the end of the code. The list only names the categories of materials and does not differentiate between different types of concrete, bricks, timber, etc., although each type has a different potential for reuse and recycling.

For the purpose of this report, it seems appropriate to present an overview of some common CDW materials and the possibilities of putting them back to use in some form or other (Table 1.1). The list is by far not complete and can be extended after more detailed investigations.

Hazardous materials are not mentioned – they have to be treated and disposed of with special care.

2.6 Prerequisites for reusing or recycling CDW

Efforts to promote the reuse and recycling of CDW have taken a fairly long time to develop, as it entails a change of perception amongst all parties involved. CDW has long been considered waste material that is of no further use and therefore only fit to throw away.

- a. Therefore, the first prerequisite is to accept that CDW is a valuable resource, which can be reused as it is, or reprocessed to make new products. In most places, this means a radical change of perception, which is not readily accepted. Therefore a great deal of research, pilot projects, information campaigns and other activities are needed to popularize the concept.
- b. It has to be more profitable to reuse or recycle CDW than to dispose of it (“Turn Trash into Cash”). An effective mechanism for this is to impose high taxes on disposal in landfills and heavy fines on fly-tipping. Subsidies and tax exemptions for recycling are a further means to encourage reuse and recycling.
- c. If CDW is to be reused or recycled, there must be a market for such materials and products. In other words, the price of recycled CDW must be low enough to attract buyers and it must be profitable for the manufacturers to recycle CDW.
- d. The price alone is not the only factor – the recycled products must be of equal or better quality than new products. If the same quality as new products cannot be achieved, the building codes, standards and specifications need to be adjusted to allow for lower quality products to be used in lower value applications. A system of quality certification will help to enhance consumer confidence. Recycled CDW must be absolutely free from contamination with hazardous materials.
- e. For CDW to be reused or recycled, the demolition of buildings has to be carefully planned, properly organised and strictly controlled. This deconstruction with well trained and motivated manpower must take place in the reverse order of construction.
- f. It is of utmost importance that each CDW fraction is separated at the source, stored and transported separately, and protected from contamination or mixture with other waste.
- g. An important incentive for reusing and recycling CDW is to award best practice certifications, similar to the ISO 14001 certification for environmental management systems.

Material	Process	End use
Plain concrete (DW)	crushed	Aggregate
Fresh concrete (CW)	Washed to remove cement and recover aggregate	Aggregate
Reinforced concrete	1. Crushed and steel bars removed 2. Steel recycled	1. Crushed concrete reused as aggregate 2. New reinforcement steel
Clay bricks and roof tiles	1. Cleaned 2. Crushed 3. Pulverised	1. Reused for masonry 2. Aggregate 3. Mixed with lime to produce mortar
Calcium silicate bricks	1. Cleaned 2. Crushed 3. Pulverised	1. Reused for masonry 2. Aggregate 3. Recycled into new calcium silicate bricks
Natural stone masonry	1. Cleaned 2. Crushed	1. Reused for masonry 2. Aggregate
Natural stone slabs	1. Cleaned 2. Crushed	1. Flooring, cladding 2. Aggregate
Ceramic tiles	1. Cleaned 2. Crushed	1. Flooring, cladding 2. Aggregate
Asphalt paving	1. Crushed and cold-mixed 2. Crushed and hot-mixed	1. Road base, fill material 2. Road construction
Mixed DW (ABC = asphalt, bricks, concrete)	Crushed	Road base, fill material
Steel	1. Cleaned 2. Recycled	1. Reused steel components 2. New steel components
Aluminium	1. Cleaned 2. Recycled	1. Reused Alum. components 2. New Alum. components
Timber beams, doors, etc.	Cleaned	Reused as beams, doors, etc.
Timber boards	Cleaned	1. Reused as shuttering and other products 2. Feedstock for engineered woods
Timber (miscellaneous items)	1. Cut to suitable sizes 2. Chipped	1. Firewood, co-processing 2. Landscape mulch, soil conditioner, boiler fuel, etc.
Plastics	Recycled	New products
Gypsum plasterboard	1. Cleaned 2. Crushed 3. Recycled	1. Reuse as boards 2. Soil conditioner 3. New gypsum products
Glass	1. Cleaned 2. Crushed 3. Recycled	1. Reused for windows, mirrors, etc. 2. Aggregate 3. New products
Electrical and sanitary fixtures	1. Clean 2. Separate unusable items into individual components to facilitate recycling	1. Reuse 2. New products
Insulation	1. Clean 2. Recycle	1. Reuse 2. New products
Packaging materials	Recycle	New packaging material

Table 1.1 Some common CDW materials and their possible reuse

3. CDW in developing countries

The one main finding of this investigation is that very few studies exist on the reuse and recycling of CDW in developing countries. While a great deal of work is being undertaken in the field of municipal solid waste (MSW) management, only relatively few researchers and institutions deal with CDW.

The fact that CDW is a growing problem in all developing countries is well known to the public authorities and to the experts of research institutions and the construction industries. But in none of the developing countries has there been a significant progress towards reducing, reusing and recycling CDW.

In the course of these investigations, information was collected from various developing countries and e-mail queries were sent out to many experts worldwide. The results are summarised below, listing the countries from West to East.

3.1 Mexico

A conference presentation (Ref. 7.3) on CDW recycling in Mexico was provided by Dr. Günther Wehenpohl (GTZ). It presents general guidelines for collecting, separating and recycling CDW, but is not a case study. It appears that CDW recycling is not yet being practiced in Mexico generally – at the most in a few locations as pilot projects – but serious considerations are being given to CDW management on a national level.

3.2 Chile

A query was sent by Ms. Johanna Klein (GTZ) to the colleagues at the GTZ Office in Chile concerning the status of CDW management there. The response from Ms. Elke Hüttner and Mr. Alvaro Zurita was that there is currently no significant activity in Chile, but that the environmental authorities are well aware of the need to address the problem as soon as possible. CDW regulations are apparently in preparation, but these are not expected to be ready for quite some time.

A voluntary agreement on clean production (“APL - Acuerdo Produccion Limpia Sector Construccion, Región Metropolitana”) exists since a few years, but CDW recycling is only one of the many aspects.

3.3 Brazil

Of all the Latin American countries, Brazil seems to be the only one in which research and development work is being undertaken systematically on the issue of CDW recycling. In some municipalities, such as São Paulo and Belo Horizonte, CDW management is already in operation – the system includes registration of companies that transport CDW, a well-located network of CDW deposit sites, and recycling plants, in which aggregate for road construction is produced and metals and organic fractions are separated for further use. The municipalities are the main consumers of the aggregate. However, there is no systematic control of the CDW delivered and of the resulting aggregate, which was found to be of inconsistent quality. Furthermore, political changes have frequently caused the system to come to a halt. (Ref. Case Study 5.1 “Pilot CDW recycling project in the State of São Paulo”).

The research work that is being conducted since about 5 years at the Polytechnical College of the University of São Paulo, documented in a few conference presentations (Ref. 7.2; 7.20), is very promising, and it is expected that Brazil will take the lead in CDW management in Latin America.

3.4 South Africa

Most searches for CDW information in Africa led to websites in South Africa. But the information found is of a more general nature. It does however indicate that CDW is collected and reused and recycled to some extent. The website of the Council for Scientific and Industrial Research (CSIR) mentions that “South Africa currently faces challenges such as the lack of a national waste information system, the need for a waste act, support for recycling and the need to set waste targets. If addressed, these challenges could facilitate the development of a C&D sector” (Ref. 7.11).

Dr. Günther Wehenpohl (GTZ) mentioned that he visited a CDW recycling plant near Cape Town, during the Wastecon 2006 conference. An e-mail was sent to the conference organiser requesting information and contacts, but no reply has been received.

3.5 Egypt

The information on Egypt originates only from one source, which is a conference paper, entitled “Sustainable Guidelines for Managing Demolition Waste in Egypt” (Ref. 7.1), presented by Marwa S.M. Al-Ansary at the Forum Barcelona International RILEM Conference on the “Use of Recycled Materials in Buildings and Structures” (Nov. 2004). The objective of this paper was to recommend practical guidelines to be added to the Egyptian Executive Regulations 338/1995 of the Egyptian Environmental Law no. 4/1994 to manage the amount and types of demolition waste in Egypt. The guidelines were scientifically tailored and were based on the responses from 35 Egyptian construction companies regarding how construction waste is handled on their projects, and from 40 responses of people with different backgrounds on ways to reduce the disposal of building materials waste in Egypt.

