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# DESIGNING BUILDINGS USING RECLAIMED STEEL COMPONENTS

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## ABSTRACT

*The consumption of non-renewable resources and the creation of wastes have been identified as among the key issues that our society must address in order not to prejudice the opportunities of future generations. Yet the way we design and construct our buildings leads to huge volumes of waste being generated as well as the use of large amounts of materials, the extraction of which leads to considerable environmental damage. So, how can we design buildings in a way that creates closed loop materials systems that minimize waste generation and primary resource use?*

*The objective of this paper is to review work carried out at Ryerson University in Canada funded by NRCan and CISC to identify ways in which construction can set up reuse loops for steel components so that waste and the demand for primary steel are reduced. In particular, the design and construction issues related to the use of salvaged steel components will be reviewed, through a series of case studies to draw out lessons and conclusions about the implications of component reuse in construction. The case studies are of projects that reuse steel components from old buildings into new buildings. They suggest that opportunities for steel reuse are significant but the industry needs to establish appropriate structures and cyclical systems and methods to ensure that components can be easily reclaimed from old buildings for reuse. Furthermore, certain ingrained industry design processes need to be overcome for reuse of steel (and other components) to become more acceptable.*

## KEYWORDS

deconstruction, recycling, reuse, salvage, steel

## INTRODUCTION

As a result of ever-expanding economies and populations, the world's demand for materials is putting enormous pressure on natural resources. In today's global economic climate, competitive advantage realised through efficient resource use is likely to generate increasing strategic benefits. The continually escalating costs of oil demonstrate that scarcity of resources can cause incredible increases in costs for commodities that were once taken for granted. Buildings are huge reservoirs of materials and embodied energy. They are combined in various, increasingly more complex ways, which often make their assembly and disassembly difficult to achieve. The following three major issues have led to an increasing interest in the role of recycling and reuse of construction materials, including steel:

- The need to reduce greenhouse gasses from production and transport of buildings materials.
- The need to decrease consumption of primary resources.
- The pressure to reduce waste to landfills.

In North America there is an increasing recognition that waste is an asset to be valued, and this is leading to interest in reuse and recycling in construction. This is partly driven by the widespread adoption of the LEED® (CaGBC 2004) green building rating system which is having considerable impact on the industry, but is also due to potential economic benefits. Waste is increasingly regarded as a lost resource and lost profit. Processes that add value to waste materials can lead to significant financial benefits. However, current, standard construction

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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.

Steel components are particularly suitable to be readily recovered from demolition projects and incorporated into new construction, although mechanisms are required to stimulate the market for recovered resources. Designers are increasingly looking to incorporate reused and recycled components into construction projects, but there is a need to understand the implications for the design and construction process when reclaimed steel (and other) components are used. The intention of this paper is that a series of case studies will help generate an understanding of the differences that occur with component reuse.

## INDUSTRIAL ECOSYSTEMS

McDonough and Braungart (2002) and others, advocate a change to systems which are based on the principles of industrial ecology where all waste is treated as a resource. They suggest that we need to redesign our systems so that all materials at the end of one life cycle become a resource for the next. To achieve this, both manufacturers and consumers need to change their approach if the industrialized world is to maintain its standard of living and developing nations are to raise theirs to a similar level without adversely affecting the environment. Traditional models of industrial activity, in which individual manufacturing processes take in raw materials and generate products to be sold plus waste to be disposed of, should be transformed into more integrated models: industrial ecosystems, where the effluents of one process serve as the raw material for other processes, thus significantly reducing or eliminating the need for primary material resources and waste. For example, the use of blast-furnace slags from steel manufacture and fly-ash from electric-power generation as a partial replacement for cement.

In an ideal industrial ecosystem resources are not depleted any more than those in a biological ecosystem; a piece of steel can potentially show up one year

in a drinks container, the next year in an automobile and 10 years later in the structural frame of a building. However, to move significantly towards such a system requires changes to the way the construction industry operates today. Currently, there are barriers resulting from organisational and economic conditions. Industry scepticism and tradition have been identified by Catalli, & Williams (2001), as standing in the way of designing for disassembly:

“Standard practices for construction, renovation, and demolition are heavily geared towards the fastest, easiest and most economical way to get the job done. Designing and constructing for disassembly, when viewed in isolation, can seem costly and laborious compared to the norm. However, the incremental cost will be diminished or even eliminated when practices become more standardized and when the cost savings in terms of recycling and reuse as well as the environment are factored into the overall equation. Potentially, less money will be spent on new materials or landfill, making designing for disassembly a more economical venture.”

