Ontario Eco-Architecture

Submissions to the
Ontario Association of Architects Committee On The Environment

Call for Papers for
ENVIROFEST, April 1996
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Last year when The Committee on the Environment published our first Ontario Eco-Architecture publication we expressed our pleasure at the tremendous response to our 'call for papers' represented by the number and quality of the submissions. What we weren't prepared for was the overwhelming response of architects and other professionals. Our modest first run of 300 rapidly sold out; we are now into our second printing. It was with the knowledge of how valuable this document was considered and the sales that we enthusiastically undertook our second 'call for papers'.

Another year has passed and with it advances in environmental architecture. Our objectives for the "call for papers" and the publication have remained the same:

To start with, we continue to measure the level of interest in environmental subjects held by the architectural community.

We want to reach members that have an interest and feel they can make a contribution either by way of example and case study or conceptually in expressing innovative approaches, propositions, or research. We also want to stimulate and involve members, promoting the work and ideas of Ontario architects both within the Association, and also more broadly to others.

Our hopes that the second year would see an increase in the response were satisfied. We received more expressions of interest covering some new subject areas and approaches. Indeed, we received two papers from repeat authors, reflecting ongoing developments to last year's submissions.

The papers in this publication represent a large percentage of the original submissions. Each author has developed and amplified their work with a modest amount of direction from
the COTE. We provided encouragement, a few editorial comments, and generally kept the process as open as possible while maintaining the necessary discipline of format and length.

Responsibility for ensuring that the project was a success is given to Gary Pask and Barbara McLean. The tremendous effort involved in coordinating, discussing, and working with each of the authors to produce this work is gratefully acknowledged by the Committee.

The committee also wishes to acknowledge the excellent design and layout of the publication provided again by Reactor Art & Design.

This project has been exciting to continue because of the devotion of the authors to their subjects. The Committee sincerely wishes to thank the authors for their participation and efforts in contributing to this project.

The papers presented in this publication document a high level of interest in environmental design. Added to last year's publication, the ideas contribute to an increasing body of experience in our community.

We are sure that again this year, architects will find this publication a tremendous resource and inspiration encouraging us to consider the many possibilities in our work for greater environmental sensitivity, reduced ecological impacts, and better performance.
Introduction

Barbara McLean, B.E.S., B.Arch., OAA

Member,
OAA Committee on the Environment

A seemingly benign comment in one of the papers sparked some interesting discussion amongst committee members on the difference between what is important versus what interests people and led to further insight into how we market environmentally responsible architecture.

Terry Robinson writes in the opening essay “owner and occupant interest in healthy indoor environments is high—considerably higher than interest in more global issues such as energy efficiency or resource depletion—since it is the indoor environment which has the most immediate impact on people in terms of productivity, health and well-being.”

While we accepted as true that peoples interest in environmental issues would increase once they felt a direct impact, it did not seem to bode well for the environment if this meant global concerns would be excluded.

You can't help but be shocked by Susan Reed Tanaka's statistics and comments in her paper: “Each Canadian, on average, consumes 25 times the resources of a person in a developing country.” While North Americans account for only 7% of the world's population, we create half of its waste, and yet, it seems it is not until our own personal health and well being is at stake from contaminates that surround us in our homes and workplaces that we 'get interested'.

People's general 'disinterest' is understandable; it is human nature to be preoccupied with our selves and the present; however noble and imperative it is to concern ourselves with others and the future it takes a concerted effort. By accepting and acknowledging this fact, we can redesign the way we present environmental architecture to the public.

The environmental movement was launched into the political agendas of North Americans with the slogan 'Think Globally, Act Locally'. The logic was that, by thinking about global issues, we
would be moved to make changes in our individual lives. Small changes would achieve results which would have huge ramifications for the health of the planet. Important slogan: without it the world’s problems, being gargantuan, would leave the individual feeling helpless and unable to act. The problem is that until the critical mass required for individual actions to have global impact is achieved, we have a hard sell and few buyers.

For example, I think of my own situation as a cyclist living in the city. As I ride my bike, especially on a cold, windy, rainy day, I do not find much comfort in the thought that my non-polluting mode of transportation is helping to reduce global warming. The reason? For every one of me, there are still hundreds of warm, dry motorists zooming by blowing pollutants in my face. As long as cyclists are a minority, it will be hard to get people out on their bike for the sole reason to ‘save the environment’. If we sell people instead on the personal benefits of cycling; the physical exercise, the leisurely pace, the feeling of freedom, the wind blowing through their hair, savings to the pocket book, and no traffic jams or parking hassles, we will have a greater chance of making a significant impact on reducing ozone depletion.

