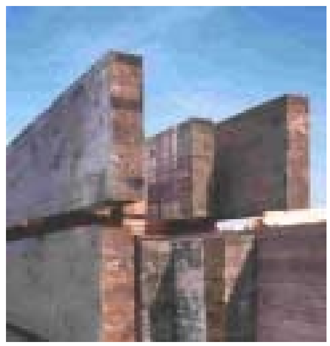
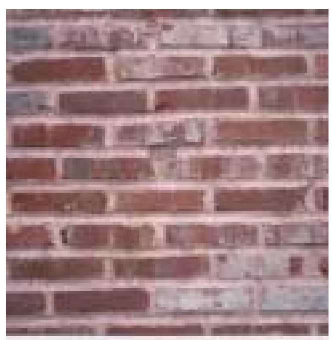
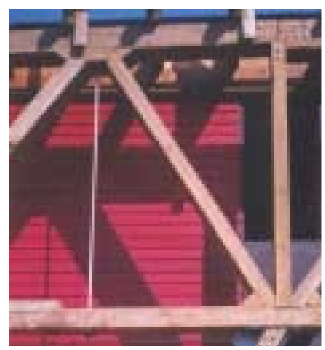
OLD TO NEW

DESIGN GUIDE

SALVAGED BUILDING MATERIALS IN NEW CONSTRUCTION

3RD EDITION (2002)


Greater Vancouver Regional District

BUILDSMART
Greater Vancouver's source for sustainable building solutions

OLD TO NEW

DESIGN GUIDE

SALVAGED BUILDING MATERIALS IN NEW CONSTRUCTION

Prepared by

Paul Kernan, MAIBC

Under contract to:

Greater Vancouver Regional District
Policy & Planning Department

3rd Edition January 2002

For more information please call the GVRD at 604-451-6575 or
e-mail: BuildSmart@gvrd.bc.ca

The following individuals and companies have contributed in various ways to the preparation of this guide. Their assistance is gratefully acknowledged:

Robert Brown, Stefan Brunhoff, Cedric Burgers, Robert Burgers, Peter Clark, Cameron Desautels, David Desrochers, Paul Fast, Jeanette Frost, Corrine Fulton, Glen Gordon, John Guenther, Dave Jackson, Hugh Ker, Ken King, Richard Klopp, Leo Levasseur, Eva Matsuzaki, Mike McColl, Thomas Mueller, Dave Orsetti, Freda Pagani, Duane Palibroda, Ron Pearson, Jonathan Rider, Hank Roos, Karl Simmerling.

A & P New & Used, All Around Demolition Ltd., Bent Nail New & Used, Chilliwack New & Used, D. Litchfield & Co. Ltd., Mike's New & Used, P & B Used Building Materials, Pacific Heritage Woodworks Inc., Surrey New & Used, Tham Demolition Ltd., The Glass Station, Vancouver Timber

Table of Contents

PREFACE

Sustainability has emerged as a widely held and necessary notion to guide all future human endeavors. It has environmental, social and economic dimensions, embraces all facets of human activity, and spans local actions through to redressing the major inequities that exist between developed and developing nations. Environmental sustainability will require gaining greater utility from all resources before returning them to nature.

Simply improving the performance of new buildings - making them more resource efficient and with increased potential for recyclability and reusability - will be insufficient to realign the built environment towards a sustainable future. Attention must be directed at the use and upgrading of existing buildings. Discussions related to the rehabilitation and reuse of buildings has been largely within the domain of historical preservation. Changing attitudes toward resource use and environmental limits to growth will require us to rethink the environmental value of existing buildings and their constituent materials. Indeed, along with developing new skills, knowledge, and attitudes on environmental issues, architects will have to learn to be more "curators" of the built environment rather than "creators." [1]

Each generation of buildings over the past 100 years or so has its own materials palette and construction techniques – varying in quality, quantity and accessibility. Existing buildings that are refurbished or decommissioned represent a vast source of future building material. Although the majority of buildings were created without a view for re-use or recycling of their constituent materials, components and systems, a large portion will be salvaged and re-made into "new" building. Indeed, whereas the construction industry has historically considered the harvesting of natural resources, the future will see increasing harvesting of resources from the built environment.

Although the wider use of salvaged material will depend on the development of a used materials "infrastructure" for identifying, locating, accessing and reprocessing quality used materials, the key will be for architects and builders to engage the opportunity. Architects will be required to look creatively at re-using existing buildings, materials and components in conjunction with a host of new materials that will become available as the building industry examines innovative ways of turning wastes into useful resources.

[1] Levinson, N., "Renovation Scoreboard." *Architectural Record*. Vol. 181. January 1993. p. 70.

Acknowledging that salvaged materials will become a major part of design, learning how to create a coherent architectural work from this disparate collection of elements as well as designing buildings to more readily facilitate this process in the future are the primary objectives of this manual. It provides an important addition to the growing body of knowledge on environmental responsible building design. Written by architects for architects, the manual structures and elaborates on the essential issues associated with reusing building materials and components and offers constructive strategic and practical guidance on the way that materials are sourced and specified.

Dr Raymond J Cole
School of Architecture, UBC

THE LOCAL CONTEXT

Increasingly industrial, commercial and residential buildings in the Lower Mainland are being deconstructed rather than demolished. However, only the most marketable and easily salvageable materials (i.e. heavy timber, large dimensional lumber, architectural antiques) are currently being removed at deconstruction projects. The majority of salvaged structural wood is exported to the U.S. where British Columbia' s first growth Douglas Fir heavy timbers and large dimension lumber are valued as building materials. The non-salvageable components are either recycled (reprocessed) or disposed of in local landfill sites. A significant number of buildings are still simply demolished. In 1998, an estimated 1,100 houses were demolished in the Lower Mainland, with little or salvage of materials.

A poor understanding of the benefits of deconstruction and a negative perception of salvaged building materials among building industry professionals, are two reasons why salvaged materials are not being used more widely in the Lower Mainland. Developers, driven by tight development schedules and financing considerations, have little interest in giving more time to building deconstruction. Architects, engineers, specification writers and contractors often perceive salvaged building materials to be of inferior quality. They lack information on how to procure and incorporate used building materials in new construction projects or how to address warranty and material appearance issues with their clients.

These are real concerns which must be addressed before salvaged building materials can be used on a larger scale in new construction projects. A few local architects and contractors have incorporated salvaged materials in their building projects. The C.K. Choi building and the Liu Centre at UBC, the City of Vancouver Asphalt Materials Testing Facility and the Railspur Studios on Granville Island (under construction) are some of the better known local examples where salvaged building materials have successfully been used to produce well-designed and attractive buildings. The project architects were motivated by the environmental benefits, the "historical element" and the exceptional quality salvaged building materials can offer to designers and their clients.

The development of this guide was first discussed at a symposium organized by the Deconstruction/Demolition Planning Committee (D2PC) in May 1999. The D2PC is a multi-stakeholder, provincial committee responsible for developing a deconstruction strategy for B.C.. At the symposium, architects, engineers, specification writers and builders indicated that they need practical guidance on how to design and incorporate salvaged building materials in new construction projects.

The Design Guide provides just that: practical, relevant, up-to-date information on designing with salvaged building materials. It draws on the experience of local architects, project managers and general contractors who have been "through the process." It also provides detailed information on the availability, quality and cost of used building materials in the Lower Mainland. The Guide represents a overview of our current knowledge of designing with salvaged building materials, it is a "living document" which will grow with our expanding knowledge in this area.

Thomas Mueller
GVRD Policy & Planning Department

SECTION 1

1.0 INTRODUCTION

1.1 DESIGNING WITH SALVAGED MATERIALS

Using salvaged building materials in place of new materials can be an effective means of conserving natural resources, and reducing embodied energy, as well as having tangible economic benefits. The use of salvaged materials is not as easily incorporated into conventional building practices as other green design strategies. Once a decision has been made to build in an environmentally responsible manner most of the challenges are technical in nature. While there are technical issues to be addressed in using salvaged materials, the most significant differences relate to the processes of specifying, locating, and acquiring the materials.

1.2 THE GUIDE

The purpose of this design guide is to provide architects with practical information to encourage and facilitate the use of salvaged building materials in typical new construction projects. Two recent symposia provided the initial impetus for the guide. In particular a workshop on "Using Salvaged Building Materials in New Construction", at the symposium in May of 1999[1], identified a high level of interest amongst architects in the topic. It is hoped that increasing interest in using salvaged materials will act as a catalyst to both improve, and expand, the supply of salvaged building materials, and to simplify the process of obtaining these materials for use in new construction projects. The guide focuses on three specific topics:

1. Case Studies

Three local buildings that have been designed and constructed using salvage materials are presented. The principal salvaged materials used, and the sources of the materials, are listed. Key milestone s during design and construction are identified.

2. Typical Project

Section 3 is structured around a typical design and construction project, viewed from the perspective of the architect. Salvaged materials have traditionally been used in small-scale

[1] Symposium sponsored by GVRD, Capital Regional District, Fraser Valley Regional District, BCHMC, BC Buildings Corporation, Recycling Council of BC, and BC Environment.

residential construction and renovation projects, typically not involving architects. This section focuses on projects larger in size and assumes design professionals will be involved.

Although considerable creativity must sometimes be applied in finding new uses for salvaged materials, once minimum quality standards are met, there are relatively few technical problems related to the substitution of salvaged materials for new product. However, there are major differences in the methods of obtaining salvaged materials, and creative contractual and procedural solutions are required to deal with issues related to the variability of the supply of these materials. The experiences of the architects of the case study buildings are drawn on to demonstrate contrasting approaches to the challenge of integrating salvaged materials use into conventional architectural projects.

3. Salvaged Materials

The need to provide detailed information to architects on the range, availability, and sources of recycled materials in the Lower Mainland of BC was identified at the May Symposium. It appears unlikely that a comprehensive web-based database of salvaged materials will be developed in the near future. The alternative approach of architects researching the use of salvaged materials without basic information, is time consuming, and difficult to make cost effective within the parameters of typical professional fee structures.

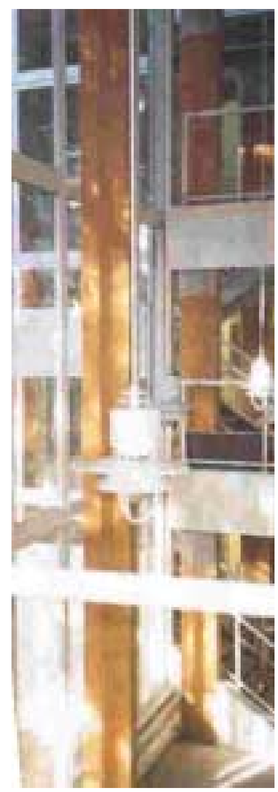
To provide a first step in designing for salvaged materials use, a list of construction materials and components available from salvaged sources is provided in Section 4. Based on the 16-division Masterformat, it provides information on the characteristics, cost, availability, selection, and quality of salvaged material in each building material or component category. Appendix A provides lists of local sources of salvaged materials, and other contacts and resources. The potential for construction cost savings is also explored through the analysis of a study building designed in schematic form and priced on the basis of both new ands salvaged material. A detailed comparison of new and salvaged material costs is provided in section 4, and individual material and component prices are listed in Appendix B.

SECTION 2

2.0 CASE STUDIES

Significant and ingenious architectural design often emerges out of constraint rather than freedom and from conviction rather than routine practice. Buildings which are designed to be conserving of resources, well adapted to their locale, which work in concert with climate and natural systems and which are responsive and comprehensible to their users will be potentially richer human experiences - and sustainable.[1]

Much of the information in this guide is based on the experiences of the architects, owners, and contractors, of local buildings which have been constructed using salvaged materials. Three such buildings are featured as case studies, the City of Vancouver's Materials Testing Lab and, the C.K. Choi and Liu Centre buildings at UBC. These buildings demonstrate not only that high levels of salvaged materials use is possible, but that it can be achieved without sacrificing conventional architectural goals.



[1] Raymond J. Cole, Design for the Next Millennium, The C.K. Choi Building for the Institute of Asian Research.

City of Vancouver Materials Testing Lab.

900 East Kent Avenue South, Vancouver, BC

Encouraged by the architects, Busby and Associates, and with salvaged structural material available from recently demolished warehouse buildings on site, the City of Vancouver decided to make the new Materials Testing Lab a demonstration project. Although other environmental strategies are employed, the primary focus has been to maximize the use of salvaged materials. Approximately three-quarters of the building's structure and fabric are constructed using salvaged and recycled materials. Even custom components specifically made for the building are fabricated from reused materials. For example, glazing throughout the building consists of sealed glazing units fabricated from salvaged glass, in frames milled on site from old wood decking material. Cost savings of approximately $50,000 have been attributed to the use of salvaged materials, although these savings must be offset against some increased construction management fees and labour costs.

Project Team

Owner	**City of Vancouver**
Architect	**Busby and Associates**
Structural Engineer	**Fast and Epp**
Mechanical Engineer	**Keen Engineering**
Electrical Engineer	**Reid Crowther**
Landscape Consultant	**City Staff**
Construction Manager	**K. Edgar King & Associates**

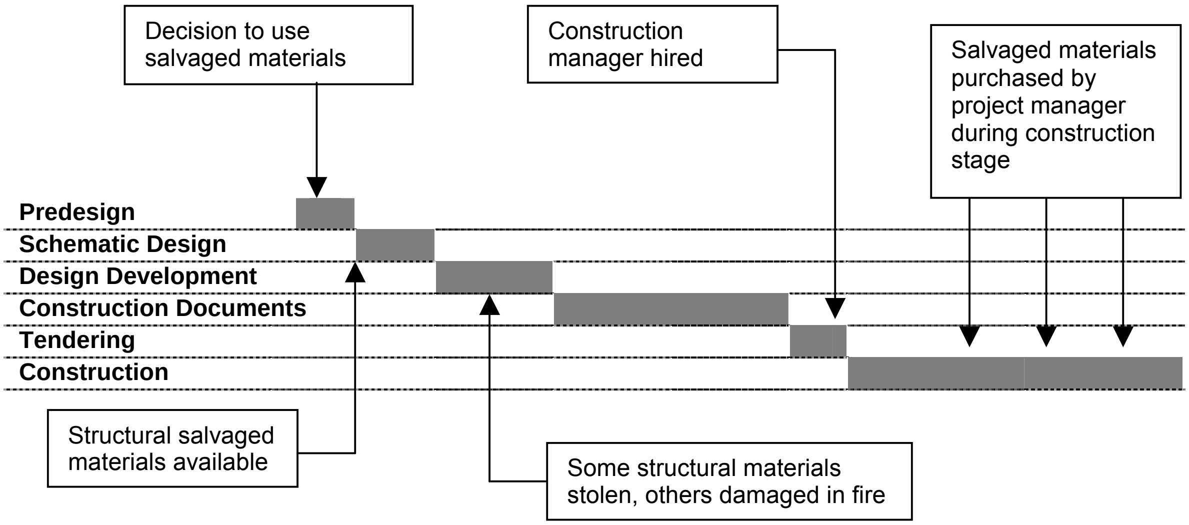
Building Type

Building Description	Laboratory Building
Building Floor Area	4,284 Sq.ft.
Construction Cost	$630,000 ($129 / Sq. ft.)
Construction time	9 months
Completion Date	September 1999
Contract Type	CCDC-5 Construction Management Sub-trade contracts - Short form CCDC-2

Principal Salvaged Materials

	Material	Source
Structure	Wood trusses, wood beams, glulam beams, wood decking.	City of Vancouver Litchfield Tham Demolition
Secondary structure	Roof decking - 2nd floor - glulam beams on edge	P & B New and Used
Exterior walls	Wood framed using salvaged 2"x8"decking material (t&g decking remilled as 2"x6"studs) Rigid polystyrene insulation Plywood sheathing	From on-site building Litchfield Signs and hoarding
Interior partitions	Wood framed using salvaged 2"x8"decking material (t&g decking remilled as 2"x6"studs)	From on-site building
Cladding	Siding (60% salvaged)	Litchfield
Doors	Interior doors (In addition to salvaged doors a number of damaged doors which had been returned to the manufacturer were also used)	Shanahans
Windows	Wood frames and sashes - fabricated on site Insulating glass units fabricated from salvaged sealed units	 The Glass Station
Mechanical	HVAC unit Fans Plumbing fixtures	Demolition site unit located by construction manager
Electrical	Light fixtures	Mike's New and Used

Project Timeline



C.K. Choi, Institute for Asian Research, UBC

1855 West Mall, Vancouver, BC

An extensive and articulated environmental agenda, including the use of salvaged materials, was part of the building program from the earliest stages of the project. Design of the building coincided with the planned demolition of the Armories building on an adjoining site, providing an opportunity to salvage and reuse the large span timber trusses from the old building. Disassembling the trusses and using the individual timber components allowed a more appropriate structural system to be developed to suit the needs of the mostly small program spaces. All of the salvaged materials for the project were located by the architects, and purchased by the owner, prior to tendering the project. Although estimation, and measurement, of total salvaged materials is difficult, the design team feels confident that the target of 50% salvaged and recycled material content has been met.

Project Team

Owner	**University of British Columbia**
Architect	**Matsuzaki Wright**
Structural Engineer	**Read Jones Christoffersen**
Mechanical Engineer	**Keen Engineering**
Electrical Engineer	**Robert Freundlich & Assoc.**
Landscape Consultant	**Cornelia Hahn Oberlander**
Construction Manager	**UBC Staff**
General Contractor	**Country West Construction**

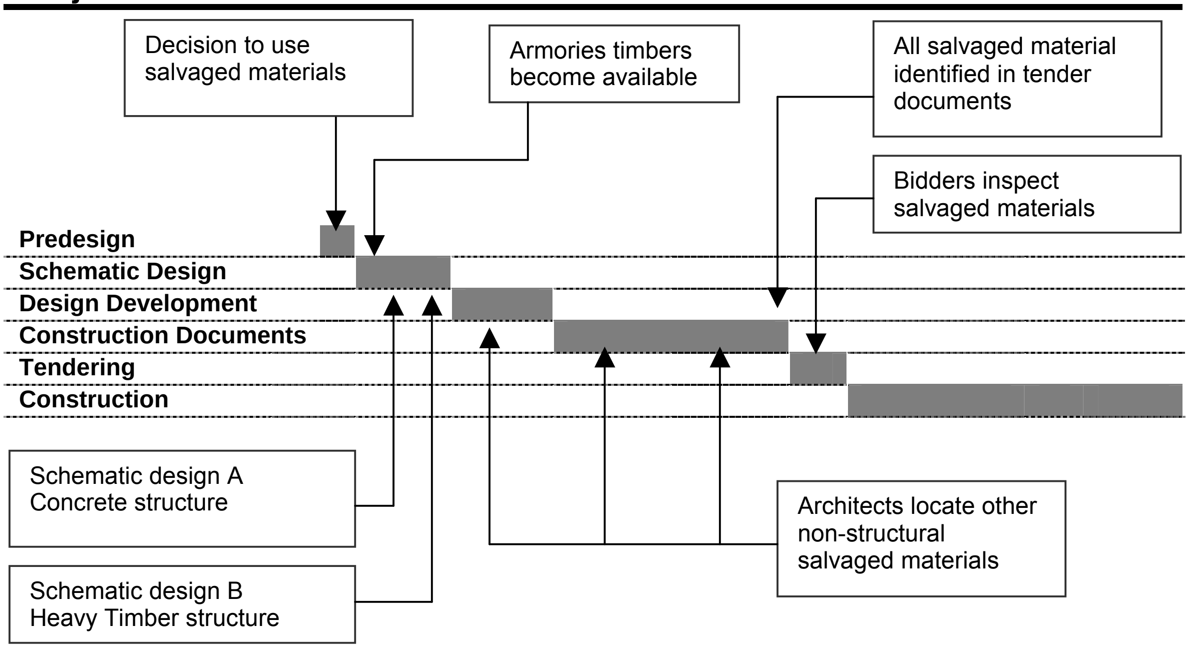
Building Type

Building Description	Academic offices and meeting rooms
Building Floor Area	30,000 sq. ft.
Construction Cost	$4,500,000 ($150 / Sq. ft.)
Construction Type	Heavy timber / Combustible
Completion Date	February 1996
Contract Type	CCDC-2 Stipulated Price Contract

Principal Salvaged Materials

Component	Salvaged Material	Source
Primary Structure	Heavy timber columns and beams	UBC / Litchfield
Secondary Structure	Some wood framing material	
Exterior Enclosure	Brick cladding	
Interior	Doors and frames, some wood framing, Steel stair, guard rails Washroom accessories and toilet partitions	Litchfield
Mechanical / Electrical	Unit Heaters, Electrical conduit	

Project Timeline



Railspur Studios, Local Artisans Studios & Gallery

1420 Old Bridge Road, Granville Island BC

The project involved the renovation of an existing industrial building, to provide studio and gallery space for local artisans. Architects Hugh Kerr and Stefan Brunhoff introduced the idea of salvaged building materials at an early stage in the project. The principal salvaged materials used, dimension lumber, were obtained by the materials consultant, from two local suppliers. Sizes and quantities were listed in the project specifications, and much of the material was made available for inspection during the tendering period. Additional materials were obtained during the course of construction. Formwork plywood and lumber from the project were salvaged and have been sold to a salvaged materials supplier for future re-use. In addition to dimension lumber, interior doors, and batt insulation, obtained from a movie set, will be used in the project.

Project Team

Owner	**CMHC – Granville Island**
Architect	**Hugh Ker & Stefan Brunhoff Associated Architects**
Structural Engineer	**Equilibrium Consultants**
Mechanical Engineer	**Keen Engineering**
Electrical Engineer	**Robert Freundlich & Assoc.**
General Contractor	**Makam Construction Ltd.**
Materials Consultant	**K. Edgar King**

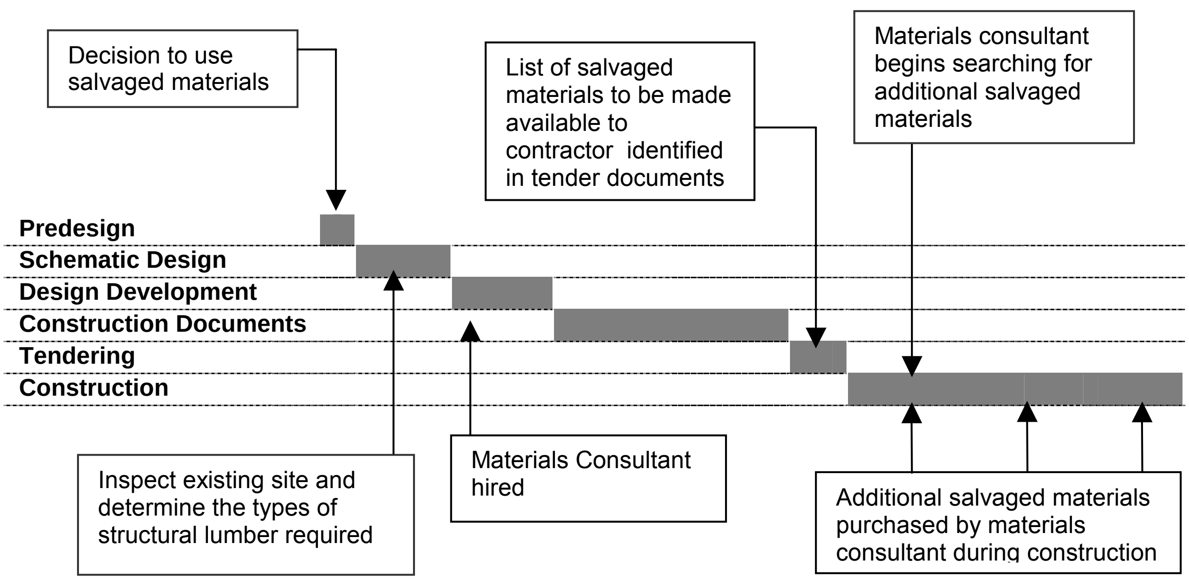
Building Type

Building Description	Artisan Studios and Gallery
Building Floor Area	16 600 sq. ft.
Construction Cost	$ 1,500,000 ($90 / Sq. ft.)
Construction Type	Combustible / Heavy timber
Completion Date	November, 2000 (Expected Date)
Contract Type	CCDC-2 Stipulated Price Contract

Principal Salvaged Materials

Component	Salvaged Material	Source
Primary Structure	Dimension Lumber	Litchfield & Co. Ltd. Vancouver Timber
Secondary Structure	Roof Decking: 2” x 6” tongue and groove, 1” x 8” shiplap	Litchfield & Co. Ltd. Vancouver Timber
Miscellaneous	Interior Doors	
	Batt Insulation	
	Formwork lumber and plywood	Paraline Ventures

Project Timeline



Ardencraig

353 West 11th Avenue, Vancouver, BC

Ardencraig comprises four townhomes designed within the framework of an existing heritage home and garage. The use of salvaged materials is just one of a number of environmental strategies employed in the building and associated site work. Ardencraig is an excellent example of the rehabilitative reuse of an existing structure; over 90% of the wood in the original structure is retained. Additional salvaged materials, obtained from deconstruction of an existing garage, were used to construct a coach house behind the main structure. Salvaged framing members were also used to strengthen the roof trusses and increase the space available for insulation. Other salvaged materials include granite from the existing foundation walls, and stained glass used in feature windows.