The proposed guidelines were evaluated by a number of prominent national and multinational construction organisations in Egypt. The paper summarises the proposed Egyptian demolition waste management guidelines, which cover: (1) the waste management hierarchy based on the ‘4Rs’ Golden Rule of Reducing, Reusing, Recycling and Recovering of waste; (2) the different implementation stages, which start from the early planning phase, followed by the tendering and contract formulation phase, and finally the execution phase; (3) the various techniques, methodologies, procedures and strategies recommended to reduce the amount of waste and (4) the degree of involvement of all the construction industry parties (owner, engineer, designer, and contractor) in the implementation of the guidelines.

While the disposal of CDW is regulated in Egyptian Environmental Law, illegal dumping of CDW on public roads and highways and near residential areas is widespread. Sustainable solutions to the CDW problems have yet to be introduced. The recommendations presented in the paper serve as a good basis for introducing changes, but more political support is needed to enforce their implementation. There must also be a concerted effort of all stakeholders, i.e. the local authorities, the construction industry, the manufacturing industry, researchers, building owners, etc., to play active roles.

3.6 Palestine

A Diploma Thesis (Ref. 7.28) was prepared in 2005 by Samuel Schmid, a student of the Fachhochschule beider Basel, in Muttenz, Northwest Switzerland, on “Recycling and Reuse of Construction and Demolition Waste in Palestine”. The thesis was conducted with the support of the GTZ in Palestine and coordinated by Prof. Dr.-Ing. Dieter Mutz. It is a comprehensive study of the political, environmental, economic, social, technical and other aspects of CDW management in the Palestinian Territories, with comparisons of the status of CDW treatment in Europe (Switzerland and Germany) and three developing countries (Brazil, Egypt and India).

The CDW problem is especially severe in the Palestinian Territories, in particular the Gaza Strip, where military attacks have led to the destruction of a great number of buildings. Most of the CDW treatment is illegal and uncontrolled, causing serious environmental problems. Two experimental research programmes have been conducted at the Islamic University of Gaza to test the feasibility of using CDW in concrete, road construction and concrete hollow blocks, with encouraging results.

A pilot project for recycling CDW has been implemented in Rafah by the Italian Technical Cooperation, which installed a small jaw-crusher to produce CDW aggregate. It was found that CDW materials are suitable for road applications as a base course layer, but that more research is necessary to optimise applications in concrete mixes. Nevertheless, it seems unlikely that the CDW treatment will continue after the Italian project is over. Since the legal framework for CDW management is inadequate, illegal dumping of CDW is expected to continue for quite some time.

The Thesis, therefore, proposes several measures to promote the reuse and recycling of CDW, on the basis of which private enterprises would be more inclined to participate in the process. Regulations and standards for reusing and recycling CDW need to be introduced, as well as taxes and incentives to regulate the price of recycled CDW. Since CDW aggregate would compete with quarried material, opposition is expected from importers and quarry operators. Therefore, it is suggested that they should be involved in developing the production and use of recycled CDW.

Since this study was completed in December 2005, a query was sent to the GTZ office in Palestine to get an update of the current situation. As the local GTZ Project Advisor, Wa'el Safi of the GTZ Project Office Gaza replied, the activities are still continuing, despite the tense political and economic conditions, but progress is slow and no longer in the hands of GTZ Gaza. (Ref. Case Study 5.2 "Pilot CDW recycling project in Rafah").

3.7 India

The Ministry of Urban Development issued a "Manual on Municipal Solid Waste Management" (Ref. 7.23) in the year 2000. It contains a chapter on CDW, but also clearly states that CDW reuse and recycling is not practiced in India.

A further publication appeared in 2001, entitled "Utilisation of Waste from Construction Industry" (Ref. 7.32), published by the Technology Information, Forecasting & Assessment Council (TIFAC). Only the Executive Summary is available on the website, but it gives a fairly good overview of the status of CDW management in India. Contrary to the "Manual on Municipal Solid Waste Management" referred to above, this publication mentions that there are demolition contractors who specialise in "planned deconstruction so that the recovery of good material can be maximized for re-use. Recovery rate varies from 25% in old buildings to as high as 75% in new buildings". Unfortunately, no further documentation was found on planned deconstruction in India. Queries were sent out to several experts and to some contractors, of whom only one replied, confirming that he has been involved in planned deconstruction. No other response was received.

The TIFAC survey, however, mentions that on the whole, CDW recycling is not widely practiced, the main reason being that the possibilities of recycling are not known to the majority of building professionals. Those who were aware of them stated that the building specifications do not provide for the use of recycled products. Others indicated that they do not use recycled CDW, because it is not available.

It is known that some reputed research institutes in India are investigating possibilities of reusing CDW, but no details have yet been identified.

3.8 Sri Lanka

The devastation caused by the Asian tsunami in Sri Lanka resulted in an incredible mass of demolition debris. However this debris cannot be compared with CDW in the normal sense, as it was mixed with all kinds of other materials, sea water and decaying organic matter. The reuse or recycling of such debris is extremely difficult and only possible if the main fractions can be separated reasonably well. Surprisingly, very little information is available on the Internet – the only reference to the reuse of building debris found was in two UNEP documents (Ref. 7.6 and 7.33), which mentioned that the tsunami survivors were encouraged to “salvage recyclable and re-saleable materials, such as steel reinforcement rods, timber and bricks”. Nevertheless, most of the waste is dumped into landfills.

3.9 Indonesia

Banda Aceh suffered the greatest devastation of all tsunami affected countries. It is assumed that the debris was handled in the same way as in Sri Lanka, although the UNEP Reports do not specifically mention it.

However, the website of UNEP IETC (International Environmental Technology Centre), Japan (Ref. 7.34), which propagates environmentally sound technologies (ESTs), describes an ongoing two year (2006-2007) Disaster Management Project, called the DEBRI Project (Demonstrating ESTs for Building Waste Reduction in Indonesia). “The aim of the DEBRI Project is to support the reconstruction and rehabilitation in Banda Aceh through developing partnerships for the application of environmentally sound technologies (ESTs) to the treatment/reuse/recycle of debris waste generated by the Indian Ocean Tsunami, and subsequently the construction/demolition waste generated on a day-to-day basis. The project is executed by building partnerships with the Indonesian Ministry of Environment, and working closely with local governmental agencies, civil society organizations, technology suppliers, and other UN Agencies. The International Solid Waste Management Association (ISWA) provides expert input to the project”.

“The project takes a three-pronged approach, looking at the issues of technology support, capacity building and economic instruments. The project develops a waste management mechanism for handling, treatment, reuse and recycling of tsunami-generated debris, which can subsequently be applied to day-to-day construction/demolition wastes. It identifies and demonstrates ESTs for debris management, and builds capacity of local government officials in debris handling and processing. It also develops a package of economic instruments to ensure long-term viability of ESTs, and disseminates knowledge and experiences gained to other affected countries in Asia”.

“The project supports, and is inherently linked to, ongoing programmes and projects of the local government in the affected region. The experience gained from the project is to be shared to strengthen the ongoing post-tsunami recovery and rehabilitation work in other affected countries as well”.

3.10 Thailand

Thailand was not affected as severely as Indonesia, but also had to cope with a great deal of demolition waste. However, no specific information was found on how the demolition waste was treated other than disposal in landfills.

In the 3R Portfolio for Thailand (Ref. 7.31), there is a brief mention of the cooperation project between GTZ and the Pollution Control Department in a study on “The Management of Construction and Demolition Waste” (Ref. 7.15). This study was made available for this investigation by the GTZ office in Thailand. The study, conducted by Ulrich Fimpel, is a comprehensive “Report on the International State of the Art” – it is not a report on the CDW

situation in Thailand, but in the final chapter recommends effective interventions at different levels in Thailand, by which CDW management can be introduced there.

Correspondence with the Asian Institute of Technology in Bangkok in November 2006 revealed that Ass. Prof. Dr. Ulrich Glawe had just begun a study on CDW in Thailand and SE-Asia (in cooperation with UNEP and UNESCAP, funded by ADB). He confirmed that CDW information is lacking in Thailand and other countries in the region.

3.11 Malaysia

A Construction Waste Management Seminar was held in Malaysia in March 2003, but the brief report on the Seminar mentions that data on CDW management is still lacking in Malaysia. In response to an e-mail query, the seminar coordinator, Assoc. Prof. Dr. Joy Jacqueline Pereira of the Institute for Environment and Development (LESTARI), sent a copy of the seminar proceedings (Ref. 7.10), which contains some interesting papers. These show that a certain amount of reuse and recycling of CDW is practiced in Malaysia, but as one paper states: “the Malaysian scenario is one where groups are interested, but afraid to venture into the business for lack of adequate data regarding its feasibility”. This is true for many countries.

Dr. Joy Pereira recently led a research project (2002 – 2005) on “Waste Minimization and Recycling Potential of Construction Materials”. The project was a collaboration between LESTARI and FRIM (Forest Research Institute of Malaysia), funded by the Construction Industry Development Board of Malaysia (CIDB). The project report is not yet available, but it is expected to provide valuable information on the subject. With this, Malaysia is likely to take a leading role in CDW management in Southeast Asia.

