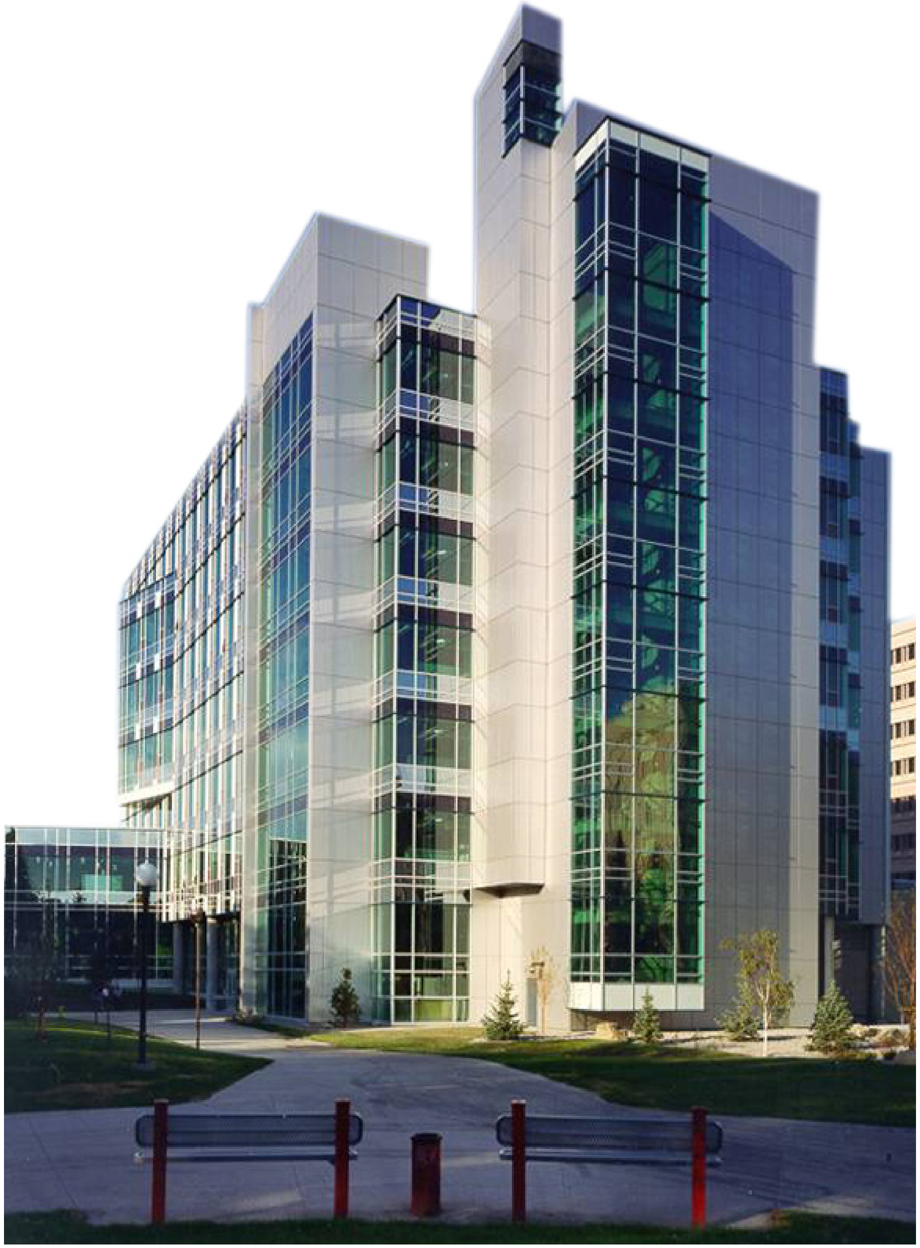


INFORMATION AND COMMUNICATIONS TECHNOLOGY BUILDING

UNIVERSITY OF CALGARY
CALGARY, ALBERTA

STANTEC, HOK + BARRY JOHNS ARCHITECTURE

Kate Harrison
M. Arch Candidate
University of Waterloo

ICT BUILDING

CALGARY, ALBERTA

QUICK FACTS

Building	Information and Communications Technology Building
City	Calgary, Alberta, Canada
Year of Construction	Completed September 2001
Architect	Stantec, HOK, Barry Johns Architecture
Consultants	Earth Tech (Canada) Inc. (Mechanical/Electrical), Stantec Consulting Ltd. (Structural/Landscape), Stantec Architecture Ltd, HOK Canada (Interiors), Ellis Don Construction Services (Construction Manager), DMC Resources Ltd. (Project Management)
Program	Shared lecture, classroom and faculty office space between Computer Science and Electrical & Computer Engineering Faculties
Gross Area	17,500m² (188,370sf)
Owner	University of Calgary
Climate	Cold (Arid)
Site Conditions	Elevational Rise of 6.1m from one end to the other over 146m (slope 1:16)
Aesthetics	Exterior polished curtain wall system contrasts interior ‘raw’ materials
Structural	Main Floor: Concrete base and structural steel; Tower: Cast-in-place concrete on a 9m x 9m grid
Mechanical	Hybrid System of natural ventilation and VAV
Special Construction	Structural Slab Hydronic Radiant Cooling
Daylighting	Offices and communal lounge spaces along perimeter for maximum light, computer labs, seminar rooms and circulation are internalized in plan
Shading	Solar gain mediated by through glazing and light-shelf built into curtain wall
Ventilation	Hybrid system: operable windows and standard VAV
Adaptability	3m x 5m Unistrut grid allows for repositioning of partitions, lighting and mechanical in accordance with users needs
User Controls	Operable windows in each office allow for direct user control of personal space
Estimated LEED	Silver - 37 points
Cost of Construction	$38.7 Million ($32.5 Million to construct, $6.2 Million in equipment and start-up)
Maintenance Cost	Currently under study by the U of C Faculty of Environmental Engineering - apparently performing well in accordance with design energy models
Special Circumstances	CBIP grant for $80,000 for expected 25% annual savings on energy costs, $18.5 M in Provincial Access funding, $4.5 M in provincial Infrastructure Renewal Envelope funding and $15.7 M from the University and community
Awards	2001 Building of the Year - Alberta Construction Magazine[1]