The developer reports that the *green* design aspect of the project was a positive benefit in marketing units to potential purchasers.

Project Team

Owner	**Chesterman Property Group Inc.**
Architect	**Allan Diamond Architect**
Structural Engineer	**Jeff Allester**
Construction Manager	**Armin Gottschling**
Landscape Consultant	**Claire Kennedy Design**

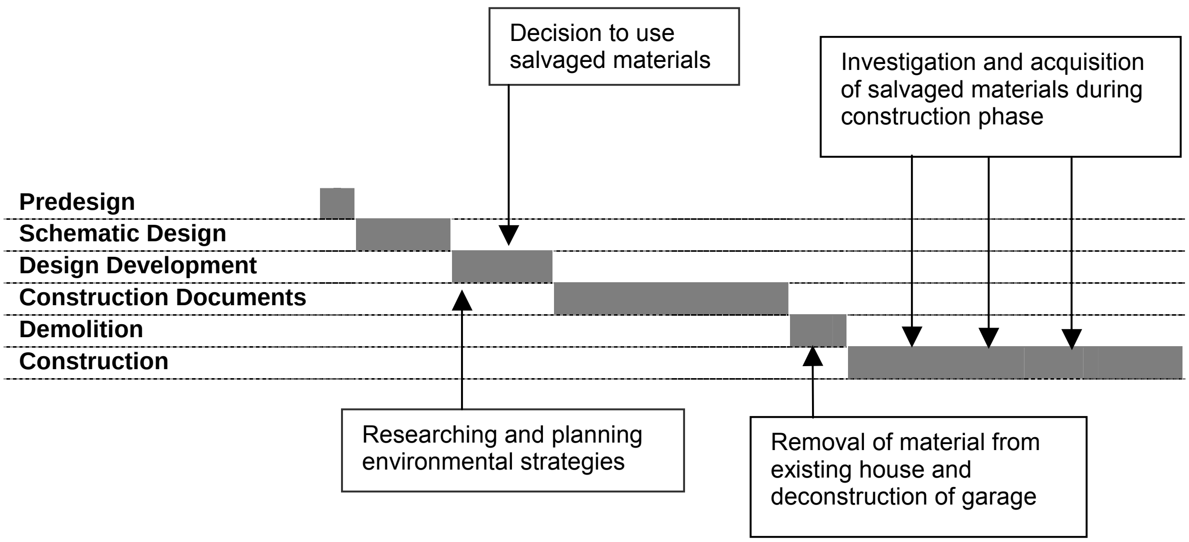
Building Type

Building Description	VBBL Group C
Building Floor Area	4700 sq. ft.
Construction Cost	$520,000
Construction Type	Combustible
Completion Date	August, 2000
Contract Type	Construction Managed, Fixed Fee

Principal Salvaged Materials

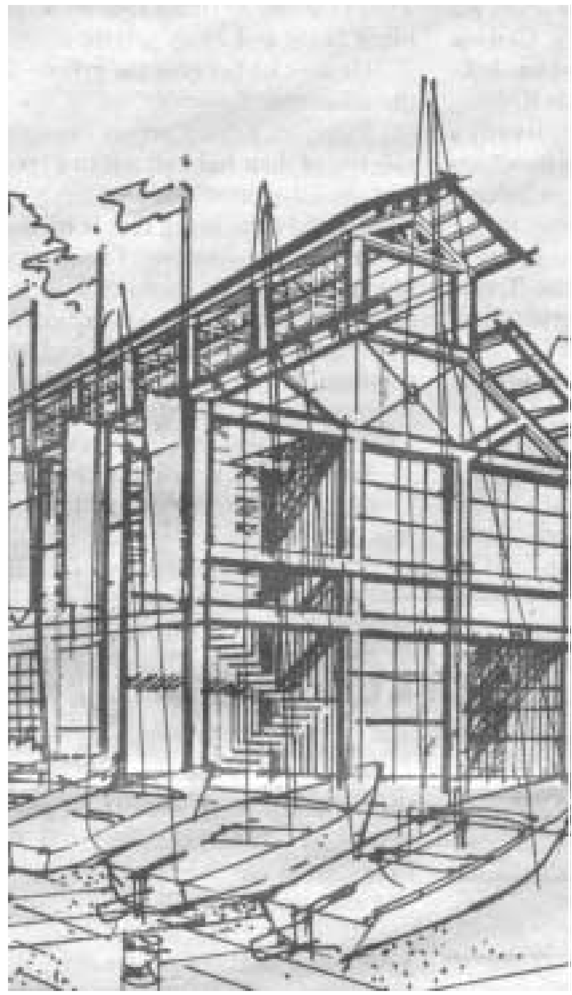
Component	Salvaged Material	Source
Primary Structure	Dimension lumber and studs Roof truss strengthening members	Existing building and salvaged materials suppliers
Secondary Structure	Studs	Salvaged material suppliers
Landscaping	Cobblestones	Private purchase
	Granite rocks	Existing house foundation
Miscellaneous	Stained glass	Stained glass artist

Project Timeline



Coach house – framed with salvaged materials

Port Moody Sail & Paddle Centre
Rocky Point Park, Port Moody, BC



The building, which is currently in design stage, will provide storage and repair space for rowing shells and small sailboats. Second floor accommodation will include offices, and a *grand room* to be used for community functions. The principal salvaged materials will be heavy timber roof trusses forming the main roof of the building. The trusses were obtained from deconstruction of a building at the Flavelle Cedar Mill site in Port Moody. The original mill building was built in the early part of the last century. The timber trusses, which will be exposed on the interior, will determine the character of the building and in particular of the grand room. The architects are investigating the possibility of using other heavy timber salvaged material from the Flavelle Mill in the new center.

One of the difficulties designers face in working with salvaged structural materials is accommodating existing member sizes. In the case of the Port Moody Sail Centre, schematic design of the building was completed before detailed measurement of the existing trusses was possible. In the final design the architects were able to accommodate slightly different truss dimensions than were originally anticipated by varying the size of a covered outdoor space along one side of the building.

Project Team

Owner	**City of Port Moody**
Architect	**Robert Burgers Architect**
Structural Engineer	**Fast and Epp**
Mechanical Engineer	**NDL Consultants Ltd.**
Electrical Engineer	**Mahanti Chu Engineering Ltd.**

Building Type

Building Description	Sail centre
Building Floor Area	9,000 sq. ft.
Construction Cost	$750,000
Construction Type	Combustible / Heavy Timber
Completion Date	Fall 2001
Contract Type	CCDC 2

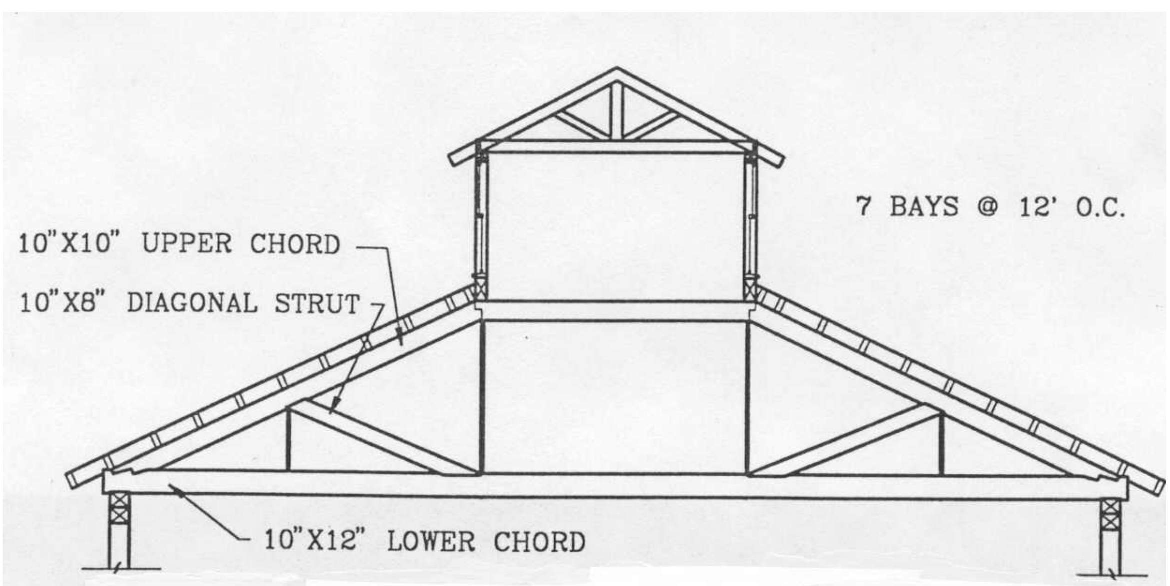
Structural Design

The trusses were generally in sound condition. Some repair work was necessary to address joints between truss members that had opened as a result of movement during removal form the original building, and relocation of the trusses. Localized areas of rot were repaired by removing deteriorated wood, and replacing with sound material. Additional wood for this purpose was obtained from a stockpile removed from the original building at the same time as the trusses.

Modifications were also necessary in order upgrade the trusses to meet current code standards. Steel plates were used to improve the seismic integrity of joints, and steel bracing was added to accommodate unbalanced snow load requirements.

The trusses will be refinished by sandblasting wood and steel members, and repainting the steelwork. Checks in the wood and disused bolt holes will be filled.

Trusses after removal from the Flavelle Cedar Mill



Heritage survey drawing of trusses

Liu Centre, for the Study of Global Issues - UBC

Northwest Marine Drive, Vancouver, BC

The Liu Centre, as a successor to the C K Choi building, continues UBC's commitment to 'green' design. The use of salvaged materials responds to a number of sustainable goals identified by project stakeholders at the beginning of the design process. Many of the glulam beams and most of the cedar decking was obtained from the deconstruction of the Pan Hellenic House on the same site as the new Centre. (Other material from this building was used at the City of Vancouver, Materials Testing Lab.). In keeping with efforts to reduce finish materials, the salvaged beams and decking, which form the roof structure, have been sandblasted and will remain exposed. All surplus glulams and decking have been sold for reuse.

All Liu Centre photographs courtesy of Architectura

Project Team

Owner	**University of British Columbia**
Architect	**Architectura, in collaboration with Arthur Erickson**
Structural Engineer	**Bush Bohlman & Partners**
Mechanical Engineer	**Keen Engineering**
Electrical Engineer	**Robert Freundlich & Assoc.**
Landscape Consultant	**Cornelia Hahn Oberlander**
General Contractor	**Haebler Construction Ltd.**

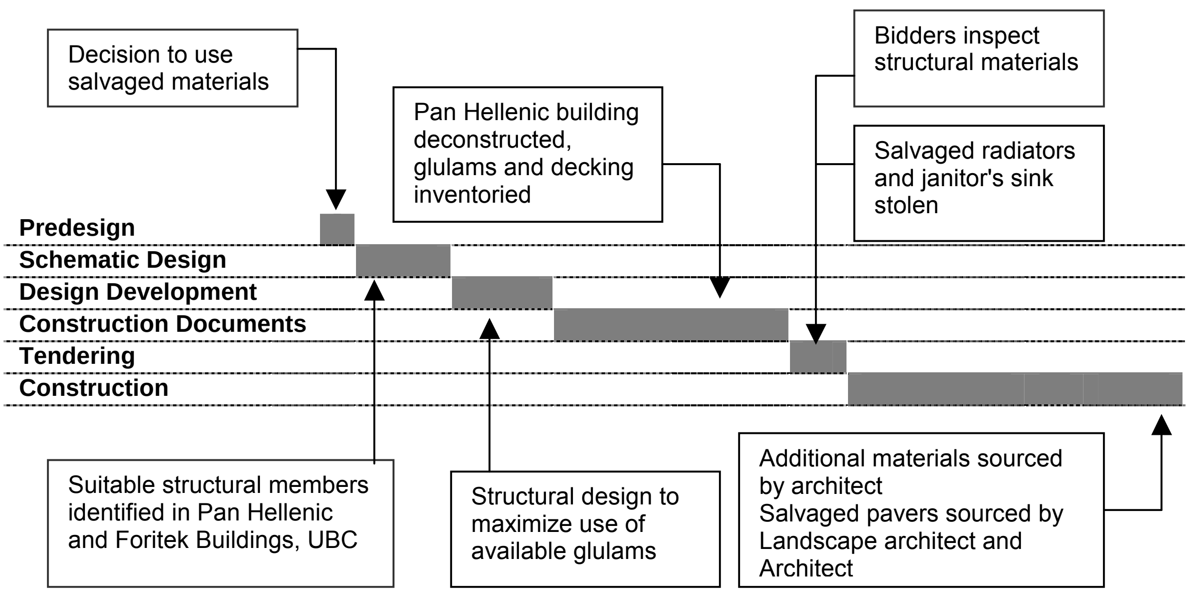
Building Type

Building Description	Research And Conference Facility
Building Floor Area	19,000 sq. ft.
Construction Cost	$3,000,000 ($158 / Sq. ft.)
Construction Type	Heavy timber / Non Combustible
Completion Date	March 2000 - 10 month construction schedule
Contract Type	CCDC-2 Stipulated Price Contract

Principal Salvaged Materials

Component	Salvaged Material	Source
Primary Structure	Glulam beams and columns	Deconstruction of Pan Hellenic and Forintek buildings at UBC
Secondary Structure	Roof decking (2" and 3" t & g decking)	Litchfield & Dubreuil Architectural Salvage
	Rough carpentry (plywood, studs)	Reused formwork
Mechanical	Radiators, copper pipe, valves	Surplus, UBC Forest Science Centre
Landscaping	Concrete pavers	Residential renovations
Miscellaneous	Grab bars, exterior furnishings	Surplus, UBC Forest Science Centre

Project Timeline



Maxem Holdings Building

758 Harbour Side Drive, North Vancouver, BC

The recently completed warehouse and office building provides office and warehouse accommodation for Suntech Optics, a manufacturer and distributor of sunglasses. The use of salvaged materials was just one component in a larger green design strategy that included the use of fly ash concrete, natural ventilation, low VOC finishes and external solar shading devices. Salvaged glulam beams were obtained directly form the deconstruction of an existing building, the Eatons warehouse on Renfrew Street in Vancouver. Bunting Coady Architects, the architects for both the Maxem Holdings building, and the Renfrew Street project, identified the potential for reuse of the beams and were able to design the Maxem Holdings Building to accommodate the material. The involvement of the architects in both projects, and the parallel project timelines was key to the efficient use of salvaged material.

Project Team

Owner	**Maxem Holdings**
Architect	**Bunting Coady Architects**
Structural Engineer	**Fast & Epp**
Mechanical Engineer	**VEL Engineering**
Electrical Engineer	**Nemetz & Associates**
Construction Manager	**Norson Construction**
Landscape Architect	**Vaughan Landscape Planning and Design**

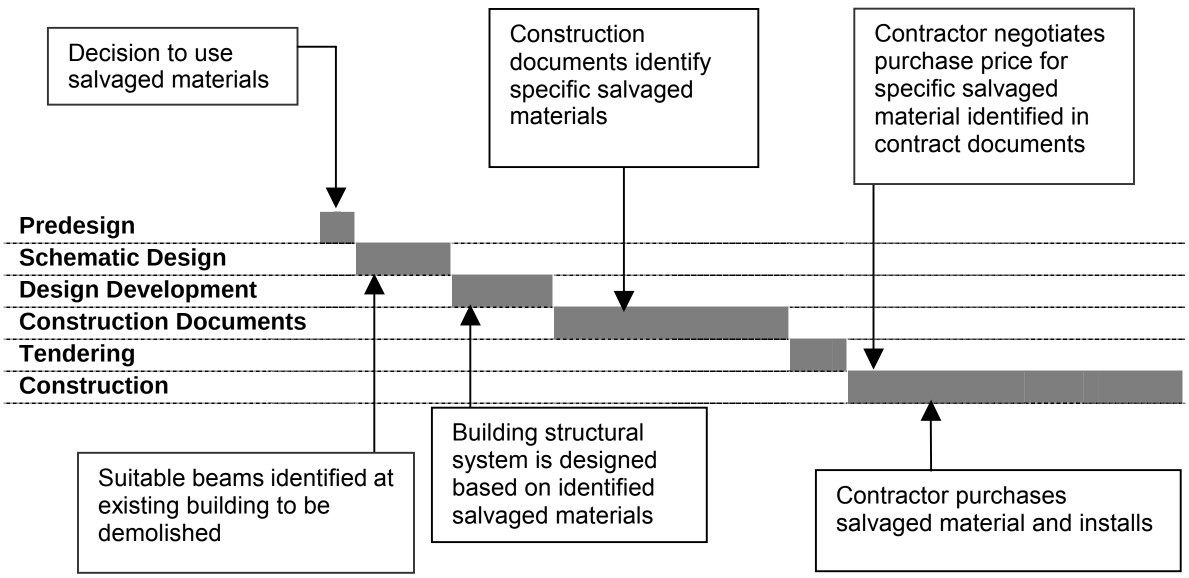
Building Type

Building Description	Office and warehouse
Building Floor Area	27,000 sq. ft.
Construction Cost	$2.0 million
Construction Type	Non-combustible
Completion Date	Sept. 2001
Contract Type	Modified CCDC-2

Principal Salvaged Materials

Component	Salvaged Material	Source
Primary Structure	Glulam beams 9" x 36" x 37'-0" 7" x 36" x 37'-0"	Deconstruction of Eaton Warehouse

Project Timeline



The salvaged glulams were used as floor and roof beams in the office portion of the building. Originally designed for a different structural application, the beams were too deep for the required structural spans at the Maxem Holdings Building. To avoid an inefficient space requirement that would have resulted from a conventional structural design, the beams have been installed sideways resulting in a 9" deep 36" wide member. On the upper floor where the span is larger beams have been braced with steel tension members to create trusses. Beams were refinished on site by sandblasting and sealing.

Cranberry Commons Co-housing

4272 Albert Street, Burnaby, BC

Cranberry Commons, a 22 unit, 24,000 sq. ft. apartment and townhouse co-housing project was completed in the fall of 2001. The Cranberry Commons' sustainability committee worked with the consultants and contractors to integrate a number of energy efficient and environmentally responsible features into the design. Salvaged materials were used in an effort to increase resource use efficiency.

The principal salvaged material used was wood framing. Approximately 30% studs, and 90% of floor joists were obtained from salvaged sources. (Exact figures on quantities of material used are not available, however in wood framed residential buildings, floor joists would typically represent 25 to 30% of the total framing lumber.) In addition to framing, salvaged wood floors were also used in a number of suites.

Project Team

Owner	**Cranberry Commons Cohousing Community**
Architect	**Birmingham Wood**
Structural Engineer	**Chiu Sandys Wunsch Engineering**
Cohousing Consultants	**Community Dream Creators**
Project Manager	**Artian Construction**
Contractor	**Artian Construction**

Building Type

Building Description	Cohousing apartments and community centre
Building Floor Area	24,400 sq. ft.
Construction Cost	$
Construction Type	Combustible
Completion Date	Fall 2001
Contract Type	CCDC Project Management

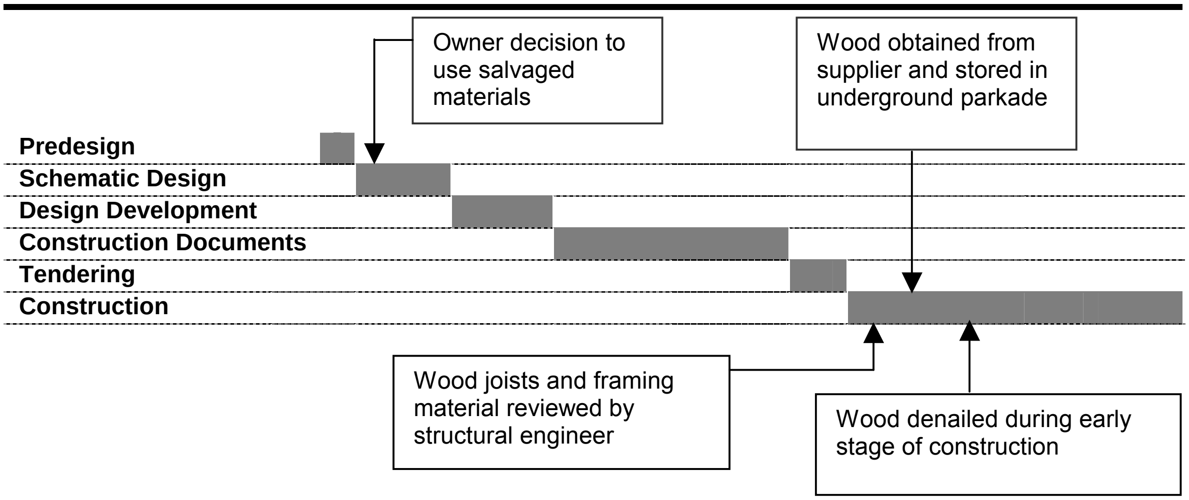
Principal Salvaged Materials

Component	Salvaged Material	Source
Primary Structure	Dimension Lumber 2 x 10 Joists 2 x 6 Wood studs 2 x 4 Wood studs	D. Litchfield Inc.
Finishes	Hardwood flooring	D. Litchfield Inc.

The project was undertaken using a standard construction management contract. Joists and studs were obtained by the contractor / construction manager, from a single salvaged materials supplier, during construction. This contractual method has the disadvantage that the use of salvaged materials is dependent on appropriate materials being available when required. With certain categories of salvaged material this would present problems, however the wood framing used at Cranberry Commons is generally readily available from salvaged suppliers. An emphasis on wood framing resulted in a relatively high salvaged materials content for the project with minimal effort required for acquisition. Denailing, carried out on site by the contractor, was a time consuming process and as a result the use of salvaged material did not generate cost savings. Purchasing previously denailed material from a salvaged materials supplier may have been a more cost effective approach.

Many of the salvaged wood joists had previously been graded, and grade stamps were visible. Where wood was not stamped, the structural engineer visually reviewed material at the suppliers yard to confirm acceptable quality. No major difficulties were reported in using the salvaged wood. A difference in joist depth makes mixing of new and salvaged joists difficult, however as the majority of joists were from salvaged sources this was not a significant issue.