In increasing numbers we are discovering that many environmental actions have an immediate personal benefit which is an attractive way to sell their far reaching benefits to the planet. When you read all the papers presented here you will find this discovery to be somehow present in the viewpoint of each paper. I am excited about these papers because they illustrate how environmental architecture can enrich and improve our lives now, and at the same time, hopefully, enable future generations to enrich, improve- and enjoy- theirs.

In Materials and Systems, Monica Kuhn writes on Roof Greening – gardens that supplant asphalt and gravel. The appeal of this practice can be viewed as much for the vision of a more beautiful urban landscape: the potential pleasure of floral scents and wild butterflies as for the increased energy efficiency, decreased carbon dioxide and reduced storm water runoff they ensure.

In Projects, Douglas Pollard and Jiri Skopek in their Emerald Gate Residential Project include all the elements of environmentally responsible architecture in their design, but what is unique is how they are viewed as much for their immediate benefit to inhabitants in terms of social and personal well-being as they are for their impact on larger issues.

And in Education and Philosophy, Nina Marie Lister and Paul Stevens look at Environmental Education. They see the ecological design of school buildings and play yards as improving the quality of a child’s school experience, and having a more long range benefit of instilling the ‘green philosophy’ in our future citizens.

Just a few examples. In all the papers there lies a thread of hope that environmentalism will catch on, not because of doom and gloom, but because of the benefits we can obtain today - and the added knowledge that we are at the same time helping the future of the planet.
Architects and the Indoor Environment: The Challenge of Selecting Low-Emission Materials

Terry Robinson MOAA, MRAIC, MASHRAE
Senior Researcher
Scanada Consultants Ltd.

INDOOR AIR QUALITY, SOURCE CONTROL AND THE ARCHITECT’S ROLE

Environmental design has broadened in recent years to encompass not only global and local environmental issues, but also the quality of the indoor environment. Owner and occupant interest in healthy indoor environments is high — considerably higher than their interest in more global issues such as energy efficiency or resource depletion — since it is the indoor environment which has the most immediate impact on people in terms of productivity, health and well-being.

Most initial efforts to improve the indoor environment have involved the dilution or removal of pollutants through ventilation and filtration, and have therefore been within the domain of the mechanical engineer. However, it is now increasingly recognized that pollutant source control is the most effective approach to cleaner indoor air. This shift in focus places the architect in the key role of ensuring a healthy building through selecting low-emission products
and specifying construction techniques which minimize emissions.

Pollutant sources in buildings include combustion processes (e.g. carbon monoxide from parking garages), microbiological growth (e.g. mould in humidification equipment), particulates (e.g. lead in paint dust) and chemical offgassing from building materials and equipment (e.g. formaldehyde from composite wood panels, volatile organic compounds from caulking). This paper focuses primarily on the architect’s role in reducing chemical pollutants from building materials. The paper highlights recent research on material emissions, lists sources of information available to architects, outlines remaining obstacles and presents design strategies for minimizing emissions.

LESSONS LEARNED FROM RECENT RESEARCH

The amount of emissions research taking place in Canada and internationally has increased dramatically in the past five years. While this science is still very much in its infancy, a number of key — and often surprising — findings are emerging which will have major implications for architects in their material selection process.

Order-of-Magnitude Variation in Emission Rates: Perhaps the most significant finding, and one which architects will find frustrating, is that emission rates vary enormously from product to product within a given category of materials. Table 1 draws upon two recent Canadian studies (Ortech 1995, SRC and Figley 1995) to provide examples of the variation in emissions of total volatile organic compounds (TVOC) among common building materials. There is typically at least one and often two or three orders of magnitude of difference in emission rates between the best and worst performers. This finding means that a generic approach (e.g. carpeting versus sheet vinyl flooring) to selecting materials has little value. Emissions data for specific products are required.

Unexpected Sources of Emissions: Another interesting finding has been the presence of strong emissions from materials regarded as relatively benign. For example, in one recent study (Ortech 1995), the two worst performers were genuine surprises. The highest formaldehyde emissions came from a facto-

