C.K. CHOI BUILDING
VANCOUVER, BRITISH COLUMBIA

MATSUZAKI WRIGHT ARCHITECTS INC.

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QUICK FACTS

Building Name	C.K. Choi Building- Institute of Asian Research at UBC
City	Vancouver, British Columbia
Country	Canada
Year of Construction	1996
Budget[1]	$4.5 Million
Total Project Cost[2]	$6.0 Million
Architect team	Matsuzaki Wright Architects Inc. Eva Matsuzaki MAIBC, Principle Kiyoshi Matsuzaki MAIBC Joanne Perdue MAIBC
Consultants[3]	Structural - Read Jones Christoffersen Ltd.; Mechanical - Keen Engineering Co. Ltd.; Electrical - Robert Freundlich & Associates; Landscape - Cornelia Hahn Oberlander, Landscape Architect, FCSLA FASLA; Elisabeth Whitelaw, Landscape Architect, CSLA; Landscape Contractor - North by Northwest Landscape
Program	Institute of Asian Research
Gross Area[4]	3,200 m² (55% building footprint)
Site Area[5]	18,000 sq. ft.
Client	University of British Columbia
Climate	Temperate
Special Site Conditions	None
Structural System	Heavy timber and concrete slab construction.
Number of Stories	Three

Awards and Honours	1996 British Columbia Earth Award, Building Owners and Managers Association; 1997 Building Award of Excellence Consulting Engineers of British Columbia; 1998 "Lieutenant Governor of B.C." Award of Excellence, Architectural Institute of British Columbia (Matsuzaki Wright Architects); 1998 Award of Innovation Excellence, Architectural Institute of British Columbia; 2000 Earth Day Top Ten Award, American Institute of Architects Committee on the Environment

INTRODUCTION

As part of a $500 million dollar building plan at the University of British Columbia (UBC), the C.K. Choi Building for the Institute of Asian Research was made a demonstration ‘green’ building. Approval for a ‘sustainable’ building agenda was given provided that ‘the original program, schedule and budget were maintained.’[6] A workshop was set up to include the entire team and establish the goals of the project. ‘The workshop was attended by the Dean in charge of the facility, the Director of the Institute, representatives of the user group, a representative from the university’s physical plant department, the architect and the sub-consultants (the structural, mechanical, and electrical engineers and the landscape architects). Additionally Dr. Ray Cole (a well known researcher in ‘green’ buildings) from the UBC School of Architecture was present as a resource.’[7] It is important for buildings of this scope to have a clear direction in the preliminary stages; the workshop is a good strategy to put ideas on the table and develop a strategy to meet the goals.

Figures 1 and 2: The C.K. Choi Building borders on a natural-growth forest on the edge of the UBC campus to the west, and other campus buildings on the other sides.

PROGRAMME

The C.K. Choi building is a 3,000 square metre graduate research building at the University of British Columbia. It is the new Institute of Asian Research with ‘five centres carrying out research representing China, Japan, Korea, South Asia and Southeast Asia.’[8] The building’s programme consists of offices, graduate student workstations and seminar rooms. An important component of the building’s agenda is a ‘tenant awareness program, promoting informed user control of the various systems.

Figures 3 and 4 (Top): The west side of the building slips into the natural forest. Figure 5 (Bottom Right): The ginko biloba leaf. Figure 6 (Bottom Left): An example of a mature ginko tree as planted on the C.K. Choi Building site.

SITE

In North America, landscape plays an increasingly important role within sustainable building practices. Both environmental consciousness and ecological sensitivity are the primary focus of landscape ideals, while cultural significance is at times contemplated from a North American point of view. Regional sustainability is typically promoted, while traditional ties to the land and related building solutions are contrived as a result of North America's early colonial ideals. The local economy is rarely embodied in landscape practices, usually reflecting a larger infrastructure of loosely connected – increasingly infrastructure dependant – entities, alien to their environments. At the C.K Choi building, the designers have accepted environmental responsibility for site specificity and building integration. While Japanese gardens and related landscape traditions have been an important precedent for landscape architects around the world throughout history, it is important that the project is didactic, if not for reverence alone. The designers have set out to meet firmly established criteria regarding the landscape's role in this project.

The landscape management strategy for the C.K. Choi Building involves the interplay between trees and vegetation, water, ground, surface and, of course, the building itself. Native or indigenous plants are used in order to best mediate local climatic forces acting on, and within, the site. The plants have been chosen for the little maintenance they require to flourish. The building is separated from the street by a line of Ginko Biloba trees. While they are not native to North America, but South East China, they grow quite well and have a high capacity for the filtration of air borne pollutants. As highly resilient plants they are deep rooted, which allows them to grow on dry sites. Ginkos can grow 60- 80 feet tall and have fan-shaped leaves. They have a yellow colour in the fall and embody environmental and cultural significance within the siting scheme.[9]

The background to the project is a dense forest predominated by tall coniferous trees over 100 feet high. The forest is in good condition with undergrowth of salal, ferns, and huckleberries in undisturbed areas. Specialists have determined that the forest requires minor alternations in order to improve long-term health and sustainability. Selective clearing, thinning and pruning are some of the approaches taken in order to achieve long-term goals. To improve light penetration, the removal of weak trees, dead branches and some thinning was necessary. The forest provides a source of cool wind in the summer as a result of its location west of the building; forest thinning assists this as well. It enables the healthiest, wind-firm trees to reach mature growth. As an added benefit, the clearing of underbrush and deadwood helps minimize the threat of fire by reducing dry kindling on the forest floor.

