DECONSTRUCTION AND DESIGN FOR REUSE: CHOOSE TO REUSE

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ABSTRACT

This paper/presentation will detail the theories and realities of a project to deconstruct a 1930's, 1,400 square feet wood-framed house for reuse into the construction of an approximately 3,600 square feet social services facility for at-risk young men. The paper/presentation describes how design for reuse can be applied to existing building materials in situ when the new building use is known prior to deconstruction. This presentation/paper will describe the reuse design, and processes, environmental issues, technical and regulatory issues involved in creating a model for other potential applications of deconstruction/reconstruction as a single continuous project.

KEYWORDS: Deconstruction; Building Materials Reuse; Design for Reuse

INTRODUCTION

Excerpt from Design Q&A by Charles and Ray Eames, 1967. The following questions were asked by Madame Amic and answered by Charles Eames.

> **Q:** What is your definition of "design?"
> **A:** A plan for arranging elements in such a way as to best accomplish a particular purpose.
>
> **Q:** Is it a method of general expression?
> **A:** No – it's a method of action.
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> **Q:** Does the creation of design admit constraint?
> **A:** Design depends largely on constraints.
>
> **Q:** What constraints?
> **A:** The sum of all constraints. Here is one of the few effective keys to the design problem - the ability of the designer to recognize as many constraints as possible - his willingness and enthusiasm for working within these constraints - the constraints of price, of size, of strength, balance, of surface, of time, etc.; each problem has its own peculiar list.

Design Q&A was written at a time when most designers considered material constraints primarily in terms of costs, utility and aesthetics, and when resource scarcity and environmental impacts were not given their current emphasis. Regardless of a greater understanding of the environmental impacts of the built environment, the concept that the designer must solve human needs within a fully recognized set of constraints is timeless. Waste is not inevitable, but the result of design decisions – whether through intention or omission. Failing to consider the implications of building design on the use and waste of limited natural resources leads to significant problems.

US EPA has estimated that U.S. companies generate 136 million tons of building-related construction and demolition (C & D) waste per year, of which 92% is from renovation and demolition. With the US building stock rapidly aging and pressure rising to upgrade it, this waste stream can only increase. EPA has also estimated that only 20-30% of C&D waste is presently recycled.

The building industry has an enormous environmental impact. The U.S. Geological Survey has performed a "materials flow" analysis showing that, excluding materials used for food and fuel, construction activities consume 60% of the total materials used in the U.S. economy. The continued use of virgin materials for construction consumes enormous amounts of material and energy, while continued disposal of building waste fills up landfills and buries potential resources rather than extracting their maximum value for productive uses. Both upstream and downstream impacts of these practices increase emissions of greenhouse gases – from the loss of forests as carbon sinks, the burning of fossil fuels in virgin product extraction and manufacturing, and the release of methane (a greenhouse gas 21 times more powerful than carbon dioxide).

While recycling of C&D debris is an important part of the solution, efforts are growing within the solid waste community to find innovative reuse options that, in accordance with EPA's long-standing "solid waste hierarchy," preserve even more of the value incorporated in the original product while saving more energy and producing fewer greenhouse gas emissions than recycling could.

Deconstruction is defined as "the disassembly of buildings so as to safely and efficiently maximize the reuse and recycling of their materials." While limited salvage has long been a part of demolition practices, deconstruction aims to increase reuse options by pushing materials salvage beyond such items as windows, doors and light fixtures to include such elements as flooring, siding, roofing and framing where these materials have retained their value. In some cases, deconstruction can generate items that are no longer available anywhere – such as the old-growth Douglas fir and redwood lumber that has been removed from closing military bases.

Deconstruction has been growing, but it remains an immature industry that has not yet gained wide acceptance. In order to succeed, deconstruction needs to be developed to the point that industry and policy makers can understand it as a transparent, flexible, mainstream, and intelligent alternative to demolition.

Current roadblocks to the growth of deconstruction exist at the both the "supply-side" and the "demand-side" of building materials' life cycles. At the supply-side is the design of buildings and construction techniques and materials that hinder disassembly and reuse. At the demand-side is the failure of designers to specify used materials where appropriate; and the failure of building codes to address the reuse of building materials. Nascent research is beginning to address some of these problems, e.g., the University of Florida is studying the issue of "design for deconstruction" and the USDA Forest Products Laboratory is studying how to appropriately regrade reused dimensional lumber. However, demonstration projects are needed to prove the validity and attractiveness of deconstruction and materials reuse options – particularly to the private sector.