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<th>MATERIAL</th>
<th>TVOC EMISSIONS (µg/m²h)</th>
<th>NO. OF SAMPLES</th>
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<tr>
<td>Carpet</td>
<td>652</td>
<td>11</td>
</tr>
<tr>
<td>Carpet Undercushion</td>
<td>470</td>
<td>6</td>
</tr>
<tr>
<td>Sheet Vinyl Flooring</td>
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<tr>
<td>Medium Density Fibreboard</td>
<td>835</td>
<td>5</td>
</tr>
<tr>
<td>Composite wood (structural lumber)</td>
<td>290</td>
<td>3</td>
</tr>
<tr>
<td>Composite Wood (structural panel)</td>
<td>384</td>
<td>3</td>
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<td>Composite Wood (architectural, coated)</td>
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<td>Gypsum Board</td>
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<td>Foam Insulation</td>
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<td>Glass Fibre Insulation</td>
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<td>Latex Paint</td>
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Table 1. Range of Emission Rates Found in Two Recent Canadian Studies
ry-finished solid wood cabinet door; this product had been packaged in shrink-wrap before the finishes had cured adequately. The highest VOC emissions came from a sample of poured concrete; this was not due to the concrete itself, but rather to the form oil residue. These findings highlight the need — already well known to those designing for the hypersensitive — to take a comprehensive approach to all the materials employed in a building.

Sink Effects Can Greatly Affect Pollutant Levels: Researchers are just beginning to understand the complex phenomenon of “sink effects”, in which materials can absorb emissions from other materials, re-releasing these emissions slowly. Carpet and drywall are two of the most important sinks in buildings. For example, ongoing research by the Environmental Protection Agency and the National Particleboard Association in the U.S. suggests that formaldehyde levels in test houses may only be half as high as predicted, due to the sink effect of drywall. The positive impact of sinks is to reduce peak concentrations, while the negative impact is to prolong such emissions over a longer period.

Risk of Material Contamination: Related to sink effects has been the finding the materials can easily become contaminated on site during construction or even in warehouses. Recent testing of Natural Resource Canada’s (NRCan) Advanced House demonstrations (SRC and Figley 1995) found extremely high hydrocarbon emissions from two carpet samples, one hundred times higher than the next highest sample, with these two samples likely having been subjected to on-site spills of cleaning solvents or finishing products.

Odour Determines Complaints: Apart from the actual health and irritation impacts, odour appears to be the key element in determining human response to indoor pollutants. Health research is beginning to draw links between chemical sensitivity and cacosmia, which is an adverse reaction to odours. Studies by Public Works and Government Services Canada of recarpeting in federal government buildings have found that carpeting techniques involving reduced emissions of 4-PC, which is emitted from the latex backing and gives new carpet its characteristic odour, leads to greatly reduced complaints by occupants.

Sources of Information on Material Emissions

For architects interested in low-emission products, there is considerably more information available now than five years ago, with primary sources including labelling programs, advisory publications, emission databases and demonstration projects.

Labelling Programs

Labelling programs represent a positive step toward enhancing the availability of lower emission products in the marketplace. Such programs encourage manufacturers to examine their
production processes, in many cases leading to no-cost or low-cost improvements. While the emission levels set by such programs are often criticized as being too high, the key accomplishment is clearly the establishment of test methods, certification procedures and industry participation. The levels themselves can be lowered later in accordance with the industry's capacity. Table 2 summarizes the emissions requirements of current voluntary programs in Canada.

**Carpeting:** In 1993, the Canadian Carpet Institute (CCI) adapted the U.S. Carpet and Rug Institute's labelling program. Maximum emission rates are set for total volatile organic compounds (TVOCs), 4-phenylcyclohexene (4-PC, which gives new carpeting its distinctive odour), styrene and formaldehyde. At present, 70% of Canadian manufacturers are participating and the program has led to a significant reduction in emissions, particularly 4-PC.

**Particleboard:** The Canadian Particleboard Association's (CPA) testing program has been in place for more than a decade. Although the formaldehyde concentration limits are still four to six times Health Canada's target level for total formaldehyde concentrations (F-P Adv. Cttee. 1987), CPA's program has succeeded in lowering emissions by an order of magnitude since the early 1980s.

**Environmental Choice® Program:** Indoor emissions are one of many environmental characteristics considered in assigning an Ecologo® label. Requirements were developed in the late 1980s for the maximum VOC content of “wet” products such as paints, wood stains and finishes, adhesives, caulks and sealants. The Program has contributed to the industry's shift from solvent-borne to water-borne paints, with the durability of water-borne paints now approaching that of solvent-borne. The Program has recently been expanded during the past year to include a broad range of building materials. For particleboard and fibreboard, lower levels of formaldehyde have been set than in CPA's program. Prefinished hardwood flooring and office partitions are evaluated in terms of their contribution to TVOC concentrations under typical loading conditions. Requirements for carpet and carpet undercushion use the CCI emission criteria as a minimum, while limits are set for resilient flooring on the maximum TVOC emission rate. However, for these three flooring products, a “total load point” approach is used which combines various
environmental attributes. Therefore, an architect does not know whether a product has qualified for the Ecologo because of low emissions, high recycled content, recyclability or a combination. Requirements are also being developed for photocopiers, fax machines and office furniture. The Program's "Certified Products and Services" lists manufacturers and products which comply with Ecologo requirements.