BREAKING FROM CONVENTION

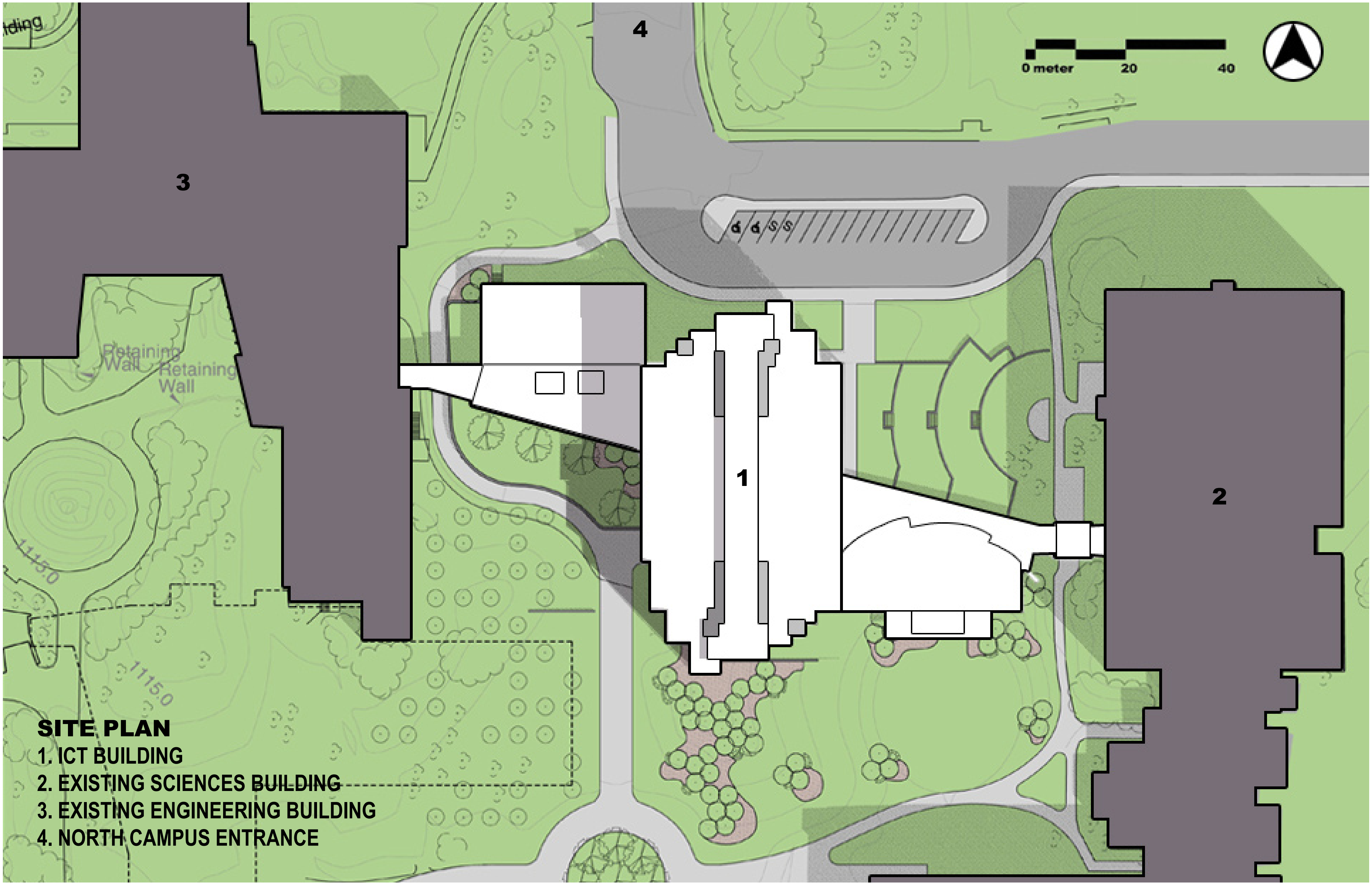
The ICT Building at the University of Calgary is an exceptional building. It merits this title through the unique combination of two integral parts: passive ecology coupled with technological advancement. Not only does its construction make it stand out as a formidable example of Canadian sustainable design, but it is also notable for its sensitivity towards the integration of the building's users and their interior environment. The ICT Building is a showcase for inter-faculty group dynamics: the space is shared between the Computer Science and Electrical & Computer Engineering faculties.[2] Located strategically between the existing Science and Engineering complexes, the ICT Building functions as both a physical and symbolic link between the two faculties.

The main floor is stretched along a ramp extending 146 metres and rising 6 metres from one end to the other, mediating the topographical constraints of the site. The building houses shared teaching and research laboratories, faculty offices, and student study spaces as well as one 300-seat, two 150-seat lecture theatres and two 80-seat classrooms extending from the ramp corridor. The tower comprised of six floors of offices and research space stays within the limits of a typical nine by nine meter (9 metre x 9 metre) concrete structural grid. With the introduction of the main floor ramp, the building was able to gain an additional 3,000 square meters of lecture and amenity space while staying within the original budget. The main floor uses the grid of the tower above as a regulating element and relies upon structural steel framing to provide the sinuating shapes of the lecture halls that emanate from the spine of the ramp. The main floor was intended not only to be a physical connector, but also serve as a campus centre at the north end of the university by providing gathering places, food services, entertainment and retail.[3]

