Preface

In the most recent project the American Institute of Architects New York Chapter led with the Chinese University of Hong Kong Architecture Department, sustainability has been the focus of an interdisciplinary workshop held in China. Sustainable planning, design and development refer to the strategies of practice and intervention aimed to accommodate present human needs in a manner, which considers the full spectrum of indigenous natural and cultural systems. It also seeks a course of minimally disruptive action that will lead to the systems' enhancement and long-term viability. For sustainability to be embraced as a guiding principle in the Chinese context, it must be shown to offer clear and compelling economic and social benefits. INFORM has made a substantive contribution by examining critical areas of a resource intensive process: construction and demolition (C&D).

The pace of construction in China has steadily quickened over the last decade. Compared to agricultural communities and fishing villages, modern high-rise buildings not only offer many new amenities but also introduce other environmental side effects. During this juncture, it is all the more important to embrace a cradle-to-cradle concept in design and construction. With the appropriate implementation strategies, economic development and sustainability can be complementary.

It is recognized that sustainable design and construction tackles issues such as energy and water efficiency, air quality, and environmentally friendly building materials. This paper is based on an INFORM research report and focuses on a specific area of resource efficiency: construction and demolition waste reduction. The full report is a comprehensive analysis using New York City public construction and current private sector practices as a reference. While waste reduction theories and methodologies for building professionals are universal, regional contexts may vary in both the United States and China. Readers are encouraged to adopt innovative approaches to enhance this material and resource intensive process in the creation of our built environment.

Joyce S. Lee, AIA
Chair, Committee on the Environment
American Institute of Architects, New York Chapter

Introduction: Why Prevent C&D Waste?

Waste prevention, also called source reduction, means reducing the amount or toxicity of waste generated. It can be accomplished by reducing the quantity of materials used, or by reusing existing materials. In contrast to waste prevention, recycling is a method of managing waste that has already been generated. Waste prevention conserves natural resources, avoids the energy needed to manufacture new products, and reduces pollution.

Since most C&D waste is land-filled, preventing the generation of this waste can substantially decrease the need for landfill space. This, in turn, decreases the need for trucking and for processing waste at transfer stations, as well as the fuel use and environmental impacts that those activities impose. Upstream, preventing C&D waste reduces the need for extracting and processing of raw materials, and it lowers the cost of their collection, processing, and disposal. In economic terms, waste that is prevented does not incur any management costs. Preventing waste by reusing materials and purchasing more efficiently also saves money on avoided procurement.

Because of the enormous benefits that accrue from waste prevention, US Environmental Protection Agency (EPA) has made it the top waste policy option, above recycling, landfilling, and incineration. It has also been recognized by the United Nations as a crucial element in achieving environmental sustainability.

Part I The Project Planning Process

Preparing a Waste Plan and Setting Waste Prevention Goals

A waste plan is critical simply because it puts waste on the map. The first step is to identify where potential problems lie. It can include an analysis of waste to be generated by materials and quantities along with an estimate of waste management costs.

A complete waste plan for construction projects lists specific materials (concrete, bricks, wallboard, metals, wood, etc.) and identifies targeted amounts for reduction, salvage, reuse, or recycling. An additional timeline makes it possible to identify when specific materials will be generated (e.g., rubble from demolition or packaging from interior finishing) in the construction process. With this approach, waste prevention goals can be set for the project, along with goals for specific materials and arrangements for storage, shipping, or reuse. Incorporating the goal of waste prevention into the project's specifications can bring the client one step closer to reducing the amount of C&D waste going to the landfill.

Establishing Responsibility for Waste

Clearly assigning responsibility for waste at the planning stage of a project can provide an incentive to reduce the amounts generated later on.

The demolition contractor is always responsible for demolition waste. Once construction begins, it is usually the general contractor (GC) who is responsible for providing dumpsters and managing materials for reuse, recycling, or disposal. On private sector projects, the general contractor hires the subcontractors and therefore can exert some pressure on them to be less wasteful. The GC has an incentive to do this because money saved through waste prevention belongs to the general contractor.

Extended producer responsibility (EPR) policies extend producers' responsibility for their products and packages to the end of their lifetimes. Selecting suppliers' contingent on their willingness to take back materials does not necessarily increase costs. A company, however, that takes them back may save money by doing so.