Project Timeline



Salvaged material can be seen at rim joist locations

Deconstruction Case Study

Pan-Hellenic House – UBC

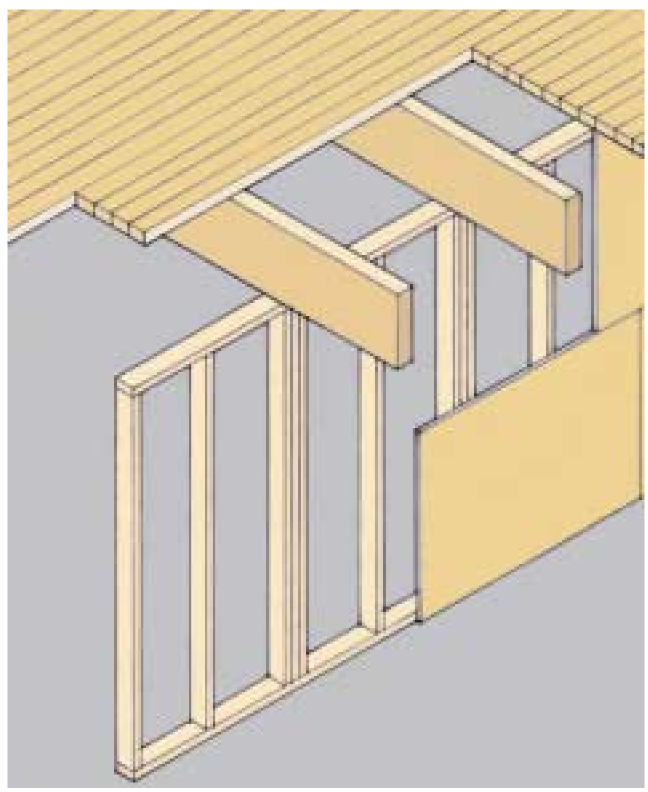
Building Description

The 6,600 square foot Pan Hellenic house at the University of British Columbia was a sorority house constructed in 1959 / 1960. The building was located on the site of the new Liu Centre for the Study of Global Issues. During the early stages of the development of the Liu Centre, and as an extension of that building's sustainability agenda, it was decided to deconstruct the Pan-Hellenic House and to recycle and reuse as many materials as possible.

Type of Construction

The two-storey building was constructed using a combination of wood framing materials. Wood stud walls and built-up posts supported floor and roof assembly of glulam beams and t & g cedar decking.

This form of construction was popular in non-residential and some residential buildings from the late 1940s to the 1960s. The use of solid decking, capable of spanning greater distances than plywood sheathing, allowed for greater spacing of support members requiring larger glulams rather than dimension lumber joists. These materials have greater salvage value than the wood joists and plywood used in more contemporary wood framed buildings.



Material Recovered for Reuse

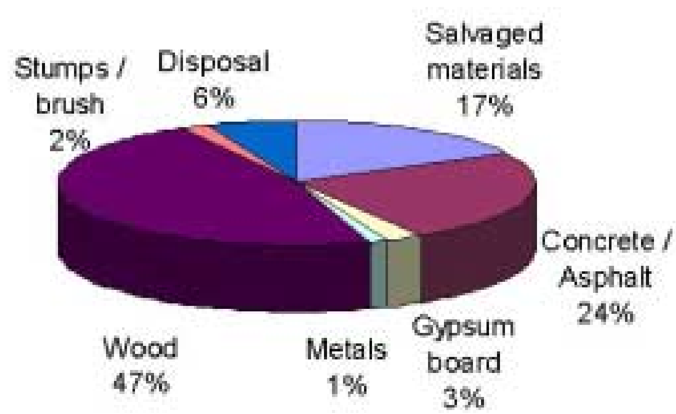
A total of 22,200 board feet of wood was recovered, approximately 3.25 board feet per square foot of floor area of the original building. Glulam beams and cedar decking material were reused at the Liu Centre. This 19,000 square foot building (approximately 3 times the size of the Pan-Hellenic House) is primarily of non-combustible construction but with some areas of heavy timber construction. Sufficient material was obtained from the Pan-Hellenic House deconstruction to provide all of the required heavy timbers for the Liu Centre.

In addition to the glulam beams, approximately 13,000 board feet of dimension lumber and cedar decking were also removed for reuse. As a comparison a new 2,200 square foot single-family dwelling contains approximately 19,000 board feet of framing material (studs, joists and trusses).

Summary of Salvaged Lumber

Component	Size	Length	Linear feet	Board feet
Glulam beam	14.5” x 5”	48’-0”	1,248	7,490
Glulam beam	17” x 8”	56’-0”	112	1,270
Cedar decking	2” x 6”	6’ to 20’	8,265	8,270
Cedar decking	3” x 6”	6’ to 18’	1,824	2,740
Wood studs	2” x 4”		2,930	1,930
Cedar siding	1” x 8”		200	130
Cedar siding	1” x 4”		1,158	390
Total				22,220

Other non-wood materials salvaged for reuse include, doors, roof insulation and gravel. Materials removed for recycling include, wood, steel (primarily rebar), gypsum board and concrete. In total over 90% of material was either recycled or salvaged.



Material diverted by volume

Deconstruction Process

Deconstruction of the Pan Hellenic House was carried out over a 7-week period and required approximately 156 person days of labour. Of this total approximately 16 person days was required for asbestos removal. Deconstruction requires more time than demolition, however many of the activities are common to both processes. Time requirements are the same for the removal of gypsum board, asbestos and concrete footings. Conventional demolition of the Pan-Hellenic House without material salvage would have taken less time with lower labour costs. The higher costs for the deconstruction were offset by revenue from salvaged materials, savings from avoided disposal costs and material cost savings in the construction of Liu Centre.

Deconstruction Timeline

Wks	Activity	Person days
1	Interior finishes and gypsum plaster removed	45
2	Gypsum board, doors and windows, floor sheathing and wall insulation removed	14
3	Roof gravel and insulation removed, interior stucco removed	28
4	Cedar decking removed from roof, glulam beams removed	27
5	2nd floor walls removed, cedar decking removed, 1st floor walls removed	16
6	Concrete slab and footings excavated, rebar removed, site graded	24
7	Final clean up and inspection	2

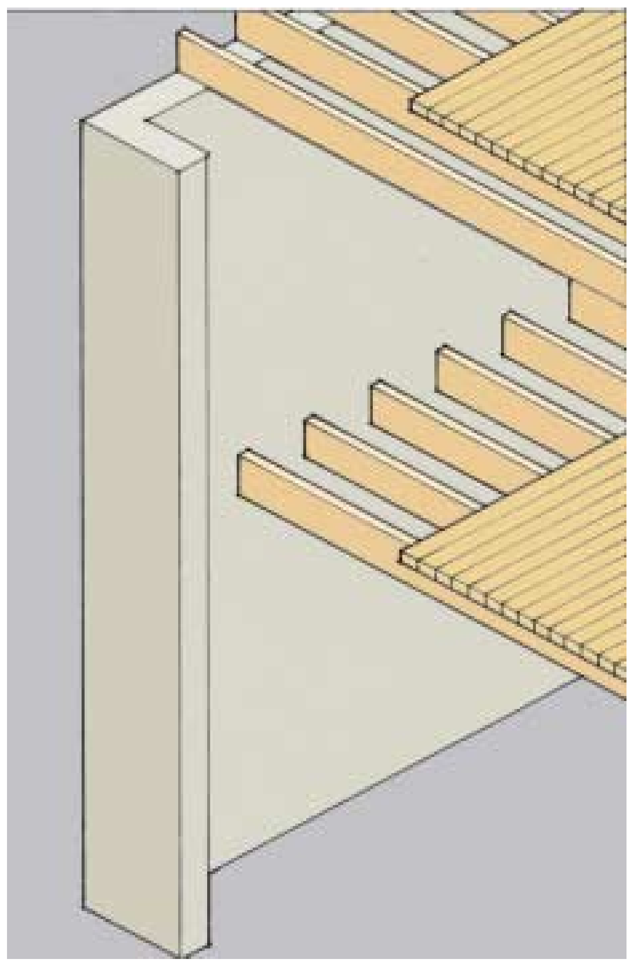
Deconstruction Case Study

1127 – 1141 Richards Street, Vancouver

Building Description

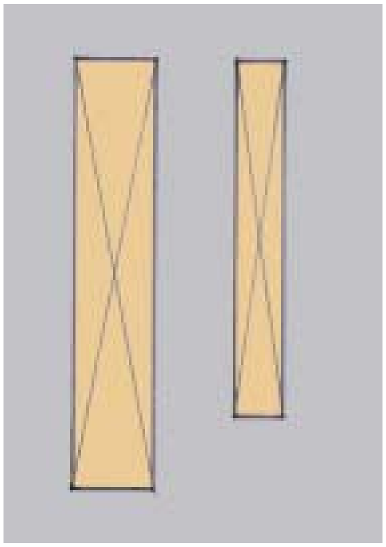
The 3,872 sq. ft. building at 1127 Richards Street was originally built in the 1940s. Prior to deconstruction it housed a sheet metal shop. Demolition of the existing project was tendered competitively with no specific requirement that materials be salvaged or recycled. This demonstrates that building deconstruction for salvage and recycling of materials can be as cost effective as conventional demolition.

Type of Construction



The two-storey building was constructed with a combination of poured in place concrete, and concrete block walls. These load-bearing walls supported wood floor and roof joists spanning approximately 25 feet. Wood decking spanned the joists, but it was not feasible to salvage this material.

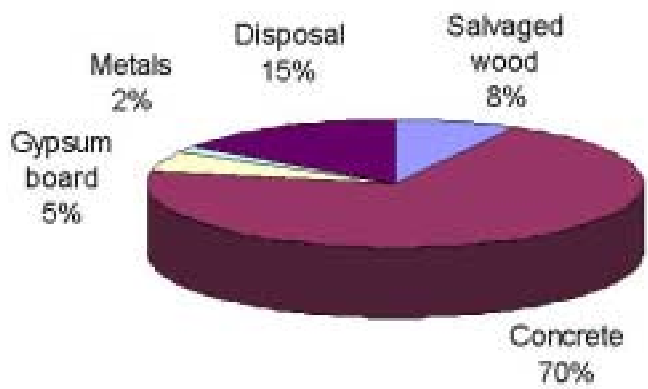
Material Recovered for Reuse



Comparison of 3” x 14” joist with 2” x 12” joist

A total of over 15,000 board feet of Douglas fir joists were salvaged, approximately 4 board feet per square foot of floor area. Almost all of the joists were 3” x 14” in lengths of 15 to 26 feet. These members are considerably larger than the typical joists used in contemporary construction. In new applications they will most likely not be used as joists but rather as beams, either individually or built up. Most of the timber removed was sold to a dealer in Washington State.

Over 323 tonnes of material were removed from the building (excluding the foundations, which have yet to be taken out). Approximately 15% (by weight) of the building materials were not salvageable or recyclable and sent to disposal, principally roofing materials, insulation and miscellaneous interior materials



Material diverted by volume

Deconstruction Process

Timber was removed by hand, cleaned, denailed on site and stacked for transportation. The concrete and masonry components were taken down and the material is crushed with a back hoe. Reinforcing steel is removed by hand.

SECTION 3

3.0 TYPICAL PROJECT

3.1 PREDESIGN

Client's Decision to Use Salvaged Materials

Architects have a key role to play in the initial decision to use salvaged materials and in helping clients make this decision. Initial reaction of owners, and future building users, is often negative; the image of "building with garbage" often comes to mind. The architects of the case study buildings were influential in advocating the use of salvaged materials and persuading their clients that successful high quality buildings could be achieved. The completed buildings, and high levels of user satisfaction reported, bear out their initial conviction. In many respects the buildings are seen as providing superior work environments to comparable conventional buildings.

Environmental Concerns

In the context of growing public awareness of environmental problems, the demand for higher environmental standards and sustainable building can only increase. Already more enlightened owners, such as UBC and the City of Vancouver, are responding to the challenge, and environmentally responsible design is a key component of design briefs for new facilities.

In the case of the C.K. Choi Building, the owners' decision to use salvaged materials was part of a larger environmental agenda that included energy efficiency, use of natural light and ventilation, and water use reduction. The fortuitous availability of large timbers from a building on an adjoining site, scheduled for demolition, resulted in the use of larger quantities of salvaged materials than might otherwise have been possible.

Reasons for building owner to consider use of salvage materials

- Demonstrates leadership and innovation.
- The quality of salvaged materials, especially lumber, is often better, resulting in a better building.
- Cost benefits; salvaged materials may be cheaper, definitely won’t cost more.
- May result in unique buildings, and increased employee satisfaction
- Green buildings as marketing tools. Public opinion and awareness about environmental issues is evolving.
- Building can incorporate historical associations.
- Performance equal to that of conventional building can be achieved

From Demolition / Deconstruction Seminar 1999

Many commercial organizations are also developing environmental agendas, and seeking to incorporate environmental principals into their business practices and the buildings they occupy. REI, a Seattle coop company selling outdoor equipment, is recognized as a leader in protecting the outdoors for recreation. In response to members' expectations that their operations be consistent with the company's conservation ethic, new stores in Seattle and Denver have incorporated many green design strategies including the use of salvaged materials.

Photos courtesy of Mithun Architects

REI Store, Seattle, Mithun Architects

Most clients however, are unlikely to have highly developed environmental agendas for their projects, and in many cases the idea of using salvaged materials, or of incorporating other green strategies, may come from the architect initially. It is important to have the full support of the client, particularly if significant quantities of salvaged materials are to be used. Depending on how, and at what stage, salvaged materials are obtained additional design or construction time may be required. It is also likely that a greater level of professional service, and associated fees will be required, although these may be offset against savings in construction costs. Architects should consider the need to negotiate increased fees with the owner, or agree some method of sharing savings in construction costs.

Potential Cost Savings

The issue of the potential cost savings resulting from the use of salvaged materials is discussed in more detail in Section 4. Clearly, with certain projects there are opportunities to reduce construction costs, and this is obviously an attractive prospect for owners. Cost savings of approximately $50,000 (7.5% of construction cost) were achieved at the Materials Testing Lab as a result of salvaged materials use. However, reusing construction materials does not automatically result in savings, and architects are cautioned against over-estimating the potential, or letting this be the sole driving force behind a decision to use salvaged materials.

Whatever the motivation, it is vitally important that owners are fully supportive of the decision to use salvaged materials, and be aware of, and willing to share any associated risks.

Setting Goals

It is common practice in designing green buildings to establish goals for environmental performance. Building environmental impacts are measured by comparison with conventional buildings, or as a percentage of existing standards such as the National Energy Code or ASHRAE 90.1 standard for energy consumption. It is relatively easy to set similar goals for the use of use of salvaged building materials. (Percentage of salvaged material use is most easily measured in terms of cost of equivalent new material.) The examples of the case study buildings demonstrate that, with particular building types, considerable substitution for new material can occur. The CK Choi building and Materials Testing Lab have salvaged and recycled materials content of 50% and 70% respectively.

Not all architects and owners will want to set such ambitious goals 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:

- The size of the proposed building. Because of the nature of the supply of salvage materials and the different acquisition process involved salvaged materials are most easily, and cost effectively, obtained in relatively small volumes. Greater and more efficient use can therefore be achieved in smaller buildings.
- Previous experience of the design team and contractor, with the use of salvage materials. Knowing how and where to located and acquire salvage materials can improve the efficiency and cost effectiveness of the process.
- Time available during both design and / or construction phases, to locate and acquire salvaged materials
- Type of construction of the building. Wood and wood products represent the largest category of salvaged materials; buildings permitted by code to be of combustible, or heavy timber construction, offer the best opportunities for salvaged materials use.
- The level of implementation of other environmental strategies.

On small to medium sized projects using combustible construction, up to 25% use of salvaged materials can be easily achieved. Achieving higher percentages will require more effort and time, although goals of 50 or 75% are realistic.

3.2 SCHEMATIC DESIGN

Contractual Arrangements

While technically the use of salvaged materials is similar to construction using new product, the process of obtaining salvaged materials differs significantly from normal industry practice. For this reason the conventional contractual relationships may not be the most suitable. This is the appropriate time to discuss these arrangements with the owner and decide on the most appropriate contractual approach. Some key considerations are:

- The level of salvaged material use proposed
- The type of materials to be acquired from salvaged sources
- The time available to research and obtain materials both during design and construction
- Whether the owner already possesses significant quantities of salvaged materials. For example from existing buildings on site.
- The stage at which materials are to be acquired and the party responsible for locating and acquiring them.

The case study buildings demonstrate different contractual approaches, the C K Choi and Liu Centre, stipulated price contracts, and the Materials Testing Lab a construction management contract. Many other factors unrelated to the use of salvage material will also determine the choice of construction contract.

Case Study Building Construction Contracts

Building	Construction Contract	Salvaged Materials
Materials Testing Lab	CCDC - 5 Construction management contract	Provided by owner or located and purchased by construction manager during construction
C.K. Choi Building	CCDC - 2 Stipulated price contract	Provided by owner or located by architect prior to tender and purchased by owner
Liu Centre	CCDC - 2 Stipulated price contract	Provided by owner or located by architect and purchased by owner

Once the decision has been made to use salvaged materials, and goals have been established, the areas in which these materials are to be used should be studied. At this stage it is useful to draw up a preliminary list of materials and components that may be acquired from salvaged sources. The table on the following lists the main areas of salvaged materials use in the case study buildings and can be used as a starting point in developing a list.

Principal Salvaged Materials in Case Study Buildings

System	Material / Component	Best Source
Structural wood components	Heavy timber columns and beams, Glulam beams	Specialty Suppliers, Demolition Contractors Salvaged building materials suppliers
Non-structural wood components	Wood studs, t&g sheathing,	Salvaged building materials suppliers Specialty Suppliers
Cladding	Brick	Demolition Contractors Salvaged building materials suppliers
	Wood siding	Specialty Suppliers
Interior	Doors and frames, Prefabricated stair	Salvaged building materials suppliers
Mechanical	Plumbing fixtures	Salvaged building materials suppliers
	Washroom accessories	Demolition Contractors, Salvaged Materials Suppliers
Electrical	Light fixtures, conduit	Salvaged building materials suppliers
Finishes	Wood flooring	Salvaged building materials suppliers Specialty Suppliers
Site work / Landscaping	Pavers	Salvaged building materials suppliers Masonry Suppliers

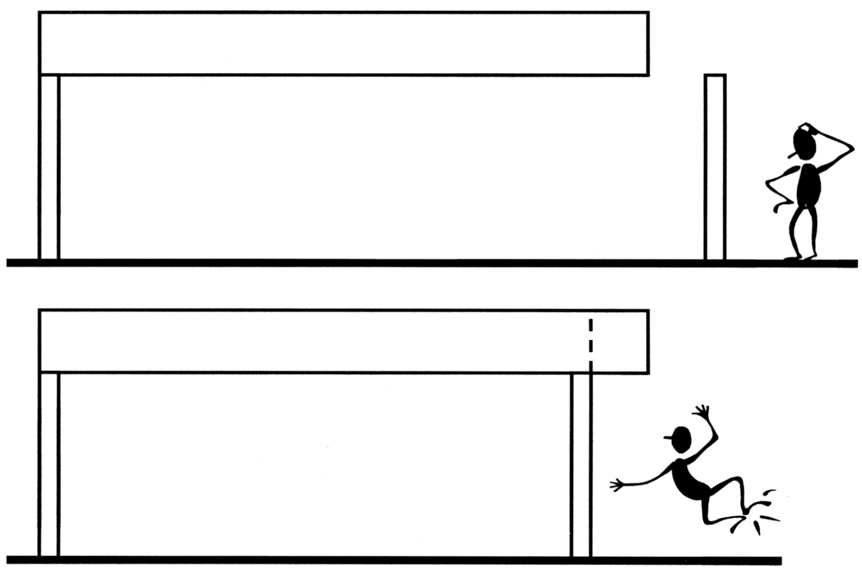
Consultants

There is potential for salvaged materials substitution in all building systems. All consultants should be aware of the owner's decision to use salvaged materials and be requested to identify opportunities within the material and components they specify.

As structural components represent one of the largest groups of salvaged materials, it is essential that the structural engineer be supportive of the decision to use salvaged materials. Considerable ingenuity may be required in developing solutions with a limited palette of materials. Each of the case study buildings used salvaged materials for main structural systems although the methods used were different.

At this stage in the design, basic layout of spaces and column grids and spans are being determined. An understanding of the range of wood columns and beams typically available from salvaged sources will be of benefit. As the building layout is developed in schematic form, the size of program spaces will determine the structural grid, and the size of beam spans. For buildings of combustible or heavy timber construction, this is an appropriate time to discuss the range of sizes typically available in glulam or timber beams. If glulam beams are generally available in lengths up to 7 metres it would be unwise to design 7.2 metre spans and hope to find the right beams during the construction phase. A better approach would be to design to span 6 metres and if necessary trim 7 metre beams to size. Keeping structural spans as short as possible will make the acquisition of beams easier. It is also worth remembering that if wood structural members, have suffered deterioration it is most likely to be at the ends, trimming may be required reducing the length of members.

The benefits of selecting appropriate structural spans



In all case study buildings salvaged structural materials were available during the early design stages. The structure of each building was designed based on actual timber components already available, although the approaches were different.

C. K. Choi Building

Unsuccessful attempts were made to utilize the trusses from the old Armories building in two recently designed, but at that time, unbuilt buildings. In the case of the new Student Recreation Building, the Armories trusses were found to be two feet too short for the designed spans. It may have been possible to use the trusses intact in this building if they had been available at a time when the design could have been adapted to suit the truss sizes. However, although the trusses had to be disassembled for use in the CK Choi building, this did allow greater design flexibility and a structure more suitable to the relatively small program spaces.

Deconstruction of Armories building - removal of roof trusses

Materials Testing Lab

The two main trusses at the Materials Testing Lab are used in their original configuration, with some modifications, but were disassembled and refabricated with new connections. In part this was necessary to allow for pressure treatment of the components which had previously been located in an interior environment. It is important to ensure that new locations of structural timbers are compatible with previous uses or that measures are taken to protect the wood if interior members are used outside.

Structural details, Liu Centre, above, Materials Testing Lab right.

Liu Centre

Glulam beams from the Pan Hellenic House building were identified and measured prior to deconstruction of the building. Design of the heavy timber portions of the Liu Centre was based on these measured sizes. Generally this process worked well although in one case an existing glulam was damaged during removal and did not fit the new structural span. It is important to ensure the salvage contractor is aware of which materials are to be reused, and also in what form they will be used prior to deconstruction. Care must also be taken in deconstructing buildings that materials to be reused are not damaged. Salvage contractors have developed special tools and techniques to carefully remove material.

Adhesion testing was carried out to confirm the strength of the glue used in the original beams.

Sources of Salvaged materials

Once a preliminary list of salvaged materials has been developed, consideration should be given to where they may be obtained. Salvaged materials may be obtained from a number of sources:

- A suitable existing building on site, or on an adjoining site. This is perhaps the best way to obtain salvage materials. Particularly if the building can be identified and materials measured and an inventory taken prior to design of the new building. Obtaining materials in this way from a single source also results in greater consistency of material quality and appearance.
- An existing building off-site. Many of the advantages of an on-site building. If demolition and salvage contractors can be made aware of the project's material requirements they may be able to assist in identifying a suitable building.
- A salvaged building materials supply yard
- Demolition / Deconstruction contractors - on-site sale
- Specialty salvaged materials suppliers / brokers. Particularly for heavy timbers or glulam beams.

More information on the sources of specific materials is provided in Section 4, and local suppliers are listed in Appendix A.

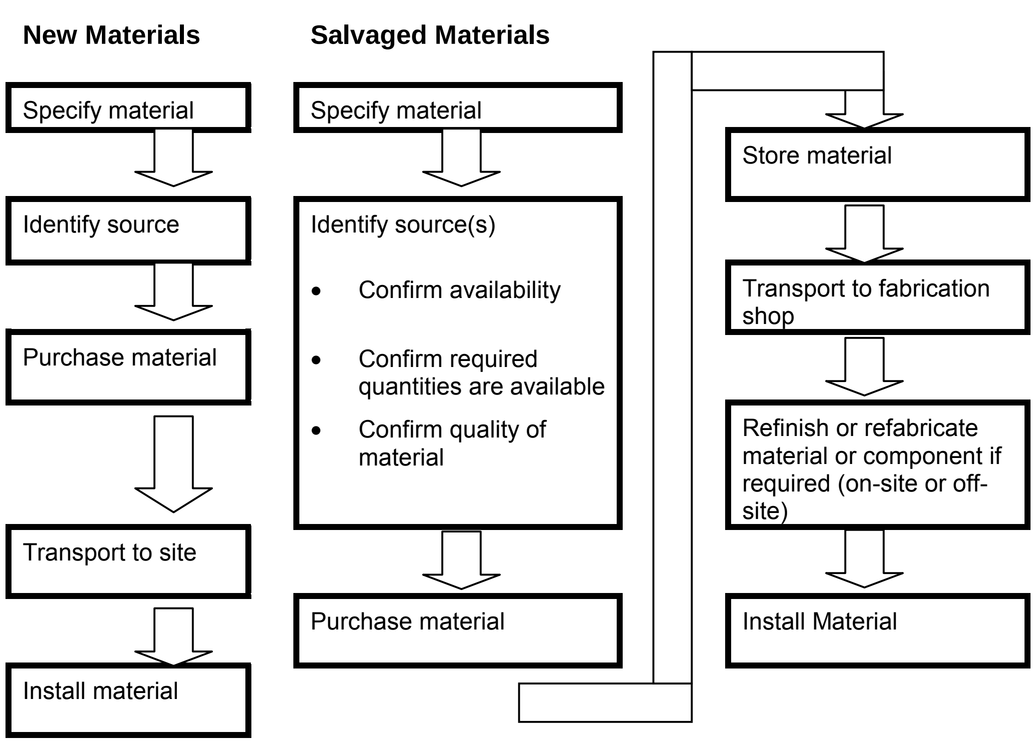
The successful use of salvaged structural materials in the case study buildings resulted, in part, from the availability of suitable structural components at an early stage in the design process. The ability to design the Materials Testing Lab building around the large trusses, and to disassemble the armories trusses to provide smaller components, which could be integrated into a design that was still somewhat fluid, were key factors in their success. Designing a building based on a fixed set of structural materials, may appear to be constraining, however in terms of salvaged materials use it is much easier that designing without reference to availability of materials and attempting to locate specific materials later. For larger buildings it is almost essential to have the bulk of structural materials available prior to detailed design of the building.