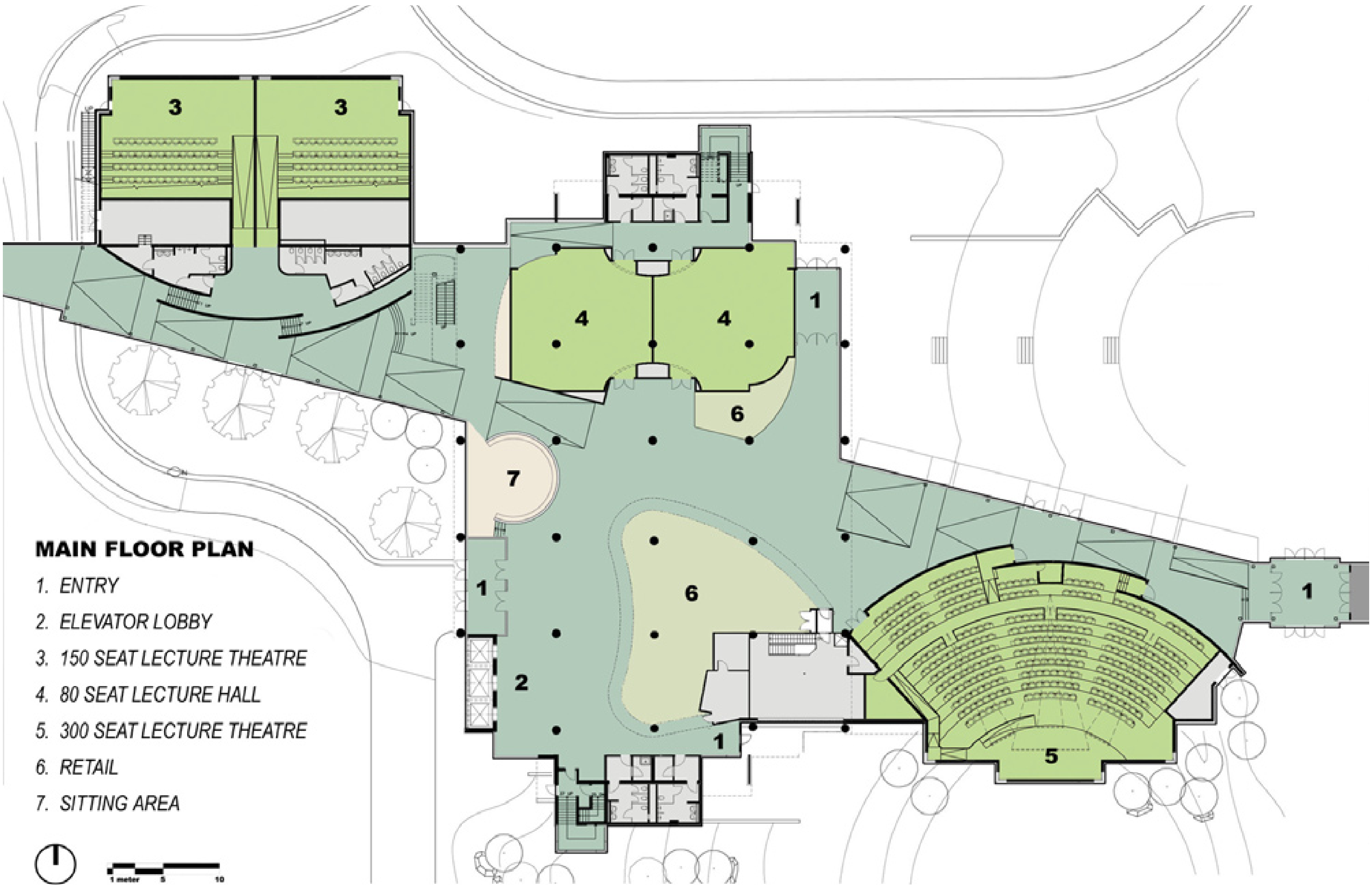
In order to best understand the design criteria for the building, the members of the different faculties were invited to participate in a three-day "visioning session"[4] outside of the University setting. Through a number of different programming exercises the design team was able to ascertain the most important issues of design for the actual occupants of the building. The faculty had only one main desire: access to fresh air.

The design process became informed by that single decision. The desire for access to fresh air allowed the architects to "[push] the boundaries of conventional institutional design."[5] Because of this insistence, the overall design of the building had to conform to providing for that condition.

North-west corner of the University of Calgary ICT Building

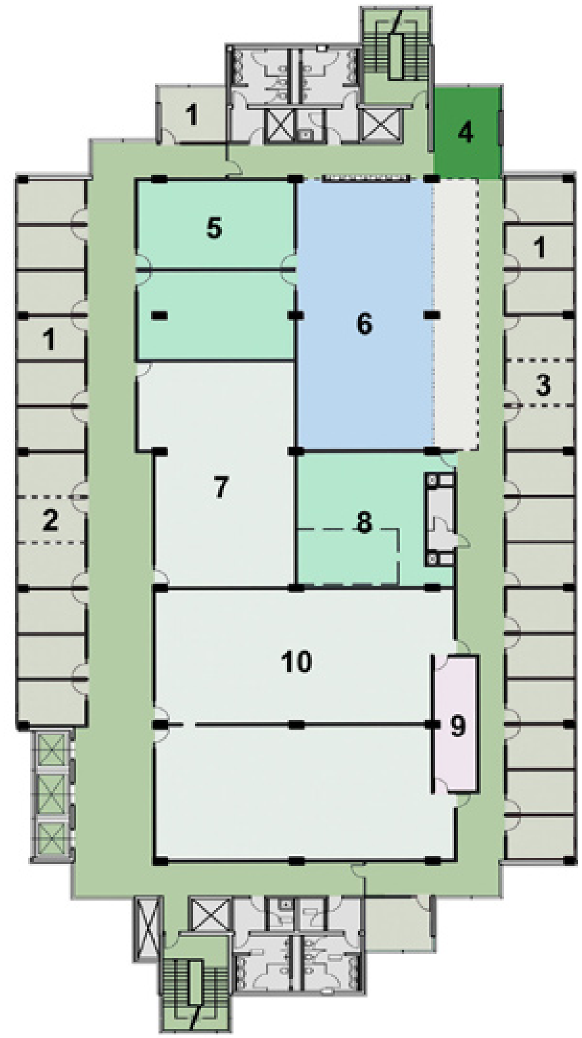


4
0 meter
20
40
3
Retaining
Wall
Retaining
Wall
1
2
1115.0
1150
SITE PLAN
1. ICT BUILDING
2. EXISTING SCIENCES BUILDING
3. EXISTING ENGINEERING BUILDING
4. NORTH CAMPUS ENTRANCE


MAIN FLOOR PLAN
1. ENTRY
2. ELEVATOR LOBBY
3. 150 SEAT LECTURE THEATRE
4. 80 SEAT LECTURE HALL
5. 300 SEAT LECTURE THEATRE
6. RETAIL
7. SITTING AREA
1 meter
5
10

TYPICAL FLOOR PLAN

1. OFFICE
2. MEETING ROOM
3. GRADUATE MEETING ROOM
4. LOUNGE
5. RESEARCH LAB
6. GRADUATE STUDENTS
7. UNDERGRAD LAB
8. MICROWAVE + TELECOM
9. TECH SPACE
10. UNDERGRAD RESEARCH



INNOVATIVE MECHANICAL SOLUTIONS

The facility is the first in North America to use Structural Slab Radiant Cooling (Hydronic).[6] The concrete structure acts as a type of heat-sink. Plastic pipes are embedded in the lower portion of the concrete structural slab in the six floors above grade. Water run through the pipes is cooled to approximately one and a half degrees below ambient temperature.[7] This effectively dissipates seventy percent of the building's inherent cooling-load of the structure, and heat gained from occupants and equipment. This allows the cooled air generated at the ceiling level to follow natural physics and drop, cooling the floor below.

