The Process of Designing with Reused Building Components

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Abstract

Using reclaimed components has significant implications on the "process" of how to design a building as well as its construction. Traditional relationships and design procedures may not be best suited to maximize material reuse and appropriate construction contracts are needed to accommodate component dismantling and reuse. This paper considers the practical implications of component reuse strategies on the process of designing and constructing buildings. How does the design team have to adapt its working methods to maximize the potential for reusing components? What are the contractual and liability issues? What are the implications for the client? The paper highlights the lessons learned from reusing salvaged and reclaimed materials in Canadian construction projects. Using the experience from these projects the paper outlines the differences in process that design teams need to embrace, and some key procedural points that need to be integrated into architectural handbooks of practice.

Keywords:

Reuse, recycling, reclaimed materials, design process

1 INTRODUCTION

The widespread adoption of the green building rating systems such as Leadership in Energy and Environmental Design, or LEED, [1] has had a considerable impact on the industry in North America and has increased interest in reuse and recycling in construction. In addition, difficulties with waste disposal and limitations on land filling have stimulated interest in the potential economic benefits of alternatives. Waste is becoming regarded as a lost resource and a loss of potential profit. Processes that add value to waste materials can lead to significant financial benefits. This has driven considerable interest and research into issues of deconstruction, design for deconstruction, and reuse of components and material recycling. Publications such as "Old to New – Design Guide for Salvaged Materials in New Construction", published by the Greater Vancouver regional District [2], and "Design for Deconstruction SEDA Guide for Scotland" [3] illustrate the increased interest from local government in North America and Europe for the potential for building material reuse to address waste minimization. In California, the Integrated Waste Management Board published a Technical Manual for Material Choices in Sustainable Construction [4] which outlines the opportunities for reuse in construction, and lists potential components that can be successfully reused. In 2001 the IWMB also published a Deconstruction Training Manual [5] which aims to grow a viable industry and reduce the amount of construction and demolition debris that makes its way into California's waste stream.

It is generally recognized that the use of recycled materials and the reuse of components in buildings can lead to lower environmental impacts. However, at present, in North America the perceived difficulties inherent in the incorporation of reclaimed materials into new buildings often discourage clients and designers from embracing reuse unless it is for principled rather than financial reasons. Although materials costs can be lower through reuse, it must be recognized that these may be offset by higher labour costs and increased design time, and fees, resulting from more research required by the design team. In addition, there is likely to be greater uncertainty over costs and program as delays can occur if key components cannot be readily sourced or there are delays in the demolition process.

Existing buildings are huge reservoirs of materials and components which can potentially be mined to provide much needed resources. Reuse of many components from old buildings can significantly reduce the life cycle environmental impact of new buildings. It can also create new jobs and business opportunities. There is increasing recognition that use of recycled materials and reused components extracted from an old building can potential lead to a reduction in waste that needs to be disposed of, a reduction in primary resources used and savings in greenhouse gas (GHG) emissions [6].

However, current, standard construction and demolition practices focus on the fastest, easiest and most economical way to get the job done. When this is combined with a lack of clear information and guidance for designers and owners about the implications of specifying reclaimed components and recycled materials, it creates barriers to a more ecologically sound use of resources.

At present, in Canada the perceived difficulties inherent in the incorporation of reclaimed materials into new buildings often discourage clients and designers from embracing reuse unless it is for principled rather than financial reasons. Although materials costs can be lower through reuse, it must be recognized that these may be offset by higher labour costs and increased design time, and fees, resulting from more research required by the design team. In addition, there is likely to be greater

uncertainty over costs and program as delays can occur if key components cannot be readily sourced or there are delays in the demolition process. Thus, using reclaimed components has significant implications on the "process" of how to design a building as well as its construction. Traditional relationships and design procedures may not be best suited to maximize material reuse. These issues need to be understood by the design team and client so that appropriate strategies are put into place.

Figure 1: The Mountain Equipment Coop has pioneered component reuse in many of its retail stores. This one located in Ottawa reused many parts of the previous building on site, including the foundations.

2 METHODOLOGY

This paper considers the implications of materials reuse strategies for the process of designing and procuring buildings. The intent is to understand the changes that a design team need to make to the design process to facilitate greater reuse of components in construction and to indicate strategies and recommendations about how to maximize reuse potential. The focus is on how the intention to use salvaged and reclaimed materials affects the design process, and what designers need to know and how they need to adapt their standard processes to fulfill the potential for component reuse.