EnvirodesicTM Certification Program: This recently-announced labelling program, targeted specifically to healthier indoor environments, is a partnership between the Lung Association and Green-Eclipse Incorporated and has recently begun testing and certifying products.

Learning From European Approaches: Europeans have implemented some innovative labelling approaches to promote a more informed marketplace. In addition to Germany's well-known "Blue Angel" Environmental Label, there are two recent programs which could serve as models for future Canadian activities. The Danish Indoor Climate Labelling Program has developed a single number for product comparisons, based on the time required for emissions to drop below 50% of recognized odour and mucous membrane irritation thresholds. Trade standards have been developed for carpets, doors and wall and ceiling products, and are underway for other floorings and windows. The Program is referenced (as a recommendation) in the 1995 Danish Building Code. In Sweden, architects have been major users of a voluntary industry labelling program administered over the past three years by the Swedish National Flooring Trade Association. Manufacturers provide actual TVOC emission levels for specific products at four weeks and at 26 weeks after production.

Advisory Publications

Canada Mortgage and Housing Corporation (CMHC) has produced three recent publications of interest to architects. "Building Materials for the Environmentally Hypersensitive" (Jools 1995), released this year after considerable debate with manufacturers, provides advice on the suitability of over 170 materials for hypersensitive occupants. "Healthier Indoor Environments: Canadian Sources of Residential Products and Services" (Cullbridge 1994) includes a directory of manufacturers supplying low-emission products. "Healthy Materials" (Robinson and White, ed.) is an international newsmagazine which reports on the latest developments in emissions research, testing and applications.

Non-governmental publications are also available on environmentally preferred materials, including indoor emission characteristics. The most comprehensive book by a Canadian author at this time would appear to be "Environmental By Design" (Leclair and Rousseau 1992). Two American newsletters, "Indoor Air Quality Update" and "Indoor Air Bulletin", provide frequent coverage of emission research and new products.
Other Information Sources

Emission Databases: In Canada, major sources include Health Canada's Canadian Indoor Source Profile (CISP) database, the National Research Council's new consortium on emissions research, Saskatchewan Research Council, Ortech Corporation and Concordia University. While some of their data are proprietary, much is publicly available.

Task Force on Material Emissions: With over 100 members and associates representing industry, government, the research community and health professionals, this group meets twice yearly to identify priorities in emissions research and to share information. CMHC sponsors and chairs the Task Force.

Material Safety Data Sheets: Manufacturers and suppliers have MSDS's available for any products with health and safety risks. MSDS information includes the total volatile organic content, the presence of any carcinogens, threshold limit values (i.e. accepted toxicity level) and lethal concentration levels. While not always easy to read, the MSDS can be a starting point for comparing materials such as paint, adhesives and wood finishes.

R-2000 Procurement List: With the adoption of indoor air quality requirements by the R-2000 Program in 1994, there has been an increasing demand for information on acceptable products. The R-2000 Program's procurement list covers carpet, vinyl flooring, paints and finishes, adhesives and composite wood products.

Design Tools: Computer modelling has been a key element of emissions research and now two examples of “user-friendly” design tools are being developed for practitioners. In late 1995, the National Research Council entered into a three-year joint venture with the U.S. National Institute of Standards and Technology to develop a WindowsTM-based model which will allow architects to predict indoor contaminant levels before a building is constructed. In the housing sector, Natural Resources Canada is refining a simple model known as “CleanAir-2000” to assist builders and designers in assessing the impact of their material selections. Both models will facilitate the determination of trade-offs among materials and between source control and ventilation.

Demonstration Programs: Low-emission materials are being incorporated into an increasing number of leading-edge buildings and demonstration programs. The major finding reported by design teams is no surprise — it is difficult to obtain emissions data. Nevertheless, some breakthroughs have been achieved at little additional cost. Some Canadian examples include CMHC's demonstration house in Ottawa for the hypersensitive and “Healthy House” demonstrations in Vancouver and Toronto, NRCan's ten Advanced House projects, the Ontario Ministry of Housing's Barrhaven multi-unit building for the hypersensitive in Nepean, the Ontario Government's Whitby Mental Health Centre, NRCan's C-2000 Program for office buildings and CMHC's IDEAS Challenge for apartment buildings. In the U.S., two of the best known projects are the San Francisco Main Library, a $120 million, 36,000 m complex being completed in the spring of 1996, and the National Audubon
Society’s new headquarters building in New York, a 1993 major retrofit of a building more than one hundred years old.