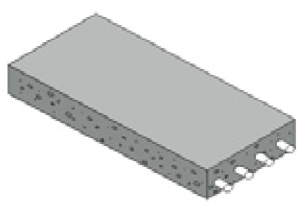
Pipes in the concrete are embedded 50mm above the underside of the slab. In total, the building has seventy kilometers of 16mm plastic pipe set in the building's structure.[8] Each floor is separated into three general areas used for calculating the necessary cooling loads; east, west and interior systems are separated from one another. Operating within the different areas, twenty nine by nine meter (9m x 9m) zones are defined per floor. In turn, each zone is divided into three different three by nine meter (3m x 9m) sections, which each have a dual circuit. Each zone is independently controlled, allowing for greater over all control of the building temperature.

The water coolant in the slab is part of the university's central circulation loop. The water is sufficiently cooled upon entering the building that no additional refrigeration is required. This became a significant cost benefit; no additional upfront investment was required for coolant supply or refrigeration. The incoming coolant is used in two separate buildings systems before being discharged back into the university's circulation loop. First it is used in the building's minimized air handling system cooling coils, and second, it is passed through the plastic pipes in the radiant slab cooling system before it is returned.[9] Often Hydronic slab systems run both cooled and warmed water through the slab in order to modify the building temperature. However, despite frigid Calgary winters, because of the large concentration of computers and electronic equipment, the ICT Building need only supply cooled water to moderate the ambient temperature.

The radiant cooling system in the ICT Building relies on the principles of radiant heat transfer for comfort instead of air temperature. Conventional mechanical

Below: Hydronic pipes are carefully laid, and secured to rebar prior to the pouring of the concrete slab.

Above: Details of pipes being attached to the concrete reinforcing. Right: Zone valve controls. Below: Conceptual schematic of pipe placement in slab.

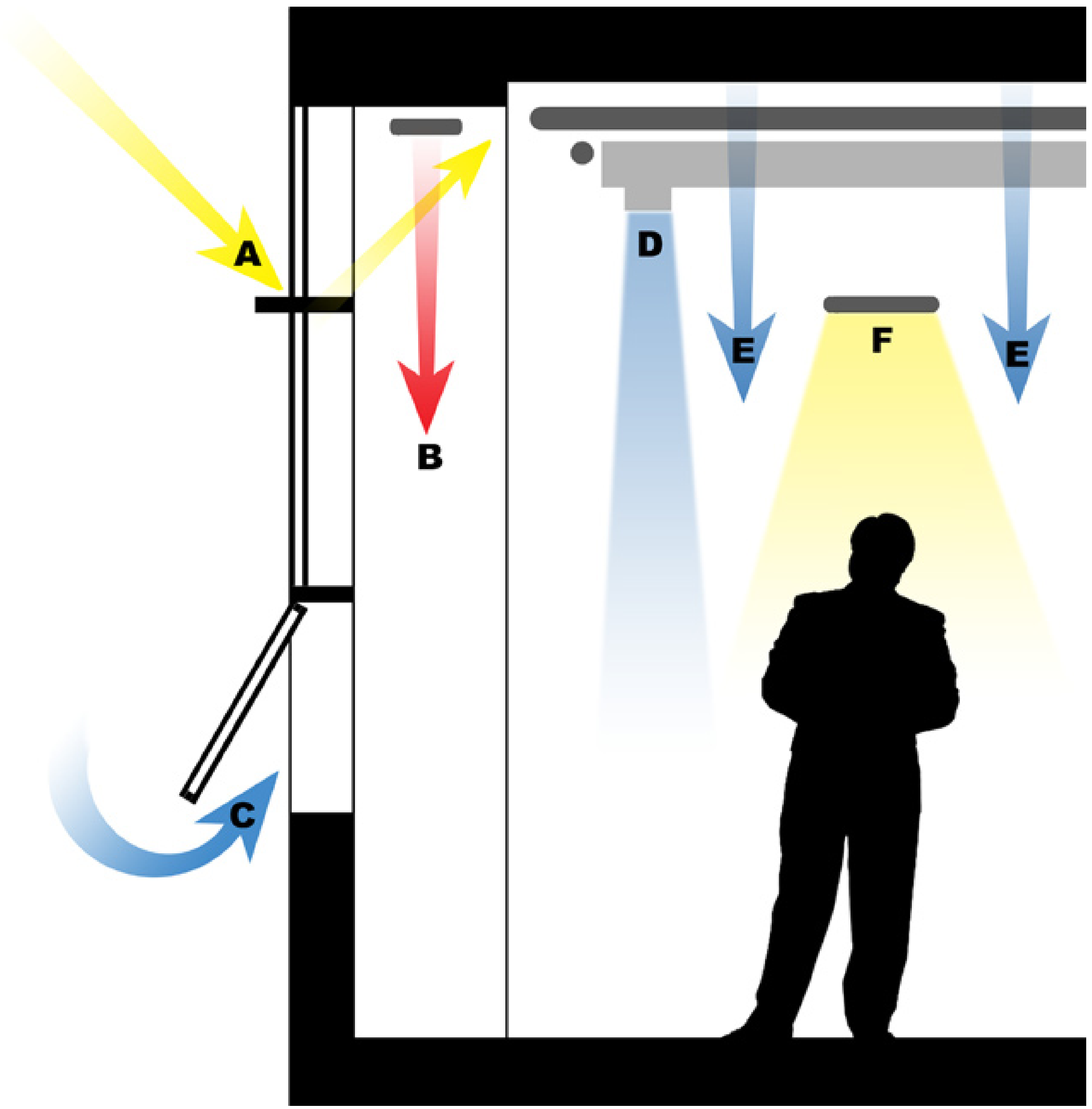


systems are designed only to control air temperature. A radiant energy based system cools objects and the building itself in its place. This allows for the separation of ventilation from thermal conditioning, "providing fresh air and conditioning independent from each other."[10] In the radiant cooling system, the air system is not the primary source of heating and cooling.

This separation permitted three vital components to the ICT Building's design: 1) Operable windows in all faculty offices, 2) the reduction in mechanical duct sizes and 3) ability to rely on passive solar principles for venting the building. As an added bonus, the reduced duct sizes and cooling-loads allowed for significant savings on capital costs for the mechanical system; the required floor space in order to house mechanical equipment was lessened and the overall floor to floor height of the structure was reduced by 375mm.

The classrooms and labs on the interior of the building are vented primarily through a standard variable air volume [VAV] system. A single ventilation system serves all typical floors, both perimeter and interior. The air handling system, like the radiant slab, is divided into small temperature control zones. Each zone has a separate thermostat and VAV control box. This varies both the space heating and cooling as dictated by the associated thermostat. Additional cooling is provided through the air handling system; however it represents only a fraction of the total cooling needs of the building. As such, Jim Sawers, the project's lead mechanical design engineer, boasts that the total air flow and ducting in the building was reduced by a fifty percent.[11] Additional heating for perimeter spaces is provided through radiant panels at ceiling level.