As an aesthetic approach to integrate the building and landscape, ferns and maples were planted in the forest to 'allow for a relationship of scale of the majestic forest to its manmade surroundings.'[10] Studies have determined the location of footpaths in order to prevent root compaction on site. These paths are constructed of compacted earth with a gravel topping and are lit by recycled and re-furbished, low-voltage lighting.[11]

SUSTAINABLE DESIGN/ ENVIRONMENTAL CONTROLS

In sustainable design, priorities should be established early in the design to divert the conventional approach to building design. Conventional construction often has little relation to vernacular construction. While conventional construction speaks about local industry – limiting long-distance transportation of materials is important – the way that the systems and materials are used requires careful consideration of the environment. From a local perspective, the C.K. Choi building uses benchmarks that reflect the climate, materials that are found locally and building systems that engage the local climate.

As a result of a successful workshop, specific targets were set for resource and energy use. By reducing resource and energy use, the building sustains itself to a degree and contributes to a sustainable environment also. To outline some of the goals, the team proposed: 50% less water use than normal; no sewer connection; 50% re-used/ recycled materials; reduction of energy use below ASHRAE 90.1 levels by 35%; lighting for less than 5 watts per square metre [0.5 W/ft2].[12] 'The implementation of a team approach to all work sessions facilitated an early and comprehensive understanding of the cross-disciplinary relationships of different aspects of the project.'[13] Most of the targets were reached as a result of the team's coordination.

Like all buildings, the institute relies on the integration of systems, which use different energy sources, for a comfortably conditioned internal environment. Passive solar design, natural ventilation and other sustainable approaches reduce both heating and cooling loads in the building. In other words, the integration of natural systems reduces the use of mechanical systems. To outline some of the approaches and their results in terms of the buildings performance, the following outline separates systems in terms of three energy sources: water, wind and sunlight.

<u>Water</u>

Water is a precious resource and becoming increasingly scarce in large parts of the world. It is important to both minimize its waste and find alternatives to chemical treatment. Nature plays a key role in water filtration and circulation, which the institute has addressed through its 'water and landscape' strategies.

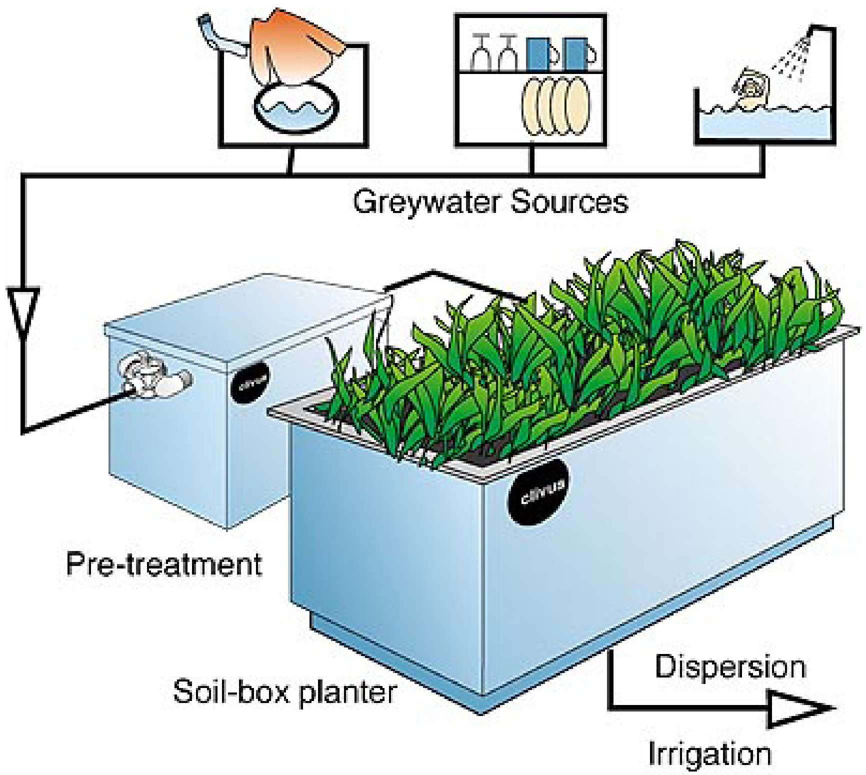


Figure 7: Grey water filtration and treament process schematic for wastewater.