This paper is based on work carried out to examine the processes used for building component reuse in Canada. The discussion below focuses on key aspects of the design process and how they are affected by component reuse, particularly those aspects that have been identified as potentially varying from standard design processes as outlined in the Canadian Handbook of Practice for Architects [7]. The work is based on a survey that was carried out of the Canadian construction industry. This survey focused on Canadian projects that included significant amounts of component reuse. Key participants in these projects were interviewed or filled out a questionnaire, and this information was analyzed. In addition, a literature review was carried out of international practices for integrating reused components into buildings. A full report of this project is available elsewhere [8]

3 TYPES OF REUSE

Reclaimed and salvaged materials and components (RSMC's) available for reuse can be generally categorized into 4 types:

- On site reused component - which may be whole structures or individual components such as bricks from an old building on a site into a new building.
- Salvaged from other sites – components such as bricks, timber or steel taken from a demolition site and used in another project (usually local), and requiring little reprocessing.
- Reconditioned components – these are components that are taken from a demolished building and require some improvement to be sold again for use in a new location. This may include radiators, doors, staircases, etc.
- Recycled content building products (RCBP's) – these are often readily available building products that include significant amounts of feedstock material that is taken from demolition or other reuse sources. This may include some gypsum boards, steel components, etc.

It is important to keep in mind that using each of these in a building project requires different tasks and strategies at different stages of the design. In addition, current market conditions have an impact on the availability of all these components. Recycled content building products have the least impact on the design process as they are often available directly from manufacturers "off the shelf". Components salvaged from other sites are often the most difficult to integrate as they need to be identified and sourced at the appropriate time in the design process which may be difficult. On site reuse allows the design team to assess what is available and design the new building around the components that are already at the site. Therefore, assessing the potential for different types of reuse, and the sources that are available at the pre-design stage of a project, are essential for future scheduling, resource planning and cost estimating.

4 LESSONS FROM COMPLETED PROJECTS

4.1 Commitment

In the absence of a legal compulsion to reuse and recycle, it is essential that the client or developer is supportive of the principle of component reuse. Projects quickly founder when the client has doubts about this strategy, as inevitably there will be times when the standard product option looks tempting. Also, the client may have to fund the purchase (and thereby securing) of materials and components as they become available throughout the project, which may occur earlier than in a typical project. For this reason it may be helpful to appoint a contractor as part of the design team. This will have implications on the form of contract used, so alternative contractual arrangements need to be discussed with the client, particularly if high levels of salvaged material use are planned.

Expectations for the design may require some tolerance to the duration of the design and construction phases since they will depend entirely on the supply of suitable materials and goods.

The survey of projects that reused components clearly indicated that the decision to focus on RSMC needs to be made early in the design process. Approximately 80% of respondents stated that the decision in their projects was made at the Concept Design stage, with a few making the decision right from the beginning during the Design Team Selection. It appears from evidence of completed projects that if a decision to use RSMC is left until the outline or detailed design stages it is far more likely to have a detrimental effect on costs during construction and schedule while material was being procured. This is often because the design of the building has progressed too far without consideration of what components may be available.

4.2 Costs

Almost half of responses to the survey indicated no impact on design fees, but others did indicate a significant increase in workload for the design team which should be recompensed. It is to be noted that the projects which had higher design fees also had a higher proportion of RSMC and were considered to be pilot or 'test' projects.

There is a strong consensus that material cost (including refurbishment/reprocessing) are decreased by use of RSMC – 95% of responses indicated either minimal or significant savings most likely attributed to the lower costs of used materials even when refurbishment of the component was factored in. Conversely, there is a strong indication that construction labour costs increase, possibly due to additional dismantling and handling costs. Particular cost savings were noted when major components of an old building are reused on the same site in a new structure as they are directly offsetting the purchase of new materials. However, good documentation of the old components is useful to avoid unexpected surprises. It was also noted that transportation costs and the consequent environmental impacts are reduced if components are reused close to their original location, and this is usually the case as most reused components are sourced locally.

Surprisingly, the survey did not identify issues and additional costs related to storage of reused materials. Since purchase may have to occur at a time when materials are available rather than when they are needed on site, there may be longer storage times, but these were not highlighted as a problem, nor were there additional costs identified as linked to this.

4.3 Setting goals

There is inevitably hesitance to set ambitious goals for reuse without previous experience of salvaged materials use. The decision as to what level of use of salvaged material should be determined based on some or all of the following criteria:

- Salvaged materials are most readily and cost effectively obtained in relatively small volumes due to the nature of their supply and the different acquisition processes involved. More efficient use can therefore be achieved in smaller buildings.
- The knowledge and experience of the design team about how and where to located and acquire salvage materials can improve the efficiency and cost effectiveness of the process. So previous experience of the design team and contractor with the use of salvage materials is significant.
- The process of locating and acquiring salvaged materials can be longer and more unpredictable than regular construction materials. Therefore, flexibility in time available during both design and/or construction phases is helpful.
- Opportunities for up to 25% use of salvaged materials can easily be achieved provided that the design uses readily demountable materials such as steel or heavy timber construction since these products represent the largest category of salvaged materials. It is not uncommon to reach 50-75% salvaged material on small to medium sized projects of this nature although these targets may increase the time and effort needed to achieve them.