Educating the Participants and Publicizing its Waste Prevention Goal

A good waste plan educates all the participants in a project: contractor, architects, facility managers, suppliers, and workers. On most construction projects, waste is not a priority. The waste plan would, therefore, increase awareness of the issue, and help establish waste prevention goal. One approach is brainstorming about the project-specific waste prevention. This can help promote the behavioral changes needed to prevent waste. Even earlier in the process, general training sessions can be held on environmentally responsible construction.

Part II Waste Prevention and Building Design

Design is at the heart of waste prevention. Architects have the major responsibility for every construction project: they set its direction and interact with the client and all of the contractors. Waste prevention cannot be accomplished unless the architects are committed to it and have a good understanding of the required strategies.

Choosing the Architect

Waste prevention is unlikely to happen without real advocacy by designers. Since "we've always done it this way" is a common refrain in construction, committed architects not only have to find ways to incorporate waste prevention into their designs, they must also be vigilant in ensuring that new design approaches are properly implemented by contractors.

A key to success is choosing an architect who is both knowledgeable and enthusiastic about the issue. Asking prospective architects to provide documentation of their prior experience in waste prevention provides useful information about their background.

Once an architect is chosen, it is essential that he or she produces a clear design and establishes good communication with the contractors. This will help prevent wasteful mistakes in electrical, mechanical, and structural installations. No documentation exists on how much waste is created from undoing and redoing in construction projects, but anyone involved in construction knows how often this occurs. Sometimes the plans are unclear or incorrect, at other times the contractors misread them. The result is construction that does not function properly and must be torn out and re-done. Sometimes there is a mismatch between designers and contractors.

In many cases, computer-aided design (CAD) can be a great help in the design process, as well as in the accurate sizing and management of construction materials. It can help coordinate design changes so that a change made on one set of plans for a project is carried through on all the other plans as well.

Reusing Existing Buildings and Materials

Designers can contribute to the reuse of buildings in three ways: 1) by reusing an existing building instead of building a new one, 2) by reusing the materials in an existing building, and 3) by designing a new building to facilitate its reuse in the future.

Building reuse is an asset management issue, but it is also a design issue. Reusing and renovating a building instead of building a new one can reduce materials use and waste, and it can also save money. The decision to reuse is ultimately made by the client, but architects can play a major role. Their training equips them with a special ability to identify creative possibilities for the reuse of structures and materials. They can perform feasibility studies, lend their expertise to asset management decision-making, and participate in value engineering process.

Moreover, reuse of existing structures can also reduce the need for new infrastructure—roads, sewers, electrical supply—and all the waste that these create. Since most architects are accustomed to buying "new," just making them aware of the possibilities of reuse can be a big step forward.

Preventing Obsolescence: Design for Durability and Adaptability

Length of product life is a key to preventing waste: if a person wears a coat for ten years instead of five years, the waste generated per year of use is cut in half. Durability of materials and style of the coat determine the length of its life—even if the materials are still serviceable, it may be discarded because it is unfashionable. The situation with buildings is similar but far more complicated. Waste can be prevented and much money saved by designing buildings that last longer. Longevity of building is determined by the durability of materials and construction, and also by its adaptability to changing needs.

Durability of Materials and Construction

If the objective is longevity, durability needs to be balanced with adaptability. Making a building or its components more durable can save money in the long run and also reduce environmental impacts by reducing the materials consumption and waste generation result from replacement. On the other hand, if a building constructed for durability is destroyed long before its expected life span is completed, the reverse may be true, because the durable materials, which may have cost more, will not have provided their optimum benefits.

The fact that different components of a building have different life spans has to be factored into the design. Whereas the building's outer shell may be designed to last 50 to 100 years, the service elements (heating, ventilation, light, and power) may last only 15 years and the interior elements (ceilings, partitions, communications equipment) only five years.

The accounting systems used to evaluate bids have an important impact on the material selection. In public construction procurement, many decisions are made by accepting the lowest bid based on "first costs" only. This may lead to the purchase of lower-quality, less durable materials. Yet, life cycle costing that looks at costs over the entire lifetime of the product is likely to yield the greatest economic and environmental benefits.