For smaller buildings it may be possible to find suitable structural materials in sufficient quantities at a single salvage materials yard or from a broker in the case of heavy timbers or glulam beams. For larger buildings this is likely to be more difficult unless an entire building scheduled to be demolished, and containing the needed materials, can be identified. However if the larger part of structural materials can be obtained from a single source it is feasible to obtain smaller quantities form suppliers.

Acquisition of Salvaged Materials

When specifying new material, architects and designers are used to choosing from a wide product range, and generally need have little concern about variations in quality and availability. Selection of appropriate materials can be made based on previous experience with a particular material, or on the basis a review of product catalogues, technical literature and sample material. Initially architects may find the process involved in identifying and acquiring salvaged materials a little cumbersome and limiting. However, those who have used salvaged materials, have not identified any significant difficulties with the process provided sufficient time is allowed and appropriate procedures are implemented. The case study buildings demonstrate that differences in the nature and acquisition process of salvaged materials need not effect the quality of the final building.

Comparison of Materials Acquisition Processes



3.3 DESIGN DEVELOPMENT

During the design development stage of the project, more detail can be added to the list of potential salvaged materials to be used. Sizes and outline specifications of materials and components can be developed. If possible, size ranges, rather than fixed dimensions, should be specified initially. For example, although there may be an ideal size, for overhead doors, the design may be flexible enough to accommodate slightly wider or narrower units.

A further example, from the Materials Testing Lab, is the use of salvaged interior doors. Although a good supply of flush wood interiors doors is readily available from salvaged material suppliers, it is not always possible to acquire large numbers of doors of exactly the same height and width. Consistency of dimensions is clearly an objective in terms of visual appearance, however this does not necessarily have to extend to all doors in the building or even to all doors of a particular type. All doors within particular continuous areas were required to be the same height but variations were permitted between separate areas and from floor to floor.

Flexibility may also be needed in specifying exterior cladding. During the design development stage, the drawings of the Materials Testing Lab indicated cladding without specifying the material. Both metal cladding, and the wood siding that was eventually used, were considered to be acceptable. The final choice was based on availability of material at the time of construction. The need for this level of flexibility, and if possible the range of likely cladding materials, should be discussed with the planning department if design approvals are required.

Design for Future Reuse

To facilitate future reuse of materials, care should be taken to ensure that both salvaged and new materials, are detailed, and installed, in such a way that they can be readily removed at some future date. In the same way that we place high value on old materials, it is likely that in the future, the same regard will be paid to many of the better quality new and used materials we use today. Even more so when the materials have a history that goes back beyond their current use.

As materials and components are incorporated into buildings during construction, they must be physically attached, or held in place. In some cases the weight of the material itself is sufficient, but usually some form of mechanical fastener of chemical bond is required. Attachment with adhesives or other chemical bonds is often irreversible and means the material cannot easily be disassembled to allow reuse. In some cases adhesives are the only realistic choice, but where possible mechanical fasteners should be used. Unfortunately it is almost impossible to salvage bricks from recent masonry construction because of the use of cementitious mortar. Older bricks held together with lime mortar are much easier to disassemble.

Environmental Criteria

Designers should be aware that there are other environmental criteria, beyond those addressed directly by the use of salvaged materials, that should be considered in choosing to use salvaged rather than new materials. In a number of instances the benefits of using salvaged materials must be weighed against the advantages of using new materials, which may be more energy or resource efficient. This is particularly the case with reuse of mechanical and electrical equipment. Even in cases where newer more efficient components are available from salvaged sources, the selection may be limited, and it may not be possible to efficiently match the size of unit to the particular application requirements. Although savings in embodied energy may be achieved by using a salvaged component, the loss of operating energy efficiency, as a result of over-sizing, would be much more significant over the full service life of the component. However in many cases it may be possible to refurbish old equipment and improve its energy efficiency by replacing motors, fans etc.

Similar arguments apply to electrical light fixtures. In many cases older fluorescent or incandescent lights, removed from existing buildings as part of energy upgrades, find their way into the salvaged materials market. It is possible to retrofit the original fixtures with new ballasts and to accommodate more energy efficient lamps. Many of the light fixtures at the Materials Testing Lab were from salvaged sources.

A common green building strategy is to reduce water consumption in buildings. Low flow plumbing fixtures are available, and in some cases are now mandatory. It is feasible to reuse plumbing fixtures such as sinks and bathtubs, and to retrofit them with low flow accessories. However adapting old toilets to meet current standards represents some difficulties. Simply reducing the capacity of the tank to comply with low flow requirements may result in inadequate performance of the fixture.

3.4 CONSTRUCTION DOCUMENTS

Building Permit

The BC Building Code, or Building By-law in the City of Vancouver, plays a significant role in determining the types and quality of materials that are permitted in construction. In addition, the Code and By-law reference numerous standards that also define quality of materials and components. Both the BC Building Code and City of Vancouver Building By-law, deal explicitly with the use of salvaged materials. The code refers to *"used materials"* but the intent is clear:

> *Unless otherwise specified, used materials, appliances and equipment are permitted to be reused when they meet the requirements of this Code for new materials and are satisfactory for the intended use* (BC Building Code 2.4.1.3. 1))

Although the general principle of permitting salvaged materials is clear, the question as to whether particular materials or components meet the specific requirements of the code, or referenced standards, or are satisfactory for the intended use, may be more difficult to establish.

Architects have generally received a favourable response from municipal regulators when proposing to specify and use salvaged materials. In part as a result of the success of the Materials Testing Lab, the City of Vancouver is on record as "encouraging contractors to use recycled / salvaged building materials where the materials meet Building Code requirements". In all cases the municipal building department should be made aware of the intention to use salvaged materials at an early stage. In order to ensure acceptance and avoid misunderstandings there should be ongoing communication and information exchange. Salvaged materials should be identified and noted on permit drawings.

Wood Grading

All wood commonly used in construction is classified according to species group, and is also marked with a grade stamp, indicating the grading authority, the mill of manufacture, the moisture content of the wood at the time of manufacture, and the grade of the wood. Grading is based on size and location of knots, and slope of grain. The purpose of grading is to identify the quality of wood intended for specific types of application. Dimension lumber is face stamped approximately 2 foot from the end of the each piece of wood. Grade stamps are applied at the point of manufacture, and play a key role in determining the use or range of uses of the wood in structural framing applications. The table below, from the BC Building Code indicates the permitted spans for 2" x 10" floor joists at 16" on centre.

Part 9 BC Building Code- Residential loads

Species Group	Grade	Allowable Span (m)
Douglas Fir / Larch	Select Structural	4.70
	No. 1 and No. 2	4.51
	No. 3	3.58
	Construction	1.84
	Standard	1.78
Hem-Fir	Select Structural	4.64
	No. 1 and No. 2	4.51
	No. 3	4.37
	Construction	1.84
	Standard	1.78

Wood members from buildings older than the early 1960s are unlikely to have grade stamps. However it is generally accepted that wood from older buildings is at least equal, and often better in quality to comparable new wood. Older wood tends to be denser, and have fewer knots than newer material of the same species. However lack of grade stamps can be a serious impediment to the use of salvaged wood in load-bearing applications.

A solution to the problem of lack of grade category is to assume the materials are of the lowest grade. In the case of the 2 x 10 listed above the municipal inspections department might reasonably accept a classification of No. 3 grade for reused joists. (Construction or standard grades are not commonly used in construction.)

Salvaged lumber may also be re-graded. Lumber used at the Materials Testing Lab was visually re-graded on site by a City employee who was also a certified wood grader. Pacific Heritage Woodworks a local supplier of salvaged timbers and large dimension lumber will provide regrading of all wood they supply.

Salvaged wood material may have bolt holes or notches, and there are, as yet, no protocols for accounting for these defects when assigning grades. Recent experimental testing in the US has considered bolt holes to be equivalent to knots for grading purposes, and it is likely that in the future grading standards for salvaged wood will be developed.

It is also worth noting that many non-load-bearing uses of dimensioned lumber do not require graded material, for example, blocking, strapping etc.

Right, 2" decking material remilled as studs.
Above, non-structural uses of salvaged wood

3.5 TENDER / CONTRACT AWARD

Alternative Construction Contracting Approaches

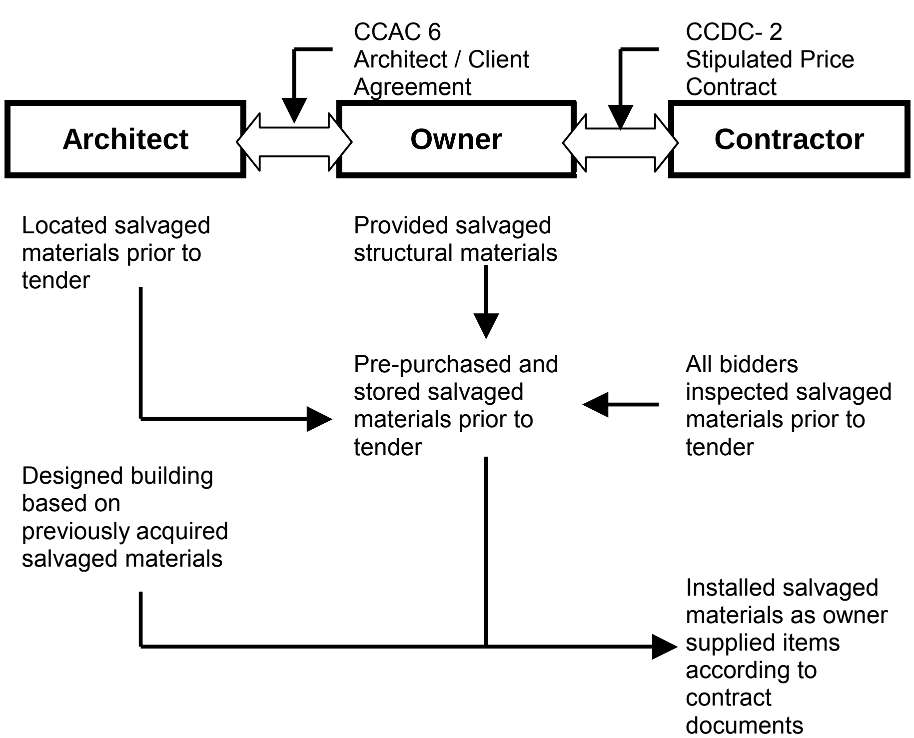
The importance of identifying the construction contracting approach to be used, at an early stage in the project, has been previously discussed in the context of establishing goals for the overall level of materials reuse, and in determining which materials should be acquired from salvaged sources. The case study buildings employ different contracting approaches. The success of each building suggests that either method is viable. Regardless of which contract type is used, some changes to normal methods of materials selection, and acquisition are inevitable.

Stipulated Price Contract / General Contractor

Construction of the C.K. Choi building was based on a standard CCDC-2 Stipulated price contract, The diagram on the following page illustrates the contractual arrangements between architect, owner and contractor and the process involved in acquiring salvaged materials.

Salvaged materials were researched and located by the architects, and purchased by the owner, during the pre-construction phases of the project. All of the salvaged materials for the project were available for inspection by contractors at the time the project was tendered.

CK Choi Building Salvaged Materials Acquisition Process



Contractors bidding the project were not required to investigate the unfamiliar processes of salvaged materials acquisition, or to make assumptions about the availability of appropriate materials. The process therefore did not differ significantly from a conventional tender, and bidders were not exposed to increased risks as a result of uncertainties relating to the use of salvaged material. This method of acquisition required additional time during the pre-construction stages to allow the architects to search for and locate appropriate salvaged materials. It was also necessary for the owner to access construction funds at an earlier stage than would normally be the case.

If the owner has pre-purchased and stored salvaged materials, contractors should be given the opportunity to inspect the materials in order to understand the quality, need for refinishing etc. of the materials they will be using.

The project specifications should also recognize the quality of the material and indicate the level of additional work that is expected prior to installation. For example hollow metal doorframes may be damaged during salvage operations, and may have dents or other defects that will be apparent even after repainting. Contractors need to know if these will have to be repaired, or if the frame can be installed "as is". Repair of minor damage can be expensive and contractors need to have an understanding of the expectations of the owner and architect as far as quality of finished product is concerned. To a certain extent the degree of repair necessary in this, and other cases, will depend on the location within the building of the material or component. A pristine finish may be required in major public spaces within the building, but may be less critical in storage areas or other less frequently used spaces. Ideally in the case of doors and frames, each would be examined prior to tendering and a schedule produced indicating location of each door, and specifying a level of quality / repair required. Again this entails additional work for the architect and highlights the need for additional fees.

Stipulated Price Contract and Use of Salvaged Materials

Advantages	Disadvantages
• Architect selects appropriate material during pre-construction stages and has more control over quality and appropriateness for design • Contractors may view the salvaged materials prior to bidding the project • Once tenders close and contractor is selected, construction costs are known with the same level of certainty as in a typical construction project • Additional construction time is not required (although use of salvage material may require different skills)	• Owner must pre-purchase materials incurring construction costs earlier in the project schedule • Materials must be stored until the appropriate stage of construction. Security and / or additional insurance may be required • Less flexibility for introducing salvaged materials later during the construction stage • Additional design time and fees may be required to permit architects to located appropriate salvaged materials

Stipulated Price Contract without Pre-purchase of Salvaged Materials

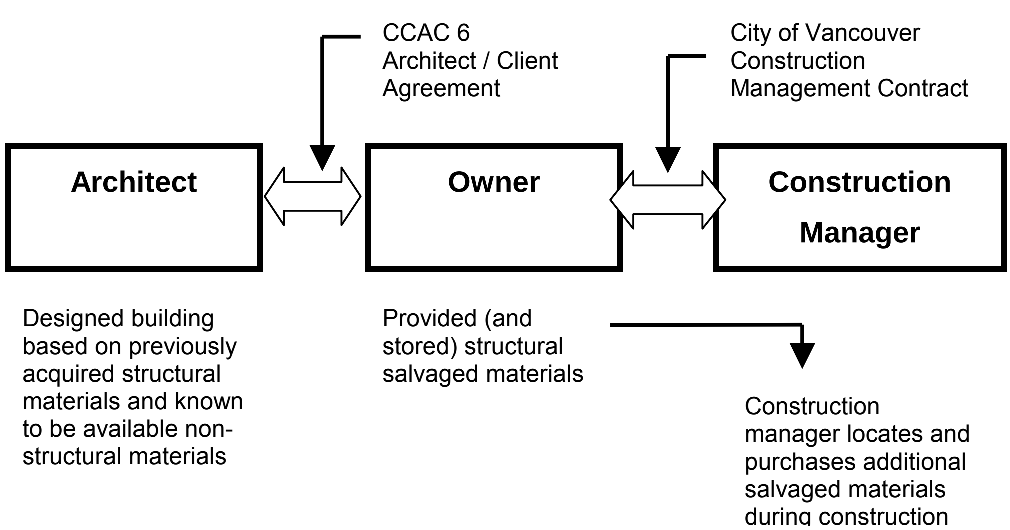
Experience has suggested that when contractors bidding a project are given the choice of providing new or salvaged materials, they will invariably choose to bid on the basis of using new material. The reluctance to choose salvaged materials is understandable and results from:

- Unfamiliarity with the acquisition process for salvaged materials
- Unfamiliarity with the use of salvaged materials
- Uncertainty about the availability of materials at the appropriate time during construction
- Uncertainty about the suitability of available salvaged materials

Construction Management

The materials acquisition process at the Materials Testing Lab and the various contractual arrangements are illustrated below. Initially, the owners' intention was use a conventional general contractor delivery method. Acquisition of non-structural salvaged materials was to be the contractor's responsibility, and tender documents gave the contractors the option of using salvaged or non-salvaged materials. Unfortunately for a number of reasons, including those described above, most contractors decided not to bid on the basis of salvaged materials. When the results of the bidding process were reviewed it was apparent that little salvaged material other than the structural members provided by the owner would be used. An alternative, construction management approach was therefore implemented.

Materials Testing Lab Salvaged Materials Acquisition Process



The main structural materials were provided by the owner and were available early in the design stage. However, theft, and an unfortunate fire, resulted in the loss of some material. A tour of local salvaged materials yards by the owners and architects during design stage suggested that a large and varied selection of salvaged materials were available. However, the inconsistency of supply of certain materials was not immediately obvious. Design proceeded on the basis that salvaged materials would be available at the appropriate time. However when the construction manager attempted to locate and purchase materials during construction, many of the materials that had been identified as being suitable were no longer available.

Construction Management Contract and Use of Salvaged Materials

Advantages	Disadvantages
• Can allow for greater use of salvaged materials • Owner is not required to access construction funds during pre-construction stages of the project • The construction manager can respond quickly to the opportune availability of salvaged materials during construction	• Final construction cost is not known until the project is complete • All salvaged materials are not available at the start of the construction stage. The design is completed without necessarily knowing which materials will be available from salvaged sources at the appropriate time • Potential delay in construction schedule if salvaged materials are not available when needed

3.6 CONSTRUCTION AND CONTRACT ADMINISTRATION

Timelines

Although some salvaged materials may require more preparation and finishing than new material, construction schedules should not need to be extended to accommodate the reuse of salvaged material, provided all materials are available at the appropriate time during construction. This requires that all materials be available at the start of construction, or alternatively, that the contractor, or construction manager, know where, and how to obtain salvaged materials and that sufficient time is allowed. Whether this is possible in practice will depend, to some extent, on the level of salvaged material use and the particular materials required. Some delays were experienced during construction of the Materials Testing Lab when salvaged materials were not immediately available when required. In part the delays can be attributed to the firm commitment of the project team, and owner, to use salvaged materials whenever possible.

All of the salvaged materials used in the C.K. Choi building were acquired prior to construction, and where available to the contractor when required. Construction was not therefore delayed as a result of the use of salvaged material.

Field Review

In reviewing construction using salvaged materials some allowance should be made when the appearance of material is not of the quality that would generally be expected of new material. Minimum standards must be set for quality and appearance of salvaged materials and components, but to expect all salvaged materials to be indistinguishable from new material is unrealistic. In comparing salvaged components with minor defects with comparable new product it should be remembered that once the building is occupied, all materials essentially become used materials. In most normal service environments new materials will quickly exhibit signs of use.

To a certain extent the approach taken will depend on the contractual arrangements and the methods used to procure the salvaged material. If the owner is supplying the material to the contractor, it is difficult for the architect to deem it unacceptable on the grounds of appearance, unless specific details of refinishing have been specified and not been complied with.

Letters of Assurance to be provided after completion of construction should not present any unique problems with respect to salvaged materials.

Municipal Inspections

The building code position on the reuse of materials has been discussed previously, in Section 3.4. There have been reports of individual inspectors reacting unfavourably to the use of salvaged materials and of some inconsistency in interpretation of code requirements. However if the use of salvaged materials has previously been discussed with the municipality, and particularly if specific salvaged material use has been identified on permit drawings there are unlikely to be difficulties.

If additional salvaged materials, not identified on the permit drawings, are used it may be appropriate to identify this material on the final set of record drawings.

Trades Resistance

Some initial contractor resistance to the use of salvaged materials is to be expected. Although most construction workers will appreciate the qualities of old lumber and heavy timbers, the same may not be the case with reused doors, or previously used plywood sheathing. In both case study buildings, first reactions to the use of salvaged material made reference to building with "garbage".

However, as the buildings took shape, attitudes of the workers, as well as the future building users, changed and became strongly positive. Working with salvaged materials can provide construction workers with opportunities to acquire new skills. Use of salvaged materials may also foster more traditional construction skills of cutting and fabrication, rather than current common practices of measurement, ordering, and installation of prefabricated components. For example the windows for the Materials Testing Lab were milled and fabricated on site by the Construction Manager's own forces. Within a broader context the shift from material costs to labour costs resulting from the use of salvaged materials has significant benefits in terms of creating additional construction industry jobs.

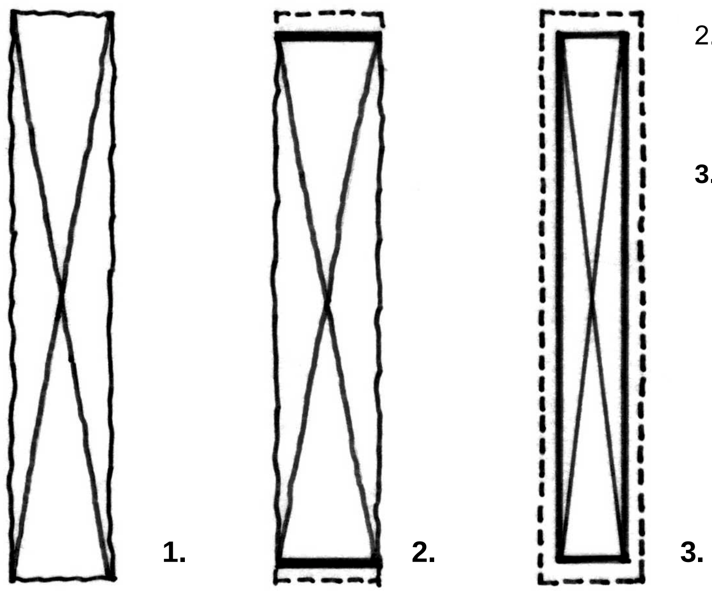

On-site fabrication of window frames, Materials Testing Lab

Greater care needs to be exercised in working with salvaged materials. When using new material, workers can usually assume that additional material can be quickly and easily obtained. For example, if workers run out of dimension lumber as a result of poor planning or unnecessary wastage, new material can be readily purchased at many lumber stores. This is not the case with salvaged materials. Greater care needs to be taken. If a small piece of lumber is required, off-cuts should first be checked for suitability before cutting a larger member.

Working with old lumber

As wood ages it becomes hard and more difficult to work. Cutting old wood will blunt saw blades quicker than working new material. However more frequent replacement of blades is unlikely to add significantly to overall project costs. The widespread use of nail guns makes the density and hardness of the material less of a problem.

Older dimension lumber does not always conform to current sizes and standards of finishing. Old lumber was originally rough-cut; for example joists were sawn, trimmed and edged, but not planed, and saw marks are often visible on the surfaces. Later one or two edges of the rough-cut material were planed in order to provide smoothness for attachment of decking, and to provide uniformity of joist depth. Modern framing material is typically planed on all sides, S4S, and as a result the finished dimensions may be 1/2" to 3/4" less than the original rough cut dimension. Mixing salvaged and new dimension lumber in construction must take account of these size differences.



1. Old joist - rough cut
2. Old joist - S2E - planed two edges to allow more regular nailing of decking material
3. **3.** New Joist S4S - planed four sides

Comparison of Old and New Joists

One of the advantageous characteristics of old wood is its low moisture content. Moisture content of heavy timbers and framing material, which has not been exposed to the exterior environment, is likely to the same as or lower than new kiln dried material. This wood is dimensionally stable and will not shrink in the same way that new wood will. Care must be taken however to allow for differential movement to avoid cracking of finishes if salvaged material is used alongside new material.