4.4 Design process

A factor that clearly emerged from the survey was the importance of integration in the way the design team functions as a key reason for utilizing a higher than average amount of RSMC's into their project as well as achieving building energy performance exceeding normal standards. Design teams that employ the Integrated Design Process [9] provide a clear benefit, as this leads to early involvement and buy in from the whole design team. Furthermore, it is important for the design team to be enthusiastic about the reuse/recycle route, and to accept that this may require the team to adapt the normal working practices, and be prepared to take the initiative when it comes to overcoming the unpredictable hurdles that may present themselves. This is clearly linked to remuneration and design fees, but as noted above, if decisions are made early enough the additional design costs need not be substantial.

Previous experience of design consultants with the use of salvaged materials, or willingness to accept the concept and adapt their processes is important. Some firms hire a specific person to source reused materials which may be an opportunity for new specialist roles within design consultancies and for young and enthusiastic employees to learn and benefit from the process. Similarly, the commitment of contractors and sub-contractors to reuse/recycle is recommended as they can assist or be responsible for the sourcing of suitable materials and components. This may require that contractors become involved during the schematic design/design development phases since material acquisition happens much earlier than for typical projects.

Beyond having potential contractual implications, inexperienced or disinterested contractors may have a negative influence on the project team in their use of pressure tactics such as increasing the construction costs due to 'unfamiliar practices' or by not being able to properly locate salvaged/recycled materials. This results in the undermining of the project's intentions by reverting back to new materials and components, albeit with more familiar methods. Thus, the goals of the project need to be clearly explained to, and embraced by, potential contractors before or during the time of tender or contract negotiation.

When reusing buildings and their parts in situ a structural engineer is needed with expertise or past experience in appraising the existing structure and, if necessary, defining work to be undertaken to make the structure reusable, and adapting the existing building for the incorporation of new uses and features (e.g. staircases, lifts, building services plant and distribution). Again however there is the potential issue of an engineer's reluctance in using RSMC by disputing or dismissing the need to properly assess and approve the conditions of potential materials and components. It may be necessary that other building science expertise be sought to also appraise the existing building services, envelope and other features, and to define work to be undertaken to make them reusable, depending on the scope of the reuse.

4.5 Factors deciding what to reuse

When selecting which reused components of a building or recycled materials to use, one starting point that has been used is to base decisions on embodied energy content. It would be appropriate, therefore, to concentrate on reusing and reclaiming goods and materials with high embodied energy as savings will have the greatest

potential energy saving impact. This would suggest reuse of metals, plastics, bricks and generally high value processed components. Another approach could be based on the quantity of material available and if used, could theoretically be the total amount diverted from landfills. For this environmentally beneficial scenario, determining the quantity would then be based on the weight or volume of the materials used. In this instance, the focus would be on larger components and concrete which represent the heaviest/bulkiest items to divert.

Unlike traditional projects where designing the structure, mechanical and electrical and other main systems take precedence over final material selection and procurement, when incorporating RSMC the task of sourcing materials is often the driver during the schematic design phase and one of the key influences on the layout, structure and other systems used.

Figure 2: It is often most practical to reuse components or whole structures on the same site. This directly offsets costs and environmental impacts of primary materials.

4.6 Sourcing reused materials and components

Sourcing RSMCs required designers to foster new relationships with organizations they may not traditionally be in touch with. Some demolition contractors, and salvage companies now have sales staff specifically intended to identify and market construction components they have identified as of value to the building industry. These may range from whole buildings, such as prefabricated industrial buildings that can be readily dismantled, to individual components such as beams, stair cases, doors, etc. They often know beforehand when existing buildings are scheduled to be demolished, so establishing contact with them can provide sources for appropriate materials. However, briefing demolition contractors to ensure minimum damage to components scheduled for reuse is sometimes necessary. The UK's National Green Specification [10], for example, calls for demolition contractors to indicate what is to be reclaimed and produce a method statement indicating how the goods will be extracted in good condition, palletized and protected during transportation and storage.