One of the papers of the CWM Seminar 2003 (Ref. 7.10), was entitled “Construction Waste Management – the Putrajaya Experience” (Ref. Case Study 5.3 “Construction Waste Management – the Putrajaya Experience”). It describes the efforts to minimize waste generation in the development of the new administrative seat of the Malaysian Government. However, it also shows that much still needs to be done in terms of awareness promotion, legislation, monitoring and encouraging reuse and recycling of CDW, which is still underdeveloped. (Ref. 7.7, 7.9 and 7.10)

This is confirmed in a website of the Malaysia University College of Engineering and Technology, where an article was found on CDW Management (Ref. 7.16), which states that “Recycling C&D waste ... is still new and not fully implemented in Malaysia since C&D waste generation is not a significant or major problem here. The possibility of recycling of C&D waste from the construction industry is becoming more important due to the lack of space for waste disposal. In addition to the environmental benefits in reducing the demand on land for disposing the waste, the recycling of C&D wastes can also help to conserve natural materials and to reduce the cost of waste treatment prior to disposal”. It is expected that some developments will take place in Malaysia within the next few years.

3.12 Philippines

No specific information was found on CDW management in the Philippines, but there are several references to Solid Waste Management and a long term Zero Waste goal. It is interesting to note that in 1999 the Philippines was the first country in the world to ban incineration. In 2000 a landslide at a landfill site killed about 300 people, who were making a living by sorting through the waste. As a consequence, the Solid Waste Management Act of 2000 (also called Republic Act 9003) was passed which mandates decentralised waste management, segregation of waste at source and separate treatment of recyclables. The Act does not refer specifically to CDW, but to solid waste in general. (Ref. 7.4 and 7.18)

Recycling has been boosted by the establishment of materials recovery facilities (MRFs), which are locally based and require small amounts of capital. But these are not conceived to handle CDW on a large scale. It is evident that CDW management is not yet sufficiently developed in the Philippines and needs to be addressed as soon as possible.

3.13 Significance of CDW in developing countries

3.13.1 Difficulties of introducing CDW Management Systems

The investigations have shown that CDW management is not being practiced in a systematic way in any of the developing countries, although sporadic individual activities exist in almost all the countries. Experts in all the countries are aware of the need to avoid, minimize, reuse or recycle CDW and are preparing the ground for the introduction of such practices. This, however, takes considerable time, as has also been the case in the industrialized countries, where CDW management practices are now quite advanced.

The main reasons for the slow progress in developing countries are

a. the lack of awareness amongst the general public about the problems associated with the uncontrolled disposal of waste

Over many generations, waste has been viewed as something that is not fit for further use and must be discarded or destroyed. The resulting environmental, health and economic problems are not usually well documented or publicized, so that public awareness of these problems is often very limited. Quite often, the reaction to such information is indifference and inactivity, even amongst the public authorities – this attitude is not only encountered in developing countries.

b. the lack of public acceptance that wastes are valuable resources

In many countries, handling waste has the lowest status in the society and is left to socially underprivileged groups. Therefore, the notion that wastes could have any value does not exist. Hence the idea of separating wastes into different fractions at the source and collecting them for reuse or recycling finds little acceptance. It takes a long time to change the mindset of the people – it has also been a long, step-by-step learning process in industrialized countries.

c. the reluctance of most people to deal with waste

It is well known that the handling of wastes can be dangerous, e.g. inhaling of fine particles; blisters, burns and illness from toxic substances; severe cuts from broken glass and metal scrap. Furthermore, the concept of using wastes as recycled products and the fear of future problems that may arise due to inferior qualities of materials makes builders reluctant to use them.

d. the ease of disposing of waste legally or illegally

There is often no pressure on people who dispose of their waste wherever they please. Even if there is legislation against such practice, in most cases there are no negative consequences for non-compliance. In many countries there are no fees for disposal in landfills or the fees are too low to encourage waste minimization, separation and recycling.

e. the lack of a clear CDW management policy

Many governments are still in the process of developing guidelines and regulations for CDW management. In most cases, CDW is only a part of municipal solid waste and also treated as such, without taking the special requirements of deconstruction, separation, decontamination, reprocessing, and other activities into consideration. Since there is no clarity on these issues, there can be no effective CDW management.

f. the lack of technology, know how and standards

Not all building materials based on CDW provide the same strength and durability as the materials they were designed to substitute, but if the price is low, this drawback can be accepted. However, for CDW to be reused or recycled profitably, the required technical characteristics of the materials must be standardised and ensured, and methods of processing, testing, quality control, and certification must be developed. This is rarely the case in developing countries. There are research institutes that are in the process of developing and testing methods and materials, but this is a long process.

g. the lack of a market for reusable or recycled CDW

As mentioned above, “the Malaysian scenario is one where groups are interested, but afraid to venture into the business for lack of adequate data regarding its feasibility”. This reflects the situation in most countries – markets can only develop where products of acceptable quality and at competitive prices are in demand. As long as the legal, technical, institutional and economic prerequisites do not exist, there is little chance for markets to develop.

h. the tough competition in the building materials sector

As described above, in the case of Palestine, “CDW aggregate would compete with quarried material and thus face resistance from importers and quarry operators”. As with all commercial products, recycled CDW has to overcome a number of obstacles before establishing its place in the market. It must, however, also be remembered that once a by-product becomes a useful building material, higher prices are charged, so that the benefit of using cheap materials is quickly lost.

i. the lack of funds

Recycling CDW generally requires a variety of technical equipment, which is not always available in the country. The funds for procuring such equipment, even for a pilot plant, are often not available in developing countries, or the available funds are used for other purchases that have been given a higher priority than CDW recycling.

j. the lack of infrastructure

In order to introduce a functioning CDW management system, a number of facilities have to be in place, such as materials recovery yards, transportation and storage facilities, adequate roads, trained manpower, reliable control mechanisms, facilities for decontamination and safe disposal of hazardous waste, etc. These take time to establish and test under working conditions.

k. the lack of national waste information systems

A functioning CDW management system has to be based on reliable data on the types and quantities of waste materials, a mapping and monitoring system of the locations and availability of waste materials, information about the current demand for the various types and quantities of these materials, etc. Although the total amount of available waste is generally large, it may be produced in numerous decentralized units, making collection extremely difficult. It is necessary to develop special CDW networks and associations of stakeholders in the CDW industry within a country or region. This takes considerable time to develop.

l. the lack of information on good practices

Any country or region intending to develop a CDW management system has no time to learn from its own mistakes, but has to learn from others, who already have well functioning systems. Therefore, information on good practices is of vital importance for the introduction of a CDW management system. Nonetheless, good practices in one country may not be totally transferable to another country and may require a certain amount of adaptation.

m. unstable political situations

A functioning CDW management system requires political stability and political support to enforce its implementation. There must also be a concerted effort of all stakeholders, i.e. the local authorities, the construction industry, the manufacturing industry, researchers, building owners, etc., to play active roles. As can be seen in the example from Palestine, in an environment of political unrest, it is hardly possible to achieve the desired progress.

3.13.2 Negative impacts of failure to introduce CDW Management Systems

Inactivity and failure to address the CDW issue is already causing serious problems in most countries. The most obvious negative impacts are:

a. irreparable environmental damage

Landfills are always associated with the permanent destruction of landscapes, with air pollution from the smell of decaying material or toxic fumes of incinerations, with soil pollution from decaying and toxic substances, particularly from mixed wastes, and with water pollution from leachates.

b. serious health hazards of uncontrolled disposal and incineration

Landfills are also associated with the proliferation of pests (disease transmitting insects, rats and other creatures). The air, soil and water pollution can be the cause of a variety of health problems in the area. Scavengers, who search for usable items in the waste are particularly endangered by sharp and heavy objects, landslides have killed many people (e.g. about 300 people in the Philippines in the year 2000, 14 people in São Paulo in 1989).

c. reduction of useable space, due to rapidly increasing landfills

With the geometric progression of population growth and urbanisation in most developing countries, landfills are growing at an incredible pace and are consuming immense areas that are badly needed for productive development and recreation. Considering that CDW can constitute up to 50% of municipal solid waste means that the rate of growth of landfills could be reduced by half, if CDW were excluded. Of course, even the quantum of MSW needs to be reduced to zero, or at least an absolute minimum, in order to check this negative impact.

d. economic and social retrogression

The reduction of useable space results in skyrocketing land prices, while the area in the vicinity of landfills rapidly lose their value and become populated by the socially underprivileged. High and medium profile businesses and industries, tourism facilities and the like tend to move to other areas, thus reducing the number of job opportunities, leading to further social decline and to politically unhealthy situations.

e. depleting natural resources

Disposing of CDW without reusing or recycling it means new materials and products have to be excavated and manufactured. The result is rapid depletion of natural resources through increased quarrying and deforestation, which worsens the scale of environmental degradation. It also means a severe economic loss, which could be offset by reusing and recycling CDW.