Quality and Appearance of Materials

Generally if materials have been selected prior to construction, quality should not be an issue. Owners, architects and contractors will likely have inspected materials. In the case of some salvaged materials such as wood products, the aged appearance is considered a desirable effect. The patina of weathered surfaces is a much sought after quality and even rust stains and old boltholes may be acceptable. Care needs to be taken if salvaged materials from different sources are mixed. Additional finishing may be required to achieve a consistent appearance.

Problems may arise with non-structural materials or components obtained by the contractor or a construction manager during construction. Some standards and quality control measures should be established before material acquisition. The architect, and engineers if appropriate, should review all salvaged material.

3.7 TYPICAL PROJECT SUMMARY

The following summary lists some of the main considerations and activities associated with salvaged materials through each of the typical project phases.

PREDESIGN PHASE

- Discuss and agree use of salvaged materials with client
- Establish goals for salvaged materials use
- Review likely impact of salvaged materials on overall project costs
- Discuss the need for additional professional fees
- Prior to selecting consultants, consider previous experience with use of salvaged materials, or willingness to accept concept.

SCHEMATIC DESIGN

- Discuss alternative contractual arrangements with client, particularly if high levels of salvaged material use are planned
- Begin to establish which materials and components will be from salvaged sources based on established goals
- Investigate the potential of obtaining structural materials from an existing building.
- Visit local used building materials yards to establish general availability and quality of materials.
- Discuss scope of project and preliminary list of materials with demolition contractors and salvaged materials suppliers.
- Discuss use of salvaged materials with other consultants, particularly the structural engineer

DESIGN DEVELOPMENT

- Add more detail to list of salvaged materials. Allow for flexibility in choice of materials and ranges of sizes.
- Discuss possible pre-purchase of high value materials with owners
- Discuss proposed use of salvaged materials with municipal building department
- Continue to discuss list of required materials with salvaged materials suppliers.
- Consider possibility of pre-purchase of suitable high value materials

CONSTRUCTION DOCUMENTS

- Identify all salvaged materials on building permit drawings
- Continue to develop list of salvaged materials
- Consider pre-purchase of suitable material
- Establish procedures for grading salvaged wood
- Establish standard for salvaged materials to be obtained by contractor or construction manager

TENDER / NEGOTIATION

- Arrange for contractors to inspect pre-purchased materials

CONSTRUCTION / CONTRACT ADMINISTRATION

- Review quality of salvaged materials obtained by contractor or construction manager
- Review use of salvaged materials with municipal inspector

SECTION 4

4.0 SALVAGED MATERIALS

4.1 INDUSTRY STRUCTURE

The demolition and salvaged building materials industries are separate, but closely related entities. The disassembly, removal, and disposal of buildings at the end of their useful service life may be accomplished through either demolition or deconstruction. Demolition refers to the *"rapid destruction of a building with or without prior removal of hazardous materials"* [1]. Deconstruction on the other hand involves *"taking a building or structure apart in a manner that achieves safe removal and disposal of hazardous materials and maximum salvage and recycling of materials".* Full, or partial, deconstruction of buildings provides the material for the salvaged building materials industry. Increased construction industry demand for salvaged materials will encourage more deconstruction and materials recovery.

Benefits of Deconstruction
• Significant quantities (up to 90%) of demolition waste can be diverted from landfill disposal.
• Worker and public health and safety is protected through the correct removal, handling, and disposal of a number of hazardous materials commonly found in older buildings.
• Deconstruction is a labour-intensive process and creates jobs, both in dismantling buildings, and in the salvaged building materials industry
• Deconstruction provides a supply of affordable, and in many cases, high quality used building materials.
• The use of salvaged materials conserves natural resources and protects the environment.
• The use of salvaged materials reduces embodied energy (i.e. the energy required to acquire raw materials, manufacture, and transport new construction materials)

From: Provincial Demolition Material Diversion Strategy - Discussion Paper

Building demolition is regulated by individual municipalities, typically through building and development by-laws. Permits are required before any building may be demolished, and increasingly, municipalities are concerned about the proper disposal of hazardous material. Deconstruction of buildings takes considerably longer than demolition but does allow for the correct removal and disposal of hazardous materials. Removal of useful building material is a labour-intensive process, requiring special skills and tools if materials are to be removed without damage. Deconstruction of a single-family residence may be accomplished in a week, with larger

[1] Demolition Materials Diversion Symposium, Summary Report, Dovetail Consulting Inc. / Salasan Assoc. Inc. 1998

buildings taking as long as 2 or 3 months.

Most demolition projects are tendered and awarded to demolition contractors on the basis of competitive bidding. Owners of buildings to be demolished are in many cases involved in new construction projects, and are usually anxious to proceed quickly with the new development. They are not normally concerned with whether or not the building is deconstructed or demolished. However the time needed to remove the existing building is often of concern. In cases in municipalities where demolition permits cannot be issued until such time as a development permit is also issued. The lack of time and the short interval between issuance of a demolition permit and the start of construction, is a significant impediment to increasing the practice of deconstruction. However it does offer an opportunity for inspection of the existing building and identification and documentation of suitable salvage material.

A number of different types of contractor are involved in demolishing or deconstructing buildings and supplying salvaged materials. Three categories are identified although it is important to understand that boundaries are somewhat fluid, and activities practiced by contractors can vary and change.

1. Demolition Contractors

The main focus of these contractors is on demolition, although they may also carry out some deconstruction, and sell the more valuable materials such as heavy timbers, to salvaged contractors, or specialty sub-contractors. Unless they also have a salvaged building materials yard, demolition contractors typically are not a major source of salvaged materials. However they will often sell material on-site when deconstructing or demolishing buildings. The term deconstruction is not widely understood, and most contractors use the term demolition, even when large portions of their work may be classified as deconstruction.

Demolition / deconstruction

Typical salvaged materials yard

Most demolition contractors are now practicing some level of deconstruction on selected buildings. However, as they are generally not properly equipped to remove materials without damage, the level of material salvaged is currently low. In many cases demolition contractors will sub-contract to salvage contractors or specialty sub-contractors for removal of specific components or materials.

2. Salvage Contractors / Salvage Building Materials Suppliers

Purchase materials from demolition contractors and sell to the general public and building contractors through a salvaged building materials yard. The terms salvage contractor and salvage building materials supplier refer to the two aspects of acquiring and selling materials. In some cases they may contract to selectively deconstruct portions of the building, and remove particular materials themselves, but usually the demolition contractor removes the material from the building. (One of the local salvage contractors also operates as a demolition contractor and obtains salvaged material from their own demolition / deconstruction projects.)

Salvage building materials suppliers represent the basic resource for general-purpose salvage materials. The larger yards have a good selection of structural and non-structural materials and components. The main salvage contractors, with the best-organized yards are:

- Litchfield Demolition - Coquitlam, BC
- P & B New and Used - Surrey, BC
- All Around Demolition - Burnaby, BC
- Bent Nail New and Used - Abbotsford, BC

Unfortunately only the larger yards have inventory systems, but the more organized will have an idea of what materials are in the yard on a day to day basis. Most yards are prepared to accept "shopping lists" of materials from architects or contractors, and will attempt to acquire materials over a period of time. If material is available, but not required immediately, suppliers will store the material at their yard although they will generally expect to be paid in full.

As discussed previously much of the best material is not to be found in used salvaged building materials yards, and they are not always the best place to begin a search. However architects intending to use salvaged materials should visit local yards to gain an understanding of the range, quality and selection of available materials. A list of Lower Mainland salvaged building materials yards is provided in Appendix A.

Traditionally salvaged building materials yards have catered to a "cash-and-carry" market, mainly supplying small quantities of materials, or single items, to small contractors or the home renovation market. The recent success of some key local projects, have demonstrated the potential of supplying higher volumes of materials to larger commercial / institutional projects.

3. Specialty Suppliers / Brokers

Specialty suppliers, or brokers, who purchase specific salvaged materials, particularly those with high value, such as heavy timbers. In many cases demolition contractors, and even salvage contractors who have their own yards, will sell directly to these companies.

There are a number of local specialty suppliers of heavy timber, large dimension lumber, and glulam beams, who also maintain yards. These suppliers frequently de-nail, clean, prepare, re-grade and re-cut salvaged wood, providing a value-added product for export or local markets.

Pacific Heritage Woodworks' Yard, Whonnock, BC

Specialty contractors represent one of the best sources of salvaged materials. They act as intermediaries between demolition contractors and purchasers. Because they deal in a single material only, they can generally provide a much wider selection than all but the largest salvaged materials yards. Specialization also allows contractors to carry more inventory, although demand for heavy timbers is high and much of the best material is exported to the US and overseas.

The services generally provided by each of the categories are listed below.

Services Provided by Contractors

□ Service always provided
■ Service sometimes provided

	Demolish / deconstruct buildings	Selective deconstruction	Sell to sub-contractors or brokers	Sell to the public / building industry
Demolition contractors	□	■	■	
Salvage contractors / Salvaged building materials suppliers	□	□	■	□
Specialty suppliers / brokers		■		□

4.2 NATURE OF SALVAGED MATERIAL

Salvaged building materials may be broadly classified in two categories, high value materials, and high volume materials.

High Value Materials

Heavy timbers, large dimension lumber, and glulam beams represent the largest category of high-value salvaged materials. These materials are primarily available through specialty suppliers although the larger salvaged building materials suppliers will also have access to the same materials. Heavy timbers are in high demand, and in the case of old growth Douglas fir columns and beams, comparable new product may no longer be available. Other high value materials include mechanical and electrical equipment, used office furniture and architectural antiques.

High Volume Materials

High-volume materials are generally available at all times from salvaged building materials yards and in many cases are inexpensive when compared to the cost of new product. They are relatively easy to obtain in small quantities, particularly if some flexibility in terms of material specification is possible. Filling larger orders is more difficult, and if the materials have to be located, and acquired from a number of sources, cost saving potential can be reduced. However, large quantities do become available from time to time when commercial or institutional buildings are deconstructed, and if demolition or salvage contractors are given enough notice they may be able to provide larger numbers with significant cost savings.

Comparison of High Value and High Volume Salvaged Materials

	High Value Materials	High Volume Materials
Examples	Heavy timbers, heavy timber wood trusses, large dimension lumber (>2" x 6"), architectural antiques, HVAC equipment	Dimension lumber, t & g wood decking, doors and frames, windows, brick mechanical and electrical components, etc.
Demand	High demand from contractors and brokers. Often used in high quality timber framed residential projects.	High demand from small contractors and the general public. Typically used in small renovation projects, but also recently on some larger projects
Supply	Good	Good
Source	Mainly specialty suppliers and brokers, also salvaged building materials supply yards	Salvaged building materials supply yards
Potential for Cost Savings	Heavy timber - relatively small HVAC equipment - large	Significant if obtained in large volume from a single source.

Quality

In many cases the quality of salvaged materials is comparable to that of new materials, particularly where some form of refinishing is carried out. With most materials and components, minor imperfections are not significant, and may be expected within a short period of service life, even if new materials are used. The pristine appearance of most new buildings on opening day rarely lasts, even with ongoing maintenance and renewals. With materials such as brick it is generally accepted that appearance improves with age.

Salvaged trusses at Vancouver Timber's yard in Burnaby

In the case of other materials, for example dimension lumber and heavy timbers, the functional quality of salvaged material may be superior to comparable new product available today. Other salvaged materials have historical associations providing a physical link to the past. The social and cultural significance of these links should not be underestimated in an age where few artifacts, including buildings, are designed to last for long periods of time. In this context, imperfections in materials can be accepted and even welcomed.

Patina left by steel connectors on wood truss components.

Quality and Cost of Wood Materials

One of the difficulties encountered in attempting to compare costs of new and salvaged wood materials concerns the issue of quality. The quality of wood harvested in the past is generally acknowledged to be better than the standard wood components typically used in construction today. Salvaged wood typically has low moisture content and is dimensionally stable. A comparable current product, although one not commonly used in framing applications in new construction, would be kiln-dried material.

Most salvaged dimension lumber is Douglas Fir or Hem-Fir (a mixture of Hemlock and Douglas Fir). Dimension lumber used for most residential construction framing today typically comes from the SPF (spruce-pine-fir) group. This material is less expensive than Douglas Fir or Hem-Fir. When used as joists or as other structural members Douglas Fir or Hem-Fir have greater structural strength and can span greater distance than SPF wood.

When compared with currently used framing material such as the SPF species group, salvaged material is more expensive. When compared with higher quality currently available material the cost comparison is more favourable, although there is still little potential for cost savings. In most cases when the additional costs associated with obtaining salvaged dimension lumber are included, salvaged material will be more expensive.

Unit Cost Comparison

	Salvaged	**New**	**New**
	Hemlock or Douglas Fir Denailed	SPF (Spruce Pine Fir)	Hem Fir – Kiln Dried
2 x 4	$0.35	$0.26	$0.34
2 x 6	$0.50	$0.47	$0.56

Salvaged wood must be denailed prior to reuse. Denailing is a labour intensive process, typically costing $0.15 per linear foot. The cost is generally the same regardless of the cross sectional area of the wood in question, and therefore represents a greater portion of the cost of small dimension lumber. In the case of 2 x 4s, denailing represents over 40% of the cost of the salvaged product. With larger dimension wood, for example a 2 x 10, denailing only increases the cost of salvaged wood by 20%. For this reason the use of larger sized salvaged dimension lumber offers greater potential for cost savings.

Unit Cost Comparison - Dimension Lumber (per lineal foot)

	Salvaged Hemlock or Douglas Fir			**New**
	Material Cost	Denailing Cost	Total Cost	Hem Fir – Kiln Dried
2 x 4	$0.20	$0.15	$0.35	$0.34
2 x 10	$0.70	$0.15	$0.85	$1.00

In the case of heavy timbers opportunities to reduce costs by substituting salvaged material are even greater.

Unit Cost Comparison - Heavy Timbers (per lin. ft.)

	Salvaged	New
	De-nailed Hemlock or Douglas Fir	Douglas Fir
12 x 18	$8.70	$33.3
8 x 10	$3.95	$18.33
6 x 10	$2.80	$6.30
6 x 8	$2.70	$5.00

Selection

With the exception of dimension lumber, heavy timber, and other wood products, the selection of salvaged materials available at any one time, is limited compared to new materials or products. Given the wide range of products dealt, with suppliers are generally reluctant to keep large inventory and tend to concentrate on materials that sell quickly. However if sufficient time is allowed to acquire materials, a greater selection is available.

In terms of material selection and availability, a distinction can be made between generic type materials, such as dimension lumber, and more specific components such as doors and frames, or washroom accessories. Non-specific materials are relatively easy to acquire from salvaged sources and selection is less of an issue. One wood stud is much the same as another, and substituting a reused stud is relatively straightforward. In specifying specific components on the other hand, architects are used to choosing from a greater range of products.

4.3 COST ANALYSIS

The opportunity to reduce construction costs is often proposed as a benefit of using of salvaged materials. Within certain limits there are real opportunities for significant savings. However, the use of salvaged materials does not always necessarily result in savings. The salvaged building materials industry, as it is presently structured, is primarily geared towards supplying small-scale residential construction projects. The major difficulty associated with the use of salvaged materials relates to acquiring materials from a single source in sufficiently large quantities. The time needed to locate and purchase salvaged materials and components is critical to achieving overall cost savings. If materials can be obtained from a single source, for example a single existing building, and in sufficiently large quantities, savings can be realized.

Cost Comparison of Representative Materials (Summer / Fall 1999)

	New Material	Salvaged Material
Glulam beam 3" x 12" x 10'	$73	$23
Wood stud 2" x 4" x 8'	$2.80	$2.72
Wood joist 2" x 10" x 13'	$13.00	$11.05
T & G Wood decking 2" - per sq. ft.	$1.55	$0.46
Bi-fold doors (pair)	$43	$10
Hollow core interior door and frame	$89	$40
1/2" Plywood - per sq. ft.	$0.57	$0.28
Vinyl Window - double glazed	$200	$100
2" EPS insulation - per sq. ft.	$1.09	$0.14
6' Aluminum framed patio door - double glazed	$420	$225

Cost Comparison

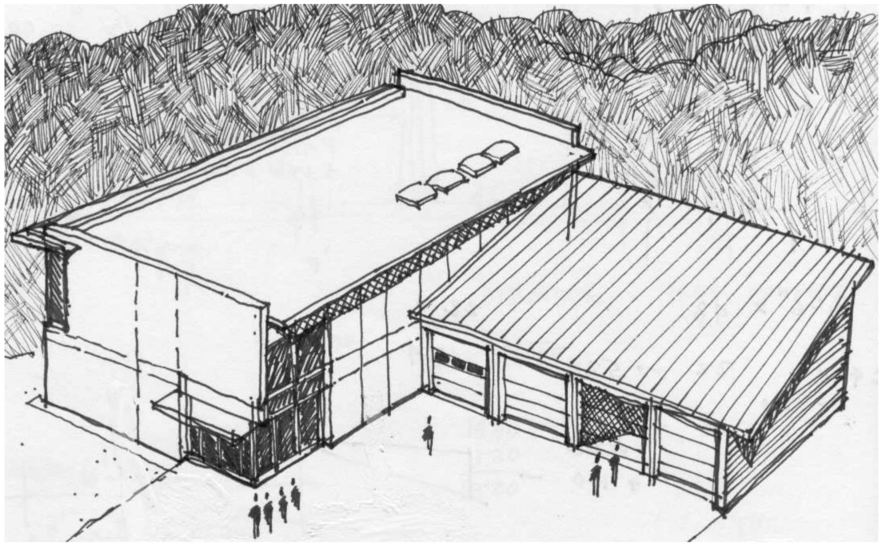
In addition to comparing the cost of specific new and salvaged materials it is useful to study the potential for cost savings in the broader context of a typical building project. To establish a framework for cost comparisons, a hypothetical test building was studied. The building was designed in schematic form, using rules of thumb to determine dimensions of structural members. Approximate areas and quantities were measures and a list of materials and components was developed. The list is not a complete take-off of all materials in the building but instead concentrates on those materials and components most commonly available from salvaged sources. Overall, using the cost of new material as an indicator, the materials listed represent approximately 48% of total building materials. The full list of materials compared is provided in Appendix B.

These materials were then priced as new materials and compared with the price of comparable salvaged materials.

New material prices were established using "Means Construction Cost Data, 1998", with adjustments made for Canadian dollars and to reflect regional differences for Vancouver. The costs of salvaged materials were determined by visiting three of the larger local salvaged materials yards and interviewing suppliers. In many cases the materials in question were readily available and sale prices were recorded. In other cases it was necessary to request prices for the materials assuming they were available. Taxes are included in both sets of prices.

The test building consists of a small 2 storey, 3120 square foot, wood framed office building with an attached 4 bay garage. The building is of a size and occupancy classification normally permitted to be built of combustible construction, and offered many opportunities for salvaged materials use. The relatively small size also increased the potential for obtaining required materials from a small number of sources.

Sketch perspective of test building



The overall construction cost of the building was estimated to be $394,000 ($126 / Sq. ft.). Of this total, material costs were assumed at 42.5% (with labour assumed at 42.5% and general requirements, overhead and profit at 15%).

Distribution of Construction Costs by Building System

Element	Total Cost	Material Cost	Percent of Total
Foundations	$15,735	$6,687	4
Substructure	$9,945	$4,226	3
Superstructure	$48,000	$20,400	12
Exterior enclosure	$52,600	$22,355	13
Roofing	$12,110	$5,147	3
Interior construction	$85,149	$36,188	22
Mechanical systems	$103,873	$44,146	26
Electrical systems	$54,166	$23,021	14
Special Construction	$12,503	$5,314	3
Total Building Cost	$394,080	$167,484	100

Cost Comparison - Individual Materials and Components

The material used in this comparison are those most commonly available from salvaged building materials suppliers and those that have been successfully used in construction. The full take-off list of materials in Appendix B, and can be used for cost comparison of individual materials and components. While all the materials listed are not always immediately available, provided sufficient time is allowed, they should be obtainable in the quantities required for a relatively small building.

Cost Comparison - Overall Building

For a number of reasons not every building material or component can be salvaged. Because of they way they are formed or incorporated into buildings, certain materials may be difficult or impossible to salvage without damage while it may be uneconomical to reuse others. However there are opportunities for salvaged materials use in almost all areas with the exception of foundations, substructure and membranes, which account for relatively small amounts of overall costs. As mentioned previously, the comparison focused on materials commonly available from salvaged sources, and omitted materials that are not normally available, or are impossible to salvage.

Overall savings of $39,374 were achieved as a result of substituting salvaged materials. This figure represents approximately 50% of the cost of new materials in the categories compared. When compared to the total cost of the building (labour, materials and overhead / profit) the use of salvaged materials would result in a cost saving of approximately 10%.

Summary of Test Building Costs

Building System	**Cost of New Materials**	**Cost of Salvaged Materials**	**Cost Saving**
Superstruture	$22,196	$10,559	$11,637
Exterior Enclosure	$43,478	$25,689	$17.789
Roofing	$6,272	$860	$5,412
Interior Construction	$2,830	$1,460	$1,370
Mechanical	$850	$484	$366
Electrical	$4,000	$1,200	$2,800
Total	$79,625	$40,251	
Total Savings			**$39,374**

In reviewing these figures some additional points should be considered:

- Additional costs may be incurred in locating and obtaining salvaged materials. As previously discussed the degree of difficulty and associated costs will depend on the type and more specifically the quantities of materials required.
- Additional professional fees may be required if the architect or construction manager is required to locate and review salvaged materials.
- Additional cost savings can be achieved if the owner can provide salvaged materials.

Cost Analysis Case Study 1

LIU CENTRE
UBC, VANCOUVER, BC

Owner
University of British Columbia
Architects
Architectura
Contractor
Haebler Construction Ltd.

Project Description

The Liu Centre is a research and conference facility at the University of British Columbia. The decision to use salvaged materials was supported by all project stakeholders and was formalized as one of 60 sustainable goals agreed upon at the start of the project.

Salvaged Materials

The principal salvaged materials used at the Liu Centre were Douglas fir glulam beams, and cedar t & g decking material. Concrete pavers used in site landscaping were also obtained from salvaged sources. The majority of salvaged glulam beams and cedar decking came from the deconstruction of the Pan Hellenic House, an existing building on the Liu Centre site (Report available from GVRD – Thomas Mueller T. 436 6818). Glulam beams were also obtained from the deconstruction of the Forintek building at UBC. Materials from the UBC buildings were provided by the owner. Additional cedar decking material was required, and was purchased from two local salvaged materials suppliers, D. Litchfield & Co. Ltd., and Debreuil Architectural Salvage. Materials from the existing buildings were inventoried by the architects at an early stage in the design phase, and where available to the contractor when required. Additional materials obtained during construction where located by the architect, and purchased by the contractor. The architects provided assistance in locating suitable materials and were available to review and approve the quality of salvaged materials.

Salvaged Cedar Decking

Salvaged Glulam Beams

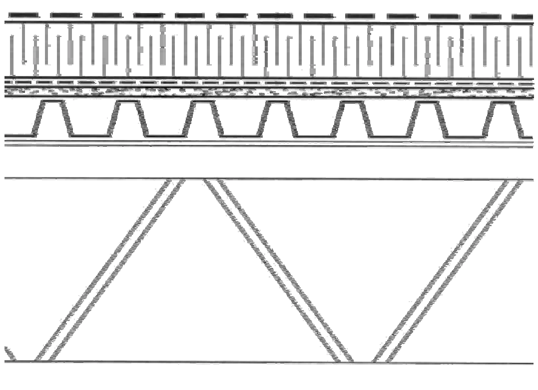
Cost and Quality of Materials

The principal materials used at the Liu Centre, glulam beams and cedar decking, offer considerable potential for cost savings. Deconstruction of older commercial, industrial, and institutional buildings generates large volumes of both materials. Because of the relatively high cost of comparable new material, prices for these salvaged materials are low, even when the cost of testing and refinishing is included. The table below provides a comparison of typical new and salvaged materials.