Adaptability

There is little point in making a building more durable if it is not adaptable to future needs and is therefore likely to be demolished long before the end of its projected life. Durability decisions must factor in anticipated changes in functional needs, fashion, and technology. The shell of a building needs to be durable and to include design elements that facilitate future additions to the structure. Adaptability is particularly important for interior elements, which are most likely to be altered frequently.

At this early stage of the "information age," the needs that buildings must serve are already changing very rapidly. Desktop hardware has proliferated—computers, fax machines, and printers require different work surfaces, storage, and space configurations. This equipment has also increased power demands and altered lighting, ventilation, and thermal management requirements. These demands require adequate floor-to-floor height and power systems that are accessible and expandable.

The problem is compounded by the difficulty of predicting future needs and by clients' interest in obtaining new buildings that provide the best fit to current needs. Again, it is necessary to strike a balance—if the probability of a building's future conversion is low; it is not worth the added cost for adaptability.

Design for Disassembly

Around the world, products are increasingly being designed for disassembly. New designs have resulted from "extended producer responsibility" (EPR) laws, which require companies to take back and recycle their products. In Germany, the automobile industry has pioneered design for disassembly techniques and has built large factories to disassemble vehicles. An interesting question is to what degree this new idea could be applied to construction.

Some key features of the design of cars for disassembly are: 1) identifying and labeling plastics by resin, 2) using fewer fasteners and fasteners that facilitate disassembly, 3) selecting materials that can be reused or recycled, 4) reducing the number of different materials used, and 5) eliminating toxic components whenever possible.

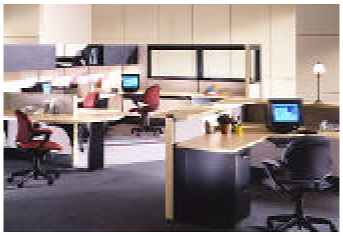
Some of these strategies are clearly applicable to construction. For example, screws or other fasteners might be used instead of nails or adhesives, and the labeling of materials would facilitate disassembly and reuse. Basically, these techniques involve a change in thinking: in drawing up plans, designers need to consider how the structure will be handled during renovation, rather than simply focusing on getting the project built as quickly and cheaply as possible. A sharing of industry knowledge is part of what are required to bring about such change in the construction industry.

The buildings of today are the forests of tomorrow—a potentially huge resource for materials that can be reused and recycled. Design for disassembly is the key to making the reuse and recycling of today's buildings economical. One problem is that a great deal of composites and particle boards are used in construction today—they will have little value for reuse or recycling in the future.

Documentation of architectural plans can also have an important role in the disassembly process. It is important to retain plans and develop an efficient system for accessing them many years later when renovation takes place. In addition, supplementing plans with photographs taken during construction can help pinpoint where studs and wiring systems are located.

In contrast are the "intelligent" electronic products now under development by some European electronic equipment manufacturers. These products contain a computer chip known as a "green port", which provides information to facilitate disassembly and reuse. It would be helpful if buildings likewise reserved a specific place where the original architectural plans were kept along with documentation of renovations and any other information relevant to disassembly and reuse.

Movable Walls



Open-space offices with modular wall panel systems are a major innovation in design for disassembly that has already affected the construction industry. While these designs come from the furniture industry, they accomplish significant C&D waste prevention because they replace fixed walls with flexible systems that permit space to be reconfigured by disassembling and then reassembling the components. The systems also allow for simple replacement of any damaged sections. In the past, before these systems became available, reconfiguring office space meant tearing down walls and building new ones, which created waste not only from the destroyed walls but also from the ceilings, flooring, and electrical systems damaged in the process. Although modular panel systems are initially more expensive than gypsum wallboard, their benefits have been recognized and they are widely used.

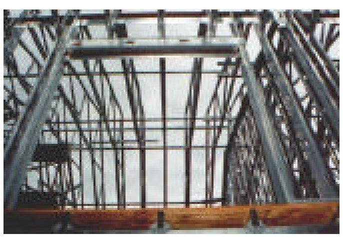
Technology for modular power cabling has been available for 20 years. Wall systems can be designed with the wiring inside the panels and these can be coordinated with network floors that provide easy access to electrical outlets. Moving the panels simply requires plugging them into a different outlet in the floor. Such systems can meet growing electrical needs and reduce waste substantially.