**Remaining Obstacles**

Although emissions information is becoming more readily available, architects are still confronted by a number of obstacles and frustrations in their pursuit of lower-emission materials.

**Lack of Product-Specific Emissions Data:** As Table 1 clearly indicates, emissions vary by orders of magnitude among similar products, making product-specific data essential. Such data is still difficult to obtain for most materials. Testing in environmental chambers is expensive and test procedures often need to be customized for specific materials and building applications. Manufacturers are generally sceptical regarding the value of such testing, often citing the lack of proven health effects. Fearing the potential loss of market, manufacturers generally prefer meeting some established standard, rather than reporting on actual emission levels.

**Variations in How Emissions Data are Reported:** As can be seen in Table 2, emission test results may be expressed as an emission rate (e.g. \( \text{g/m}^2\text{h} \)), as a chamber concentration (e.g. \( \text{g/m}^3 \) or parts per million) or as a total volatile content (e.g. \( \text{g/L} \) or % by weight). Both the emission rate and the concentration will be affected by the loading ratio (the ratio of the material’s surface area to the test chamber volume) and the air change rate. Not many architects will be comfortable manipulating the necessary equations to “translate” these many formats.

**Complexity of Emission Test Results:** Unlike thermal performance such as R-value for insulation or seasonal efficiency for heating, there is no single number which can be used to compare emissions. A long list of chemical compounds with names like 1,1,1 trichloroethane is of little value to an architect. The concept of total volatile organic compounds (TVOC) is being used increasingly for comparisons, but has also been criticized, since the typical test methodology underestimates certain hazardous VOCs, such as chlorinated hydrocarbons.

**Variation in Emission Rates with Time:** Wet and dry materials have very different emission characteristics. For example, paints have very high emissions for the first days after application but then drop quickly to nearly zero emissions, while wood composite panels can take a year for emissions to drop by 50%. Since emission rates decrease over time, it is essential to know whether emissions data relate to emission rates at the time of production, installation or occupancy.

**Real Buildings Versus Chamber Tests:** Architects need guidance on extrapolating environmental chamber results to the expected impacts in real buildings. In addition to the material loading ratios and air change rates noted above, other factors which may be considerably different include the degree of exposure to the indoor air, temperature, relative humidity, material
thickness and age of the material. The State of Washington has attempted to address this problem by requiring that materials, furniture and equipment, when tested under “normal” conditions, do not contribute more than a specified level of TVOC, formaldehyde or particulate concentrations five days after installation.

**Lack of Guidelines on Acceptable Pollutant Levels:** Of the hundreds of chemical compounds emitted from common building materials, definitive health data exists for only a few, making it difficult to establish guidelines for “safe” levels. Canada’s “Exposure Guidelines for Residential IAQ” (F-P Adv. Ctte. 1987) only provide numbers for formaldehyde, other aldehydes, particulates and various combustion gases. Threshold limit values (TLVs) developed for industrial environments are not regarded as appropriate for office and school environments. Little information is available on the effects of long-term exposure to combinations of chemicals at low concentrations. Investigations of buildings with IAQ complaints have rarely found pollutant concentrations which exceeded TLVs. ASHRAE recommends using 1/10 of TLVs, while others recommend 1/100. A further complication is that the sensitivity of individuals to indoor pollutants varies dramatically, even in the non-hypersensitive portion of the population.

**Building Sources Versus Occupant Activities:** Emissions from building materials are augmented by additional emissions from occupant activities, furnishings, cleaning procedures and consumer products. The two most serious emission sources in buildings — second-hand smoke and photocopiers — are usually beyond the architect’s control. A general rule of thumb has been to limit building-related emissions to 50% of acceptable levels, but clearly this percentage will vary with each chemical.

**DESIGNING FOR LOW-EMISSION ENVIRONMENT**

Despite the many unanswered questions and obstacles which remain, enough is known about the impact of material emissions on the indoor environment that architects should begin to reduce pollutant sources in buildings by selecting low-emission materials and specifying construction techniques which will minimize emissions.

**MATERIAL SELECTION**

Efforts should be focused on priority areas. Large interior surfaces, such as floor coverings, paints, partitions and cabinetry/shelving, have a correspondingly large impact on the surrounding air. Low-emission alternatives are increasingly available and these should be specified wherever economically possible. The following list is by no means comprehensive, but provides some directions.