3.13.3 Benefits of introducing CDW Management Systems

While there are a number of difficulties in establishing a CDW Management System in a developing country, the benefits outweigh any drawbacks encountered. The main benefits of introducing sustainable CDW Management Systems are:

a. environmental improvement

With less space being required for landfills, less space is degraded by pollution and unsightly conditions. With less need for virgin materials, the need for quarrying and deforestation is reduced, leaving more of the natural environment in its original state. Moreover, less energy is required to manufacture new products from raw materials, releasing less CO₂ and other harmful substances into the air, soil and water.

b. healthy conditions

A reduction or avoidance of landfills means less pollution, less diseases, fewer injuries and fewer accidents, and consequently has a direct impact on the health of the people. This is a significant economic factor, as the people's productivity increases proportionately with better health conditions. With a better environment and healthy conditions, investors will be attracted and will help the local economy to grow.

c. increase of landfill life spans

In most countries, although zero waste may be a target, landfills for MSW will continue to exist for many years, but if CDW is not dumped there, the life span of the landfills can be doubled. This would slow down the pace of economic and social degradation and provide more space for productive activities.

d. saving natural and financial resources, as well as foreign exchange for imports

By reusing and recycling CDW, these do not have to be replaced by new materials and products, thus reducing the need for procuring new raw materials, either from within the country or by imports. This conserves natural resources and saves the cost of excavation, transportation and manufacture, or the foreign exchange required to import the materials and products. In addition, reusing and recycling CDW saves having to pay the ever increasing tipping fees. Once CDW producers realise the value of reusing and recycling, illegal tipping will no longer be an option.

e. saving energy for production of new materials

As each excavation, transportation and manufacturing process for new materials requires more energy than is required to recycle those materials, the high energy costs make this a significant financial gain. Furthermore, less energy consumption has a positive impact on the environment by reducing CO₂ emissions and other pollution, as mentioned under a. above.

f. reduction of costs of new constructions

Since the costs of recycled materials have to be lower than those of new products, in order to be marketable, they will serve to reduce the costs of new constructions.

g. creating new jobs

"Incinerating 10,000 tons of waste creates 1 job, land filling the same amount creates 6 jobs, recycling the same 10,000 tons creates 36 jobs." (This is quoted in numerous websites, but its origin is not known). Since demolition contractors can make a good profit from salvaged building parts, this will become a vital branch of the building industry, offering many new jobs for the sorting and transportation of CDW, for running transfer stations, and other related work. The same applies to the recycling industry. It is true that scavengers already earn a living from landfills, but they belong to the informal sector without job security, safety measures and acceptable social status. Employing these people in regular jobs within the formal sector will help to raise their social status, their self respect and their standard of living.

4. CDW in industrialized countries

Virtually unlimited information on CDW management, recycling, zero waste initiatives and similar subjects in industrialized countries is available from various sources, and is increasing daily, providing enough material to fill several PhD-Theses over the next few years. It is therefore difficult to do justice to it in a summary, as there are a great many aspects and facts to be dealt with. Hence this section must not be viewed as a compendium, but merely as a brief outline, highlighting the main points.

4.1 Background

The history of waste management probably began in England in the mid 19th century, when a report linked disease to filthy environmental conditions. Incineration of waste began about 1874 in England and in 1885 in the United States. The first waste recycling plant was established in New York City in 1898. In the 1920s, landfills were becoming a popular way of reclaiming swamp land while getting rid of trash. In Germany, and probably most of Western Europe, regular collection and transport of refuse began after 1920. Resource shortages caused by the World Wars encouraged recycling, and resource conservation programs established during the war were continued in some countries without an abundance of natural resources, such as Japan, after the war ended.

However, it was not until the energy crisis of the early 1970s that a general rethinking began in terms of saving energy through recycling. For instance, recycling aluminium saves 95% of the energy required for virgin production. Although the percentages are less, recycling paper (64%), glass (60%), steel (74%) and plastics (80%) also save considerable energy and substantially reduce the volume of waste disposed in landfills.

In the 1980s the first initiatives for minimising and recycling CDW began to develop in industrialized countries. In Germany the Federal Quality Association for Recycled Building Materials (Bundesgütegemeinschaft Recycling-Baustoffe e.V.) was established in 1984. The Association, which unites the major recycling companies in Germany, has its Headquarters in Berlin. In January 2006, it has also become the Headquarters of the European Quality Association for Recycling e.V. (EQAR), which is the umbrella organisation of the Quality Associations of the European Union. There are similar associations in other regions.

Since the 1980s there has been considerable progress in CDW management systems in the industrialized countries, in particular in North America, Western Europe and Australia / New Zealand. Although the policies and activities differ from country to country, there are a number of common principles and CDW management strategies, which are described below.

4.2 Present trends in CDW management in industrialized countries

CDW management does not begin once a product becomes waste, but at the very beginning of the product's life cycle and in the planning stages of the buildings in which they are to be used. The various strategies, activities and stages are described in this section.

4.2.1 Life Cycle Analysis (LCA)

LCA provides a methodology for considering each stage of the product's life from extraction of the raw materials, through manufacture and construction, use and disposal. In CDW management, the life-cycle approach is changing from the "cradle to grave" approach to the "cradle to cradle" approach, which suggests that the grave of one cycle can be the cradle of its own or another cycle. Like in an intact, functioning ecosystem, the waste from one living organism becomes food or shelter for another organism.

LCA generally uses the following six environmental criteria (Ref. 7.13):

- a. **Resource use**, which considers the availability of materials.
- b. **Embodied energy**, which includes the energy used in manufacture, transport and construction.
- c. **Embodied pollution**, which investigates the extent to which pollution control legislation is followed during manufacture, construction, useful life of the product and at the end of its useful life.
- d. **Recyclability**, which considers the possibility of prolonging the life of depleting resources as well as avoiding or reducing the energy and pollution caused by manufacture from virgin materials.
- e. **Material efficiency**, which considers the burden on the supporting structure, as stronger and lighter material will achieve the same task with less use of materials.
- f. **Product life**, which considers the manufacturer's guarantee period, the remaining life of the building and a possible extended life due to reclamation – the longer a product lasts before replacement, the better it is in terms of the environment.

Such considerations have led to the formulation of the Green Paper on Integrated Product Policy (IPP), which was adopted by the European Commission in February 2001, and the concept of Product Oriented Environmental Management Systems (POEMS) and other related systems. (Ref. 7.14)

An important instrument of IPP is **Producer Responsibility**, which commits the producer or importer to take back and recycle products that they have put on the market. This internalises the cost of waste treatment etc. and thus creates an incentive to design and produce products with lesser cost of disposal and reuse. At the EU level this is a reality in relation to cars and electronic equipment, but not to building materials.

4.2.2 Design and planning considerations

In designing and planning new projects, architects and engineers are expected to take the following aspects into consideration:

- a. **Resource saving design**
With regard to building materials, this means incorporating locally available materials, components and systems (saving energy and costs of transportation), simple designs that minimize the need for sophisticated equipment, and designs that minimize wastage (such as modular design and use of prefabrication and pre-cut components).
- b. **Designs for future changes and extensions**
Incorporating sufficient flexibility into the building designs can ensure a reduction of wastage and demolition when changes and extensions become necessary at a later stage.
- c. **Use of durable and non-toxic products**
Durable products reduce the need for early replacement and thus contribute to waste minimization. Hazardous and toxic products require special treatment and disposal measures, which should be avoided as far as possible.
- d. **Maximum use of recycled products**
This ensures closed loop recycling of building products, which is the basis of a sustainable CDW management system.
- e. **Labelling of products**
Providing details of origin, quality, certification, etc. will help to categorise the products for reuse or recycling. This will also minimize the use of toxic or hazardous materials.

f. Specification of required quantities

In the past, the materials required for construction were usually over-estimated or rounded up in the bills of quantities (BoQs). This led to a significant amount of excess material that had to be disposed of and invariably ended up in landfills. BoQs must now specify exact quantities to avoid any wastage.

g. Planning for deconstruction

This is an important requirement to ensure minimum wastage and maximum recovery of usable components and materials.