The benefits of reduced air handling in the radiant slab system are manifold. A conventional all-air cooled building is required to provide outdoor air for ventilation - typically twenty percent of the total air volume - however a radiant system



TYPICAL PERIMETRE OFFICE SECTION

- **A.** SOLAR GAIN MEDIATED BY LIGHTSHELF
- **B.** RADIANT CEILING PANEL
- **C.** OPERABLE WINDOW ALLOWS FOR NATURAL VENTILATION
- **D.** PARTIAL AIR SUPPLY THROUGH DUCTING
- **E.** RADIANT SLAB COOLS OFFICES FROM ABOVE
- **F.** ADDITIONAL LIGHT SUPPLIED BY T8 FLOURESCENT LIGHT FIXTURES

The main circulation ramp on the ground floor gently rises as it heads towards the Engineering building on the West side of the building.

is simplified, being able to provide up to one hundred percent outdoor air for healthy conditions and building make-up air because the air provided need only be supplied at room temperature.[12] This allows for the fan power and the heating and cooling requirements for moving and conditioning the air to be greatly reduced. The infrastructural cost for all-air based systems is great - filters need to be changed, fans and bearings need to be maintained, and controls on terminal devices must always be operational. In short, less energy, space, equipment and maintenance is required to move water through a building as compared to air.

The use of the structural slab radiant cooling system affected the building's overall interior design. In order to function correctly, the concrete slab above had to remain exposed so that the cold air could drop to cool the space below. This was the catalyst for an overall decision to simplify the materials used throughout the building. Thus the decision was made: all materials used in the construction of the building would be the "finishes" of the building. No additional dry-walling was done, no suspended ceiling systems were provided. This in turn made the building unconventional from the point of a typical "commercial" office building: the typical interior finishes were removed, and a more refined palette was chosen. Ironically the interior looks "unfinished," but as Len Rodrigues points out, it is just "finished in a different way that what we normally consider 'finished.'"

However, this decision posed a challenge during construction. Not only did the required formwork and expansion joints need to be tailored for every corner and detail, but the construction crews themselves needed to take extra precautions while working. Typically little attention or concern is paid during construction to minor scuffing and chipping of concrete works because it is simply patched and then covered by a finish material such as gypsum board. In the case of the

ICT Building, great care had to be taken at every stage of the project. However, according to Jim Sawers, the biggest risk during the construction of the building was the damaging of the loops of plastic piping, "…especially when the concrete slabs were being poured."[13]

In any other commercial building, without the suspended ceilings, the visible ductwork and electrical equipment attached to the ceiling would have been considered an eyesore. Conversely, in the ICT Building, the architects embraced the runs of sheet metal and electrical raceways, and exploited them for their capacity to function as an ordering element. Through the corridors the ducting and wiring moves silently overhead, drawing the gaze through the building. In this way, the building occupants move in accordance with the circulation of air.

STRUCTURAL SLAB HYDRONIC RADIANT COOLING

+ Tubes are embedded in the concrete slab

+ Allows for peak load shifting due to thermal storage capacity

+ Water is mixed in a glycol solution and cooled by an air-to-water heat pump, a cooling tower, or a ground-source

+ Since the radiative surface is a whole floor or ceiling surface, the water need only be 1.5°C below ambient temperature

+ Moving water through pipes saves 70% of fan power normally used to condition a building

+ Reduces the capital cost of Air Handling Units

+ Reduces floor space needed for Mechanical systems

+ Reduces slab-to-slab floor heights, lowering building structural costs, allowing for extra floors in taller buildings

+ No space conditioning equipment necessary on exterior

+ Eliminates fan-coil and induction unit noise

+ Minimizes the circulation of contaminants within the air

+ Cooling is more evenly distributed; drafts can be eliminated

+ Less exfiltration of cooled air with open doors or windows

+ Amortization of system can occur within 5-7 years[14]

+ Limited by the risk of condensation in very humid areas; most economical when the humidity is less than 15%

+ Systems have a relatively slow system response. However, once room surfaces reach a desired temperature, they can maintain that temperature with relatively little extra energy[15]

Clockwise from left: The ICT Building during construction - the south stair tower with the solar chimney opening being built; An interior view looking up the chimney; Now completed, both the north and south chimneys boast the best vantage points on the entire building.

In order to facilitate the adaptation of space after occupancy, the architects specified a three by five meter (3m x 5m) Unistrut grid to be carried throughout the interior to allow for repositioning of partitions, lighting and mechanical in accordance with the users needs. As such the lighting, mechanical and partitioning can be moved simply five feet over if desired.

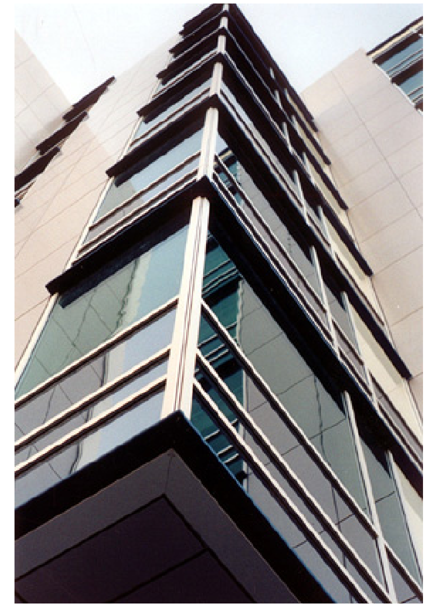
MAXIMIZING PASSIVE POTENTIAL

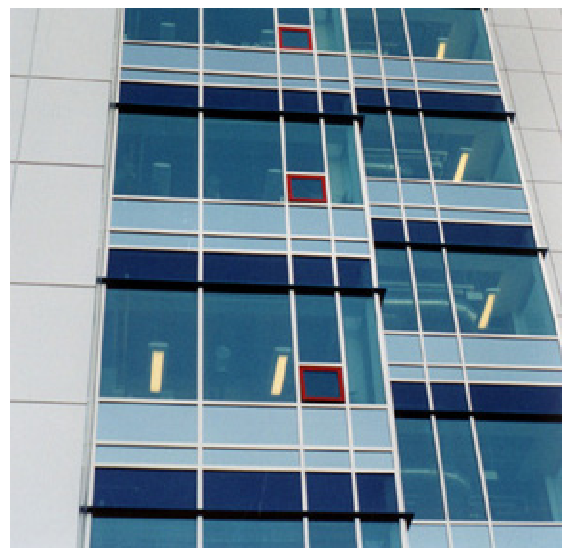
In order to capitalize on the benefits of the decoupling of the ventilation and space conditioning, the architects and engineers took advantage of the inherent possibilities for passive ventilation of the structure. To do so, the design team exploited two basic physics principles: the Bernoulli Effect and the Stack Effect. In the first, differences in wind velocity create a pressure differential which results in air flowing from the higher to the lower air pressure region. In the second, air is warmed, causing convection, with the warm air rising and being replaced by cooler air.[16]