As mentioned before, the building does not use a sewer connection, which is a considerable accomplishment on the designer's part. Water is used for both energy components of the building, by way of steam for space heating and hydro electricity for lighting, ventilation, domestic hot water and powering office equipment and computers. Due to minimal energy requirements, underutilized power from the adjacent Asian Centre Building supplies all power needs without any new electrical service or transformers. [14]

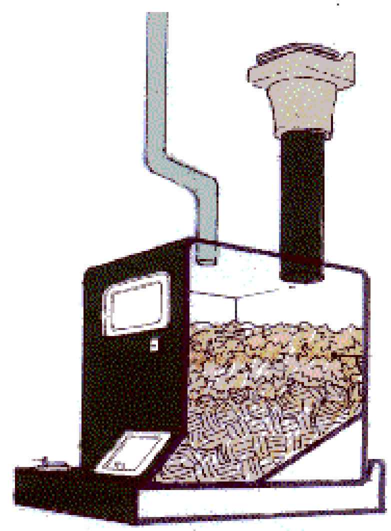
The monthly heating component is actually 69% higher than the ASHRAE 90.1 building benchmark. Due to the high window-to-wall ratio, the original design estimate projected that the 'building would require 1,113 GJ [1,074,000 MBtu] per year for space heating, compared to 605GJ [573,000 MBtu] for the prototype building [.]'[15] The other factor contributing to increased heating loads is the constant 9.4 litres per second [20cfm] per person of fresh air infiltration.[16] Waste heat from the campus underground steam infrastructure is captured and used to heat domestic hot water for the building.[17]

While the C.K. Choi Building will continue to require higher-than-desired amounts of steam, UBC has launched a $35.2 M project to upgrade and retrofit campus buildings, improving water and electricity uses. At the moment the campus consumes 146 million kWh of electricity, 836 million pounds of steam, uses more than 4.2 billion litres of water, and emits more than 60 million kilograms of $C0_2$ from the energy used in its buildings. The new energy and water management program proposed by ECOTrek [18] is intended to annually reduce UBC's $C0_2$ emissions by up to 15,000 tonnes, campus energy use by up to 20 per cent, water use by 40 per cent, deferred maintenance costs by $20 million, and save UBC approximately $2.5 million each year. The University's commitment to sustainability is much broader than it's investment into the C.K Choi building.

In the C.K. Choi Building, overall energy performance between steam and electricity combined is about 23 per cent less than the ASHRAE 90.1 benchmark building with total energy costs around 57% lower. While the savings are significant, this still does not reach the projected goal of energy use 35 per cent lower than ASHRAE 90.1. From past electricity readings, monthly peak demands have average reductions of 45 per cent lower than the initial design estimate and 75 per cent lower than the ASHRAE 90.1 benchmark. Annual use of electricity is 69 per cent below the prototype building. This low use of energy is attributed to such aspects concerning an office/ user oriented approach as well as overall infrastructure criteria. Robert Freundlich & Associates, the electrical consultants are largely responsible for these criteria.[19] As the source of electricity, BC Hydro is working with green criteria[20] in determining a solution to the growing demand for electricity in B.C.[21] While C.K. Choi is designed to minimize the use of electricity, it is always important to understand the environmental orientation of the energy source.

As with the steam and electricity meters, the water meter is read through the centralized Building Management System (BMS).[22] Energy use is kept to a minimum, while water and waste management at the institute has been successful also, allowing the building to operate outside of a sewer connection. The facilities include ten composting toilets and three trapless ventilated urinals that require no water. These are connected to five Clivus Multrum Model M28 Composters. [23] The composting toilets alone save 1,500 gallons of potable water per day.[24] A grey-water trench, lined with recycled PVC and filled with gravel, runs along the front of the building and handles the filtering. 'In this subsurface biological marsh, planted with reeds, sedges and irises, the water from sinks and 'tea' from the composting toilets together with rainwater runoff is purified by natural processes and released into a subsurface irrigation system.'[25] A 7,000-gallon cistern collects rainwater and together with water released from the filtering system, irrigates the landscape in the summer months. 'The aerobic composting system is continually ventilated and reduces the volume of waste by 90%. The end product is a humus–like amendment product that is rich in nitrogen and other useful elements. Returning nutrient-rich humus to the earth restores depleted soil conditions.'[26] Low water use fixtures are installed throughout the building to further conserve to use of water. 'Frequent testing by Vancouver City Health Department shows that water leaving the system has lower counts than water from Vancouver taps.'[27]

Figure 8 (Above Left): The curved roof helps with ventilation as air is drawn through windows on main floor. Figure 9 (Above Right): Work area. Figure 10 (Below Left): Diagram of composting toilet. Figure 11 (Below Right): View to the central work area.