Designers may have to visit local used building materials yards, demolition contractors and salvaged materials suppliers to establish general availability and quality of materials, and to discuss the scope of their project and provide a preliminary list of materials that they are looking for. Larger, or more committed design firms are beginning to develop an expertise in locating salvage components, and may have dedicated staff for this purpose.

Local municipal departments may know when demolitions are likely to occur and can direct design teams to potential sources of materials and components. Furthermore, there are an increasing number of locally based materials exchange schemes often web based that provide access to a range of materials sometimes for free.

Both reconditioned goods and recycled content building products (RCBPs) can generally be sources in the same way as regular materials and components, although additional research may be necessary to identify appropriate suppliers. RCBPs and reconditioned goods are generally easier to acquire due to their availability, and can be incorporated and procured in a similar way to new material up to and during the schematic design phase. For reconditioned goods, during schematic design, responsibility for component acquisition would still need to be allocated as there may be additional tasks associated with locating appropriate supplies. It needs to be established who will source the particular components? Will the design team specify the performance requirements and pass this function on to the contractor with a general requirement that reconditioned components should be used, or will the design team locate the specific component? Most of the survey respondents suggested that in existing projects building components were generally defined by a performance specification and that the contractor was responsible to source the components. This would therefore require that the specification, in addition to a performance statement similar to goods made with new materials, indicate either the amount of recycled content required within the material or that the component be reconditioned.

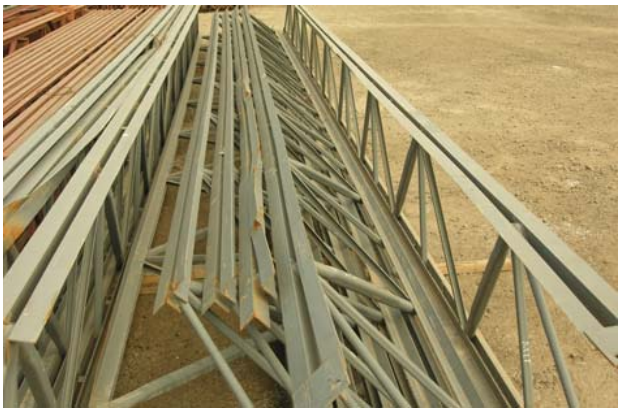

Figure 3: Open web steel joists can often be dismantled for reuse, but the new structure needs to be designed around the available spans.

If the intention is to reuse all or part of an existing building in situ, the search for available existing buildings for reuse in their entirety will need to commence at the pre design stage of the project. Once an existing structure is identified, a full survey of the building to be reused is needed and if possible, original drawings and specifications should be located to assist with identifying potential material re-use opportunities and dismantling efforts.

4.7 Construction process

When reusing buildings and their parts in situ, preferably a deconstruction specialist should be hired if possible, or a contractor with an interest in deconstruction, in order to dismantle the salvaged materials designated for re-use. Some projects in Canada have used not-for-profit / youth programs / government job skills training program as sources for lowering the cost of dismantling and re-conditioning as well as providing economic opportunities for the less-fortunate.

The design team needs to establish procedures for grading salvaged components to ensure they meet functional requirements and regulatory standards. This may require visual inspection, structural or other testing, and possible refurbishment.

5 Conclusion

Certain key factors emerge from the pioneering projects that focus on reuse. These include:

- It is important to have commitment of the entire design team at the early stage of the process.
- Projects need clear goals with commitment of all the design team and client.
- The Integrated Design Process facilitates a great likelihood of successfully using RSMCs
- Sourcing RSMCs required designers to foster new relationships with organizations they may not traditionally be in touch with.
- Responsibility for identifying RSMCs needs to be clearly established - who will source the particular components?
- Procedures for grading salvaged components need to be established and any regulatory issues identified.
- Cost savings are possible in material costs, but some of these are offset by additional labour costs.
- There can be additional design costs. This can be due to redesign to suit when sourcing reused components.
- Projects with the highest savings usually focused on reuse of the existing building already on site.

Designers need to recognize that there are some significant differences to the design process if reuse of construction components is a goal of a project. Reused components have different patterns of availability which need to be accommodated. Also, the limited range of components requires the design team to be more flexible and to develop the building design around the available reused components rather than the traditional process of designing the main features of the building and then identifying the components that will meet the required specifications. This means that ideally the specific reused components need to be identified at an early stage in the design process, perhaps when traditionally a contractor may not yet be involved.

The standard design stages as outlined in the Canadian Handbook of Practice for Architects (and other similar manuals in other countries) will need to be adapted with new tasks included that focus on what needs to be achieved and at which stages, to facilitate successful component reuse. It is hoped that the next stage of this work will develop a manual of tasks to help design teams that wish to design with reused components.

6 acknowledgments

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