Publications such as “Old to New—Design Guide for Salvaged Materials in New Construction”, published by the Greater Vancouver regional District (Kernan 2002), and “Design for Deconstruction SEDA Guide for Scotland” (Morgan & Stevenson 2005) illustrate the increased interest from local government in North America and Europe for the potential for building material reuse to address waste minimisation. In California, the Integrated Waste Management Board has published a Technical Manual for Material Choices in Sustainable Construction (IWMB 2000) 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 (IWMB 2001) 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. Many authors have reported on a variety of projects that attempted to include dismantling, recycling and reuse, and have worked closely with industry on a variety of deconstruction

and reuse projects, mainly focusing on low rise timber frame construction (Guy & McLendon, and Kibert *et al*). They have identified a series of factors including labour costs, tipping fees, hazardous materials, existing markets, reuse materials markings, material grading systems, time constraints, economic constraints, contractual agreements, and public policy as relevant to the successful implementation of deconstruction and reuse practices. Other work has carried out life cycle assessments of different strategies for the removal and disposal of military barracks buildings demonstrating the environmental benefit of reuse (O'Brien *et al*).

## REUSE

Reuse of components generally requires little reprocessing, so greater environmental benefits generally result when compared with recycling. Thus, from an environmental, and often economic, point of view it is desirable that as many components of a building as possible are extracted from the waste stream for reuse at the end of their useful life. Reuse is most realistic for engineered components that can be disassembled. There are 3 ways of reusing previously used materials or components in a project:

1. Reuse an existing structure on the site and possibly add to it or extend it. It may be possible to use this approach, which is known as “adaptive reuse,” in many urban developments. It is now relatively common, for example, with heritage structures as they are seen to have cultural value.
2. Deconstruct and move most or all of the components of an existing building to a new location. Relocation occurs frequently for pre-engineered steel buildings such as industrial buildings and warehouses, and occasionally for other building types. Temporary buildings offer lessons for designing to allow future relocation.
3. Reuse individual components extracted from the demolition of one project in a new building. This form of reuse is commonly known as “component reuse.” It is not yet common in building construction industry other than for heritage components. Considering future deconstruction at the design stage can help make it more feasible that components are reused.

## CASE STUDIES

This paper is based on a project called *Facilitating Greater Reuse And Recycling Of Structural Steel in the Construction and Demolition Process* (Gorgolewski *et al*, 2006). The methodology used was to survey the industry to identify issues and problems of steel component reuse in construction. This survey identified a series of 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. From the survey a series of case study buildings were identified that included steel reuse and these were investigated in more detail. The case studies were selected based on availability of information, and relevance to the industry to act as exemplars. Real projects of this kind provide the benefit of experience of implementing alternative ways of sourcing materials, and the lessons learned can be relevant to other projects. The projects were used to develop an understanding of the particular problems that arise which may affect wider implementation of reuse strategies of steel components. Below are presented three of the case studies that feature reuse of components from one site into a new building at a new location (the 3rd type of reuse identified above). These projects were researched through meetings and discussions with the design team and visits to the site to collect a standard list of information that was developed from the industry surveys. These case studies form part of a larger group of buildings that were identified as featuring steel component reuse in various forms. Information on these is available at [www.reuse-steel.org](http://www.reuse-steel.org).

### BedZED

The Bedington Zero Energy Development (BedZED), located in South London, England, is a mixed-use housing and workspace project that integrates sustainable design practices into many aspects of its design and construction process (see [www.bedzed.org](http://www.bedzed.org)). Completed in September, 2002, the scheme consists of 82 residential dwellings, 18 live/work spaces and further work-only spaces, together comprising 8,500 m<sup>2</sup> of floor space. The scheme

**FIGURE 1.** The Bedzed development.



uses a load-bearing masonry structure, but with some structural steel elements, particularly in the workspace areas. It illustrates how reclaimed components from local sources can be readily integrated into a development of this kind, significantly reducing embodied energy, other environmental impacts and costs. Altogether, 3,404 tonnes of reclaimed and recycled materials were used, accounting for about 15% of the total materials in the project. Most of the materials came from sources within 50 km (35 miles) of the site, reducing transport movements and the associated environmental problems.