A cool draft is produced in the space between the warm area and the cool-air intake opening. The rate of airflow caused by convection is governed by the difference in the level of openings, with greater airflow resulting from a greater height differential between the openings. To this end, the north and south stairwells in the ICT Building became solar chimneys. By inducing a convective airflow across the floor plates through the use of operable windows, warmed air within the stair towers rises, and as cool air replaces it, in turn, it is warmed and rises as well. The warmed air is exhausted from the stairwells through an opening at the top of the tower. This process effectively “flushes” the building.[17]

Conversely, the building’s orientation works contrary to passive-solar best-practice: its main axis is oriented north-south as dictated by site demands. This complicated the overall solar strategies, especially the articulation and construction of the building envelope.

The expansive east and west façades result in higher cooling loads early and late in the day due to difficulty in providing shading for the low sun angle. As a result, the timing and magnitude of the peak solar gain within the building changes contrary to most conventional buildings. To combat this, precise calculations were needed to size both the VAV boxes and percentage of openings in the building façade to meet the cooling demand of the calculated loads. For this reason, the quantity and dimensions of the operable windows were kept to a minimum (10-15% of the façade area as recommended by project engineers from EarthTech)[18] so as not to impede the stack-effect by depressurizing the building.





Clockwise from the left: View of the interior stair from the north facade; Corner detail of the stair tower from the north-east corner; Detail of the exterior facade on the north side - note operable windows are framed in red; and the mechanical penthouse during construction.

Building Component	Conventional Building	Radiant Slab Building
Glazing*	14.00 $/SF	19.00 $/SF
Mechanical System	22.00 $/SF	14.00 $/SF
Electrical System	16.00 $/SF	15.00 $/SF
Floor to Floor Height	12¢-6*	11¢-0*
Tenant Upgrade Costs	10.00 $/SF	7.00 $/SF
Energy Use	18 kwh/SF/yr	10 kwh/SF/yr

**Based on 50% glazing area/wall ratio.*

The chart above outlines the typical costs of building components for commercial buildings based on buildings in both Europe and North America. As the chart illustrates, the upfront investment in the high-performance building envelope for the radiant slab building is more than compensated for in the reduced costs for its mechanical and electrical systems. The conventional and radiant slab buildings also differ greatly in the amount of energy consumed per annum, adding another dimension of cost implication over the lifespan of the project. Source: Geoff McDonell, "Windows Pave Way for HVAC Innovation."

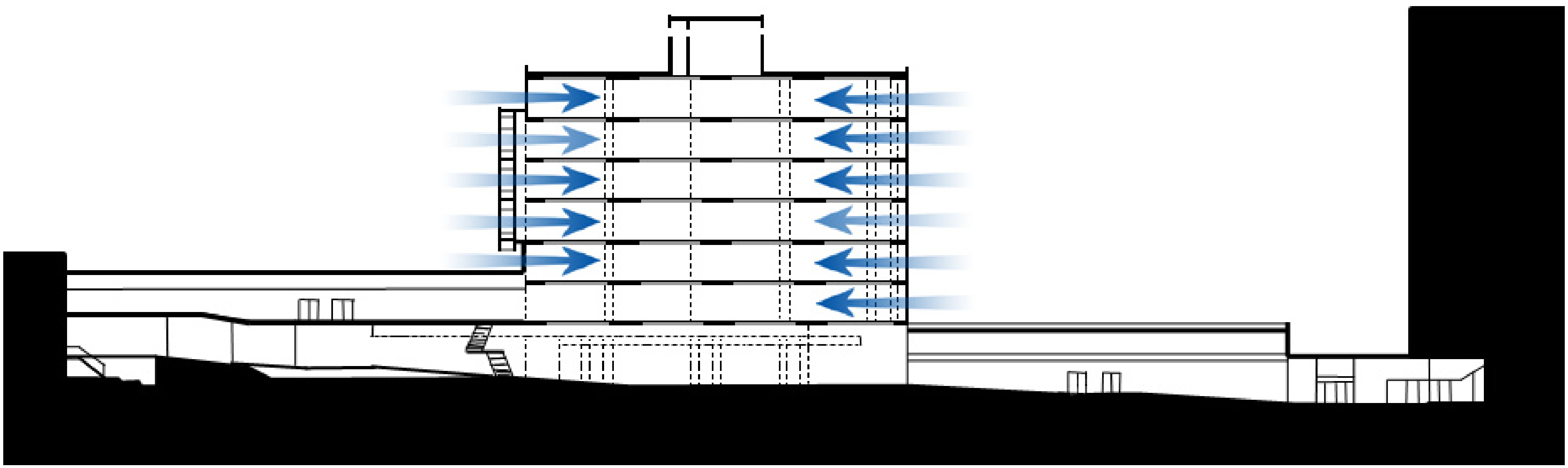
BUILDING ENVELOPE

The Building's exterior skin became crucial to the building's mechanical systems: it had to keep the interior cool and prevent solar gain in the sunny Southern Alberta climate. When asked if there is something particularly Canadian about this building Len Rodrigues was quick to point out that Canadian architects pride themselves on their ability to properly design building envelopes. A high-standard curtain wall was specified with low-emissivity glazing. The back pans were left off on the interior and incorporate a radiant heating panel at ceiling level. The heating panel serves a second function as well; it acts as a light-shelf to redirect sunlight deeper into the spaces adjacent to the exterior walls.