Unit Cost Comparison

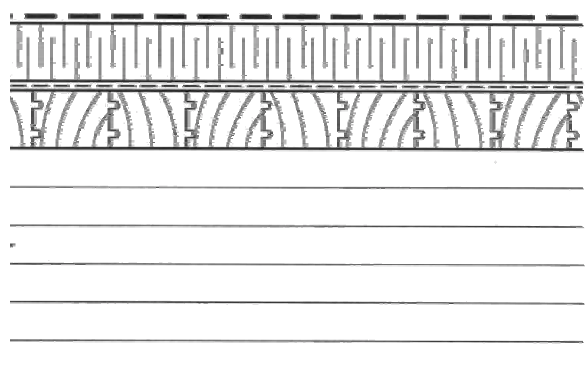
Material	Unit	Salvaged	New
Douglas Fir Glulam Beam 9" X 27"	Lin Ft	$23.00	$51.00
3" x 6" Cedar Decking	Lin Ft	$1.00	$2.10

One of the difficulties in comparing costs is the difference in the nature of current building material when compared with materials salvaged from earlier buildings. In many contemporary buildings of non-combustible construction, steel decking material is used in floor and roof assemblies. At the Liu Centre 3" x 6" salvaged cedar decking is used in place of steel. (Although wood is a combustible material the building code permits wood members over a certain size to be used in place of non-combustible material).



Typical roof assembly – Steel construction

- **Roof membrane, insulation, vapour barrier**
- **Gypsum board**
- **Profiled metal decking**
- **Open web steel joist**



Liu Centre roof assembly

- **Roof membrane, insulation, vapour barrier**
- **2" or 3" Cedar decking**
- **Glulam beam**

Salvaged cedar is less expensive than comparable new material, but the cost savings would be less significant if compared to a more common contemporary material such as steel decking. In comparing salvaged material costs, a decision must be made as to which type of new material or assembly should be priced. For the purpose of the analysis in this study new cedar decking is used for comparison.

In the cost comparison table below, the salvaged glulam beam are afforded a negative cost value. This reflects the fact that these materials were owned by UBC, having come from demolition of an existing campus building the Pan Hellenic House. The additional cost to provide the materials for the Liu Centre project was the cost of removal from the original building and temporary storage only, approximately $2,800. After completion of the Liu Centre, surplus glulams were sold to a salvaged materials supplier at the market value for salvaged materials, approximately $3,000, resulting in a credit to the project of $200. The monies received from the sale of surplus beams were thus slightly more than the total cost of the original salvaged beams. Similarly much of the salvaged cedar decking was also obtained from the Pan Hellenic House, and was supplied by the owner at a cost that represented the cost of removal and storage of the material only.

Cost Comparison of Salvaged and New Materials

	Salvaged Materials		**New Material**	**Difference**
Material				
Glulam Beams	-$200			
Testing* / certification / storage	$1,750			
Refinishing	$4,500			
Modification of beams and steel connectors	$3,300			
Total		$9,350	$24,500	$15,150
T & G wood decking	$7,150			
Refinishing	$2,975			
Freight / contractor o/h	$2,350			
Total		$12,475	$24,000	$11,525
Concrete Pavers	$1,000			
Shipping	$400			
Total		$1,400	$2,700	$1,300
Total Salvaged Material Cost		**$23,225**		
Cost of Comparable New Material			**$51,200**	
Cost Savings to Owner				**$27,975**
Additional Consultant Costs				
Architect		$5,650		
Total Project Savings				**$27,975**

* Testing for adhesive strength, by Levelton Engineering.

If the discounted costs of the owner provided salvaged materials is replaced with the cost of purchasing these materials from local salvaged materials suppliers the overall cost savings are somewhat reduced. Overall project savings resulting from the use of salvaged materials would be reduced from $27,975 to $16,275. However it can be argued that the owner has already paid for the materials obtained from the Pan Hellenic House at the time of construction of that building. It is fortuitous that the materials originally used were of a quality that permits and facilitates reuse. Viewed from this perspective it is appropriate to account for the cost of these materials based on the discounted costs. In a similar way, materials from the Liu Centre, new or salvaged, may be salvaged at some time in the future, and used in another building. The appropriate unit of measurement of utility is not the building, but rather building materials providing accommodation for ongoing human activity.

Additional Consultant Costs

The architects did incur additional costs as a result of the use of salvaged materials. During the construction phase of the project the architects assisted the contractor in obtaining additional salvaged materials. As part of this process it was necessary for the project architect to visit various salvaged materials suppliers to review stocks of material and assess quality. Some additional site review, and administrative functions were also required. Relative to the overall project fee additional costs were not significant, and the architects did initially negotiate some additional fees to cover these costs. The contractor also incurred some additional costs in obtaining and preparing additional salvaged materials. These costs were included in the contract amount, and are reflected in the costs provided in the comparison Table.

Summary

- The principal salvaged materials used were glulam beams and cedar decking
- Overall cost savings resulting from the use of salvaged materials amounted to $27,975. The total project construction cost was approximately $3 million
- Savings were achieved as a result of the owner owning much of the salvaged material used. This situation can be considered to result from the original decision to use quality materials in the original construction of the Pan Hellenic House. Easy access to the existing Pan Hellenic building facilitated a pre-deconstruction audit of materials by the architects.
- The relatively high cost of comparable new materials helps in making the cost savings significant.

Cost Analysis Case Study 2

ARDENCRAIG
353 WEST 11TH AVENUE, VANCOUVER, BC

Developer / Contractor
Chesterman Property Group
Architects
Allan Diamond Architect

Project Description

The project comprises four townhomes designed within the framework of an existing heritage home and garage. The use of salvaged materials is one of the many environmental strategies employed in the building and associated site work.

Salvaged Materials

The existing buildings were of wood framed construction, and were originally built using balloon framing. Over 90% of the wood in the original house is retained. Additional salvaged materials, principally dimension lumber, were utilized to construct the in-fill coach house. Salvaged framing members were also used to strengthen the roof trusses and increase the space available for insulation. Other salvaged materials include granite, and stained glass used in feature windows.

The developer initiated most of the *green* design strategies, including the use of salvaged materials, and was responsible for the acquisition of dimension lumber for the project. Approximately 36,000 board feet of framing materials were obtained from Vancouver Timber a local supplier of salvaged building materials. An additional 5,000 board feet of materials were obtained from deconstruction of the existing garage building. Most of the salvaged wood was used in construction of the new coach house and as new infill walls at the base of the main house.

Cost and Quality of Materials

Acquiring salvaged dimension lumber in a cost effective manner can be difficult. New framing material, although not of the same quality as salvaged framing, is inexpensive. The cost of denailing salvaged dimension lumber pushes the cost of small sized members, such as studs, above the cost of the most commonly used new framing materials from the SPF (Spruce-Pine-Fir) species group. However when compared to the cost of better quality new materials, such as kiln-dried Hem-Fir, the comparison is more favourable. The table below provides a comparison of these alternative material costs.

Unit Cost Comparison

	Salvaged	New	New
	Hemlock or Douglas Fir Denailed	SPF (Spruce Pine Fir)	Hem Fir – Kiln Dried
2 x 4	$0.35	$0.26	$0.34
2 x 6	$0.50	$0.47	$0.56

For the purpose of the cost comparison in this analysis the price of salvaged materials is compared with new kiln dried Hem Fir. Although this material is not commonly used in new residential construction, there are a number of reasons why it is appropriate for comparison in the case of a renovation project such as Ardencraig. Framing material in existing buildings will have dried to a relatively low moisture content. The shrinkage associated with this initial drying takes place soon after the original construction of the building, and is uniform through most assemblies. If new green wood is added to existing structures, shrinkage of the new components adjacent to existing framing can create problems. For this reason a better practice is to use kiln dried wood which will have a moisture content in the same range as the existing framing, and will therefore not shrink to any significant extent. In addition the size of older dimension lumber is not always the same as currently available sizes. Matching existing older construction is often easier if salvaged material is used.

Joists prior to denailing

Denailed joists

Cost Comparison of Salvaged and New Materials

		Salvaged Materials	New Material	Difference
Material				
Dimension Lumber				
Purchased	36 mbfm	$17,969	$20,437	$2,468
From House	5 mbfm	$1,125	$2,585	$1,460
Shiplap siding	800 sq ft	$120	$680	$560
Granite stone		$575.00	$1,400	$825
Total Salvaged Material Cost		**$19,789**		
Cost of Comparable New Material			**$25,102**	
Cost Savings				**$5,313**
Salvaged Materials Sold		-$825		
Total Project Savings				**$6,138**

At Ardencraig modest cost savings were achieved as a result of using salvaged dimension lumber. In part this may be attributable to the relatively small quantities of wood required. Local suppliers of salvaged materials are more likely to be able to supply smaller quantities from stock.

Additional Consultant Costs

The majority of work with respect to research and acquisition of salvage materials was undertaken by the developer. Associated costs were included with other project overhead costs.

Summary

- The principal salvaged materials used were dimension lumber
- Cost savings of approximately $6,000 were achieved as a result of using salvaged materials. The overall project cost was $520,000.

4.4 SALVAGED MATERIAL AVAILABILITY AND SOURCES

The following sections provide information on specific salvaged materials listed according to the Masterformat system. The supply of salvaged materials in some categories is necessarily limited. Details of the availability and sources of salvaged materials are also provided. As with new materials, the characteristics of salvaged materials differ significantly. The use of particular salvaged materials should be carefully researched, and if necessary samples of the materials should be tested to confirm suitability for the proposed application. A full discussion of salvaged mechanical and electrical equipment is beyond the scope of this guide although some information, based on the experiences of the case study buildings is provided.

DIVISION 2 - SITEWORK

Material / Component	Availability	Sources	Notes
Concrete paving slabs	Occasionally	Salvaged building materials suppliers	Limited range
Interlocking concrete pavers	Occasionally	Salvaged building materials suppliers Masonry Suppliers	Limited range
Foundation drainage pipes	Rarely	Salvaged building materials suppliers	
Storm and sanitary drainage pipes	Rarely	Salvaged building materials suppliers	
Chain link fencing	Rarely	Salvaged building materials suppliers	

Interlocking concrete pavers

DIVISION 3 - CONCRETE

Because of the monolithic nature of cast-in-place material, little opportunity exists for salvage and reuse. Concrete from existing buildings and structures is commonly crushed and reused as roadbase material in place of new gravel or rock. Reinforcing steel is removed and recycled. In theory, precast concrete components, both structural and non-structural could be salvaged and reused although the local supply of these materials is limited.

DIVISION 4 - MASONRY

There is a long history of reuse of brick and masonry units, and the supply of salvaged bricks is reasonably consistent and reliable. Demolition of old warehouse and commercial buildings results in large quantities of brick, in some cases up to 10 bricks per square foot of floor area. Reclaiming and cleaning salvaged bricks is a time consuming activity. Salvaged bricks typically sell for $400 - $500 per thousand, compared with a cost of $800 - $1,000 for new bricks.

Salvaging bricks from a Vancouver warehouse. Mortar is removed on site and bricks are packaged on pallets of approx. 500 units. Broken and damaged bricks are recycled.

Salmon bricks used in the interior of a warehouse wall

Salvaged bricks vary considerably in quality. In part this is due to significant variation in the quality of the original brick. Older methods of manufacturing bricks resulted in uneven firing temperatures within kilns. Many of the resulting bricks were not fired at the correct temperature. Over-burnt bricks were hard and durable, but others were soft and of low strength. These units are referred to as salmon bricks. Bricks typically did not need to be sorted, as masons laying bricks were able to identify high quality bricks and to use them in the exposed areas of walls. Salmon bricks were used for the interior portions of walls and other low exposure areas. In deconstructing masonry buildings it is not economical to identify and sort bricks. Mortar and dust also make correct identification difficult. Salvaged bricks are therefore a mixture of high quality face bricks and poorer quality salmon bricks.

Caution must be exercised in reusing bricks. All salvaged bricks should be tested and be suitable for the particular proposed application. For exterior applications, in addition to visual examination, an absorption test and a freeze thaw cycle test may be appropriate. Generally salvaged bricks and especially salmon bricks should only be used in interior location or in low exposure exterior areas where wetting is unlikely. The bricks used at the C K Choi building were originally paving bricks and are considerably harder than normal face bricks making them suitable for an exterior cladding application.

It is difficult to salvage bricks, or concrete blocks, from recent buildings because of the strength of the portland cement mortar bonding them. Prior to the 1940 bricks were laid with hydraulic lime mortar. Lime mortar is soft, crumbles easily and is readily separated from the bricks making cleaning relatively easy. Although use of lime mortar in new construction would allow future reuse of bricks, it is difficult to obtain sufficient lateral strength in veneer construction without the use of harder mortar.

Salvaged bricks available at a yard at any particular time are likely to come from a single source, and there is therefore unlikely to be a range of colours or textures to choose from.

Division 4 - MASONRY

Material / Component	Availability	Sources	Notes
Brick	Always	Salvaged building materials suppliers Masonry suppliers	Range is limited but large quantities are often available
Concrete block	Rarely	Salvaged building materials suppliers Masonry suppliers	Difficult to remove portland cement mortar.
Glass unit masonry	Occasionally	Salvaged building materials suppliers Masonry suppliers	Quantities are often limited
Exterior stonework	Occasionally	Specialty materials suppliers Architectural antiques suppliers	Individual stone components, usually granite are often salvaged from brick buildings

DIVISION 5 - STEEL

Although wood beams and trusses are more common, structural steel components occasionally become available. However the existence of an established market for salvaged steel to supply the recycling industry, coupled with the difficulty in disassembling steel structures, particularly where welded connections are used, often results in steel structural components being sold for their scrap value. Smaller steel components, which can be removed intact, are sometimes available. A steel stair and guardrails, acquired from a demolished golf clubhouse, were used at the C.K. Choi building.

Salvaged wide-flange beams

Division 5 - STEEL

Material / Component	Availability	Sources	Notes
Structural steel	Occasionally	Demolition and salvage contractors Salvaged building materials suppliers	Will typically be dismantled to remove from original building
Steel joists and girders	Occasionally	Demolition and salvage contractors Salvaged building materials suppliers	
Pipe and tube railings	Always	Salvaged building materials suppliers	
Prefabricated metal stairs	Occasionally	Demolition and salvage contractors Salvaged building materials suppliers	

DIVISION 6 - WOOD AND PLASTICS

> *There is no doubt that the timber with which this coast is covered (and which in its size and fine grain is nowhere to be excelled) would compose a valuable addition to our trading, as the article carries a very advanced price in China and is always in demand there…*[1]

There is a consistent demand for salvaged heavy timbers, and in particular, a well-established export market for old Douglas fir beams, columns and boards. Because of this demand many salvage contractors, including those with their own salvaged materials yards, choose to sell all heavy timbers to brokers from the US or overseas. As a result the available supply of heavy timbers at any particular time may be limited.

The exporting of local wood products should not be a surprise. Since the first BC sawmill was built in 1848 the largest part of local timber production has been sold abroad. The qualities of BC Douglas fir were greatly appreciated then as now, and the first export shipments to San Francisco and were paid for with gold dust.

7" x 29" Douglas Fir beams, Vancouver Timbers' yard, Burnaby

Wood has historically been the most common building material in British Columbia, and has been used in structural and non-structural applications for over 100 years. It is the most commonly reused building material.

[1] James Strange, East India Company, 1786

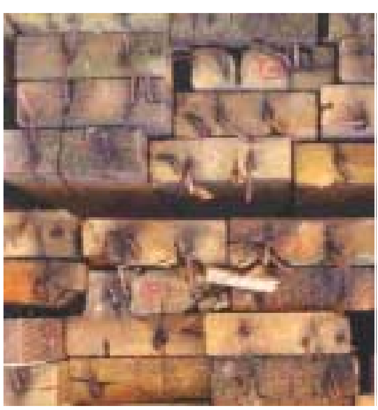
Deconstruction of buildings yields large quantities of wood of all sizes, much of it of high quality, and in some cases superior to comparable new product. Much of the higher quality salvaged wood is valued for its aesthetic values and historic associations as much as its purely utilitarian qualities.

US brokers compete with local specialty suppliers to purchase salvaged wood from demolition contractors. However, there is a large enough supply of material to satisfy current and expanded demand. Demolition of warehouses and older commercial buildings can generate between 1.5 and 15 board feet of wood per square foot of floor area. The table on the following page provides a list of materials salvaged from a recently demolished building at the Pacific National Exhibition site in Vancouver. The 68-year old Showmart building was a single storey structure post and beam structure with wood framed walls.

Salvaged and Recycled Materials from PNE Showmart Deconstruction Project

Salvaged Material	**Quantity**
• Salvaged Lumber	1,804 cu. yds. (585,000 bd. ft.)
• Plywood	105 cu yds. (45,000 sq. ft.)
• Fir Flooring	140 cu. Yds. (11,600 sq. ft.)
Recycled Material	
• Wood	2,190 cu. yds. (710,000 bd. ft.)
• Other Material	1259 cu. yds
Disposal	2,280 cu. yds

Denailing and sorting salvaged wood. Bent Nail salvaged materials yard, Abbotsford

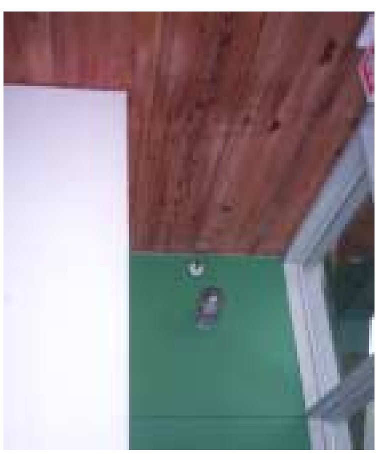


Most salvaged materials suppliers will de-nail wood and specialty suppliers will also recut dimension lumber and heavy timbers.

Division 6 - WOOD AND PLASTICS

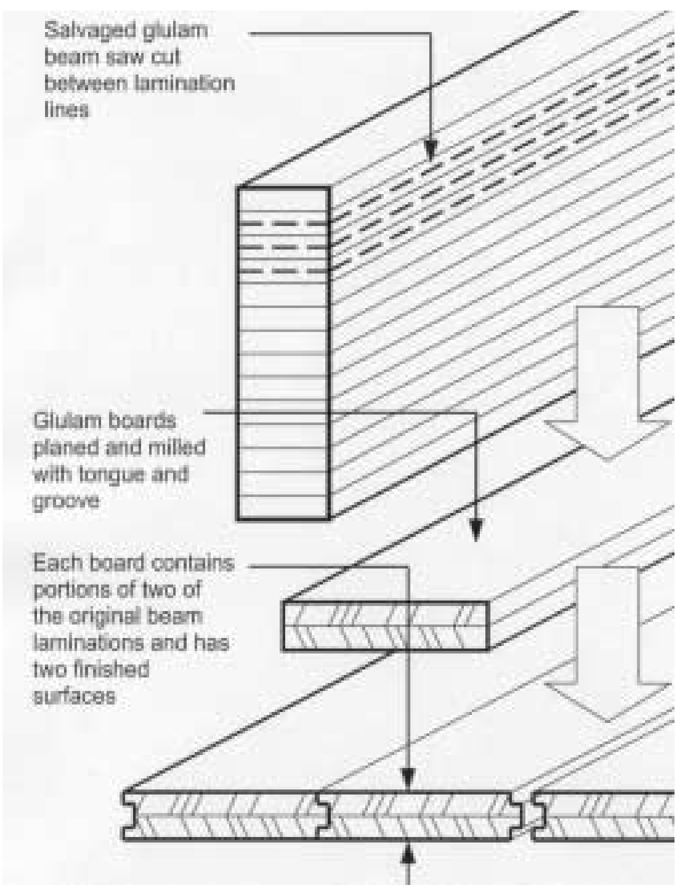
Material / Component	Availability	Sources	Notes
Dimension lumber	Always	Salvaged building materials suppliers Specialty suppliers	Large range of products and sizes
Heavy Timbers	Always	Specialty suppliers Salvaged building materials suppliers	Large range of products and sizes
Glulams	Always	Specialty suppliers Salvaged building materials suppliers	Can be resawn and remilled as 1" t & g flooring
Wood trusses	Occasionally	Salvaged building materials suppliers Demolition contractors, Specialty suppliers	
T & G Boards	Always	Salvaged building materials suppliers Specialty suppliers	Large range of products and sizes
Siding and trim	Always	Salvaged building materials suppliers	
Plywood	Always	Salvaged building materials suppliers	Quantities may be limited as there is a consistent demand from home renovators
Wood mouldings	Always	Salvaged building materials suppliers Architectural antiques suppliers	
Finish flooring	Always	Salvaged building materials suppliers	

Large numbers of glulam beams are available from more recent buildings. There is a reluctance to reuse these beams in structural applications because of concerns about the long-term performance of the glues, and the original manufacturing process of some beams. However it is possible to test the adhesive bond and confirm structural strength. If glulams are obtained from an existing building and are likely to have been originally obtained from a single source, it may only be necessary to test a small number of beams.



Glulam beams reused as floor structure at the Materials Testing Lab

One of the local specialty suppliers of salvaged wood components, Vancouver Timbers, has recently been fabricating tongued and grooved boards from salvaged glulam beams. The glulams are cut horizontally between the lamination lines (giving two different appearance options per board) and the boards are seasoned and replaned to provide an economical flooring product.



Salvaged glulam beams remilled as new flooring

DIVISION 7 - THERMAL AND MOISTURE PROTECTION

Insulation material, both rigid and fibreglass batt, is easily reused and is available at many salvaged materials yards. Large amounts of type 4 extruded polystyrene insulation boards are salvaged from protected membrane roofs. In this application the material is held in place by gravel ballast and is not damaged by fasteners.

The appearance of salvaged polystyrene roof insulation may be poor, with dusting of the outer surface, but thermal performance is not significantly affected, although a reduction in R-value to account for normal aging of the product should be made. Testing of salvaged insulation to confirm R-value is possible.

Extruded polystyrene insulation at the Materials Testing Lab

Division 7 - THERMAL AND MOISTURE PROTECTION

Material / Component	Availability	Sources	Notes
Batt insulation	Always	Salvaged building materials suppliers	
Rigid insulation - extruded polystyrene	Always	Salvaged building materials suppliers	Allow for some reduction in R-value as a result of aging
Sheetmetal cladding	occasionally	Salvaged building materials suppliers	Existing fastener holes in the material may present problems and may need to be filled
Sheet metal roofing	occasionally	Salvaged building materials suppliers	Existing fastener holes in the material may present problems and may need to be filled

Salvaged expanded polystyrene insulation

There is little potential for reusing most roofing and waterproofing membranes. These components typically have relatively short service lives and their method of installation makes removal difficult or impossible. Clay or concrete roofing tiles may be reused although the supply is limited. Profiled metal roofing and cladding panels are sometimes available at salvaged materials yards.

DIVISION 8 - DOORS AND WINDOWS

Doors

Large numbers of interior hollow core doors are available from salvaged materials suppliers. Frames are usually sold with doors, and both rated and non-rated assemblies are available. Architectural antique stores can provide older panel doors. Door hardware is also available.

Windows

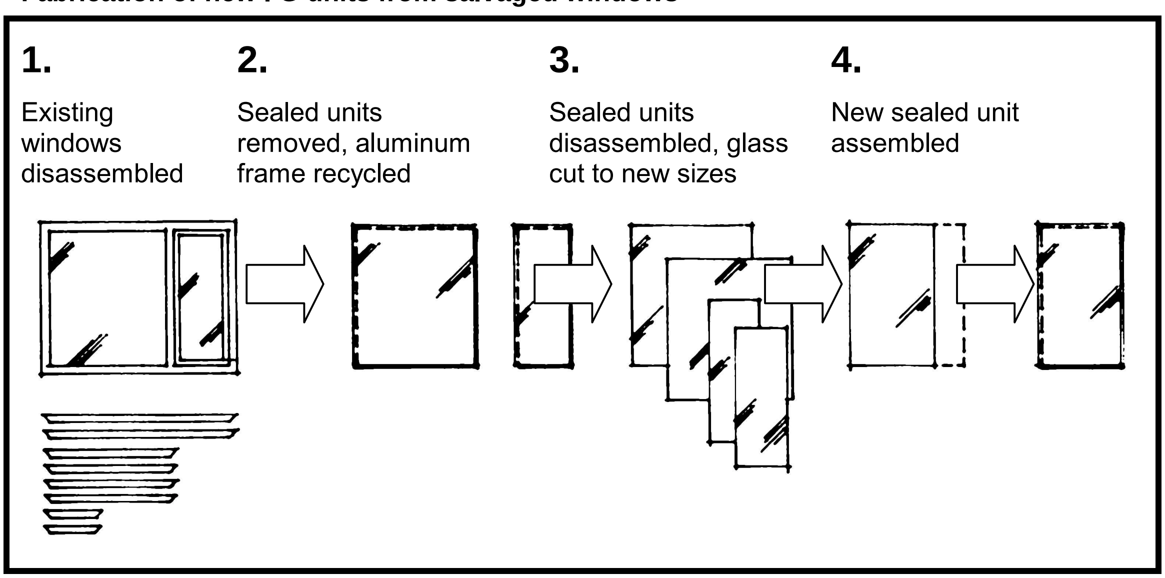
Most salvaged materials supply yards have large numbers of residential quality aluminum framed windows. Frames are typically non-thermally broken and are no longer permitted by building codes. Vinyl frames are less common but are also available. Many yards also sell new windows, which have been returned to the manufacturer because of some defect.