Design for Reuse (DfR) seeks to demonstrate resource efficiency at both ends of the building lifecycle.

The Design for Reuse project used as a basis for this paper was begun with the understanding that waste and irresponsible use of our limited resources is the result of design, that DfR has the potential to mitigate the environmental impacts of building construction, and that in order for DfR to fully realize its potential benefits, it must be accepted from the beginning of the design process as a primary constraint around which the design problem must be solved. This has already been done in a number of industries such as manufacturing, software design, and content development.

The paper begins by examining some of the current DfR practices in other industries in light of what we can learn and apply to building design. From there, it follows the progress of a case study project with an emphasis on some of the ways in which a DfR project may differ from the traditional design process.

Ultimately, it hopes to demonstrate that efficient use of materials and waste minimization are integral constraints that need to be addressed in any building project. Through Design for Reuse, building designers can not only reduce waste, but also discover additional potential for creativity and excitement in design.

DESIGN FOR REUSE LESSONS FROM OTHER INDUSTRIES

Design for Reuse is a concept that is already widely recognized in a number of fields beyond building design and construction. From manufacturing to software design, the idea of getting additional use out of invested resources (material, energy, or human) is well established and supported. This paper will briefly explore what is being done in other industries in order to discuss what can be learned from these industries as well as what is different for DfR in the building industry.

In manufacturing, "design for reuse" has been used to refer to several different concepts. One use of the phrase involves the design of a manufactured product in such a way that it can be used multiple times. This could be repeated use for the same purpose, as in refillable containers, or a secondary use after the first is complete, as in the WOBO beer bottle which was designed to serve as a brick-like building block for use in housing (reference?). The other manufacturing concept is to reuse design or components within a product – e.g. using a shared car chassis throughout several years of a particular model of car or even across model lines.

Design to accommodate multiple, sequential uses of a product demonstrates that usefulness can have a longer timescale than first use – the product can outlast an initial use, for example packaging to be used as something else, or last through several uses, such as pallets that can be used multiple times. One factor that contributes to the probability that a product will last through several uses is durability, so that the first use does not wear it out. Extra investment in the original production can realize savings over the total life cycle. Another means of assuring that utility outlives several uses is to design for compatibility – more universal design of a component means more potential for reuse. Many building materials exhibit this quality. Standard dimensional lumber can be used in many different applications with ease. Standardized masonry units are also universally useful. Consistency of size across the US ensures that bricks from different origins or sources can be easily incorporated into a single project.

By planning to reuse individual components within models or across model lines, the automobile industry reduces design time and manufacturing set-up changes. Rather than beginning each model from scratch, refinements are made to an established and generic base design. The more flexible and universally useable the base design, the more likely and efficient reuse of that design will be (reference?).

In software design, design for reuse refers to program design that uses standardized packages of code that perform commonly needed roles. With some extra upfront investment to design reusable bits of programs, those bits can be utilized across many different software applications resulting in greater efficiency and reduced design time, making the companies which adopt this practice more competitive (reference?). When beginning to move towards incorporating design for reuse into their work, software companies are advised to keep some things in mind that are just as useful to building designers as software designers. The first step is to look at the current practices within the company to see if some informal reuse is already taking place and to evaluate existing work in light of reuse potential. This step involves working from what is available and is one of the main principles of reuse that will be explored later within this paper. After the initial assessment of the company's work is completed, subsequent work is evaluated in terms of how well new code facilitates eventual reuse by others. This is the key to achieving ever-greater design productivity. For buildings, designing for future reuse is the key to ever-greater material efficiency and waste minimization.

THE PROJECT

In most respects, the process of DfR will be the same as any other design project. Notable exceptions relate to specific communication with the client about goals and expectations for reuse, careful planning for and acquisition of salvaged materials, and in some cases, greater creativity and flexibility in the design itself to fully utilize the unique potential of reused materials.

Project Initiation and Client Communication

It is critical that the client is supportive and informed about the reuse of building materials in any project. That said, there is much that the architect or designer can do to explain the importance of reuse and allay client fears or concerns about the feasibility, quality, and appearance of reused materials.