4.2.3 Considerations of the tendering procedure

Specifications, tender documents and contracts must take CDW issues into consideration, so that all the major requirements are clarified prior to commencement of construction.

a. Selection of certified contractors

In a restricted tender, in which a limited number of contractors are invited to bid, care must be taken to select only such enterprises that have a proven record of good practice or an ISO 14001 certification of compliance with environmental management standards. In open tenders, the bidders must provide evidence of completed projects of the required standards, or an ISO 14001 certification.

b. Commitment to minimize waste

Not only must there be a commitment to minimize waste, but the details of how to go about it must be specified in detail.

c. Presentation of CDW management plans

Bidders must provide details of their own CDW management plans for consideration in the technical evaluation of the tenders.

d. Payments based on fulfillment of CDW management requirements

The prerequisite for this is the detailed description of the CDW management requirements.

4.2.4 During and after construction

Good designs and specifications can save a great deal of wastage on building sites, but good site supervision and construction management are essential to ensure that the minimum requirements of sustainable CDW management are met.

a. Well organised and tidy building site

A well organised building site, in which every item has its place, including waste, will ensure minimum damage and loss, and hence less wastage.

b. Supply of material just in time

This reduces the need for storage of materials, which run the risk of getting damaged and thus being reduced to waste before being used in construction.

c. Supply of material with minimum or no packaging

Packaging constitutes a significant part of the waste generated on a building site. Only minimum packaging should be allowed and suppliers must be made responsible for its proper disposal.

d. Following the principle “Measure twice, cut once”

A lot of wastage occurs due to mistakes made during construction, particularly in measuring and fitting in components. Therefore double checks can avoid a great deal of waste.

e. Strict separation of excavated, recyclable and hazardous material

The disposal of excavated material and CDW on the same dump makes it virtually impossible to reuse or recycle any of the material. Separate disposal in separate compartments or containers is essential to ensure maximum reusability and recyclability. In particular, hazardous wastes have to be collected in appropriate containers for correct disposal. It is important to ensure that the waste containers are not misused by people looking for a convenient place to dispose of their garbage.

f. Appropriate disposal of recyclable and hazardous material

The contractor has to remove all the CDW from the site and dispose of each fraction separately in such a way as to make maximum use of the reusable and recyclable content. Hazardous materials have to be disposed of in a way that renders them harmless to humans, animals and the environment.

4.2.5 During renovation, extension and deconstruction

Apart from the complete removal of buildings, most changes and extensions of buildings are associated with the generation of waste materials to a smaller or larger extent. These activities require special experience and care, in order to keep the amount of waste at a minimum and dispose of it in the environmentally most appropriate way.

a. Appointment of licenced deconstruction contractors

Only well-trained professionals should be engaged in the deconstruction of buildings, as the technical and legal framework is fairly complex, requiring the necessary expertise, manpower and equipment.

b. Preparation of renovation, extension or deconstruction plan

Depending on the waste generating activity, the structure has to be analysed in terms of dismantling procedures, type, quality and quantity of each material to be disposed of (in particular in view of its reusability and recyclability), how it will be stored before transportation, the correct destination, and who will be responsible. A deconstruction plan is basically the sequence of dismantling in the reverse order of construction.

c. Separation at source

Each building site should be equipped with sufficient containers for the collection of different fractions of waste. The conventional practice of demolition without separation makes it difficult or even impossible to extract sufficient material and components for reuse and recycling. If hazardous or toxic waste is mixed with the rest, the whole volume of waste is rendered useless and must be dumped in a landfill.

d. Controlled deconstruction

Controlled deconstruction has been found to be far more economical than conventional demolition. There are clear guidelines and sequences to be followed, which have to be defined in the deconstruction plan. The first measure is to dismantle toxic and hazardous materials, such as asbestos, damp proof materials, sealants, paints and coatings, plasterboard, and several others. In an efficient deconstruction plan, the aim should be to dismantle one major type of waste at a time, such that the materials can be removed before they become mixed with materials from the next phase. It is important to maintain a deconstruction diary and an inventory of the materials dismantled, mentioning their conditions and destinations.

e. Disposal of deconstruction waste

Each waste fraction must have a clear destination, either to a salvaged materials dealer, a recycling or reprocessing plant, or – in the case of hazardous and toxic waste – to licenced municipal landfills for safe disposal. Many countries have exchanges in the Internet to connect businesses that have reusable goods to those who can use them, but business contacts can also be found in the yellow pages, industry directories and trade magazines.

4.2.6 Important prerequisites for efficient CDW management

While the technical side of CDW management has been outlined above, a number of other measures are necessary for CDW management systems to function. They are fairly well developed in some countries, but still far from achieving the ultimate goal of ZERO WASTE. The main issues are outlined below.

a. Research and development

Many universities, research institutes and private companies are in the process of studying the characteristics of varieties of CDW to determine their potentials for recycling. A number of methods of recycling CDW have been developed and have found their way into normal construction practice – a common example is the use of crushed asphalt, brick and concrete (ABC) waste as a sub-base in road construction and paving. There is sufficient scope for further research for a long time.

b. Legislation and enforcement

National legislation is essential for a CDW management system to function. It provides the legal framework for the licensing and operation of landfills, the landfill levy, the sanctions for “fly-tipping”, the licensing of contractors, the issue of waste collection permits, the handling of hazardous waste, the licensing and operation of transfer stations and recycling plants, and other activities related to CDW management. Along with all these regulations, enforcement mechanisms have to be established to ensure that they are followed and all fees and fines are paid.

c. Economic incentives to support the market

The most effective means to encourage reuse and recycling of CDW is to charge landfill taxes high enough to discourage waste disposal in landfills. Simultaneously, taxes on quarrying, import duties on raw materials and products, etc. should be set at a level so as to make salvaged and recycled materials more economical to use than new materials and products.

d. Establishment of professional associations

National and regional associations of deconstruction agencies, recycling enterprises, and other stakeholders are important in providing positive support and representation to their members and the industry in legislative and rule making venues that impact the recycling business, and in facilitating interaction between the member companies and other organisations, government authorities, etc. Such associations and organisations provide their members with all the necessary information and guidance on all issues of the business.

e. Certification

For the quality assurance of companies and products, certification is mandatory for survival in the CDW sector. A number of organizations have developed standards or criteria for evaluating environmentally preferable products and companies, which are tested and certified by the organizations. There are numerous directories, in which only approved products and companies are described. The best known international certification is the ISO 14001 standard, which is verified by specialized certification bodies. There are also a large number of national certifications, such as the LEED Green Building Rating System in the USA, the BREEAM Green Leaf Rating System

in the UK, the RAL Quality Seal in Germany, the ARV Quality Seal in Switzerland, to name just a few.

f. Information exchange, workshops and training programmes

As research and development progresses, there is a need for exchange of information and experiences, which takes place at workshops and seminars, and through professional journals and newsletters of professional associations. This exchange, together with training programmes conducted by educational institutions, industry and professional associations for newcomers and experienced CDW professionals, is a vital activity to achieve progress in the field of sustainable CDW management.

g. Promotion of CDW reuse and recycling

For CDW reuse and recycling to gain general acceptance, there is no alternative to active promotion through the various stakeholders. Apart from regular awareness campaigns, it is necessary for government bodies, municipalities and industry to set examples by taking the lead in designing and building according to the procedures described above. Better still, legislation should make it compulsory for government and communal buildings to be built with materials of recycled content. Such green procurement specifications are a very powerful tool to drive market innovation.

4.3 North America

Much of the information in Section 4.2 has been derived from North American websites. There is a wealth of information available on a national and state level, as virtually every State of the USA and Canadian Province has websites dealing with CDW. This shows a large extent of awareness about CDW issues and yet the proportion of CDW that is reused or recycled lags behind that of several European countries, such as Netherlands, Belgium and Denmark (ref. 7.39).

This is due, in part, to the following factors:

- Lack of legislation which mandates CDW reduction and diversion;
- Design and construction practices which preclude efficient and effective deconstruction and / or source separation;
- A lack of material recovery/reprocessing facilities (MRFs) and end-use markets for source separated materials;
- A lack of acceptance of used materials by owners, designers, contractors and regulatory agencies;
- Specified construction schedules which are too short to allow deconstruction and/or separation to occur;
- Accessibility to landfills which have low tipping fees, such as private facilities, rural sites and landfills located in the USA.

Nonetheless, there are a growing number of markets for CDW materials. The Construction Materials Recycling Association (CMRA) represents CDW materials recyclers nationwide and member recyclers are listed on their website, www.cdrecycling.org. The National Demolition Association lists buyers of CDW materials on their website, www.demolitionassociation.com.

In numerous locations in the USA and Canada, the Solid Waste Association of North America (SWANA) provides a Construction and Demolition Materials Certification Course leading to a CDW Certification (Website: <http://www.swana.org/>). SWANA serves over 7,700 members throughout North America, and thousands more with conferences, certifications, publications, and technical training courses.