Although the main construction at BedZED is load-bearing masonry, over 100 tonnes of structural steel were also required. Early in the design process, the design team identified the potential for using reclaimed steel in the project. The steel components were used mainly in the workspace areas of the development, where 1,600 m<sup>2</sup> of floor space is divided into 23 units. Ninety-five per cent of the steel used in these workspaces came from reclaimed sources (Lazarus 2003). Using reclaimed components was important to the design team to minimize the environmental impacts of using new steel. However, as Bill Dunster, the architect, recalled in a lecture given in June, 2002, *"We had terrible problems persuading people it was a sensible idea to use reclaimed steel. Once they got the hang of it and we got our quality assurance systems up and running it ended up with no problem whatsoever."* (Dunster 2002)

There are not many large stores of good quality reclaimed steel for structural purposes readily available in the UK. At BedZED, the design team, and in particular the construction managers, Gardiner and Theobald, searched local salvage yards and demolition companies within a 50 km radius of the site for appropriate structural steel sections. Three potential sources were identified, and these were inspected by the structural engineers to establish quality and suitability. The structural steel girders from the redevelopment of Brighton Train Station were found to be in good condition, suitable for reuse, and most appropriate. These supplied about 80% of the steel requirements for the project. The remainder of the 98 tonnes of reclaimed steel used came from two other local sources. The steel was stored by the salvage contractor until it was required.

The use of reclaimed steel had little impact on the design. The design team expected that the design would have to be adjusted to suit the available reclaimed steel, but in fact little accommodation was necessary. Prior to identification of the reclaimed steel, approximate section sizes had been specified by the structural engineers. The connection details were also designed to accommodate a range of sizes, allowing for more flexible sourcing. Any reclaimed material has to satisfy the requirements of client and building code officials. The structural engineers, Ellis & Moore, inspected the reclaimed sections before purchase, and established their date of manufacture and their condition in terms of rust or scaling, the number of connections used previously, and suitability for re-fabrication. Since these were common, standard sections, they were able to use information about the performance of historical sections available in the UK to establish the structural characteristics of the steel. From this they were able to satisfy all concerned about the structural integrity of the steel.

The only significant difference during fabrication from using new steel was that in some cases extra sandblasting was required to clean the steel before finishes were applied. The steel sections were re-painted prior to delivery to site and showed few signs of their previous use other than extra bolt holes and welding marks. Experience of using reclaimed steel at BedZED has identified the following important guidelines:

**FIGURE 2.** Reclaimed steel stored ready for refabrication.



- Real commitment to the idea of reuse is required from the design team and contractor at an early stage.
- It is beneficial if decisions on using reclaimed materials are made early in the design process, allowing more time to identify steel sources.
- An indication of approximate sizes and lengths of steel sections early in the design process helps to find sources for the reclaimed steel at an early stage.
- Flexibility in the design approach helps by allowing available steel sizes to be accommodated.
- The use of common steel sizes in the design helps, as these are more likely to be available as reclaimed.
- Long spans can be a problem as less reclaimed steel of this type is available.

**FIGURE 3.** Steel with plates left from its previous use.



- Storage of steel may be an issue if it is identified early in the process. However, experience suggests that salvage yards or even transport companies are often willing to store steel for significant periods.
- The type of contract used for the construction is important. A management contractor may be more willing to embrace the project aims of reusing materials than a traditionally tendered contractor.
- If a conventional main contractor is used, the requirement for reclaimed materials must be specified in a water-tight way or else the contractor may be unwilling to make the effort required and may well try to wriggle out of this once the project is underway.

In subsequent projects, the design team have found that salvage yards, demolition companies, and even transport companies are often willing to store reclaimed steel for significant periods until the steel is required. They have also noted that a construction management contract, rather than a traditional tendered contract, gives more incentive for the construction managers to embrace project aims, such as using reclaimed materials. In projects where traditional tendered contracts were used they found it more difficult to engage the contractors in the reuse process unless the requirements are clearly laid out in the tender documents.