The case study is this paper was somewhat unique in that the project began with an availability of materials rather than a programmatic need. Gainesville Regional Utilities (GRU), a municipally-owned utility possessed a vacant 1930's, 1,400 square feet wood-framed house, for which it had no functional use. Owned by successive generations of the Wesley family, the house was maintained and used as a residence for many years while land-use changes around the property resulted in the surrounding single-family residential neighborhood being replaced by the expansion of GRU facilities to meet the needs of Gainesville, Florida's growing population. With the passing of the last member of the Wesley family who wished to live in the house and the unsuitability of the structure for any of GRU's needs, the property was left vacant for several years. GRU investigated relocating the house in its entirety, but found this plan to be prohibitively expensive and could not find an interested and appropriate new user for the house "as-is".

After learning of the University of Florida's Powell Center for Construction and Environment's (PCCE) research and work in the growing field of deconstruction, GRU became interested in pursuing a partnership to find a new use for the Wesley House. Deconstruction of the house offers a method of removing the house with a minimum of waste while at the same time finding a new use for the materials available from the house in a manner that provides much more flexibility of reuse than simply moving the building.

After a search for potential recipients of the building materials, GRU found the Reichert House program for at-risk youth, which was preparing to begin design and construction of a new 3,600 square foot facility, and was greatly in need of support.

PCCE met with the director of the Reichert House Program and learned that some of the primary needs for the new facility were durability of the materials and affordability. Discussions about the reuse of the building materials revolved primarily around these issues with less attention devoted to questions about appearance, which is another concern that many clients will bring up in regard to reused materials. In terms of durability, while the finish materials from the Wesley House (primarily a large quantity of beadboard) were not suitable for some of the high-impact recreational spaces of the new facility, the Wesley materials could be used to advantage in a number of different areas of the building. Generally, PCCE and the Reichert House director felt that the beadboard could outperform the more standard drywall and plaster in terms of impact resistance and general wear. Another advantage of employing reused finish materials is that the pre-distressed condition of the beadboard could be used as a positive feature within the design. "New" is an inherently temporary condition. Polished surfaces, particularly in high-use areas, can quickly become marred or dented. Such inevitable imperfections will then standout noticeably from the rest of the finish surface giving an impression of wear and disrepair without active and costly maintenance. By using a material with an established history of use and a surface that is able to wear gracefully, the interior of the new Reichert House should be able to withstand years of hard use without requiring expensive maintenance to keep it looking the way that it was intended to be at the time of construction.

Acquisition of Materials

The acquisition of reused materials is distinctly different than acquiring new materials. New materials are typically available in any quantity desired and, with some planning, at any time they are needed. This has not always been the case. In many ways, designing for reuse is akin to historical building practices where local availability of materials, and conservation of materials was a primary design constraint. The "grave-to-cradle" approach directly ties the removal of one building (maximizing the efficiency of "mining" its resources) to the construction of another (minimizing the consumption of new resources).

Before beginning the design of the new facility or deconstructing the Wesley House, a careful inventory of the materials in the Wesley House was prepared. PCCE worked with the director of the Reichert House and the architect to review the inventory, set reuse goals for the new construction, and focus deconstruction efforts on materials that were the most suitable for reuse in this project. The material inventory was examined in light of a realistic salvage rate in order to calculate projected salvage yields. These projections established the potential area of the new facility that might reasonably be constructed from the salvage. After deconstruction, another inventory will be taken in order to verify that the required materials were salvaged.

Flexible Design

Throughout the design process, flexibility is invaluable. Initial reuse goals or material inventories may turn out to be unrealistic during deconstruction or material acquisition, or new material opportunities may present themselves and require a change of plans to fully take advantage of them. The principles of Design for Reuse were developed to help designers recognize and take advantage of the unique opportunities presented by reused materials and to approach the design with the necessary open-mindedness and flexibility.

Principles of Design for Reuse

These principles are not intended to be comprehensive, but to serve as a starting point and collection of stimulating ideas. The nature of the task of designing for reuse allows for a great deal of creativity on the part of the designer. The collective ingenuity of the design profession is bound to make any list of principles quickly obsolete as new strategies for dealing with the universal problems of resource inefficiency and waste are developed.