Apart from the international certifications ISO 9000 (for quality management) and ISO 14000 (for environmental management), the principal environmental certification in North America is the Green Building Certification, provided by the US Green Building Council (USGBC)

(Website: <http://www.usgbc.org/>) and the Canada Green Building Council (CaGBC) (Website: <http://www.cagbc.org/>). The Councils' Leadership in Energy and Environmental Design (LEED) certification process requires that the building attain points for various green attributes, including energy savings, materials usage, indoor environmental quality and efficient water usage. Certification is granted during the construction phase. Points are given for reusing materials, using materials with recycled content and recycling the waste that is produced at the construction site. Different levels of certification (Certified, Silver, Gold, or Platinum) can be attained depending on the number of credits the building achieves. Even if LEED certification is not the goal of the building owner, committing to recycling a certain percentage of the materials generated at a jobsite can be a great marketing tool and can give a company an edge over its competition.

The tendency of environmentally conscience communities and enterprises is not only to recycle a large percentage of CDW, but to aim for Zero Waste, which means eliminating all discharges to land, water and air, and ensuring that all products are made to be reused, repaired or recycled back into nature or the marketplace. While this concept first emerged in California, USA, in the mid 1970s, Zero Waste plans have been adopted around the world, especially by local governments in New Zealand and Australia. A handful of private companies have also adopted Zero Waste plans, including Xerox, Toyota, Honda, Pillsbury, Hewlett-Packard and Sony Electronics. The group spearheading the call for Zero Waste in North America is the GrassRoots Recycling Network (GRRN), a national network of waste reduction activists and professionals promoting the messages:

4.4 Western Europe

Until the 1970s, waste management was more or less the responsibility of local authorities. Each municipality had its own landfill and large cities had their own incineration plants (due to lack of space for landfills). On account of the growing problems of the increasing volumes of waste, many Western European countries introduced a range of waste disposal laws.

However, these laws were focussed on solid waste in general and not specifically on construction and demolition waste. But in Germany, for instance, a working group comprising recycling organisations in the building sector (Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau, ARGE KWTB) was formed in 1995, which a year later undertook a voluntary commitment to reduce the volume of recyclable waste dumped in landfills by 50% by the year 2005, a goal that was met well ahead of time. In 1996, a similar voluntary agreement was sealed between the Danish Ministry of Environment and Energy and the Danish Association of Demolition Contractors. In the Netherlands, the target for CDW set in the early 1990s was to recycle 90% and prevent 5% by the year 2000. While the target of 90% was achieved ahead of time, there was no data to determine whether the prevention target had been achieved.

Many statistics suggest that Western European countries are the most advanced in CDW recycling and prevention. This is largely due to regulations and directives issued by the European Union, e.g. the Landfill Directive 1999/31/EC, which aimed to improve the landfill standards across Europe. The European Waste Catalogue (EWC) classification system is designed to form a consistent waste classification system across the EU and provides the basis for all national and international waste reporting obligations, such as those associated with waste licences and permits, the National Waste Database and the transport of waste.

Another European development is the first green building assessment and scoring system, called the BREEAM (Building Research Establishment Environmental Assessment Method), which was developed in the United Kingdom in the late 1980s and early 1990s, and is the forerunner of the North American LEED Rating System. A similar building certification is being developed by the German Sustainable Building Council (GeSBC), which was established in 2007, while Switzerland is in the process of forming a Green Building Council.

The International Recycling Federation (FIR) was founded in Europe in 1990. In that year national organizations from Germany, Switzerland and Austria decided to join efforts in advancing recycling of construction and demolition waste. An important mission was to get influence on Guidelines and Regulations from the European Commission. Since then, more national organizations – the (North) Italian, Dutch and Spanish and Czech organizations – have joined FIR. The FIR has its seat in Houten, the Netherlands.

In January 2006, the European Quality Association for Recycling e.V. (EQAR) was formed in Germany. It is the European umbrella association of national quality protection organisations and producers of quality controlled recycled building materials in EU member states.

4.5 Asia-Pacific Region

In the Asia-Pacific Region, most of the information found on the net was from Australia and New Zealand. There is no doubt that CDW issues are being given increasing attention in countries like Japan and South Korea, but not much seems to be documented in the Internet.

The decision of the Australian Capital Territory of Canberra in 1995 to endorse a goal of 'No Waste by 2010', inspired the North American GrassRoots Recycling Network (GRRN) to start its national Zero Waste Campaign in late 1995. Canberra is determined to phase out its two landfills and replace them with 'recycling estates' in 15 years. In New Zealand, a third of all local government councils have passed resolutions to work for 'Zero Waste to landfills by 2015,' and central government officials are increasingly interested in the potential of Zero Waste communities to lighten welfare rolls.

Between 1995 and 2001, WasteWise Construction Programmes were run in both Australia and New Zealand. WasteWise was a partnership between the governments and major companies / associations from the building and construction industry that had volunteered their involvement. The seven year programme was designed to reduce the amount of construction waste going to landfill – thereby minimising harmful impacts to the environment and also saving money by reducing waste-related costs.

Used in both Australia and New Zealand, the Australian Waste Database (AWD) collects information on waste quantities and composition to monitor the achievement of waste reduction targets and objectives. The AWD is endorsed by the Australian and New Zealand Environment and Conservation Council (ANZECC) as the national information base for waste data. It was developed by the Corporate Research Centre (CRC) for Waste Management & Pollution Control.

In New Zealand, a project called REBRI (Resource Efficiency in the Building and Related Industries) grew from a collaborative effort (called Project Construction + Demolition) between The Auckland Regional Council, BRANZ, the Auckland City Council (with some funding by the Ministry for the Environment), beginning in 1995. The project quantified the types and amounts of crushed construction and demolition waste and looked at ways of reducing this. Trials were carried out on building sites sorting all waste materials, showing that significant savings can be made in the construction and demolition industries if cleaner production principles are applied.

In 2003, the National Construction and Demolition Waste Reduction Project was set up to extend this initiative even further, with the aim of developing tools and helping industry, councils and the community to reduce CDW at landfills and clean fills. Resulting from this project, the extremely useful REBRI Guidelines on all CDW issues were developed through close consultation with industry representatives and are freely available on the REBRI website.

4.6 Possible applications in developing countries

Since the industrialized countries have made considerable progress in developing sustainable CDW management systems, while the developing and emerging countries lag far behind, there is much that they can learn and adopt from industrialized countries.

a. Information exchange and awareness campaigns

The first step towards introducing sustainable CDW management systems is to learn about good practices in other countries. Therefore, a regular international exchange of information and experiences should take place in seminars, workshops and on the web. Networks need to be established, as well as public awareness campaigns in various media. There must be a joint effort of all stakeholders – governments, local authorities, researchers, industry, and markets.

b. Research and development of technologies

Research into CDW recycling technologies is lacking in most developing countries and should be initiated wherever possible. Cooperation with foreign research institutes and experts would prevent duplication of work and increase output. What is important is to prepare surveys of the various types and quantities of CDW in the different regions of the country (waste mapping), which is essential for a sustainable CDW management system to function. Building codes and standards have to be developed or modified to cater for new products and construction systems involving recycled CDW.

c. Development of institutional and legal basis

Authorities must establish specialized departments to organise and monitor CDW activities, legislation must be revised to support CDW recycling and minimise disposal in landfills. Stricter safety standards must be introduced and enforced to ensure the safe disposal of hazardous and toxic waste. The concept of producer responsibility should be incorporated in new legislation, although it may be more difficult to realise in a developing country than in an industrialized country.

d. Establishment of the requisite infrastructure

CDW collection systems have to be developed, whereby privatisation should be considered, in order to make waste management more efficient and economical. The important thing is to maintain short contractual periods of 3 to 5 years, and not to extend but to retender each new phase, giving new enterprises a chance to participate and to keep prices low. This could also apply to the establishment and running of transfer stations and facilities for treatment and safe disposal of hazardous and toxic waste.

e. Strengthening the market

Increasing taxes on landfilling, tax exemptions on use of recycled products, higher taxes and duties on imported raw materials and products, higher taxes on quarrying for virgin materials, etc. are all useful instruments for making recycled products more competitive. Organisations and associations need to be established to promote CDW activities. Special exchanges for salvaged and recycled goods must be established to facilitate selling and buying such products. This should be supported by entries and advertisements in professional journals and yellow (or green) pages of telephone directories. Good practice awards and eco-labelling also have strong effects in promoting the use of salvaged and recycled CDW. Similarly, public buildings that have been built with salvaged and recycled CDW are the best advertisements of the technology.

5. Case studies of CDW management in developing countries

5.1. Pilot CDW recycling project in the State of São Paulo (Brazil)

5.1.1 Responsible Authority/Persons

The information is based on research work conducted by Prof. Vanderley M. John and Prof. Vahan Agopyan of the Department of Civil Construction, University of São Paulo, together with the PhD. Candidates, Sérgio C. Angulo and Leonardo F. R. Miranda, in cooperation with Francisco Vasconcellos, Chairman of the Building Contractor Union of the State of São Paulo (Ref. 7.2 and 7.20).