Contrary to conventional practice, the incorporation of the high performance building envelope is paramount in making the ICT Building's mechanical systems functional and economical. Normally assumed to create cost premium for a project, when used in a conjunction with an unconventional mechanical system that reduces the upfront investment in equipment, the equivalent savings in the rest of the building systems can be diverted into the building envelope.[19] The

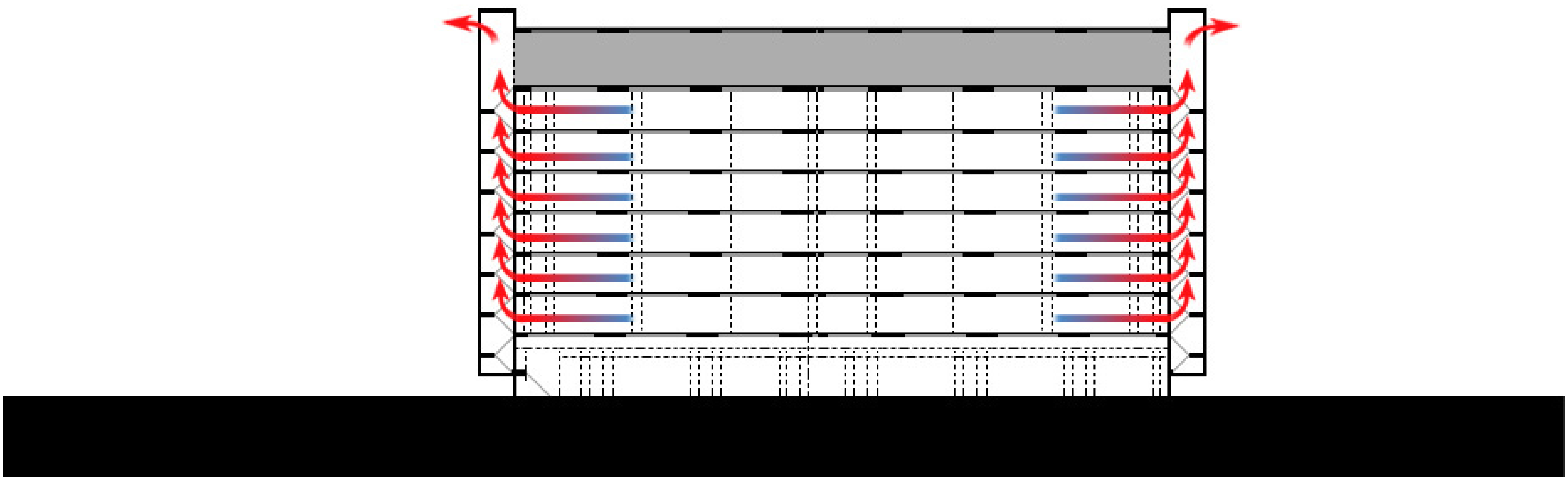
SECTION EAST-WEST

Ventilation schematic of the Bernoulli effect drawing fresh air through operable windows across the floor plate in order to flush the building.



SECTION NORTH-SOUTH

Ventilation schematic of the Stack effect drawing air across the floor plate and out through the solar chimneys located on the North and South sides.



premium invested in the building envelope can be recuperated through the cost savings from the reduced mechanical equipment - both plant and ductwork. In turn, the high-performance building envelope will ensure the reduced energy consumption and accompanying savings for the lifespan of the building. High-performance glazing offers many additional benefits as well: superior thermal resistance and solar control, improved natural daylighting and reduced lighting loads, and improved comfort. Used in conjunction with other elements such as light shelves, the quality of the interior environment is improved by allowing light to further penetrate into the building while minimizing the solar gain.[20]

Planemetrically the offices are placed along the exterior of the building, affording them the benefits of natural ventilation and access to light. In contrast to typical office buildings however, the circulation of the building is also articulated with the use of light, with the strategic placement of windows at the end of corridors. Stairs and elevators are also fully glazed, reinforcing this idea. This provides an inherent legibility of the building plan by the use of natural light.[21]

Originally the architects had designed an elaborate brise-soleil for the west façade in order to help counteract the effects of solar gain. However, it ultimately fell-victim to cost-saving value engineering because the extreme angles of the early east and setting west sun would still not mediate enough sunlight through the slats of the brise-soleil to provide enough shading.[22] Because the majority of the academic year occurs within the winter months, with a sunset at 4:23pm on December 21st, the comfort level of the building needed to be maintained during the peak hours when the building is still heavily occupied. For this reason the brise-soleil was axed and high-performance glazing introduced. Although they saved $330,000 in eliminating the brise-soleil, the capital was redirected (almost in its entirety) to bolster both the building envelope and the proposed mechanical system to accommodate the additional cooling load.[23]

Above: A detailed look at the West Facade. Left: A view of the north-east corner of the building during construction.

Above: A detailed view of the ceiling of the typical perimetre office. Left: A view of an office floor prior to furnishing.

MINOR COMPLICATIONS

The building stands testament to the integrated design team approach, though it has encountered problems since its commissioning. Difficulties have arisen from custodians and through additional needs of occupants. The custodial staff has been slow to adapt to the needs and systems of the building, treating it as though it had conventional mechanical systems. This has caused problems with expectations of quick warming or cooling of the building's spaces with the simple adjustment of a knob. Unfortunately the passive systems of the building engage a much longer response time for adjustments.

According to the architect, there have also been requests from professors asking for more carpeting, ceiling tiles and finish drywall, stating that the building appears "unfinished," while not fully understanding the over all implications of their initial desire to have operable windows, which in turn informed the design and finishing of the interior of the building.

Other questions have arisen regarding the effectiveness and flexibility of the building's Unistrut grid. With the various divisions in space throughout the building, despite the fact that partitions, lights and equipment can be moved, the modules established within the building make the creation and variation of new space problematic. The typical meeting rooms on each floor divide poorly into three smaller rooms, each three meters wide and four and a half meters deep (3m x 4.5m). Although this module works perfectly for the creation of individual private offices, as meeting rooms, for more than four people, the rooms become cramped.

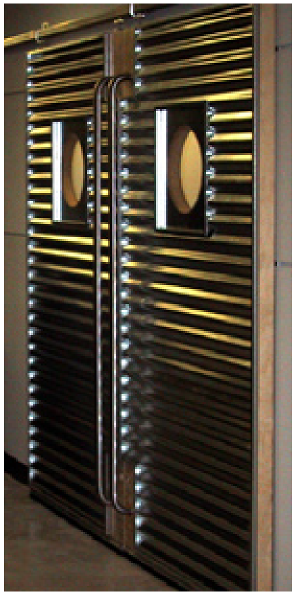
Further difficulties regarding equipment and computer security have arisen due to the use of sliding doors on the laboratories and research areas. While architecturally they make a beautiful statement, they are easily removed from their rails, thereby compromising the security of the rooms they enclose. Also, there is little storage space allotted within the labs, making storing of seldom used but necessary equipment challenging.

MAKING AN EVALUATION

The ICT Building is evidence to the strength and integrity of the design team under extreme pressure for expediency. The initial design was commissioned in October of 1999 and the building officially opened for use in September of 2001. The term 'fast-tracked' is an understatement. Despite time constraints, the building was delivered on-time and on-budget.[24] The architect attributes this to the superb organization and timing of the trades, and their willingness to participate in an "unconventional" building.