1. Work with what you have

The first principle is simple – a phrase that appears in almost all writings dealing with the reuse of salvaged materials. **Work with what you have** available (reference?). The fundamental difference between designing with reused as opposed to new materials is that the materials have already been fabricated or processed and dispersed into the built environment. If you examine the flow of new or recycled materials en-route from production to use in a building, the materials begin in large volumes and concentrations at production facilities and progressively smaller distribution warehouses until the final truckload delivers the precise quantity of materials needed at widely dispersed construction sites. The process is reversed when designing with reused materials. Salvage operations begin collecting dispersed and widely variable materials. The future certainly holds the promise that reuse networks and markets will duplicate the consistency and availability of first-run material production, but for the present working around what is available for reuse is more productive. It may also be best if reuse suppliers do not pattern themselves after first-run producers. One of the strongest arguments for reuse is the environmental benefit from conserving energy resources. The more energy invested in gathering materials, transporting them to regional distribution centers and then back out to individual job sites erodes the potential savings of reuse. It is part of embracing the design constraint of choosing reuse to adopt a different attitude towards resources. Instead of ignoring the hidden costs of material production and proceeding from the assumption that there is an infinite and cheap supply of whatever material is desired, reuse begins with the concept that supply is limited and valuable.

2. Kit-of-parts

One strategy for working with the materials that are available is to define a kit-of-parts from which to work. Like a child's stack of blocks or set of Lincoln Logs, the design problem becomes how to achieve the desired end with the pieces on hand. There are many models for how to define and use the kit. They range from the highly specific methods used in some historic preservation projects where building parts are literally numbered and reassembled, to a more modular approach with a certain number of construction elements that can be configured in nearly infinite relationships. The most useful way of working with a kit-of-parts will depend upon the project – the more limited the palette of materials, the more rigorous and careful the designer will have to be with the kit.

3. Opportunistic and systematic reuse

A refinement of the kit-of-parts strategy is to utilize a combination of "opportunistic" and "systematic" reuse (reference?). These terms have been adapted from the software design industry and define two levels of precision of reuse. Systematic reuse is a detailed and planned approach. Pieces to be reused are identified before construction and numbered or labeled. Each piece is specifically identified in the construction documents. Opportunistic reuse is less specific. A quantity of material is made available for the contractor or workers to use as needed in the project. An example would be a bundle of reused studs that can be pulled from as required throughout construction. Used in combination, opportunistic and systematic reuse provides a flexible system for dealing with fixed supplies of available reused materials. Depending upon the building design and structural or non-structural materials that are needed, systematic or opportunistic reuse will be more applicable. A post and beam structure will require a systematic approach as spans and strength of materials must be pre-determined. Non-structural surface materials may lend themselves more readily to opportunistic reuse whereby structural qualities are less important and finishes can change from surface to surface or even on one surface, as with a partial height wainscote. The availability and kinds of individual versus bulk materials will also affect systematic versus opportunistic reuse. A one-of-a-kind material is inherently a systematic reuse.

4. Soft-palette

The term soft-palette refers to a performance-based, flexible approach to specifying materials (reference?). When designing with a soft-palette the designer can give a description of the characteristics necessary for a particular part of the building, but leave the exact material to be used open until suitable materials are found. For instance, an exterior elevation can be drawn showing areas for "material one" and "material two", performance criteria for each material in terms of durability, weather protection, and quality of finish, but allow for a number of different materials to be used depending upon what is available at the time of construction. This may take away some of the control of the designer, but it would be understood that samples of prospective materials must be submitted for approval before use. This could also be seen as a return to the sort of architect/craftsman relationship prior to the 20th century, when the architect was responsible for the overall concept of the interior finishes, but the individual craftsman had a great deal of responsibility for the quality of the final product, selection of decorative elements, construction technique, etc.

5. Appearance of reuse

Working with what you have has meaning both in terms of availability and quantity, but also relative to the appearance and quality of the materials. Expectations that reused materials should be indistinguishable from new are not always realistic. It can be argued that almost immediately after occupation, all of the materials in a building become "used" whether they were originally new or not. "New" is an inherently brief characteristic, which is quickly and permanently replaced by "used". In many cases, with some work reused materials can be refinished or otherwise brought back to a like-new condition. Wood can be sanded down and oiled or polished. But it may not be necessary to do so. As long as the quality of the material is satisfactory, the appearance of it is more a question of aesthetics, which are infamously changeable. Many structural materials will spend their working lives hidden from sight behind layers of finish surfaces. Materials that will remain visible can be designed with rusticity or patina of use as an attractive part of the overall scheme. An important way of advancing the mainstreaming of reuse is to work to change perceptions of what materials are attractive, and what conditions are desirable. If newness is the only desirable appearance, then tearing out and replacing materials before the end of their useful lives will exacerbate waste problems.