**Floor Coverings:** Choose carpets with latex-free backings, such as fusion-bonded, nee-
dle-punched or horizontally woven carpets. Natural fibre (e.g. wool) carpets and nylon carpet tile have produced improved results. Avoid chemical treatment. For carpet undercushion, jute, felt, polyethylene and cork offer alternatives to latex. Carpet installation should involve a VOC-free adhesive or be done mechanically through tacking or velcro strips. Linoleum or composite vinyl tiles offer lower emissions than sheet vinyl. Relatively inert — although more expensive — floorings include ceramic tile, hardwood, terrazzo, and natural or synthetic stone.

**Paints and Finishes:** Zero-VOC paints are now available. All interior paints, wood finishes and other coatings should be water-borne. In general, prefinished materials, providing they have cured adequately, are preferred to on-site finishing. Cellulose wallpaper can be ordered. Sealers should be water-based acrylic or urethane.

**Composite Wood Products:** Formaldehyde-free medium density fibreboard (MDF) is available. Phenol-formaldehyde or MDI bonded panels (e.g. softwood plywood, oriented strand board) and cement-bonded particleboard or fibreboard represent alternatives to conventional particleboard and MDF.

**Adhesives, Sealants and Fillers:** Acrylic latex and polyvinyl acetate adhesives are recommended. Water-based contact cement and low-toxicity tile and vinyl adhesives are also available. Preferred caulking include water-based, acrylic latex and neutral-cure silicone. Gaskets should be PVC or urethane. Choose grouts with the least odour and allow them to fully cure before occupancy. Low-toxicity gypsum joint compound is available.

**Occupyant-Controlled Sources**

There are many additional pollutant sources in buildings which lie beyond the architect’s control, but can still be addressed.

**Smoking:** Ensure that smoking rooms have dedicated exhaust systems and that entrance foyers and vestibules are adequately pressurized to prevent the infiltration of smoke from likely outdoor smoking areas.

**Office Equipment:** Equipment such as photocopiers, printers and fax machines are generally regarded as the second worst pollutant source after smoking. At the planning stage, locations should be identified for such equipment, in order to isolate these from open office areas and provide dedicated exhaust systems. If the client is purchasing new equipment, encourage the purchase of lower emission models.

**Furniture and Furnishings:** Emissions can originate from composite wood products, fabrics and fabric treatment, vinyls and finishes. Again, if the client is purchasing new furniture, encourage low-emission selections and airing-out periods before delivery. The State of Washington has developed model standards.

**Cleaning and Maintenance Products:** Encourage clients to review their cleaning and maintenance practices and to substitute less odorous or toxic products where possible. The
Ontario Realty Corporation has developed screening protocols for housekeeping products (Green-Eclipse 1995). Storage areas for such products should be designed with exhaust systems.

**Construction Strategies**

Specifications should include the following, where feasible:

- Protect Materials From Contamination: In particular, protect carpeting from spills during construction and remodelling.
- Seal Emitting Materials: For example, an acrylic sealer can be used to seal exposed surfaces of particleboard (e.g. underside of countertops).
- Air Out Materials: Products, especially those with high initial emissions, such as floor coverings and furniture, should be aired out prior to installation to eliminate emission spikes.
- Increase Ventilation During Emission-Producing Activities: Higher ventilation rates should be utilized during construction, renovation and major cleaning activities. "Bake-out" procedures, involving higher-than-normal heating and ventilation prior to occupancy, may also prove useful, although their effectiveness remains controversial at this time.

**Recommendations for Action by Architects**

Over the next five to ten years, the following trends in emissions research and application can be expected: an improved understanding of material emissions, including standardized test methods and an abundance of emissions data; further research (although still far from definitive) on the health, odour and irritation effects of some indoor pollutants and an expansion of current guidelines on acceptable levels of pollutants; the greater availability of low-emission materials and equipment in the market; and an increased demand by building occupants — and subsequently building owners — for healthier indoor environments.

To accelerate these trends, architects can pursue the following actions:

- Get “plugged in” to the emissions research community and encourage the dissemination of research findings in a language and format that is more useful to architects.
- Continually ask manufacturers and suppliers for product-specific emissions data and for lower-emission products. Examples such as the San Francisco Main Library and the Advanced Houses program prove that manufacturers are willing to modify existing materials to meet a market need.
Support the acceptance of existing voluntary labelling programs in the marketplace by incorporating references to such programs (e.g. CCI, Ecologo) in specifications. Encourage other product sectors to adopt similar labelling programs.