Despite the building's innovations and successes however, one question remains: could more have been done to make the ICT Building an even better, more sustainable building? The answer is yes. Notably though, time constraints played the dominant role in preventing more environmental measures from being implemented. Many of the consequences of fast-tracking are implicit in the complications that have arisen because of the lack of proper design and detail time. For example, columns that are normally set back from the slab edge in order to facilitate the installation of the building envelope were left too close to the perimeter resulting in acoustical problems following occupancy.[25]

The building qualifies for LEED Certified, but could have easily qualified for high Gold with the introduction of other measures to ensure its viability as a sustainable project. For example, the expansive roof area of the building could have



been planted with a garden or sod roof in order to reduce the effects of heat-islanding. The building could also have incorporated measures for collecting and storing rain water in order to facilitate the watering and irrigation of adjacent green spaces. With the vast expanses of building façade and highly articulated curtain wall, solar panels could have been integrated into the design in order create a source or renewable energy for the building. The same could have been possible with the integration of a wind turbine on the roof of the tower to take advantage of the Chinook winds predominate in the Calgary microclimate. With the amount of concrete used in the building, especially as a finish material, the use of fly-ash in the cement would have contributed greatly to making the building more sustainable. Fly-ash is beneficial not only because it reuses the by-product of coal production, but it also proves better in strength, appearance and moldability than concrete made with Portland cement.

LEED GREEN BUILDING RATING SYSTEM 2.1

PROJECT CHECKLIST

Sustainable Sites	**4**/14 Possible Points
Water Efficiency	**1**/5 Possible Points
Energy & Atmosphere	**8**/17 Possible Points
Materials & Resources	**4**/13 Possible Points
Indoor Environment Quality	**10**/15 Possible Points
Innovation & Design Process	**2**/5 Possible Points
Project Totals	**29**/69 Possible Points
ICT Building Result	**Certified** Status

Even without these additional measures, the building still stands as an excellent example of sustainable architecture. Not only were considerations given to passive systems and building innovation, but accommodation of existing facilities was also considered. Not only did the designers integrate the University's existing central circulation loop for the cooling of the building, but it was also constructed using a series of pilings to accommodate existing storm sewer facilities. This alone saved approximately $300,000.[26] Because of the reduction in energy consumption, the building received full CBIP funding. Additionally, as means of ensuring its longevity, it is currently being monitored by the Environmental Engineering and Architecture departments at the University of Calgary. After one year, the building is performing slightly better than the design energy models predicted. The architect assures that the monitoring will be maintained for years to come.

LOOKING FORWARD

Len Rodrigues prides himself on the fact that the ICT Building is an unconventional building. It combines two integral parts for its success: a passive ecology in terms of systems of ventilation and cooling, and technological advancements of a high-performance building envelope and a radiant slab cooling system. These components, coupled with an interactive, team based design approach, allowed the design team of architects, engineers and other key consultants to create a noteworthy, sustainable building.

Nevertheless, despite the accomplishments of the ICT Building, barriers remain in North America when it comes to using radiant Hydronic cooling systems. Problems arise with owners, users and designers. High-performance envelopes are not preferred for commercial buildings due to a longer pay-back period when used in conjunction with a conventional all-air heating and cooling system to control both space temperatures and ventilation. The Hydronic system also presents a problem for users who perceive the need for each room to have its own temperature control. Ironically, this is only necessary in all-air systems because the temperature fluctuations are so drastic. Aesthetics are another drawback - many consumers are wary of the exposed slab required for the system to function.[27] Complications also arise with North American designers due to fee structuring. Engineering fees are normally a percentage of the mechanical and electrical budget; with a reduced system, the fees are reduced as well. Most significantly however, the expertise and experience are lacking in North America in order to properly design the systems cost-effectively.

Regardless of the barriers, one fact remains: the ICT Building works. The University, professors and students, and designers alike are proud of their building because it challenges the status quo. For the architects and engineers it was

a hard sell of many of their ideas, but as Jim Sawers points out, "…it seems to have paid off for everyone in terms of the profile of the building."[28] As such, it has been recognized by the industry as a precedent in building design, having garnered Alberta Construction Magazine's Building of the year. As simple as the systems may seem, in the end, they only add up to success for the ICT Building.

ENDNOTES

1. Dalhousie University Alumni Profile: Barry Johns
2. University of Calgary News, par. 1
3. University of Calgary News, par. 1
4. Rodrigues, personal interview
5. Down, p. 12
6. University of Calgary News, par. 7
7. Rodrigues, personal interview
8. Sawers, email correspondence
9. Corbett
10. Toolbase Services, par. 1
11. Sawers, email correspondence
12. McDonell, “Displacement Ventilation.”
13. Corbett
14. Toolbase Services, par. 3
15. Toolbase Services, par. 4
16. Fathy, “The Wind Factor in Air Movement.”
17. Down, p. 12
18. McDonell, “Windows Pave Way for HVAC Innovation.”
19. McDonell, “Displacement Ventilation.”
20. McDonell, “Windows Pave Way for HVAC Innovation.”
21. Down, p. 14
22. Sawers, email correspondence.
23. Roderigues, personal interview.
24. Down, p. 15
25. Rodrigues, personal interview.
26. Gazette, “ICT Building Scores Accolade”
27. McDonell, “Windows Pave Way for HVAC Innovation.”
28. Sawers, email correspondence.

IMAGES

Titlepage	Courtesy Jim Sawers
Page 2	Courtesy Stantec Architecture
Page 3	Site Plan: courtesy Stantec Architecture
Page 4	Main Floor Plan: courtesy Stantec Architecture
Page 5	Typical Floor Plan: courtesy Stantec Architecture
Page 6	Image courtesy Jim Sawers
Page 7	Images courtesy Jim Sawers
Page 8	Schematic drawn by author
Page 9	Courtesy Stantec Architecture
Page 10	Courtesy Professor John Rokne, University of Calgary
Page 11	Construction and finish photo of solar chimney: courtesy Professor John Rokne, University of Calgary Stairwell interior image: Author
Page 12	Mechanical Penthouse: courtesy Professor John Rokne, University of Calgary; all other images by author
Page 13	Images by authour
Page 14	East-West Building Section by author
Page 15	North-South Building Section by author
Page 16	North-east corner: courtesy Professor John Rokne, University of Calgary; West facade: courtesy Jim Sawers
Page 17	Both images courtesy Professor John Rokne, University of Calgary
Page 18	Both images courtesy Professor John Rokne, University of Calgary
Page 19	Image courtesy Stantec Architecture
Page 20	Image by author

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