Repeat, Rethink, Renew

The principle of **Repeat, Rethink, Renew** is both a hierarchy of the environmental benefits of reuse options and a set of reuse methods. Repeat refers to the direct reuse of a material in new construction exactly as it was used previously; a wall stud becomes a new wall stud, flooring becomes new flooring. Rethink involves the reuse of a material, with or without modification, in a manner that is different from its intended reuse, but in a way that is consistent with and appropriate for its inherent properties. Renew describes the combination of new materials with salvaged material in order to bring about successful reuse. The three R's of Reuse are comparable to the long-standing "solid waste hierarchy" of Reduce, Reuse, Recycle (reference?).

Repeat

Repeat involves the least expenditure of additional energy possible while giving a second life to the building material. When a framing member is directly reused as a framing member, no energy needs to be expended to ready the wood for reuse, no milling or addition of paint or other finishes. From a sustainability perspective, this is the most efficient of the reuse options.

Rethink

When employing the method of Rethink, an analysis of material properties or fitness for purpose takes precedence over the original function of the material. In fact, the more completely the original function can be forgotten or ignored, the easier it becomes to envision new possibilities. Rethink may require the modification of the material and may end up using more resources than Repeat. The house can be broken down into materials with specific qualities rather than specific functions or applications. Veneer plywood is used as a flat finish surface to cover the interior of a stud frame wall. It can be reused in exactly that way, but it need not be. Instead, the design can be based around a sheet of material with X dimensions, with X shear strength. If the veneer was cosmetically damaged in removal or was otherwise unsuitable for a finish surface, it does not necessarily follow that it can no longer fulfill a function. It could still be used as the skin of a structural panel, finish floor underlayment, or other substrate.

Renew

Renew is a reminder that reuse is not a way of designing that excludes or ignores the value of new materials in appropriate situations. Even badly worn flooring can be reused if sanded and treated with a fresh application of finish. Novelty siding from wood framed residential buildings is widely available for reuse in North Central Florida, but a batch of salvaged siding is usually a mixture of sound and water damaged boards. Combining new siding of similar profile with the salvaged siding allows reuse even when the available quantity of reused material is not sufficient to meet the total needs of a new construction project.

Design to Facilitate Future Reuse

One of the biggest obstacles to the reuse of building materials is that buildings up to the present have not been designed to facilitate the salvage of building materials. It is time and labor-intensive to disassemble existing building stock. In any reuse project, it is wise to incorporate some design for disassembly tactics to make future reuse or renovation easier.

Maintain or enhance value of material

In the optimal situation, reuse should maintain or enhance the value of the material. This is accomplished by appropriate use, fullest use, and careful consideration of applied finishes.

Appropriate use implies reusing materials in ways that are consistent with their performance characteristics. Wood siding removed from an older structure has already seen years of hard use. It is likely a rot and insect resistant species of wood. It is also likely to be somewhat worn and lacking in fine finish. An appropriate reuse of this material would be in an exterior application where its good performance can be continued and where its surface imperfections will not detract from its desirability. Interior flooring could not be reused in such an exterior application. While its hardness and durability may be appropriate, it may not be as weather resistant. Also, existing finishes that have been applied to the flooring are likely to be intended for indoor use only and could fail under the new conditions. Using interior materials on the exterior could be an example of inappropriate use, which would not maintain the integrity of the material.

Fullest use calls for the best and highest use of the material possible. It would be inappropriate to use old growth, high quality wood as a sub-floor that will never be seen once the new building is occupied. Better to use this material where it is visible and can be appreciated. Also, materials should be reused in as complete a state as possible. It is much easier to find a way to reuse a long board than a short one. Also, for later deconstruction, it takes just as much effort to salvage an 8-foot board as it does a 2-foot, but the 2-foot one is much less valuable. There is more value and flexibility in large pieces or quantities of uniform material.

A note on the **careful consideration of finishes** and adhesives; the use of lead-based paint, asbestos containing materials, and messy, difficult-to-remove adhesives has been a barrier to the successful deconstruction and reuse of materials. The required investment in time and money to remove and dispose of these contaminants has made many prospective deconstruction projects unfeasible. Learning from these past mistakes when designing for reuse will help preserve the materials on into the future.

CONCLUSIONS

Presently, the case study project involving the deconstruction of the Wesley House and the design and construction of the new Reichert House facility is in progress. The director of the Reichert House is supportive of the reuse of materials in a discreet section of the new Reichert House facility. PCCE is working with the architect-of-record for the Reichert House to refine a Contract for Design for Reuse, which sets reuse goals and calls for specific implementation of the DfR principles described in this paper. The fulfillment of the principles established in this paper will be "tested" through real-world application.