Using Less Material

Materials use can be reduced in a variety of ways at the design phase. These include the use of efficient framing techniques, standard size supplies, prefabricated materials, and the incorporation of salvaged materials into the design.

Using standard sizes in the design prevents the creation of cutoff waste and optimizes the use of materials. Also, materials can be purchased with greater ease if they are of standard dimensions.

Architects also point out some difficulties in designing for standard sizes. The sizes of materials are often based on ergonomics—the ability of a man to lift and carry a load, for example. This may not mesh with functional needs—such as the most efficient and comfortable height for a kitchen or office work surface.



Selecting certain types of materials can greatly contribute to waste prevention. For example, modular or prefabricated materials such as trusses, wall sections, and pre-cut studs and joints eliminate the waste from on-site fabrication. When production is done in a factory, waste is generally reused; at a construction project site, however, cutoffs and other waste are typically disposed of.

The quality and strength of new materials also need to be taken into consideration. This requires builders to increase their familiarity with the structural performance of the materials they plan to use in construction. In other words, it is important to avoid over engineering and to ensure that building codes are updated to factor in new, stronger materials. Incorporating previously used/salvaged materials into the building reduces the demand for new materials and the amount of waste generated.

A final issue concerns the temporary structures that are often used during the construction and demolition process. These may be essential in renovation projects, when the building has to continue functioning throughout construction. However, in the interest of waste prevention, temporary structures should be avoided whenever possible. They require a significant investment in labor and materials for a very short useful life.

Part III Construction Site Waste Prevention

In addition to the waste prevention strategies implemented during the planning, design, and deconstruction phases, INFORM found some that relate to the construction site itself. These strategies mainly involve the effective coordination of materials management, including efficient purchase and ordering of materials; efficient timing and delivery; efficient storage; and the use of materials to minimize loss, maximize reuse, prevent undoing and redoing, and reduce packaging waste.

Planning and Timing of Purchase and Delivery

To reduce the waste generated on site, coordination among all those involved in the design and construction process—managers, contractors, subcontractors, and suppliers—is essential. Meetings that bring together all of these parties should occur on a regular basis to address waste issues.

Because the contractors are responsible for ordering and purchasing materials, it is important that they tighten up estimating procedures to ensure that correct amount of material is delivered to the site at appropriate time. Excess purchases also increase the risk of material being lost, damaged, or stolen. This risk can be reduced through proper coordination between contractors and suppliers to arrange just-in-time deliveries.

The reduced storage needs resulting from just-in-time delivery are an important benefit. However, for items that are needed on a regular basis, just-in-time delivery can only work if the trucking firm is always available. Greater flexibility in parking policies would also be needed to accommodate frequent deliveries.

Storage and Handling

Once materials are delivered to the site, proper storage and handling are keys to preventing loss or damage caused by exposure to moisture, dirt, or temperature changes. For instance, bags of mortar need to be covered in plastic for protection from moisture; bricks and blocks must be stacked carefully so they will not get lost in the mud; and lumber must be covered and kept off the ground. In other words, not only is it necessary for materials to be stored where they will be secured and protected, they also need to be stored in a configuration that prevents structural or finish damage. Knowledgeable workers are, however, necessary to implement this goal.

Facilitating Materials Reuse

Reuse is a viable option for many of the most common construction site waste materials: brick, concrete, and other masonry, as well as wood, gypsum wallboard and carpeting.

Brick, concrete, and other masonry materials can often be reused if still intact. Mobile grinding units can be used to break down damaged concrete structures and the resulting aggregate used as sub-base material or backfill on site. Brick can also be crushed and used for landscape cover, sub-base material, fill, or driveway bedding.

Wood waste can be prevented and wood reuse promoted by centralizing the location of cutting operations. This encourages workers to use cutoffs whenever possible, instead of fresh pieces of full-sized lumber. Wood scraps that cannot be reused as is (such as damaged or unfinished wood chips) can still be reused in other ways. For example, mobile grinding units can convert them into walkway surfacing materials or mulch for on-site landscaping.