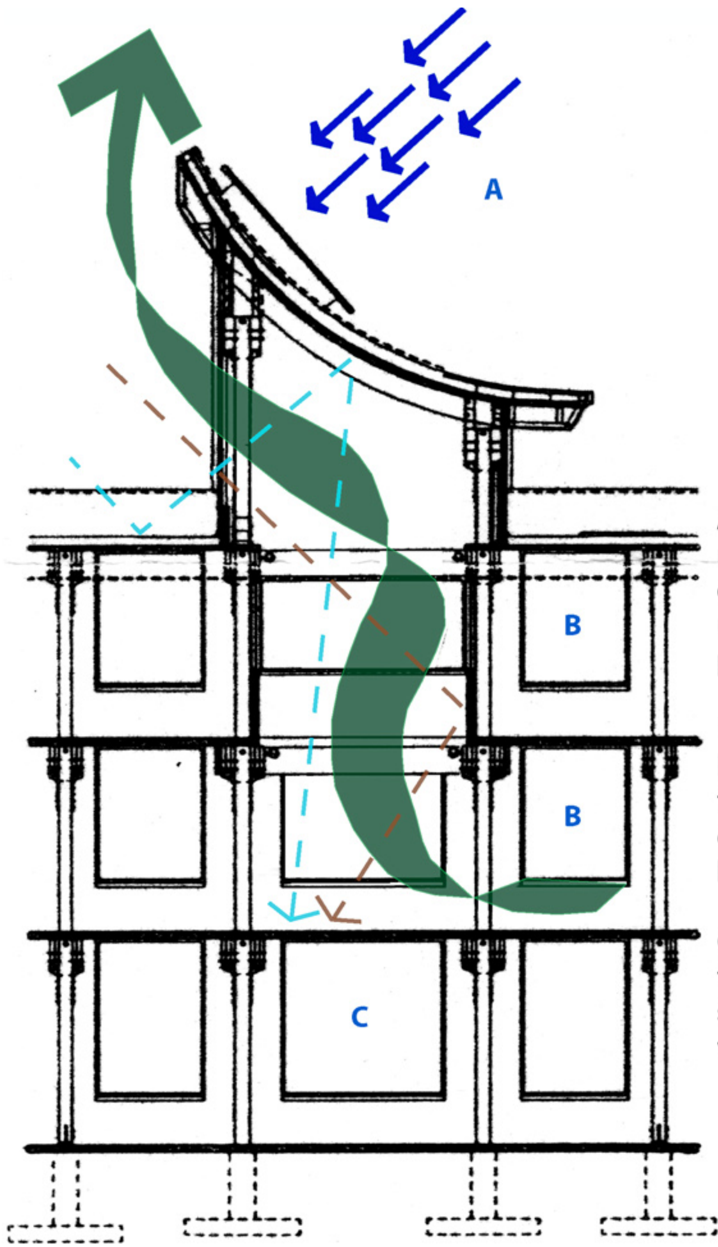


Figure 12: Atrium Cooling/Sunlight

A - South facing roofs optimize direct solar gain using photovoltaid panels

B - Windows with low-flow ventilation apertures continously flush building

C - At ground floor, chimney stacks facilitate ventilation

Wind

Buildings must consider air currents, whether the source is prevailing winds or passive solar induced convection of air within the interior, in order to harness this natural renewable source of energy. Orientation of the building is crucial in this respect. At the institute, two strategies are employed to contribute to natural ventilation. The first is the solar orientation of the five atria that moderate interior flows through convection and the second is the building's orientation toward the forest, which acts to cool prevailing winds from the west.

Natural ventilation has eliminated the traditional ducted air system at the C.K. Choi building. Inside of the atria, the building form enhances internal stack effects to provide air change through natural ventilation and localized fans. Operable windows and ventilation strips under each window ensure a continual flushing of fresh air through the building.[28] The building relies entirely on this natural ventilation for cooling, with just a few fans to push the air.[29] 'Hot water baseboard heaters temper the air below the windows. As it moves through the office, the air picks up the heat dissipated from people and equipment, and rises through the atria to relief openings at the top.'[30] As in most sustainable buildings, user controls are an important feature. Through the use of operable windows, users are intended to learn the principles of stack-effect. Building users can condition their immediate environment but should remain conscious of overall climate control. Operable windows only work to reduce mechanical venting if a comfort level is established and maintained for the entire building. Localized environmental controls offer a lesson in micro-environmentalism.

Sunlight

It should be noted at this point that each category speaks from a natural source of energy to a mechanical or artificial substitute. With the analysis of sunlight follows a reciprocal effect upon the artificial lighting strategy, which concludes with an overall effect from their integration within the building environment. Solar orientation with the related (or unrelated) envelope of a building often has the greatest effect over its climate control. At the C.K. Choi building, again the five atria are developed to address the building's solar orientation. Each atrium is capped with a dual functioning curving roof. The roof slopes up towards the north to admit a diffuse light adequate for the building's office related functions. 'The building is retrofit-ready for solar power when the technology becomes financially feasible in a northwest coastal climate with overcast conditions.'[31] The south-facing roofs are equipped for photovoltaic panels. Their orientation optimizes direct gain.