### ***The University of Toronto Scarborough Campus (UTSC) Student Centre***

This building is a new, three-storey, 4,700 m<sup>2</sup> facility located along the entrance to the main University of Toronto Scarborough campus. Completed in October 2004, the building is home to a range of student services, organizations and clubs as well as campus amenities. Sixteen tonnes of steel used in the building came from the deconstruction of the old Terrace Gallery of Royal Ontario Museum (ROM).

At the start of the project, the client and the design team developed the sustainability goals and looked to the LEED™ Green Building Rating System (CaGBC 2004) as a guide for their green agenda. A sustainable design charrette early in the process led to a strategy for the possible reuse of materials, with particular opportunities identified for structural wood decking and structural steel, and efforts were made to source those materials. Demolition companies were contacted to help identify possible sources of reusable component. Sourcing components directly from a demolition in progress and tracking down available components in salvage yards emerged as two options. With no suitable demolition projects identified, the search turned to existing stockpiles of reusable steel for the structure. Unfortunately, the quantities of available steel components found in the salvage yards did not meet the project's needs (insufficient quantity of suitable members) and the process was abandoned. However, early on

**FIGURE 4.** UTSC Student centre with reused steel in the lower wing.



**FIGURE 5.** Dismantling of steel at the ROM.



in the project, the wing under demolition at the ROM was identified as a possible source of crushed concrete for reuse as backfill and concrete aggregates in the Student Centre. Further investigation showed that while the ROM structure was largely of concrete there were also two penthouses with one-storey deep, long-span trusses built of wide-flange steel components potentially reusable in the UTSC project. There was general support from the ROM and its designers for the steel to be reused, as long as the process did not interfere with their construction schedule. The University of Toronto was asked to cover the extra costs of deconstruction and transportation of the steel components.

Establishing the structural characteristics of the reclaimed steel was easy, since the ROM still had original structural drawings of the building being demolished. During deconstruction, the steel was torch-cut, not sheared, to retain the largest useful length of steel possible and to reduce the risk of damage. The deconstruction contract included cutting the steel components to length and their delivery to the fabricator, up to 45 km from the site. Initial concerns of the design team included the economic and environmental costs associated with transporting the salvaged steel. To minimise cost and environmental impact, the steel components went directly from the demolition site to the fabricator for cleaning, refabrication and painting. Shear stud projections and other leftover attachments were removed. According to the fabricator, the cleaning process required little

additional work compared to new steel. However, a lack of advance knowledge of the steel's condition had made it difficult for the fabricator to accurately prepare a bid for the fabrication work. This, however, did not impede the project in any way.

Time constraints did create some problems, as delivery of the reclaimed steel to the fabricator was delayed due to problems at the ROM demolition site. This put into question the reuse process and necessitated the consideration of an alternate strategy for purchase. In the end, the steel did arrive in time for fabrication and delivery to site for assembly. After fabrication, the reused steel components arriving on site for construction were treated no differently than new steel components and created no difficulties during erection. The steel was fabricated with bolt connections, offering a single mechanism for construction and enabling unbolting for future deconstruction and reuse.

**FIGURE 6.** The history of the steel was purposefully left visible by not removing the plates and holes from the original use.



The extremely tight schedule afforded no time for dealing with unforeseen circumstances. For successful incorporation of the salvaged steel components the design process had to remain flexible. Once the ROM demolition was identified as an appropriate source of reusable steel, the relationship between schedules of the two projects became crucial. Unfortunately, there was very little opportunity to synchronize timelines in order to make the steel reuse easier. The one-storey truss in the ROM had been built from wide-flange steel sections. These were reused as both columns and beams. The available sizes dictated the design of the structure, which resulted in deeper beams and some over-design; consequently, the structural framing was redesigned; the beams were rotated 90 degrees, allowing ductwork to fit properly within the designed ceiling depth. The steel was exposed, with visible scars (stiffeners, gussets, holes), but cleaned with a finish matching the new steel.

The overall cost impact of reusing steel was neutral. However, as understanding of the reuse process in the industry improves, more opportunities will be identified and the cost of facilitating reuse should decrease. The cost of reclaimed steel in this project accounted for only a small proportion of the total cost of building materials used in the project as availability of reusable materials was limited.