Write to the Environmental Choice Program to recommend modifications to the current “total load point” approach, so that the Ecologo label can be more useful to architects as a means of specifying low-emissions materials.

Collaborate more closely with mechanical engineering consultants to ensure that ventilation systems and controls are suitable to predicted pollutant source strengths and locations.

Educate clients on the need to invest (i.e. architect’s time, construction costs) in low-emission materials. Promote source control to clients on the basis of increasing productivity (e.g. reduced absenteeism), reducing the potential for “sick building syndrome” complaints, creating a more positive corporate image, increasing rentability and reducing ventilation costs.

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Building Aging, Design, and the Use of Resources

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Why consider questions of building aging in a forum devoted to architecture and the environment? The process of the consumption and destruction of buildings is a logical framework, around which to consider matters of resource utilization and waste generation. For a true measure of the impact and efficiency of a building, one might amortize the capital expenditure of materials and energy, and the generation of waste from its ultimate demolition, over its productive life.

The construction of a wood-framed house has been shown to generate between 3.7 and 4.6 pounds of waste per square foot (Donnelly 1995). The National Research Council of Canada provides a figure of 40 pounds per square foot as the weight of a typical frame bungalow without basement. So, the construction of a not untypical house creates approximately four tons of site-generated waste. When a very simple house is demolished, over 50 tons of debris is generated. If the house was to last forty years, a minimum of one and one-third tons of waste could be attributed to each year of occupancy. I am sure that other papers will address the matter of how such debris is dealt with; but creators of buildings, in the first instance, should attempt to minimize the flow of waste, not merely attempt to deal with it after it has been generated. Ensuring that individual buildings endure, is an obvious way to minimize waste generation.
This paper describes the factors involved in the aging of buildings, and considers two projects relative to these factors.

**Why Does a Building’s Career End?**

A number of factors determine a building's career, and eventually cause a building's life to end. While a range of definitions and explanations exists, a generally recognized accounting understanding is that an asset is ready for disposal when it no longer retains a stock of services (rents or quasi-rents) which have a present value (PV) in excess of the 'scrap' value of the asset. Accordingly a building will endure as long as:

\[ \text{PV of ongoing services} > \text{Scrap Value.} \]

This is a nice, neat definition and seems to have survived scrutiny. For the purposes of considering real estate, some additional features might be added. Buildings have a subjective component, which productive machinery seldom does. Adding this human aspect, we might suggest that buildings are disposed of when their owners perceive that the present value of the stock of services is less than the scrap value.

The two sides of the equation must be examined.

**Scrap Values of Real Estate**

The establishment of scrap value for buildings involves a number of factors, and exists at two levels. First, a building will remain in its current usage as long as:

\[ \text{PV of ongoing services} > \text{Scrap Value of Building and Land.} \]

In this equation, when the present value of the ongoing services falls below the scrap value of the buildings and land, conversion to another use will likely occur, but the building will not necessarily be demolished. However, the present value of the stock of services can fall below the scrap value of the land alone. When:

\[ \text{PV of ongoing services} < \text{Scrap Value of Land Only} \]

demolition of the building will be almost inevitable.

Many factors outside the control of the building designer determine scrap values. For example, an increase in allowable zoning density may increase the scrap value of the site, without affecting the present value of ongoing services. Accordingly, a small building may be torn down to make way for a larger, more lucrative building. Conversely, a deteriorating neighborhood may reduce or eliminate the site scrap value. In such cases, redevelopment will not occur, and in extreme conditions, sites may be abandoned, as both sides of the equation fall below zero. In Ontario, falling real estate prices have caused the 'scrap' value of vacant sites to fall to a point that many buildings are surviving, which would have otherwise been candidates for demolition.
The designer can influence the scrap value of the building, if not the land, by allowing a future owner to be able to readily convert the structure to new uses. At that future time, the building itself will retain a stock of services, even though they are only accessed through conversion to a new use.

**Classifying Factors of Aging**

In an attempt to understand the aging factors, those affecting the left side of the equations, being the present value of the stock of services, various classifications have been developed. The U.K. Accounting Standards Committee deems that the reduction of asset value results from

- wearing out
- consumption by use
- consumption by the passing of time (i.e. leases)
- changes in technology, and
- changes in market forces.

For the consideration of real estate, a division can be made between factors internal and external to the asset. Put simply, internal aging typically relates to the wearing out of building components, while external factors relate to changes in the way buildings are used, changes in their surroundings, or changes in the way they are perceived. While the inevitable wearing out process might be predictable, shifts in the external environment and their possible impacts are very difficult to forecast. Yet, in the case of buildings, every responsible designer, lender, and investor, must attempt to use whatever crystal ball is available.