In many cases windows have been removed from buildings because of poor performance. Although there may be some applications where these windows may be reused, for example for interior use, or in non-heated buildings, they are not generally suitable for exterior reuse in new construction.


Glass from salvaged windows may be reused. Sealed units from salvaged windows will need to be disassembled, and the salvaged glass cut to new sizes, and reassembled in new units.

The Glass Station, a local company, collects used IG units from demolition contractors, disassembles the units, recuts the glass and fabricates new units. Although theoretically a wide range of sizes are available, smaller sizes are more easy to fabricate given the glass comes typically from residential windows which tend to have smaller lite sizes. A five-year warranty is provided on all units. Although care is taken to discard damaged material, glass in these new units may exhibit some minor defects and scratches. Most glazing contractors are also prepared to fabricate sealed units from salvaged glass, but will not necessarily have the access to salvaged glass, and may not be able to provide the new units as competitively. Care should be taken to avoid the use of sealed units that have failed resulting in water collecting between the panes as this may mark the glass.

Fabrication of new I G units from salvaged windows



Sealed unit fabricated from salvaged glass - Materials Testing Lab.

Division 8 - DOORS AND WINDOWS

Material / Component	Availability	Sources	Notes
Steel doors and frames	Always	Salvaged building material suppliers	Rated doors and frames are usually available
Flush wood doors	Always	Salvaged building material suppliers	
Panel wood doors	Always	Salvaged building material suppliers Architectural antiques stores	
Aluminum sliding glass doors	Always	Salvaged building material suppliers	
Overhead doors	Occasionally	Salvaged building material suppliers	
Aluminum storefront	Occasionally	Salvaged building material suppliers	
Aluminum windows	Always	Salvaged building material suppliers	
Wood windows	Always	Salvaged building material suppliers	Usually single glazed, residential type
Vinyl windows	Occasionally	Salvaged Material suppliers	
Glass	Always	Salvaged building material suppliers	
Sealed glazing units	Always	Specialty suppliers	The Glass Station
Mirrors	Always	Salvaged building material suppliers Architectural antiques stores	
Door hardware	Always	Salvaged building material suppliers Architectural antiques stores	

DIVISION 9 - FINISHES

Many finish materials, because of their method of installation or application, are difficult to remove from existing buildings during deconstruction. Finishes that are not bonded to substrate material and are not tightly fastened can sometimes be salvaged. Wood trim and paneling, particularly from older buildings, is available as is wood flooring material. Maple flooring from a deconstructed school gymnasium was reused at the Sweet Apple Antiques store in Coquitlam. A number of salvaged materials yards also supply acoustic ceiling tiles, although t-bar suspension systems are difficult to remove without damage and are not normally available.

Division 9 - FINISHES

Material / Component	Availability	Sources	Notes
Acoustic tile t-bar ceilings	Always	Some salvaged building materials suppliers	t-bar suspension systems not normally available
Wood flooring	Always	Salvaged building materials suppliers Specialty wood suppliers	
Wood paneling and trim	Always	Salvaged building materials suppliers Architectural antiques stores	
Carpet	Always		

DIVISIONS 10, 11, 12 - SPECIALTIES, EQUIPMENT, FURNISHINGS

Office Furniture

Refurbished office systems furniture is available from a local company, Surplus Office Systems. The quality of the material, desks, divider panels, filing cabinets, and storage bins, is high and considerable savings can be achieved as a result of the high cost of comparable new products.

Architectural Antiques

Architectural antiques stores serve the residential renovation market, and also provide building supplies for heritage building restoration. Recently the local movie industry has created a demand for period furniture, paneling etc. In addition to furniture, panel doors, wood framed windows, fireplace surrounds, wood paneling and trim are available. Occasionally dressed stone pieces may also be found.

Although a wide range of equipment and furnishings are available the selection within most categories of these specialized components is limited. There are however a number of exceptions. Residential appliances are available from many salvaged materials suppliers

Division 10, 11, 12 - SPECIALTIES, EQUIPMENT, FURNISHINGS

Material / Component	Availability	Sources	Notes
Toilet compartments	Occasionally	Salvaged building materials suppliers	
Louvers and vents	Always	Salvaged building materials suppliers	
Metal lockers	Occasionally	Salvaged building materials suppliers	
Fire extinguishers and cabinets	Occasionally	Salvaged building materials suppliers	
Accordion folding partitions	Rarely	Salvaged building materials suppliers	
Washroom accessories (paper towel dispensers, soap dispensers etc.)	Always	Salvaged building materials suppliers	Limited selection compared to new.
Retail display equipment	Always	Salvaged building materials suppliers	
Library equipment	Occasionally		
Residential appliances	Always	Salvaged building materials suppliers	
Food service equipment	Always	Specialty suppliers	
Laboratory fume hoods	Occasionally	Salvaged building materials suppliers	
Office systems furniture	Always	Specialty suppliers	High quality refurbished systems furniture is available from Surplus Office Systems
Kitchen casework	Always	Salvaged building materials suppliers	

DIVISION 15 - MECHANICAL

A detailed review of salvaged mechanical and electrical equipment is beyond the scope of this study. The market for salvaged equipment is not well developed and finding suitable items is often a matter of luck.

The case study buildings indicate that there is some potential for the reuse of salvaged equipment, particularly if it is relatively new. With high value items such as packaged HVAC units, there is also considerable opportunity for cost savings. Where environmental issues form part of the design brief in new construction, the focus of mechanical and electrical design is typically on energy efficiency. Systems are designed to minimize energy use, and often incorporate newer energy efficient technologies. Within this context there is less opportunity to use salvaged materials.

Salvaged plumbing fixtures, Materials Testing Lab

Salvaged plumbing fixtures are readily available, and were used in the Materials Testing Lab building. While sinks and lavatories can be fitted with new low flow fittings it may be difficult to successfully retrofit toilets to comply with water conservation by-laws. The benefits of using salvaged materials must be weighed against the disadvantages of higher water consumption over the life of the building. However as low flush toilets become more common and begin to enter the salvaged materials stream this difficulty will be overcome. Piping and ducting have not been reused to any significant extent in the case study buildings.

Division 15 - MECHANICAL

Material / Component	Availability	Sources	Notes
Plumbing fixtures (toilets, bath tubs etc.)	Always	Salvaged building materials suppliers	Most commonly of residential quality
Radiators	Always	Salvaged building materials suppliers	
Electric baseboard heaters	Always	Salvaged building materials suppliers	
Unit air Conditioners	Always	Salvaged building materials suppliers	
HVAC units	Occasionally	Salvaged building materials suppliers	
Hot water tanks	Always	Salvaged building materials suppliers	Some suppliers will provide warranties
Furnaces	Always	Salvaged building materials suppliers	

DIVISION 16 - ELECTRICAL

Light fixtures are almost always available from salvaged materials suppliers. Both residential and commercial fixtures can be found, often in relatively large quantities. Many of the light fixtures at the Materials Testing Lab were from salvaged sources. In many cases at the time electrical equipment is removed from buildings, power has been disconnected and it is not always possible to confirm proper functioning of components.

Approximately 40% of the electrical conduit in the C.K. Choi building was reused. Internal brushing was required prior to installation.

Division 16 - ELECTRICAL

Material / Component	Availability	Sources	Notes
Fluorescent lighting	Always	Salvaged building materials suppliers	
Industrial lighting	Always	Salvaged building materials suppliers	
Pot lights	Always	Salvaged building materials suppliers	
Switches	Always	Salvaged building materials suppliers	
Fuse switches	Always	Salvaged building materials suppliers	
Panel boxes	Always	Salvaged building materials suppliers	
Smoke detectors	Always	Salvaged building materials suppliers	
Transformers	Always	Salvaged building materials suppliers	
Wiring / Cable / Conduit	Always	Salvaged building materials suppliers	

SECTION 5

DESIGN FOR DISASSEMBLY

Reuse of Materials

This guide promotes the idea of improving resource use efficiency by salvaging and reusing construction materials. A logical extension of this strategy is to ensure that the same salvaged materials can be reused a second time, and also that new materials used in buildings can be salvaged and reused in the future. Although some level of salvage and reuse will inevitably occur, the amount of material that can potentially be reused in the future will be maximized if specific steps are taken during the design of buildings. To permit and encourage future reuse, buildings should be designed in a manner that permits materials to be easily and cost-effectively removed without damage.

Recycling of Materials

In addition to facilitating removal of materials for reuse, design for disassembly should also consider future recycling of materials. Although reuse of materials is preferable, recycling also improves resource use efficiency, and reduces environmental impacts. A wide range of demolition materials are currently recycled, including; concrete, steel and gypsum board. In many cases the major barriers to material recycling are not technical but economic. This situation is likely to change in the future with improved recycling infrastructure.

Designing for future recycling of materials involves many of the same considerations as designing to facilitate reuse. Removal of the material without damage is not usually critical, but facilitating material separation for recycling, and avoiding contamination are important considerations. Designing for future disassembly requires consideration of two related factors:

1. The nature of the materials and components used and,
2. The method of application of materials into assemblies and into the building

Assemblies and Components

Assembly
An arrangement of more than one material or component to serve specific overall purposes. Examples of assemblies include the total building envelope or individual walls, roofs, or parapets.

Component
Any building unit. They may be manufactured, prefabricated, or built or formed onsite, and may be basic units such as nails, cladding anchors, reinforcing bars, and membranes or may be complex units such as cast reinforced concrete slabs or window and door units.

From *CSA S478-95 Guideline on Durability in Buildings*

5.1 SELECTION OF MATERIALS FOR DISASSEMBLY

In attempting to design for future deconstruction it is necessary to consider the nature of the materials and components typically used in new construction. A distinction is often made between residential construction, and industrial, commercial & institutional (ICI), buildings. This categorization parallels, to a degree, the building code classification of combustible and non-combustible construction. The majority of residential buildings, with the exception of high-rise buildings, are of wood framed construction; typically constructed with dimension lumber, but often also using engineered wood products. Wood-framed buildings will usually have greater volumes of potentially salvageable material than non-combustible buildings.

Wood-framed buildings generally have more materials that are potentially salvageable.

Non-combustible buildings in the Lower Mainland are typically framed with concrete and tend to have fewer salvageable materials.

Larger non-combustible buildings are most commonly concrete framed, while smaller buildings often use a combination of masonry, concrete, and steel structural elements. Although many of the basic structural materials in these buildings are not salvageable, they are to a greater or lesser degree recyclable. Structural steel framing is not as common as concrete framing, but has the advantage that individual members can be disassembled and reused, particularly if connections are bolted rather than welded.


Deconstruction of reinforced concrete structures involves crushing to remove steel reinforcing. Reinforcing steel is recycled into new steel. Concrete is either crushed on site and used as fill or processed off site for use as road base material.

Typical Salvageable (and Recyclable) Materials and Components

	Combustible construction	Non-combustible construction
Primary Structure	Heavy Timbers	Concrete or steel frame (Recyclable)
	Wood framing	Load-bearing masonry (Recyclable)
	Engineered wood products	Steel beams and trusses
Secondary Structure	Wood studs	Steel studs (Recyclable)
Sheathing	Plywood	Gypsum sheathing (Recyclable)
	Shiplap boards	
Envelope	Fibreglass batt insulation	Rigid or semi rigid board insulation
	Siding	Cladding material
	Windows	
Interiors	Doors	Doors
	Bathroom fixtures	Bathroom fixtures
Landscaping	Concrete pavers	Concrete pavers

Design Considerations

It is not easy to predict which materials and components may be salvaged in the future. Whether or not particular materials will be considered worthwhile to salvage and reuse, will depend on a number of economic and environmental issues. However, based on current practice it is possible to make a number of assumptions about what materials are likely to be salvaged in the future.

The following are characteristics of materials that will tend to facilitate salvage and future reuse. Selecting and specifying materials with these qualities for use in buildings will increase the volume of material that can be salvaged for reuse.

Long Service Life Materials

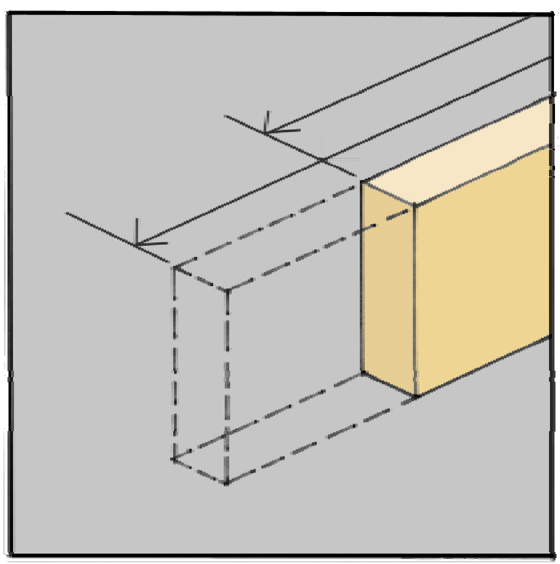
Many of the materials and components used in construction have service lives shorter than the life of the building they are used in. These materials will typically be replaced or repaired a number of times before the end of the building's service life. Some of these materials may have some residual value when the building is being demolished. Generally however, the materials and components that are suitable for reuse are those that have long service lives, equal or greater than that of the building. Examples include structural materials that can be deconstructed, and inert materials that do not degrade, including masonry, precast concrete etc. Some interior materials and components that are not susceptible to wear or mechanical damage also have long service lives, for example, millwork, plumbing fixtures, and doors.

Multifunctional Materials

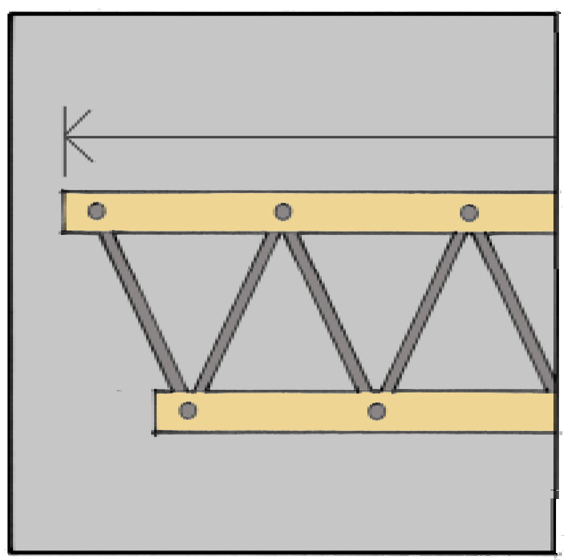
Materials that can be used for a number of different purposes or applications are more likely to be salvaged than materials with only one use. Wood materials tend to be multifunctional and adaptable to numerous purposes different form their original application. Fir decking material has been reused as framing material; glulam beams have been resawn to create finish flooring.

Adaptable Materials

Materials that are not specific to one particular application or condition have greater potential for reuse and are more likely to be salvageable. Where materials and components are reused in applications that are functionally similar to the original use, the ability to adapt to different conditions in a new building is an advantage. Many wood and engineered wood beams can be cut and adapted to new conditions. Trusses, whether wood or steel, or composite, are less easy to adapt.



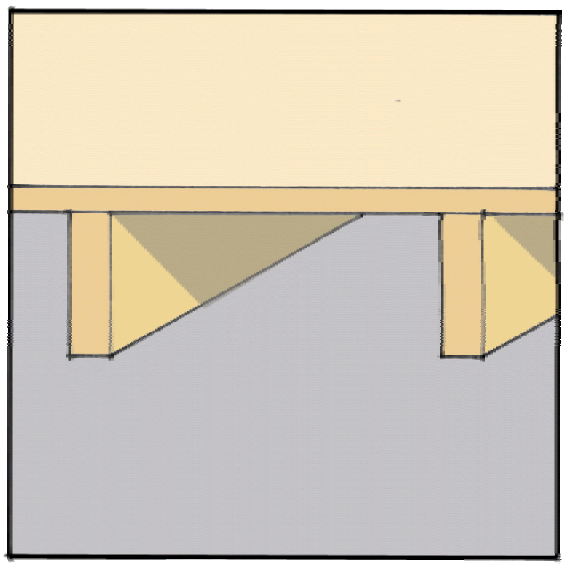
Solid lumber or engineered wood beams can be cut to new lengths to suit new span conditions.



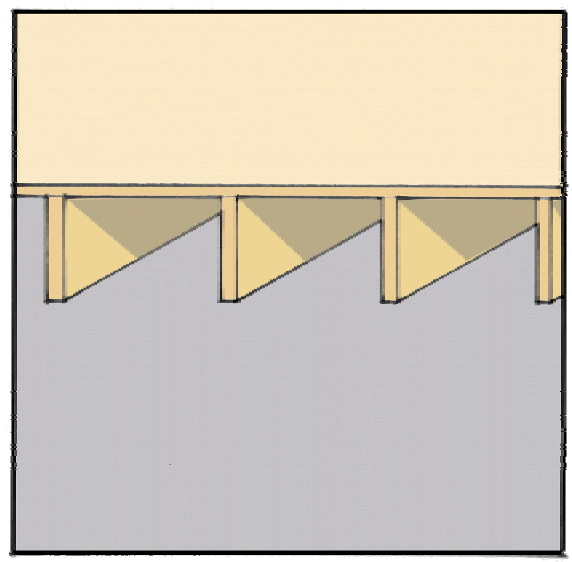
Trusses designed for a particular span condition cannot be easily modified to suit different spans.

Larger Components

A single large component, rather than a number of smaller components, is likely to be both more valuable, and easier to salvage. Older forms of wood framed construction used t & g decking as a sheathing material for floors and walls, the spanning capabilities of this material, 3 to 4 feet, in turn determines the spacing and size of supporting members, which tended to be larger sized beams. In more contemporary construction using plywood sheathing, supports have to be spaced closer together and support smaller areas and loads. As a result supporting members are usually smaller dimension lumber joists.

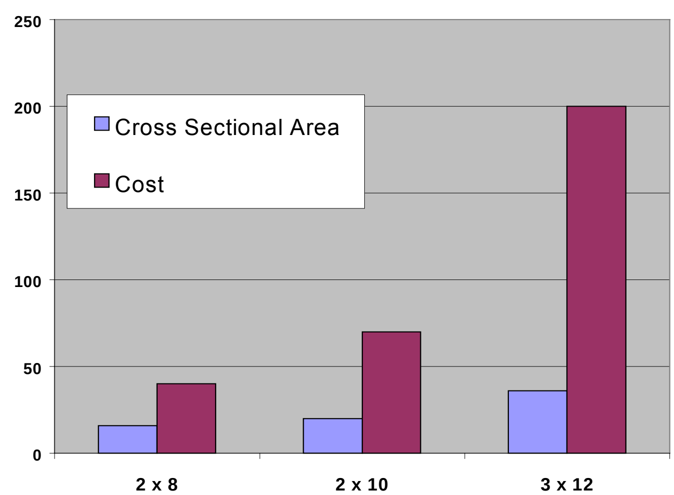


Larger beams with greater spanning capabilities are more likely to be salvaged.

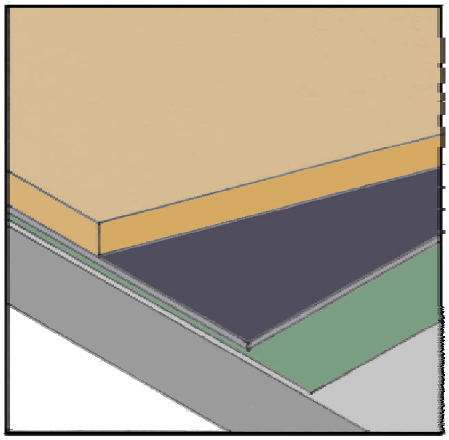


Smaller joists, even thought they may be more numerous, are less valuable.

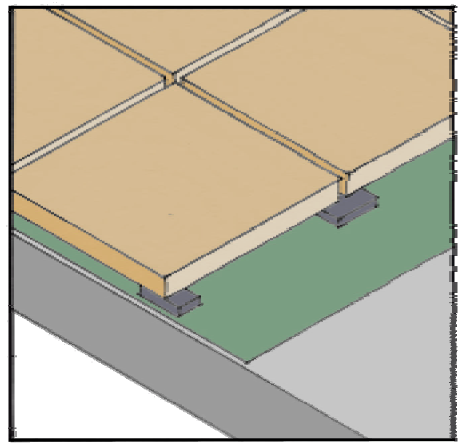
The chart compares cross sectional area (in square inches) of 2" x 8", 2" x 10" and 3" x 12" joists / beams and indicates the relative unit costs (cents / lin ft) of the structural members. As the size of the member increases from joists to heavy timber beams there is an even greater increase in the cost / value of the material. Smaller joists more closely spaced may contain more material but are still less valuable than larger members.



There may be certain circumstance where a large number of small components are a better choice than larger elements. This will be the case when the smaller size facilitates removal of material. Concrete pavers are salvageable whereas concrete topping a monolithic material is not.



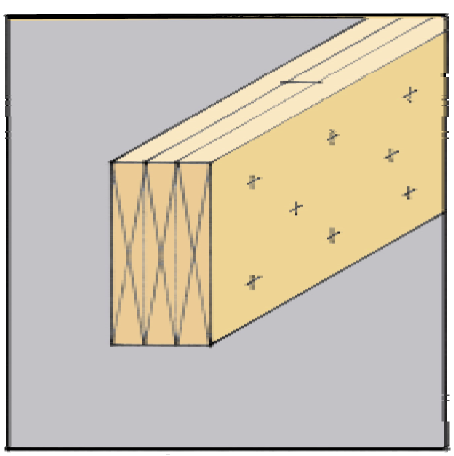
The monolithic nature of concrete topping prevents removal for reuse



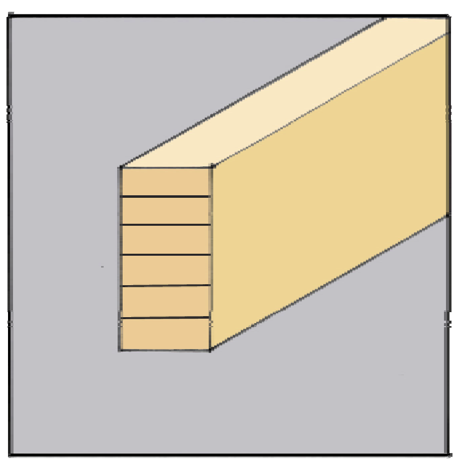
Individual concrete pavers loose laid on pedestals can be easily salvaged

Single components rather than assemblies

Beams are commonly required in wood-framed residential construction. In older houses heavy timbers are common, but more recent buildings are likely to use built-up assemblies of 2" x 10", or 2" x 12" wood joists. Joist of this size are valuable and can be salvaged; however, when nailed together to form a beam they are difficult to take apart. An alternative material for new construction is an engineered wood member such as a microlam or glulam. In addition to other environmental benefits associated with efficient use of wood, these materials have a higher salvage value and are more easily removed in a condition that will permit reuse.



Built up beams are difficult to disassemble and individual components have relatively low value.



Single element beams require no disassembly, and because of their greater value are more likely to be salvaged.