Wherever possible, natural light is introduced from two directions to soften and balance the lighting conditions. The interior lighting strategy incorporates high-efficiency luminaries with lower ambient lighting levels and supplementary task lighting where required. 'Daylight sensors and continuous dimming ballasts ensure that electric lighting is used only to supplement the available daylight. Occupancy sensors are also used to turn off artificial lights when they are not required. The connected light load is approximately nine watts per square metre [0.9 W/ ft2]. The capital premium for the lighting strategies was calculated at $43,000.'[32]

CONSTRUCTION / MATERIALS

The institute thus far reveals an approach or strategy for dealing with the influence of various energy sources on the built environment. The siting of the building and its mediation with land, climate and infrastructure, embodies a

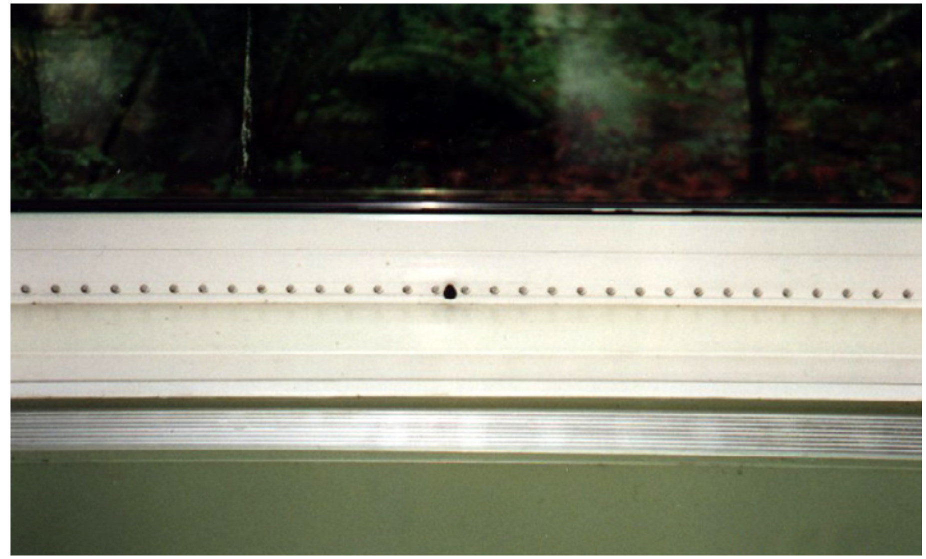


Figure 13 (Above): Air is constantly drawn into the building through small holes in the frames. Figure 14 (Below): Operable windows also allow for maximum ventilation.

Table 1.1: Recycled and Reused Materials List:

Reused brick, salvaged timber beams, concrete containing waste fly-ash and silica fume, reused wood and steel door frames, rainwater, steel containing 75% recycled content, recycled gypsum, recycled paper, recycled cellulose fiber, ventilation strips, reused electrical conduit and wiremolds, non-solvent and low emission finishes, formaldehyde free fiberboard, and recycled glass.[34]

Figure 15 (Left): Scupper detail from one of the balconies on the second floor. Figure 16 (Right): Slit windows on the west side provide dappled light from the forest.

notion of local sustainability. The designers have taken a pragmatic approach, harnessing renewable energy sources and assuming a local stewardship for the land. The flow of energy through the building is important to manage and sustain throughout its lifetime of use, which also sheds light on its after-life use. Building materials are looked at more closely in this section.

It appears that contemporary architectural practice should begin, by designing buildings for their death. The life expectancy of buildings is decreasing constantly and so lifecycle modelling is gaining interest from various eco-design groups. The embodied energy within building materials, in relative terms, should reflect the longevity of their use. Keeping the embodied energy as low as possible is always the best approach. Since buildings typically live short lives, or are at least refurbished in order to avoid demolition, materials must be salvaged or recycled to reduce waste. The C.K. Choi project goal is the incorporation of 50% recycled and 50% recyclable materials. As a result of the team's persistence the target has been exceeded. A summary of the materials both considered and used can be found in Table 1.2.

The design team's strategy was to look at all possible options, focusing first on reusing materials and second on sourcing materials with recycled content. The architects began by looking at all building components and the alternatives that are available. During construction, job site recycling was arranged further saving materials. This required that a waste management plan was arranged by the contractor, and sub contractors would keep their wastes separate. 'Different types of collection and storage systems were then worked out for different phases of the project. Hauling costs from the site were reduced. Separating and stocking piling wood ends on site provided an alternate source of wood for small framing.' The Greater Vancouver Regional District (GVRD) determined through their analysis that 95% of construction waste was diverted from the landfill.[33]

Table 1.2: Reused and Recycled Content Building Materials[35]