The National Council for the Environment (CONAMA) is responsible for the approval of a directive on CDW management, requiring all municipalities and building contractors to set up management schemes. The CDW Task Group of the Environment Chamber of the Construction Industry of the State of São Paulo is responsible for drawing up the technical standards related to the use of recycled aggregates as well as regulations for licensing CDW landfills and transfer stations.

5.1.2 Background and activities

As in most countries, the space suited for landfills in and around big cities in Brazil is extremely limited, so that landfill prices are rapidly increasing, as also the problem of illegal dumping in public areas – this was as high as 20% of the total CDW in the year 2000. Removal of illegally dumped CDW is very expensive, thus increasing the pressure to find sustainable solutions.

The Brazilian experience shows that a policy based only on regulation of CDW transportation and landfilling is not totally efficient in controlling illegal dumping. The policy has to be complemented with a network of transfer stations, which cuts down the transportation costs, making illegal dumping less attractive. Brazilian experience has shown that the cost of operating a publicly owned, free-of-charge transfer station network can be lower than the cost of collecting and removing illegally dumped CDW. Despite CDW landfilling being a feasible option in small towns, recycling will be a very important tool in big cities like São Paulo.

The new policy of CONAMA, as presented by National Resolution 307, is rapidly changing the actual situation, mainly in major cities. The resolution, which became valid after July 2004, states that

- a. Dumping CDW in sanitary landfills is prohibited.
- b. Local authorities are responsible for operating CDW management schemes, which should be able to receive both low volume and high volume generators of CDW.
- c. Each construction or demolition site must submit a CDW management plan of operation to the local authorities.
- d. Material producers, building contractors and CDW transportation companies are jointly responsible for managing CDW.

The resolution classifies CDW in four different classes:

- a. Class A – comprising rocks, ceramics and cement based materials, which are recyclable as aggregate.
- b. Class B – comprising metals scrap, glass, plastics and wood, which are recyclable.
- c. Class C – comprising plasterboard, which is not being recycled in Brazil, due to lack of that technology.
- d. Class D – hazardous materials, such as hydro carbonated compounds, asbestos, sulphates, etc.

Only Class A waste can be dumped at CDW landfills, the others must be recycled or dumped at an adequate landfill. So CDW sorting is mandatory.

The major market for CDW recycled aggregates is in road paving activities, but the development of new applications for such materials will be necessary in order to obtain massive recycling and to avoid using sanitary landfills for CDW.

Some municipalities have already implemented successful systems to manage CDW. The system includes the registration of companies that transport CDW, a well located network of CDW deposit sites and simple, stationary recycling plants, which produce aggregates and gives destination to the metallic and organic fraction. The recycling plants belong to the municipalities, which generally consume most of the aggregates as road sub-base.

5.1.3 Problems encountered

Class A construction waste, which is about 50% of the Brazilian CDW, is considered to be more mixed and variable, because there is less discipline in waste discharge. This is due to the wide variety of contractors, the high cost of waste separation, insufficient areas for waste discharge, and irregular periods of waste production. As most of the CDW containers are parked in the streets or in front of the building site, neighbours often place additional litter in the containers.

At the recycling plants, there is no systematic control of the arriving material, other than a visual inspection. There is also no quality control of the delivered aggregates.

As the use of gypsum plaster and plasterboard has been increasing very fast over the last few years, there is always a possibility of a higher concentration of sulphates, which can be potentially dangerous in recycled aggregates.

5.1.4 Outlook

A set of CDW management standards are being developed, including

- a. Design and operation of CDW landfills.
- b. Design and operation of transfer stations.
- c. Design and operation of Class A CDW recycling plants.
- d. Use of CDW recycled aggregate in paving works.
- e. Use of CDW recycled aggregate in concrete components.

Steps are being undertaken to develop a fast and cheap methodology to control the quality of recycled aggregates. The techniques must be precise enough to allow certification of the composition and other quality relevant requirements of the generated aggregate.

Other research needs are

- a. Development of new markets for mineral fraction.
- b. Influence of aggregate characteristics on its performance in different applications, such as road base, mortar, concrete components, etc..
- c. Investigation of management practices for dangerous waste, such as paint.
- d. Reducing materials wastage at building sites.
- e. Investigations of gypsum waste management alternatives, including gypsum landfill regulations.
- f. Evaluation of the environmental impacts of the new landfill regulations.
- g. Development of life-cycle analysis comparing recycled CDW aggregates with natural aggregates.

5.1.5 Sources of information

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5.2 Pilot CDW recycling project in Rafah (Gaza Strip, Palestine)

5.2.1 Responsible Authority/Persons

The information is based on a Diploma Thesis (Ref. 7.28) submitted in December 2005 by Samuel Schmid, a student of the University of Applied Sciences in MuttENZ, Northwest Switzerland, on "Recycling and Reuse of Construction and Demolition Waste in Palestine". The thesis was conducted with the support of the GTZ in Palestine and coordinated by Prof. Dr.-Ing. Dieter Mutz.

The Project Advisor of the GTZ Project Office Gaza is Mr. Wa'el Safi of the Solid Waste Management Programme, who provided an update on the situation in Gaza. Coordinator at GTZ is Markus Lücke.

The local authority responsible for the project is the Municipality of Rafah, the development partner is the Italian Technical Cooperation.

5.2.2 Background and activities

On account of continued military action over many years, the amount of demolition waste from destroyed buildings is exceptionally high, posing a serious problem in handling all the debris. Most of the waste is disposed of illegally at roadsides and on public land, but in the densely populated Palastinian Territories virtually no space is available for the disposal of waste. Furthermore, natural gravel required for construction is not available locally and has to be imported. Hence the only viable solution to the problem is to recycle the inert debris for use in new constructions.

In a pilot project in Rafah (at the southern end of the Gaza Strip), a CDW recycling plant was established by the Italian Development Cooperation Programme (IDCP) in spring 2005. It is equipped with a small jaw-crusher having a maximum capacity of 60 tons/hr.

Two independent laboratories

1. the Materials and Soil Testing Laboratory at the Islamic University of Gaza, and
 2. the Association of Engineers Laboratory
- were engaged to test the recycled debris. Dr. Rifat Rustom, UNIDO National Advisor, prepared the final test report, which concluded that the recycled aggregates were acceptable for use in concrete (particularly for non-structural applications and concrete hollow blocks) and very good for use as a road sub-base. The details of the test results are given in the Diploma Thesis.

A test road was constructed with recycled CDW aggregate, the test results of which were very encouraging. Consequently, IDCP planned to donate several big crushers

to clear the Gaza Strip of CDW within 2 years. The Thesis, however, shows that such a plan would be unrealistic, as the aggregate produced would last for 6 years of new road constructions, so that the bulk of it would have to be stored somewhere and would encourage illegal dumping of surplus CDW.

The Thesis discusses the commercial aspects of recycling CDW (costs, turnover), the need to gain confidence in RCDW and the necessary steps to develop the use of RCDW. After a detailed technical and financial analysis, the Thesis concludes that “the recycling of CDW in Palestine is possible, it would solve many problems, it is profitable, it would make Palestine a little bit more independent, and it must be promoted.”

5.2.3 Problems encountered

Developing the use of RCDW in Palestine is difficult, because of the following problems:

- There is no legal framework and no enforcement mechanism to regulate CDW disposal.
- There are no technical regulations for the process of recycling CDW.
- Facilities for recycling CDW are not available.
- There are no funds to import the recycling equipment.
- There is no confidence in RCDW – even UNRWA (United Nations Relief and Works Agency for Palestine Refugees in the Near East) refused to use the material and preferred natural aggregates, which were more expensive and less environmentally friendly.
- The current political situation with the Hamas Government has resulted in constraints on the movement of international staff to and from Gaza, as well as on the contacts of the stakeholders to the new government.

5.2.4 Outlook

According to information received from the GTZ Project Office Gaza, new crushers are being imported:

- For a project implemented by the United Nations Industrial Development Organisation (UNIDO), the Italian Technical Cooperation (IDCP) imported 2 additional crushers in November 2006, with a capacity of 100 tons/hr each
- United Nations Development Programme (UNDP) intends to import 2 crushers (300 tons/hr each) to be used for treating the rubble in the ex-Israeli settlements in the Gaza strip – the 2 year project is being funded by the Israeli government. The crushers have been procured and will be paid by the winner contractor, who will perform the crushing against fixed cost per ton. The products will be given to the Palestinian Authority free of charge which will be responsible for selling or granting the products to municipalities and other organizations. The possible use is in pavement of agricultural roads and side walks. The UNDP is trying to convince the relevant Palestinian partners to use the recycled products as a base course in the construction of the side walks of the main road in the Gaza Strip.