Although there were challenges in facilitating the reuse of structural steel, the following key lessons are relevant:

- A strong commitment on the part of the client and the project team is fundamental.
- The design should allow for the possibility of various depths of structural member, since it may be necessary to make adjustments depending on the availability of reclaimed steel and the servicing system used. This can be achieved by designing a flexible structural zone, within which various structural solutions can be accommodated.
- Timing is critical if steel is being obtained from demolition projects that are in progress. Ideally, the reclaimed steel should be available two to three months (depending on the quantity required) before it is needed in the new project. Success is more likely if the two projects, deconstruction and construction, are carefully

coordinated. Acquiring the steel ahead of time and storing it until it is needed could eliminate the timing issue.

- Identifying the structural characteristics of the salvaged steel is easier if it is from a project for which original documentation is available.
- Fabrication pricing can be difficult if the condition of the reclaimed steel surface is not well known. An accurate description of the salvaged steel, with images, or an opportunity to inspect it would improve the accuracy of the fabrication bid.
- Quality control during deconstruction of steel is important in order to avoid damage which could make the steel unusable.
- There needs to be better connection between demand for reclaimed steel and its supply. It would be useful to have access to a schedule of demolition projects, each with a brief project description.

### ***The Roy Stibbs School***

The Roy Stibbs School, an elementary school facility in West Coquitlam, British Columbia, is an example of the reuse of a large portion of a whole structure in a new location. After a fire, the school buildings had to be rebuilt very quickly to meet community needs. Another school in the northern BC community of Cassiar was no longer required and had been taken down and many of its components were in storage. The steel structure from this building was reused to speed up the construction process at the Roy Stibbs School. The new school building was designed to maximize reuse of the available steel structure. The Cassiar School was a central two storey building, with a single storey on either side housing the gymnasium and shop. It was decided that the two storey main part would be reused at Coquitlam.

The old steel was inspected to determine the viability for reuse. The structural characteristics of the steel were determined from the original construction documents, and shop drawings of the Cassiar School and the components were prepared for transportation. It is estimated that over 75% of steel for the Roy Stibbs School came from Cassiar. The original structure for the Cassiar School was designed for greater snow loads but for considerably smaller seismic forces than required at the new location.

After the decision was made to reuse the steel the structural layout for the new building adopted the same structural grid as used in Cassiar. The interior layout was adopted to suit the elementary school's functional requirements. This maximized the potential for reuse of the components, although there were some components that had to be redesigned to meet the new seismic loading requirements. Some of the joists had to have their chords repaired as they were damaged during dismantling and transportation.

On arrival in Coquitlam, the steel was inspected and damage from deconstruction and transportation was identified by an independent material testing consultant. A total of 466 open web steel joists were reused, most in the condition in which they arrived, needing only to be cleaned and touched up with primer. Others were later modified on site to work with the new structure. Some of the open web steel joists had bent and burnt-through chords and joist seats that required grinding where the flange was cut or gouged. Some bracing members were damaged at attachment to gussets. Fire proofing was mostly removed and the primer paint was in good condition except at welds. The major design issue that arose from the reuse of the structure was the change in seismic requirements from zone 3 in Cassiar to zone 4 in Coquitlam. The Cassiar School was designed for approximately 50% of the seismic load requirements in Coquitlam. Some adaptation of the structure was required, including a redesign of bracing.

**FIGURE 7.** The new Roy Stibbs school building featuring reused steel.





ing. Fortunately, the Cassiar School was designed for a snow load that was 2.5 times the snow load requirement of buildings in Coquitlam and so no additional problems were created by snow loading.

According to the structural engineer for the project, one of the “greatest challenges” with reusing structural steel at the Roy Stibbs School site was scheduling. With such a short project timeline, organizing the reuse of structural steel created many scheduling difficulties. The stockpile of steel ready for reuse was an important factor in the successful reuse of structural steel in this project. It is often difficult to arrange for a timely delivery when the steel is being deconstructed from an ongoing demolition project. The relatively easy alteration of the steel structure from one seismic zone to another demonstrates the adaptability that steel structures have.

## CONCLUSIONS

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. Designers who have attempted such an approach say that “*using reclaimed materials adds a whole new level of complexity to the project*” (Chapman & Simmonds 2000).