<u>Subgrade Material</u>	
Option:	Crushed Glass:
Comments:	-Approval from Authority Having Jurisdiction may be difficult. -Acceptable in some municipalities. -Not acceptable to the governing regulatory office at UBC.
Option:	Crushed concrete:
Comments:	-Widely used in road building industry -Lesson common in the building industry in British Columbia
Choi:	Fill used from excavation on another project on campus: -Geotechnical Engineer worked with contractor to determine a method of excavation resulting in minimal disturbance and fill requirements.
<u>Structural System</u>	
Option:	First design was a thin slab concrete structure: -Thin slab with more columns required the least volume of concrete. -Specifications to minimize cement content of concrete.
Choi:	Heavy timber post and beam structure: -Over 65% of timbers were reused from a demolished building on campus. -All timber required regarding, initially a random sample for design purposes, all were regarded prior to erection.
Comments:	Graders typically assess new timbers. Timbers with previous coring or checking were initially rejected by the grader. Structural engineer and grader worked together to enable more than 90% of materials to be reused. Timber prepurchased to ensure availability to contractor. Design must accommodate predetermined timber dimensions. Some resistance from Authority Having Jurisdiction.
Choi:	Structural steel for timber connections, concrete reinforcing, steel decks, and seismic bracing. -75% or greater recycled steel content.
Comment:	-Reported to be somewhat more difficult to weld but not problematic. -Specify criteria for recycled content and request verification from supplier.
<u>Exterior Building Envelope</u>	
Choi:	Red brick to the majority of vertical surfaces -100% reused brick
Comments:	-Sourcing and pre-purchase required to ensure availability to contractor. -Assessment and testing critical to determine durability and strength. -Technical aspects of detailing with bricks without internal cores different. -Reliance on chemical bond versus combined mechanical and chemical bond with new bricks.
<u>Exterior Window System</u>	
Option:	Aluminum frame with recycled aluminum content
Comments:	-Recycled content not available from the window extrusion manufacturers. -Impurities in recycled aluminum results in inconsistent anodized finish, believed by extrusion manufacturer to not be acceptable to industry.
Choi:	Modified PVC frame with pressure equalized cavity system.
Comments:	-No recycled content but fully recyclable (manufacturer takes back units). -Superior thermal performance to aluminum system. Incorporates trickle ventilation system within sill sections for natural ventilation when operable windows are closed.
<u>Roofing System</u>	
Options:	Water based rubberized adhesion system with polyester felts made from recycled plastic.
Comments:	-UL rated but not ULC (Canada) rated. -Not recognized by the Roofing Contractors Association of British Columbia therefore not acceptable to the University Facilities Management.
Choi:	Flat Roofs: Loose laid EPDM with gravel ballast. -Easy to recycle -Gravel ballast specified as reused but neew used to maintain warranty Curved roof: Steel. -20% recycled content. -Gavalume coating finish will facilitate future recycling.
<u>Interior Walls</u>	
Options:	Homosote Boards: Made from recycled newsprint cellulose Fibre Bond Boards: Blend of recycled cellulose fibre, perlite and gypsum.
Choi:	Gypsum Wall Board -Core from 18% recycled gypsum and 37% recycled paper -Facing from 100% recycled newsprint

Comments: -Local industry supported.
-More cost effective than other options.
-Greater recycled gypsum content possible when fire rating not required.

Insulation
Options: Fibre Glass Batt Insulation
-25% to 80% recycled glass content available.
-Check for post-consumer versus pre-consumer waste
Foam Insulation
-50% to 100% recycled polystyrene content.
Choi: Blow-in cellulose insulation.
-Made with 100% recycled cellulose fibre.
-Borate additive for fire retardancy, mold, insect and rodent inhibitor.
-Latex binder to minimize settling.

Interior Wood Doors and Frames
Choi: 100% reused from a downtown office building renovated to residential
Comments: -Sourcing and pre-purchasing necessary to complete design and ensure availability to contractor.
-Design must accommodate predetermined sizes and door swings.
-Refinishing required.

Steel Doors and Frames
Choi: 90% reused
Comments: -Same issues as above
-Labels must be intact on both doors and frames for rated assemblies.

Interior Guardrails and Handrails
Choi: 100% reused aluminum from a demolished six year old golf club house.
Comments: -Some on site modification to accommodate new design, more labour.
-New base plates connections required to meet current building code.
-New glazing required for modified sections.

Washroom Accessories
Choi: All sinks, paper towel dispensers and garbage receptacles reused.
Toilet partitions reused.

Carpet
Option: Carpet from recycled PET (plastic soft-drink bottles).
Comments: -Not recyclable (at the time of construction) and not acceptable to the University Facilities Management.
Choi: Wool-polystyrene blend product.
Coment: -Recyclable and acceptable durability to the University of British Columbia's Facilities Management.

Underlay
Option: Under-cushion from recycled tires.
Comments: -Odour not acceptable.
Choi: Fibre underlay from Chris Craft Industries
-100% pre-consumer recycled fibre from industrial industry.

Wall Tile
Choi: Stoneware Tile Company
-70% recycled glass from automotive industry.

Miscellaneous Hidden Components
Wood: -Reused plywood formwork became sheathing material
-Wherever possible, finger jointed materials were used.
-Reused cut end were stockpiled and used for small framing.
Concrete: -Increased flyash and silican fume content for decreased cement content.
Conduit: -Approximately 40% reused, dry storage required, conduit was internally brushed prior to installation.

Figure 20. Building Sections

COSTING

The budget for the project was $4.5 million or $150 per square foot. The total cost of construction was around $6 million. With many sustainable buildings there is a perception of increased costs, however, the C.K. Choi Institute was built with the same fixed, dollars per square foot budget as any other campus building.[36] The materials used balanced the total cost of the building, with some being more expensive and others much cheaper than normal. Energy efficiency contributes to cost savings in the long run. 'The total electrical savings are 191,603 kWh per year. For this achievement, B.C. Hydro provided a $44,121 incentive to the owner under the New Building Design Program.[37] Listed in Table 2.0, are the total energy costs per month.