It should be recognized that applying this strategy may result in additional construction costs in some smaller residential building types. Built-up beams are assembled on site from smaller off-the-shelf and relatively inexpensive components. For any particular span condition a single element beam will likely be more expensive. However if the future salvage and reuse value of the material is taken into account, the cost equation changes. Taking this long-term view will not be first choice of many building owners, however, when an owner deconstructs and replaces a building, the benefits of appropriate material choices are realized. The Liu Centre for the Study of Global Issues project at UBC, provides an example of an owner achieving savings in new construction costs as a direct result of an ability to reuse materials salvaged during the deconstruction from an existing building on the site, the Pan-Hellenic House.

5.2 DETAIL DESIGN FOR DISASSEMBLY

Future salvage and reuse of building materials depends not just on the nature of the materials, but also on their methods of application, and relationship with other materials and components in assemblies. In order to salvage materials, it must be possible to access and remove the materials relatively easily, cost-effectively, and without damage.

The Strawberry Vale Elementary School, although not necessarily designed with a view to future salvage of materials, illustrates a number of design features that increase the potential for salvage.

- **Larger and adaptable components (wood beams and solid wood decking)**
- **Multi-functional materials (wood beams and decking)**
- **Simple assemblies with minimal finishes**

Method of Application

Adhesives are becoming more and more common in construction. Unfortunately, in most cases they make it impossible to salvage or recycle materials. Both the material and substrate are difficult to separate which leads to damage during removal and results in contamination of recyclable materials. Mechanical fasteners such as screws, bolts, clips, and nails, are preferable to materials such as adhesives. These points are illustrated in exterior insulation wall assemblies used in many commercial and institutional buildings. Insulation must be located on the outside of the sheathing, and cladding must be separated for the insulation by a cavity. Different insulation materials require different methods of application; both adhesives and mechanical fasteners are commonly used.

Semi rigid insulation adhered using stick pins will be more easily removed in the future.

Rigid insulation can be attached with mechanical fasteners or adhesive. The use of adhesive will prevent future removal without damage to the boards.

An alternative for rigid insulation is to retain boards with continuous horizontal sub girts. These elements can also be used to attach cladding.

Mechanical Fasteners

Screws and bolts are generally preferable to nails or staples. However, if screws and bolts rust they may be more difficult than nails to remove. Corroded bolts, on trusses salvaged from the UBC Armories building, could not be easily disassembled, and as a result many of the heavy timber members were cut at joints. In this case the individual wood components were sufficiently valuable to make this worthwhile, however this may not always be true. If components are designed with screws or bolted connections, with a view to future disassembly, it is important to ensure that the fasteners are sufficiently durable, or are protected from exposure to moisture.

In the deconstruction of wood framed buildings, nails have traditionally been removed with hand tools, a time consuming process that can add significantly to the cost of small dimension salvaged lumber. New pneumatic power tools speed up the process considerably without causing significant damage to the wood. The type and number of nails used play also a role, spiral nails are difficult to remove and result in damage to the lumber. Excessive numbers of number of nails can also be a problem.

Contamination of Materials

Potentially salvageable materials can sometimes be rendered unusable as a result of contamination by other materials. The use of self-adhesive bituminous membranes is becoming more common in both non-combustible and combustible construction. Membranes are typically applied over sheathing in wall assemblies.

In wood framed construction, peel & stick membranes are typically confined to small areas, but will not be removable in the future, and will prevent reuse of plywood sheathing and framing components.

In non-combustible construction, membranes are typically applied to larger areas of sheathing. Gypsum sheathing is not reusable, but can be recycled. Recycling of gypsum board involves removal of paper or fibreglass facing. Fibreglass facing with an adhered membrane will not prevent recycling of the gypsum, but the fibreglass will not be recyclable

Sprayed urethane insulation can also contaminate materials and prevent, or make recycling difficult. Nor can the insulation itself be reused.

In some instances a finish material, or base material for a finish, may have little potential for future reuse, but its method of application may damage substrate materials that would otherwise have been salvageable. Even if substrate materials do not suffer major damage, careless use of finish material fasteners may result in high preparation and refinishing costs, and render the reuse uneconomical. The use of fasteners such as staples that can be quickly applied in large quantities should be avoided. Renovation, during the 1960s and 70s, of many older heavy timber framed buildings, involved application of gypsum board and other finishes to wood columns. Large numbers of closely spaced screws used to attach the gypsum board are difficult to remove without damaging the wood, and make remilling difficult.

Location of Material Within an Assembly

Most roofing membranes typically have a service life that is shorter than that of the building itself. Membranes suffer ultraviolet degradation, damage from water etc. and are replaced one or more times during the life of the building. The membranes themselves cannot be reused (although recycling may be possible in the future), however there are other components in the roof assembly that could be reused if the membrane can be removed without causing damage.

Torch applied membranes are difficult to remove without damage to substrate materials.

Loose laid membranes can be removed and replaced without damage to insulation or other substrate materials.

Assemblies typically have a number of materials that can be applied in different ways. Different types of membranes require different application methods. EPDM, TPO, and PVC membranes can be adhered, or loose laid. In loose laid applications, the membrane can be removed and replaced without damaging other materials (although ballast will have to be temporarily removed). Bituminous membranes are either torch-applied, or hot mopped. Both methods contaminate substrates and underlying materials, and removal of the membrane will also necessitate replacement of substrates. However bituminous membranes can also be applied in assemblies in a location that will not result in damage to other materials when replacement is required. For example a protected membrane roof assembly where the membrane is applied directly to a concrete substrate. The use of loose laid insulation in this type of assembly also facilitates removal and reuse.

Limitations

In designing for future deconstruction it is important to also consider other environmental criteria, and to use good judgement in balancing competing requirements. Selecting materials that can be reused may not always be the highest priority. Other sections of this guide identify limits to the concept of salvaged materials use, and identify factors that should be considered in determining if reuse of materials is appropriate. It is recommended that salvaged materials not be used in applications where new materials would provide better energy efficiency, or lower water consumption. A similar level of consideration should be applied in designing for disassembly. Where possible material selection and design should facilitate future reuse and recycling, but not at the expense of the performance characteristics of the building or its components.

Recommended Design Strategies

There are two principal components to designing for disassembly; selecting materials and components that are suitable for reuse, and applying those materials and components in assemblies that will permit future removal without damage.

Materials Selection

Select

- Durable, long-life materials
- Multifunctional material
- Adaptable materials and components
- Larger rather than smaller components
- Single components rather then assemblies

Assembly Design

- Design assemblies, and locate materials, so that materials and components can be easily removed without damage
- Use mechanical fasteners rather than adhesives
- Avoid materials that will contaminate other potentially salvageable or recyclable materials
- Design assemblies to prevent damage during renewal and replacement activities

Designing buildings to facilitate removal and reuse of material provides a legacy for the future. Designers and building owners benefit today from design decisions and material selections made by earlier builders. In the future, at a time when materials may be scarcer and more expensive than today, an ability to salvage and reuse materials, whether they are high quality expensive elements such as heavy timbers, or more prosaic materials such as board insulation, will be appreciated.

APPENDIX A

RESOURCES

SALVAGED MATERIALS SUPPLIERS

Name	Address Tel. / Fax.	Description
A & J Massullo Excavating Ltd.	7742 Aubrey Street, North Burnaby T. 298-3410 F. 298-3409	Salvage Contractor Salvaged building materials supplier
A & P New and Used Building Materials Ltd.	17565 64 Avenue, Surrey, BC T. 574-3977 F. 574-3977	Salvage Contractor Salvaged building materials supplier
Adriatic Demolition Services	7387 Elwell Street, Burnaby, BC T. 727-2222 F. 525-6146	Salvage Contractor Salvaged building materials supplier
All Around Demolition Co. Ltd. (Jack's New and Used Building Materials)	4912 Still Creek Avenue, Burnaby, BC T. 299-2967 F. 299-1383	Salvage Contractor Salvaged building materials supplier
Bent Nail New and Used Building Supplies	1- 31255 Wheel Ave. Abbotsford, BC T. 1-877-850-2691 F. 850-3337	Salvage Contractor Salvaged building materials supplier
Chilliwack New and Used Building Materials Inc.	44720 Yale Road West, Chilliwack, BC T. 1-800-546-8733 F. 793-2277	Salvage Contractor Salvaged building materials supplier
D. Litchfield & Company Ltd.	3046 Westwood Street, Port Coquitlam, BC T. 464-7525 F. 944-1674	Salvage Contractor Salvaged building materials supplier http://www.dlitchfield.com
Mike's New & Used	3871 River Road W, Delta, BC T. 946-9747 F. 940-9747	Salvaged building materials supplier
P & B Used Building Materials (1994) Ltd.	11947 Tannery Road Surrey, BC T. 588-1311 F. 588-1499	Salvage Contractor Salvaged building materials supplier

Name	Address Tel. / Fax.	Description
Surrey New and Used Building Materials Inc.	17861 64 Avenue, Surrey, BC T. 576-8488 F. 576-8489	Salvage Contractor Salvaged building materials supplier
Tony's New & Used Building Materials	823 – 12th Street New Westminster, BC T. 522-9127 F. 321-4256	Salvage Contractor Salvaged building materials supplier

DEMOLITION AND SALVAGE CONTRACTORS

Name	Address Tel. / Fax.	Description
3R Demolition Corp.	6921 Frederick Avenue, Burnaby, BC T. 435-2555 F. 432-1019	Salvage Contractor Demolition Contractor
A & J Massullo Excavating Ltd.	7742 Aubrey Street, North Burnaby T. 298-3410 F. 298-3409	Salvage Contractor Demolition Contractor
Adriatic Demolition Services	7387 Elwell Street, Burnaby, BC T. 727-2222 F. 525-6146	Salvage Contractor Demolition Contractor
B & L Contracting (a division of Roald Enterprises (1986) Ltd.)	313 Decaire Street, Coquitlam, BC T. 936-8682 F. 936-8682	Salvage Contractor Demolition Contractor
Bent Nail New and Used Building Supplies	1- 31255 Wheel Ave. Abbotsford, BC T. 1-877-850-2691 F. 850-3337	Salvage Contractor Demolition Contractor
C & C Demolition Ltd.	1 - 37 Wellingdon Street, New Westminster, BC T. 515-1418 F. 515-1420	Demolition Contractor
Ceda Reactor Ltd.	1590 Booth Avenue, Coquitlam, BC T. 540-4100 F. 540-4200	Demolition Contractor
D. Litchfield & Company Ltd.	3046 Westwood Street, Port Coquitlam, BC T. 464-7525 F. 944-1674	Demolition / Deconstruction Contractor Used building materials yard http://www.dlitchfield.com

Demco Disposal Service Ltd.	7987 Gilley Avenue, Burnaby, BC T. 433-5387 F. 433-7400	Salvage Contractor Demolition Contractor
Destruction Demolition Ltd.	6331 Caulwynd Place, Burnaby, BC T. 435-3111	Salvage Contractor Demolition Contractor
Dewar Pacific Projects Ltd.	11580 Mitchell Road, Richmond T. 327-2525 F. 327-3440	Demolition Contractor
Douglas Anthony Demolition	7 - 8075 Enterprise Street, Burnaby, BC T. 444-3123 F. 444-3122	Salvage Contractor Demolition Contractor
Drysdale Demoltion	3385 Senkler Belcarra T. 936-1000 F. 936-1014	Demolition Contractor
Fairway Disposal	7017 Elwell Street, Burnaby, BC T. 515-9706 F. 515-0652	Salvage Contractor Demolition Contractor
Fraser Trucking & Tractor Ltd.	9425 127 A Street, Surrey, BC T. 650-9029 F. 930-8375	Salvage Contractor Demolition Contractor
Hands On Demolition	3026 St. George Street, Port Moody, BC T. 908-0327	Demolition Contractor
Inner City Demolition Ltd.	11640 Twigg Place, Richmond, BC T. 327-0957 F. 327-2755	Demolition Contractor
Johnston & McKinnon Demolitions (1981) Ltd.	6038 Trapp Avenue Burnaby T. 526-0787 F.526-6363	Salvage Contractor Demolition Contractor

Jones Bros Cartage Ltd.	619 East 11th Street, North Vancouver, BC T. 987-3000 F. 988-4215	Demolition Contractor
K & F Demo Services	10036 - 127A Street, Surrey, BC T. 581-6785 F. 587-2801	Salvage Contractor Demolition Contractor
K-Lor Contractors Services	#7 - 2350 Beta Avenue, Burnaby, BC T. 320-0533 F. 320-0599	Salvage Contractor Demolition Contractor
Lake City Demolition Co. Ltd.	4050 Boundary Road, Burnaby, BC T. 415-0110 F. 415-0804	Demolition Contractor
McColman & Sons Demolition Ltd.	Vancouver, BC T.683-3347	Demolition Contractor
P & B Used Building Materials (1994) Ltd.	11947 Tannery Road Surrey, BC T. 588-1311 F. 588-1499	Salvage Contractor Demolition Contractor
Pacific Blasting	3183 Norland Avenue Burnaby, BC T. 291-1255 F. 291-2813	Demolition Contractor
Pacific Labour	5057 Irmin Street, Burnaby, BC T. 430-1652 F. 434-3740	Salvage Contractor Demolition Contractor
Quality Demolition & Excavation Ltd.	2034 Bradner Road, Abbotsford, BC T. 857-1711 F. 856-8377	Demolition Contractor
Steward Management	11110 - 284th Street, Maple Ridge, BC T. 462-8845 F. 462-1483	Salvage Contractor Demolition Contractor

Team Ltd.	#205 - 329 North Road, Coquitlam, BC T. 830-1081 F. 420-5464	Demolition Contractor
Thomas Environmental	5870 - 146th Street, Surrey, BC T. 591-7072 F. 591-7096	Demolition Contractor
Van-Burn Construction Ltd.	811 Cliff Avenue, Burnaby, BC T. 291-2077 F. 291-6036	Demolition Contractor
Vancouver Architectural Antiques Ltd.	2403 Main Street, Vancouver, BC T. 872-3131 F. 872-7981	Salvage Contractor
Walker Bulldozing	11860 Trunk Road, R.R.#3, Delta, BC T. 596-1791 F. 596-9494	Demolition Contractor

SPECIALTY SALVAGED MATERIALS SUPPLIERS

Name	Address Tel. / Fax.	Description
Divided Spaces Inc.	955 East 10th Avenue, Vancouver, BC T. 970-3698 F. 879-2508	Manufactures end grain wood flooring tiles and flat and edge grain plank flooring from recycled wood
The Glass Station	1161 Kingsway Ave. Port Coquitlam, BC T. 552-3738 F. 552-3778	Window Glass Recyclers. Supply insulating glass units fabricated from salvaged windows. A 5 year warranty is provided
Vancouver Timber	2350 Beta Avenue Burnaby, BC T. 202-1032 F. 925-4597	Supplier of recycled heavy timbers, flooring, and other wood components Furniture manufactured using salvaged wood
Pacific Heritage Woodworks Inc.	26324 River Road Maple Ridge, BC T. 462 1510 F. 462 1520	Supplier of heavy timbers, Sawing, milling and planing, Flooring
Surplus Office Systems	1570 Rand Avenue Vancouver, BC T. 261 4481 F. 261 4990 www.surplusoffice.com	Supplier of refurbished office furniture systems, including, panels, work surfaces, filing cabinets and storage bins

CONSULTANTS / CONTRACTORS

Name	Address Tel. / Fax.	Description
Architectura Inc.	500-1500 W. Georgia Street Vancouver, BC V6G 2Z6 T. 662-8000 F. 331-8098	Architect – Liu Centre for Study of Global Issues
Busby and Associates Architects	1050 Homer Street Vancouver, BC V6B 2W9 T. 684 5446 F. 684 5447	Architect – City of Vancouver Materials Testing Lab
Matsuzaki Wright Architects Inc.	2410 – 1177 W. Hastings St. Vancouver, BC T. 685 3117 F. 685 3180	Architect – CK Choi Building
Fast + Epp Structural Engineers	201 – 1672 West 1st Ave Vancouver, BC T. 731 7412 F. 731 7620	Structural Engineers – Materials Testing Lab & Port Moody Sailing Centre
Hugh Ker Architect	231 Carrall Street Vancouver, BC T. 688-7370 F. 687-1310	Architect – Railspur Studios
Stefan Brunhoff Architect	204-1807 Maritime Mews Vancouver, BC T. 228-1247 F. 228-1242	Architect – Railspur Studios
Robert Burgers Architect	107-657 Marine Drive West Vancouver, BC T. 926-6058 F. 926-9141	Architect – Port Moody Sail & Paddle Centre
Read Jones Christoffersen	210 West Broadway Vancouver, BC T. 738 0048	Structural Engineer - CK Choi Building
K Edgar King & Associates	5 - 1151 West 8th Avenue Vancouver, BC T. 737 7652 F. 737 3659	Construction Manager - Materials Testing Lab.
Country West Construction Ltd.	33241 Walsh Ave Abbotsford, BC T. 852 6868 F. 852 4644	Contractors for CK Choi Building

Reid Crowther & Partners Ltd.	300 - 4170 Still Creek Drive, Burnaby, BC T. 473 8514 F. 294 8597	Structural Engineers - C.K. Choi Building & Materials Testing Lab,
Keen Engineering	116 - 930 West 1st Street North Vancouver, BC T. 986 5336 F. 980 3747	Mechanical Engineers - C.K. Choi Building, Liu Centre, Materials Testing Lab & Railspur Studios
Allan Diamond Architect	1807 Fir Street Vancouver, BC T.738-8842	Architect -- Ardencraig

PUBLICATIONS

Title	Author / Publisher
"Increasing the Volume of Used Building Materials in Canadian Construction" A Report to Assist Homeowners, Contractors, Building Officials and Operators of Used Building Materials Centres in Canada	Bob Sawatsky, Jennifer Corson CMHC 1998
On Using Old Bricks in new Buildings Canadian Building Digest No. 138	T. Ritchie Division of Building Research, National Research Council, 1971
Salvaged Brick Technical Notes on Brick Construction	Brick Institute of America, 1988
"Efficient Wood Use in Residential Construction," A Practical Guide to Saving Wood, Money and Forests	Natural Resources Defense Council, 1998
"Evaluation of Lumber Recycled from an Industrial Military Building"	Robert H. Falk, David Green, Scott Lantz Forest Products Journal, Vol. 49, No.5
"Engineering Evaluation of 55-year old Timber Columns Recycled from an Industrial Military Building"	Robert H. Falk, David Green, Douglas Rammer, Scott Lantz Forest Products Journal, Vol. 50, No.4
"Effect of Damage on the Grade Yield of Recycled Lumber"	Robert H. Falk, Don DeVisser, Standen Cook, Dale Stansbury Forest Products Journal, Vol. 49, No.7/8

INTERNET RESOURCES AND ELECTRONIC DATABASES

"Demolition & Salvage: A Guide for Developers and Renovators," "Project Waste Management Master Specification," "Building Deconstruction Master Specification," "Directory of Salvage Contractors," Greater Vancouver Regional District.

http:// www.gvrd.bc.ca - keywords: 'garbage & recycling' and 'job site recycling'

"Recycling and Reuse of Building Materials" by Kurt Rathman, University of Michigan, National Pollution Prevention Center for Higher Education, Compendium on Sustainable Architecture.

www.umich.edu/~nppcpub/resources/compendia/architecture.html

"Building for the Future: Strategies to Reduce Construction and Demolition Waste in Municipal Projects," by Bette Fishbein, INFORM Inc., New York City.

http://www.informinc.org/publications.html#p

"Deconstruction: Building Disassembly and Material Salvage - The Riverdale Case Study," contains a detailed analysis of feasibility, cost-effectiveness, labour requirements, hazmat management and salvage values of deconstruction projects. Other case studies are also listed.

http://www.smartgrowth.org

Case Study: "Presidio of San Francisco - Building 901," California Integrated Waste Management Board.

http://www.ciwmb.ca.gov

Used Building Materials Association (UBMA), located in Halifax, represents non-profit and for-profit salvage contractors and used building materials yards. Offers a number of interesting publications.

http://www.ubma.pangea.ca

"C&D Waste Web" - information for Canadian construction and demolition waste management and 3Rs options. Contains case studies and reference documents.

http://www.cdwaste.com

"Overview of the Market for Reclaimed Lumber in the San Francisco Bay Area," Materials for the Future Foundation.

http://www.materials4future.org/Rec.woodworks.html

APPENDIX B

COST COMPARISON

Test Building Materials Take-off and Cost Comparison

System	Material	Size	Unit	No.	Salvaged Unit Cost	Salvaged Total Cost	New Unit Cost	New Total Cost	System Total Salv.	System Total New	Cost Saving
SUPERSTRUCTURE									$10,559	$22,196	$11,637
Beams											
	Glulams	5" x 18" x 12'	No.	24	$95.76	$2,298	$221.50	$5,316			
2nd Floor Beams											
	Glulams	3" x 12" x 13'	No.	40	$29.64	$1,186	$94.38	$3,775			
	Glulams	3" x 12" x 10'	No.	40	$22.80	$912	$72.60	$2,904			
2nd Floor Deck											
	3" Decking	3" x 6"	Sq. ft.	864	$0.57	$492	$2.30	$1,987			
Roof Joists											
	Dim. lumber	2" x 10" x 13'	No.	80	$10.86	$869	$16.48	$1,318			
	Dim. lumber	2" x 10" x 10'	No.	80	$8.36	$669	$10.38	$830			
Roof Deck											
	2" Decking	2" x 6" t & g	Sq. ft.	1104	$0.46	$508	$1.55	$1,711			
Garage Structure											
	Glulams	4" x 18" x 10'	No.	8	$57.00	$456	$184.59	$1,477			
	Trusses	24' span	No.	28			$44.07	$1,234			
	Glulams	24' span	No.	14	$191.52	$2,681					
Roof Deck											
	2" Decking	2" x 6" t & g	Sq. ft.	1060	$0.46	$488	$1.55	$1,643			
EXTERIOR ENCLOSURE									$25,689	$43,478	$17,789
Exterior Wall Framing											
	Wood studs	2" x 6"	lin. ft.	5800	$0.46	$2,668	$0.55	$3,190			
Exterior Wall Sheathing											
	Plywood (2)	1/2"	Sq. ft.	2900	$0.28	$812	$0.57	$1,653			
Exterior Wall Cladding											
	Cladding A		Sq. ft.	1300	$1.28	$1,664	$2.14	$2,782			
	Cladding B		Sq. ft.	1600	$1.28	$2,048	$2.14	$3,424			
Exterior Wall Glazing											
	Sealed Units		Sq. ft.	1210	$5.27	$6,377	$6.35	$7,684			
	Framing		Lin. ft.	1370	$7.50	$10,275	$15.00	$20,550			
Exterior Wall Insulation											
	Batt insulation		Sq. ft.	2900	$0.05	$145	$0.33	$957			
Exterior Doors											
	Garage Doors	10' x 10'	No.	4	$250.00	$1,000	$575.00	$2,300			
	Steel doors	3' x 7'	No.	4	$175.00	$700	$234.50	$938			
ROOFING									$860	$6,272	$5,412
Roof Insulation											
	2" EPS Insulation		Sq. ft.	5000	$0.14	$700	$1.09	$5,450			

System	Material	Size	Unit	No.	Salvaged Unit Cost	Total Cost	New Unit Cost	Total Cost	System Total Salv.	New	Cost Saving
Skylights											
	Plastic dome sk	3' x 3'	No.	4	$40.00	$160	$205.44	$822			
INTERIOR CONSTRUCTION									$1,460	$2,830	$1,370
Interior Partitions											
	Wood studs	2" x 4"	lin. ft.	3600	$0.25	$900	$0.44	$1,584			
Interior Doors											
	Hollow core	3' x 7'	No.	14	$40.00	$560	$89.00	$1,246			
MECHANICAL									$484	$850	$366
Plumbing Fixtures											
	WC		No.	3	$67.00	$201	$100.00	$300			
	urinal		No.	1	$123.00	$123	$150.00	$150			
	Sink		No.	2	$57.00	$114	$100.00	$200			
	Kitchen sink		No.	1	$45.60	$46	$200.00	$200			
ELECTRICAL									$1,200	$4,000	$2,800
Light Fixtures											
	PL Lamp Fixtures		No.	40	$30.00	$1,200	$100.00	$4,000			

SUMMARY

Total Cost of Salvaged Materials	**$40,251**
Total Costof New Materials	**$79,625**
Total Savings	**$39,374**