Certain key factors emerged from the projects studied. These include:

- It is important to have commitment of the entire design team at the early stage of the process. An Integrated Design Process facilitates a greater likelihood of successfully using salvaged components. Projects need clear goals with commitment of all the design team and client. A project is more likely to successfully integrate steel (and other) components if the decision to use them is made very early in the design process.
- Reused components have different patterns of availability which need to be accommodated—reused components do not generally come “off the shelf”, rather they are identified on demolition sites by salvage contractors. Also, the limited range of components requires the design team to be more flexible and to develop the building design around available reused components rather than the traditional process of designing the main features of the building and then identify-

ing the components that will meet the required specifications. This means that ideally the specific reclaimed components need to be identified at an early stage in the design process, perhaps when traditionally a contractor may not yet be involved.

- To maximise the potential for reuse, the starting point for the new design may in the future often be an inventory of the available materials from salvage. For structural design, the size and length of the available members will then determine the bay sizes in the new structure, thus maximising structural efficiency from the available components. This approach requires that the available components are identified early in the design process, and that these are purchased or reserved to prevent the salvage contractor from selling them elsewhere. Currently, salvage contractors are unlikely to guarantee the availability of specific materials or products for the duration of the design and tender period. This has cash flow implications and management consequences as the client may be required to dedicate resources to the purchase of components early in the design phase, when a contractor has not yet been appointed. It may also result in the additional problems related to the storage of purchased components.
- Alternatively, if pre-purchase of components is not possible, it is important to build in flexibility into the structural design and particularly the depth for accommodating the structure, so that the design can be adjusted to suit component availability later in the process. This requires appropriate contractual procedures to be used, as the final materials may not be specified at the time of tendering. There may be a necessity to redesign at late stage or even during construction to suit available salvaged components of desired length that have become available. This may result in the use of oversized components.
- Responsibility for identifying reclaimed components needs to be clearly established—who is responsible for sourcing the particular components? Reuse may involve the design team in considerable additional research at the front end of the project to identify, locate, inspect and choose appropriate components. Taggart (2001) has identified that: “*Creating a workable structure for a new building using salvaged materials can*

*be the single biggest challenge for architects. Many other materials and products are straightforward to use, but may be more difficult to source. . . . Procuring all the materials in advance of tender requires money up front and a great deal of research, but enables tender documents to be complete, contractors to view the materials before submitting a bid."*

- Sourcing reclaimed components requires designers to foster new relationships with organizations they may not traditionally be in touch with. Engineers and architects can benefit from developing working relationships with salvage and demolition contractors to increase their awareness of available salvaged materials, thus improving their choices when such components are required. Some demolition and salvage companies now have sales representatives who focus on marketing components with potential for reuse. In some areas, specialist reclaimed materials procurement consultants are emerging and their experience can reduce the risks of disruption or delay.
- An alternative approach can be to identify and purchase an appropriate building already condemned for demolition that contains suitable components, and reuse as many as possible in the new project. However, this may cause problems with regard to storage of components over the entire length of design period and preparatory site work.
- Procedures for grading salvaged steel (and other) components need to be established and any regulatory issues identified in order to ensure local code compliance. Testing of steel components can often be avoided and procedures are developing for assessing the characteristics of old steel components (see <http://www.reuse-steel.org/resources/designer/Articles/Historical%2Dsteel%2Dcodes/>).
- Cost savings are possible in material costs, but some of these are offset by additional labour costs, particularly if project management practices are not suited to use of reclaimed components. Additional handling and off site storage can add considerable cost to reclaimed components.
- There can be additional design costs due to redesign when reused components are identified, or

due to the design team spending additional time sourcing reused components. Allowing some flexibility in the design can be helpful. The highest savings usually occur for projects that focus on reuse of existing building materials and components already on site (where possible) rather than taking components from another site.

- As design teams adopt strategies to increase use of reclaimed components, it is likely that the standard design stages as outlined in the Canadian Handbook of Practice for Architects (and other similar manuals in other countries) may 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.

At present, the difficulties inherent in the incorporation of salvaged materials into new buildings discourage clients and designers from embracing reuse unless it is for principled or financial reasons. Although materials costs can be lower through reuse, it must be recognised that these may be offset by higher labour costs and increased design fees resulting from more research required by the design team. In addition, there may be greater uncertainty over costs, and schedule, as delays can occur if key components cannot be readily sourced or there are delays in the demolition process. However, the situation is likely to quickly change with the impact of green building rating schemes that place a value on reuse, and as salvage contractors become more aware of the value of the components they extract.

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