Gypsum wallboard that is efficiently installed will leave minimal scrap behind. Although wallboard scrap can be reused around doors and windows, this requires careful planning with the installer. In home construction, gypsum wallboard scraps are sometimes placed inside wall cavities to reduce the amount of waste for disposal. This can improve soundproofing and insulation but must be carefully evaluated in larger construction projects.

Carpet leftovers in good condition can be reinstalled in areas such as basements where rough conditions make aesthetics less important. Unworn sections of old carpets can be made into mats for hallways and entryways. Carpeting in very good condition can sometimes be salvaged and resold.

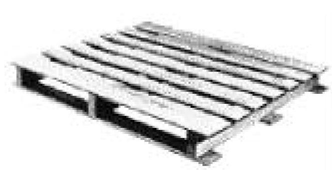
Preventing Undoing and Redoing

Undoing and redoing of work on construction projects result in the waste of materials, time, and money. These include work that is defective and must be torn out and redone, poor coordination among contractors, work that is not done according to the plans, and work that the client finds unacceptable.

The current practice of awarding contracts to the lowest bidder also promotes undoing and redoing as it can sometimes lead to the hiring of less skilled, more wasteful contractors.

Undoing and redoing of work can be reduced by better coordination and communication among the different contractors on a project, by better supervision, and by making an effort to consolidate responsibility for the completed job.

Reducing Packaging Waste: The Take-back Option



Packaging has been a major focus of waste prevention all over the world. Germany led the way in 1991 when it mandated that producers take responsibility for collecting and recycling packaging waste. This policy approach, now known as extended producer responsibility (EPR), has spread throughout Europe and Asia and to some countries in South America. The rationale for EPR is that if producers must take back and recycle packaging at their own expense, they will use packaging that is less wasteful and more economical to recycle.

This strategy can be included in construction contracts by requiring suppliers to take back packaging. Likewise, unused/leftover construction materials can also be taken back.

In construction projects, substituting reusable shipping containers for single-use containers has the potential to reduce packaging waste considerably. The feasibility of reusable containers is determined by factors such as shipping distance, delivery frequency, distribution patterns, and whether or not company-owned vehicles are used. Reusable containers generally cost more up front than single-use containers, but over their lifetimes the cost per shipment may be far less. Because they are sturdier than single-use containers, they reduce product damage and also the labor costs involved in breaking down containers for recycling or disposal.

Conclusion

The concept of salvaging and reusing materials is not new. Throughout Europe, there are old churches built from the bricks of even older Roman ruins. Columns from ancient Greek and Roman structures support the famous underground cisterns of Istanbul.

Nor is design for disassembly a new idea. Traditional Japanese farmhouses were constructed without any nails, and can be disassembled and reassembled like a puzzle. Today, many of these beautiful old structures are shipped to other countries for use as residences or inns.

Construction and demolition waste is one manifestation of our throwaway society. It is unique, however, in representing not only a huge percentage of the waste stream, but a part of our heritage that is being discarded as well. At an exhibit of Frank Lloyd Wright's architecture at the Museum of Modern Art in New York City, the notes for each building indicated "year built" and also, in many cases, "year destroyed." Much of the work of one of the greatest architects of the twentieth century landed in the C&D waste pile.

The future will be different, not necessarily because people decide to behave differently, but because the underlying factors will necessitate change. Let's assume that buildings erected today will last into the second part of the twenty-first century. What will the world be like then?

The earth will be home to about 10 billion people, compared to 6 billion today. The standard of living in heavily populated countries like China and India will have increased dramatically. This means much more crowding, much more pressure on material resources, and much greater strains on the planet's capacity to absorb wastes. When today's buildings reach the end of their useful life, the option to demolish and send them to the landfill may no longer exist. Instead, economic and ecological realities may dictate that they be preserved, refurbished, reused, or, when none of those options is possible, that their component materials be salvaged. In such a scenario, buildings designed for disassembly—those made with durable, well-marked materials, minimal toxic constituents, and able to be easily taken apart—will have the greatest value.

This paper is an excerpt from "*Building for the Future: Strategies to Reduce Construction and Demolition Waste in Municipal Projects*" by INFORM. For the full report, please visit the website at http://www.informinc.org/cdreport.html

Biographies

Bette K. Fishbein –

Joyce S. Lee --

Niles K. Ho --