Recently and based on lab tests, UNRWA has agreed to use the crushed products as a base course in road construction, which opens the door for creating and developing a good market for this new business. As reported by Rafah Municipality, the contractors have already started contacting Rafah Municipality requesting the material, which is expected to have a selling price of USD 7/ton, which covers the production cost.

GTZ Gaza approached all stakeholders and donors, in order to coordinate all initiatives concerning CDW and to co-organize a workshop with the Italians. Unfortunately, the workshop could not be implemented because of the critical security situation. GTZ has lost the leading role on the CDW issue, which is currently in the

hands of the crusher operators. However, more practical steps and results are expected in the coming months.

5.2.5 Sources of information

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- Personal communication from Wa'el Safi, GTZ Project Office Gaza.

5.3 Construction Waste Management – the Putrajaya Experience (Malaysia)

5.3.1 Responsible Authority/Persons

The information is based on seminar papers presented in 2003 (Ref. 7.10) and 2006 (Ref. 7.9) by Suresh Kumar Lachimpadi, together with Chui Yuet Yue and Zalina Ibrahim, of the Environmental Management Unit (EMU), Putrajaya Holdings Sdn Bhd.

5.3.2 Background and activities

Putrajaya is the new administrative seat of the Malaysian Government, following the Government's decision in 1993 to relocate the administrative capital from Kuala Lumpur as part of the decentralisation efforts. The construction of Putrajaya, 25 km south of Kuala Lumpur, commenced in 1996 and by 2005 it had 80,000 inhabitants. It is being developed in two phases: Phase 1 (1996-2000) and Phase 2 (2000-2010). The urban development concept of this model city is to build a "city in a garden", as well as an "intelligent city", which indicates that environmental issues are being given highest priority in the development and administration of the new city.

The developers, Putrajaya Holdings Sdn Bhd, have introduced an Environmental Management System, which takes care of the projects in the Construction Sector as follows:

- Planning stage: requiring a Waste Management Plan to be submitted with the application for planning approval; and providing the Putrajaya Environmental Management Guide as part of the contract and tender documents, instructing the bidders about the environmental requirements, which include waste management.
- Construction stage: commencing with a Kick-Off Meeting to brief the successful bidder on the need to submit an Environmental Management Compliance Plan, stating the types of waste that will be generated, the disposal method, the locations of approved dumpsites and other waste reuse/recycle plans; also ensuring that the contractors self monitor their project sites and submit their Environmental Monitoring and Audit Reports throughout the project period.
- Project completion: requiring a Project Closure Plan, which includes waste disposal (i.e. receipts and other evidence of waste disposal).
- During the entire project: project monitoring by the EMU of Putrajaya Holdings Sdn Bhd, which includes Surveillance, Enforcement, Awareness Promotion, Health, Safety, and Security.

The emphasis of the waste management practices is to ensure legal disposal on approved dumpsites and no open burning. Furthermore, contractors are encouraged to practice waste minimisation techniques, such as:

- Industrialized Building Systems;
- the use of metal formworks for casting concrete building components, to minimise wood waste generation;

- the use of steel tunnel formwork systems in high-rise buildings, constructing walls and slabs in one operation, thus reducing wood and plywood demand by about 80%;
- the use of metal roof trusses, avoiding the waste generated by conventional timber batons;
- the use of autoclaved lightweight concrete (ALC), saving on timber and plywood up to 70%, and requiring only skim coating instead of cement plastering, thus reducing wastes by 50%.

In the case of rejected fresh concrete from concrete batching plants, special steel moulds are provided for casting large interlocking concrete blocks, which are used as partition walls at raw material storage areas.

5.3.3 Problems encountered

Even with the Environmental Management System in place, it is difficult to track the final destination of wastes. Illegal dumping is still a problem.

As the waste minimisation methods are relatively new in the construction industry, various problems occur, such as

- damage and wastage caused by unskilled/untrained workers;
- building designs, which do not allow steel tunnel formworks;
- insufficient supply of prefabricated material for fast-track projects.

The Environmental Management System apparently does not foresee the reuse or recycling of construction waste (although waste segregation is recommended), but mainly focusses on legal disposal in landfills and on waste minimisation.

5.3.4 Outlook

The EMU of Putrajaya Holdings Sdn Bhd is aware of these problems and proposes the following measures in future:

- Environmental Management is to be included in the Bill of Quantities as a Mandatory Requirement and will be strictly monitored at the site.
- There will be more incentives, such as reduction of levy for Industrialized Building Systems or other construction methods that would drastically reduce the generation of construction waste.
- A special classification scheme will be introduced to categorise contractors who are committed to adopting “Best Environmental Management Practices” – an incentive to award new contracts.
- The rising cost of raw materials shall be used to push towards efficiency in material usage, manpower management (less labour intensive), better waste management and promotion of recycling/reuse of construction waste.
- Awareness promotion, in the form of training and seminars, shall be increased to ensure greater compliance with the environmental management requirements.

5.3.5 Sources of information

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6. Recommendations for further action

6.1 General considerations

As pointed out in section 3.13 “Significance of CDW in developing countries”, there are several reasons why it is difficult to introduce CDW management systems there, the first one being lack of awareness of the problems associated with the uncontrolled disposal of waste. It is well known that such awareness did not exist in the industrialized countries until the 1980s and it took more than 20 years to reach today’s level of expertise and professionalism in CDW management, which is now very encouraging and will continue to progress with growing momentum over the next few decades.

When comparing the conditions for introducing CDW management systems in industrialized and developing countries, there are great differences. While the industrialized countries have highly advanced and almost evenly distributed infrastructure, as well as the financial resources, most developing countries lack both. Furthermore, overpopulation, the explosive growth of urban areas, political instability, and a few other problems in developing countries have created more obstacles than industrialized countries had to face. Therefore, it is reasonable to assume that progress in introducing CDW management systems in developing countries will be slower than in industrialized countries.

On the other hand, developing countries can benefit from the experiences made by industrialized countries and can avoid some of their mistakes, although a successful approach in an industrialized country may not necessarily meet with the same success in a developing country. Nevertheless, help from industrialized countries will be essential for most developing countries, particularly in terms of advice on technical, administrative and legal issues, supplying equipment and in some cases financial support.

In view of the urgency and magnitude of the CDW problem, it would be highly justifiable for the Holcim-GTZ PPP2 to give it the same significance as for co-processing waste materials in cement production in PPP1. The greatest benefit can be derived from supporting institutions and experts, who have already made some progress in developing countries, as their motivation and level of expertise are high. In order to ensure smooth progress, these could preferably be institutions and experts, who have been cooperating with the GTZ and/or Holcim in the past or in ongoing projects.

6.2 Next steps

Since the Holcim-GTZ PPP2 is scheduled to end in mid 2008, the possibilities of undertaking even a small CDW project in a developing country are very limited. Drawing up a project concept, organising and implementing it, as well as conducting a final evaluation would take too much time.

However, thoughts can and should be given to finding suitable ways of promoting CDW Management in developing countries, where very little progress has been made so far. And the best way to do so is to discuss the issues in a brainstorming workshop with experts from industrialised as well as developing countries. Answers to the question, “What is required to promote CDW in developing countries” should emerge from this workshop. This valuable information should be well documented together with sufficient supporting information and widely circulated to all the stakeholders in the building industries, as well as governmental and research institutions in developing countries. Hopefully, this will generate wider interest than before, leading to increased activities in reducing, reusing and recycling CDW.

Therefore, the next steps are proposed as follows:

a. Brainstorming workshop

The participants of this workshop should be European CDW experts and selected experts from developing countries. It would be an advantage to include representatives from the European CDW industry, who might be interested in establishing partnerships with institutions in developing countries. The workshop should be coupled with a visit to a recycling plant.

In view of the short time available, the question, "What is required to promote CDW Management in developing countries," should be divided into subcomponents and discussed in small working groups, the results of which should be subsequently presented to all the participants. These can then be discussed jointly to identify areas of further action and how to go about them.

b. Publication of a discussion paper

The outcome of the workshop should be carefully recorded, with the aim of publishing a discussion paper for dissemination in developing countries, in order to sensitise the stakeholders about CDW issues and how to tackle them. It should be sufficiently detailed to provide all the main facts and explain the proposed actions for non-technical people to understand, but should be kept as concise as possible.

7. References (January 2007)

Below is a selection of information sources, mainly from the web. The information sources from countries in which CDW management is advanced, such as USA, Canada, Western European countries, Australia and New Zealand, are almost unlimited, therefore this can only be a representative cross-section.

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