Table 2.0 Total Energy Costs[38]

Month	**ASHRAE 90.1 Bldg**	**Design Estimate**	**CK Choi Bldg.**
January	$1470	$1115	$865*
February	$1190	$799	$731*
March	$1257	$722	$573*
April	$1025	$637	$508*
May	$993	$636	$472*
June	$928	$545	$409*
July	$976	$510	$391*
August	$1021	$572	$450*
September	$963	$584	$457*
October	$1169	$767	$598*
November	$1402	$935	$708**
December	$1609	$1108	$803**
Total	**$14002**	**$8930**	**$6964**
* Projected	** Weather adjusted		

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN

As a means of quantifying the overall "sustainability" of the C.K. Choi Building, a preliminary LEED rating was determined, in order to compare the measures used in this project to others throughout the country. Overall, the building scores well with 36 points, earning the building Silver Status (see Table 3).

In the "Sustainable Sites" category the building earns points for site selection, proximity to public transportation lines, reduced footprint, storm water management measures, and reduced non-roof heat-island effects. The building also earns all five (5) points in the "Water Efficiency" category due to the outstanding efforts of the design team to eliminate the need for irrigation, reduce the use of potable water in plumbing fixtures, and create innovative solutions for wastewater elimination.

The building earns an impressive eight (8) out of ten (10) points for optimal energy performance in the "Energy and Atmosphere" category. This is remarkable considering the amount of glazing used on the façade. However, the floor area to exterior wall ratio works in the favour of the design team, allowing for greater features both aesthetically and in terms of the quality of interior space, without compromising energy performance.

Table 1. LEED GREEN BUILDING RATING SYSTEM 2.1

Project Checklist	
Sustainable Sites	**6**/14 Possible Points
Water Efficiency	**5**/5 Possible Points
Energy & Atmosphere	**9**/17 Possible Points
Materials & Resources	**8**/13 Possible Points
Indoor Environment Quality	**7**/15 Possible Points
Innovation & Design Process	**1**/5 Possible Points
Project Totals	**36**/69 Possible Points
C.K. Choi Building Result	**Silver Status**

The extensive research conducted on building materials helped the building earn eight (8) points in the "Materials and Resources" category. The great lengths the design team went to in order to select locally harvested and manufactured materials that also had a large recycled component or were reused from nearby demolition sites, earned the building the majority of the "Materials and Resources" points. However, the great measures employed to divert 95% of the construction from landfill also earned the building another two points in this category.

Surprisingly, the C.K. Choi Building earned only seven (7) out of fifteen (15) available points in the "Indoor Environment Quality" category. Points were earned for the selection of low-emitting materials such as paints, adhesives and composite woods, controllability of perimeter heating systems, and daylight and views to 90% of interior spaces. Many of the missed points were due to the strict temperature ranges or other criteria required by the standards by which LEED assesses its credits. In a building that relies heavily on natural ventilation, it is difficult to maintain constant temperatures within a building without the occasional fluctuation. Therefore points missed in this category included those associated with advanced HVAC systems including a permanent means of measuring CO_2 levels, indoor pollutant control, and ensuring consistent thermal comfort of occupants.

In the final category, "Innovation and Design," the building earns one additional point for its construction waste management plan that went well above and beyond the thresholds established by LEED. Overall, the building performs very well within the LEED rating system – an impressive feat for any project.

CONCLUSION

The success of the C.K. Choi Institute is the result of a team approach, taken from the beginning of the project. The architects, clients, contractor, subs and consultants worked together to establish the goals of the project. Next a plan and strategy was established to reach the goals. The expertise of each field applied directly and individuals involved were challenged throughout the process. Both cost savings and innovation go hand in hand as a result of the pragmatism in the office and on site. The building's designers encourage all design professionals to practice discipline and creativity when addressing environmental challenges in the future.

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15. The University of British Columbia. Source: http://www.publicaffairs.ubc.ca/media/releases/1996/mr-96-68.html

ENDNOTES

1. Cascadia Region Green Building Council http://www.usgbc.org/chapters/cascadia/choi.pdf
2. Cascadia Region Green Building Council http://www.usgbc.org/chapters/cascadia/choi.pdf
3. Seeing With New Eyes http://www.iar.ubc.ca/choibuilding/matsuzaki.html
4. Cascadia Region Green Building Council http://www.usgbc.org/chapters/cascadia/choi.pdf
5. Cascadia Region Green Building Council http://www.usgbc.org/chapters/cascadia/choi.pdf
6. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
7. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
8. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
9. A Landscape Featuring Environmental Responsibility http://www.gvrd.bc.ca/sustainability/GreenBuildConf2001/Workshop%204-Cornelia%20Oberlander.pdf
10. A Landscape Featuring Environmental Responsibility http://www.gvrd.bc.ca/sustainability/GreenBuildConf2001/Workshop%204-Cornelia%20Oberlander.pdf
11. A Landscape Featuring Environmental Responsibility http://www.gvrd.bc.ca/sustainability/GreenBuildConf2001/Workshop%204-Cornelia%20Oberlander.pdf
12. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
13. Process Makes Product: The C.K. Choi Building for the Institute of Asian

Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
14. Cascadia Region Green Building Council. http://www.usgbc.org
15. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
16. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
17. Cascadia Region Green Building Council http://www.usgbc.org/chapters/cascadia/choi.pdf
18. 'A major feature of ECOTrek will be the introduction of computerized automation systems for 50 campus buildings to control heating and ventilation. The systems will automatically turn heat and fans on and off as needed, rather than running them constantly. The systems also include $C0_2$ sensors to increase ventilation rates automatically. Other features of the retrofit will include replacing inefficient incandescent street and path lights with metal halide lamps and posts; fixing steam system leaks, adding insulation to pipes and increasing the amount of condensate that returns to the steam plant; installing occupancy sensors to control urinal flushing in washrooms, and water recycling systems for use in air conditioners and lab cooling systems.' Source: http://www.publicaffairs.ubc.ca/media/releases/2003/mr-03-29.html
19. As Electrical Consultant, RFA introduced the following features into the design: Photovoltaic retrofitable power system; Modulated daylight harvesting control; Artificial illumination not exceeding 0.5 watts/ sq.ft.; High colour rendition direct/ indirect illumination system; Occupancy sensor controls; Maximized daylight utilization; Structured cabling communications infrastructure; Minimized electromagnetic fields and radiation
20. Green Criteria: 'Renewable: The energy source must be replenishable by natural processes within a reasonable length of time - at the longest, within about one average human life span. For example, hydroelectric generation relies on water, which is a renewable resource. Natural gas electrical generation relies on a fossil fuel, a resource that does not meet this renewable criterion. Licensable: The project must meet all relevant regulations and standards. Socially responsible: The project must be developed in a socially responsible manner. This criterion must be judged on a site-specific basis. Every project within BC Hydro's green acquisition process is reviewed according to specific social responsibility criteria. Low environmental impact: The project must avoid unacceptably high environmental impacts such as damage to fish populations, endangered species or air quality. This criterion is evaluated on a site and technology-specific basis. Every green project within BC Hydro's acquisition process is reviewed according to the criteria that correspond to the project's technology.' http://www.bchydro.com/info/ipp/ipp959.html
21. 'Population increase on Vancouver Island has been considerable over the past decade. The population on Vancouver Island has increased by 21% since 1991 and this increase is driving the demand for more electricity. Vancouver Island residents use a substantial amount of electricity for home heating because the availability of natural gas as a home heating fuel has come on stream in only the past 10 years. And, the demand for electricity increases at the worst time – in winter when it's cold and dark and the heating and electricity needs are high. Electricity demand on Vancouver Island is growing by 30 to 40 megawatts per year, which is equivalent to providing electricity to an additional 30,000 to 40,000 homes each year.' http://www.bchydro.com/info/ipp/ipp959.html
22. 'However due to a problem with the transducer, this water meter BMS has not been able to communicate with the meter. The main problem appears to be that the building uses such low quantities of water that the signal does not register with the BMS system. Manual meter readings from September to December 1998 indicate that the building consumes approximately 218 litres [58gl.] per day, on average.'
23. 'The C.K. Choi Building at UBC is the first all-Clivus Multrum large-scale office-building project in Canada. Each of these Clivus Composters has an annually user capacity rated at 45,000 visits. Therefore, the total annual rated capacity for the Clivus systems there is 225,000 visits. All of the Choi building's washwater (greywater) is processed on-site separately.'
24. Canadian Architect. Volume 41, No. 7, July 1996. "Green Buildings 3: Swooping for Air" p. 17
25. A Landscape Featuring Environmental Responsibility http://www.gvrd.bc.ca/

sustainability/GreenBuildConf2001/Workshop%204-Cornelia%20Oberlander.pdf
26. Seeing With New Eyes http://www.iar.ubc.ca/choibuilding/matsuzaki.html
27. A Landscape Featuring Environmental Responsibility http://www.gvrd.bc.ca/sustainability/GreenBuildConf2001/Workshop%204-Cornelia%20Oberlander.pdf 28 The C.K. Choi Building, Institute of Asian Sudies, University of BC http://www.newcity.ca/Pages/choi_building.html
29. Canadian Architect. Volume 41, No. 7, July 1996. "Green Buildings 3: Swooping for Air" p. 17
30. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
31. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
32. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
33. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
34. Design Resource http://www.designresource.org/idra97/MatsuzakiWright_ProFirstPlace.html
35. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF
36. A Constructive Idea http://www.iar.ubc.ca/choibuilding/gwill.html
37. Seeing With New Eyes http://www.iar.ubc.ca/choibuilding/matsuzaki.html
38. Process Makes Product: The C.K. Choi Building For The Institute of Asian Research at the University of British Columbia http://www.sustain.ubc.ca/pdfs/ckchoi.PDF

IMAGE CREDIT

All images in this document are by the author except those from the following:

1. A Landscape Featuring Environmental Responsibility: Figures 5 and 6.
2. Clivus Mutrum Filters Website: Figure 7.
3. Matsuzaki Wright Architects Inc.: Figures 9, 10, 11 and 12.