**Internal Factors: Physical Deterioration**

Physical deterioration is the simplest aspect of building aging, and the easiest to handle in investment analysis, accounting, or design, as it involves limited uncertainty. Most productive assets, land being a notable exception, have physically finite lives. In buildings, physical deterioration will lower the present value, by requiring the replacement or more intensive maintenance of building components. Typically, replacement reserve calculations attempt to deal predominantly with this factor.

**External Factors**

For the external causes of declining building value, the stock of services is not exhausted; but falls in value. For example, an office building might be performing its designed tasks as well as
it ever did, but the attainable rents may still decrease. This effect is caused by conditions external to the asset. Such issues usually dominate as limiting factors over physical life expectancy. Cowan (1965) demonstrates that for property it is unusual when "...the physical life of a structure is less than its functional life". While the borders between the classification of the external factors is very blurred, three categories can be described.

**FUNCTIONAL OBSOLESCENCE**

The diminishing role of the building in the market is more complex than simple wearing-out. In office space, tenants of first grade office space may come to demand column-free spaces, increased floor-to-floor heights, and more sophisticated air-conditioning. Therefore, existing buildings become less desirable, so prime office buildings are 'functionally degraded' and begin a new life, serving, at lower relative rents, tenants who are less demanding. This can occur as the market comes to expect, and new buildings offer, more features. A recent change affecting Canadian industrial buildings has been the increasing length of trucks. What was a useful loading dock dimension twenty years ago, has now become inadequate. Legislative considerations contribute to functional obsolescence in a major way, through new fire safety or health standards, an effect which can most readily be noted for highly regulated uses.

**CONTEXTUAL OBSOLESCENCE**

Contextual obsolescence deals with a building's role within a changing surrounding environment. Changing community structure may create areas which are preferred for certain uses. One might consider a street such as Toronto's Jarvis Street. As the city changed, prestigious mansions were converted to 'lesser' uses, such as apartments and rooming houses. The buildings had not changed, nor had the functions of such an occupancy changed; but Jarvis Street was no longer a desirable address. Ultimately, some of these buildings were demolished. In many cases the actions of the planning system through allowing or encouraging changes in a neighborhood, may play the biggest role in such obsolescence. Factory equipment can be often relocated, thereby avoiding contextual obsolescence; however most buildings are immovable.

**AESTHETIC OBSOLESCENCE**

Aesthetic obsolescence in buildings is an obvious factor, although apparently little considered. Much of the literature dealing with depreciation ignores it entirely, perhaps because it has little impact on many capital assets, such as industrial equipment. Manfredi Nicoletti (1968)
attempted to come to terms with this form of obsolescence. He expounded upon an “ideal of beauty”, based on “fashion and taste”. He proposed a societal “desire to conform” and that objects which “represent our personality” are most valued. This definition is conveniently comprehensive, so serves to admit a variety of reasons that we might esteem a building.

The impact of aesthetic obsolescence is significant, and clouds what otherwise might be simple, rational classifications and decisions about how to deal with buildings. Various fashions of design become undesirable, while others rise in esteem. In Toronto, it is not unusual to find fully occupied Victorian buildings, adjacent to empty

Suomi-Koti, Toronto Finnish-Canadian Seniors Center
Sedun and Kanerva, Architects

1980’s office blocks, even though the newer structure is functionally superior in almost every rational way.

Aesthetic concerns can receive official recognition and protection. Historical designation formally acknowledges the design, historical context, or an association with celebrated persons, essentially by making the site unsuitable for conversion or demolition. The scrap value of the property is effectively reduced to zero, simply because such value cannot be realized because of the restrictions imposed.

Thus, real estate decisions made by the hardest-nosed developer can be based on the fashion whims of the marketplace. What are otherwise suitable buildings, are renovated, converted, or demolished based on the market's collective thoughts on how an image of a building coincides with what we wish to express about ourselves, individually or corporately.

**Considerations of Applications**

In order to consider the application of the various principles discussed, as examples I have chosen two buildings which were clients of Elfield during their development stages.

The first, Suomi-Koti, the Toronto Finnish-Canadian Seniors Centre, was designed by Seppo Kanerva of Sedun + Kanerva, Architects. The building is located on Eglinton Avenue East
in East York. The first phase of 88 apartments was completed in 1986, and a seventh floor nursing home was added in 1992. Suomi-Koti was recognized in the 1988 CMHC National Housing Awards in the area of innovation in finance and tenure.

The second building is the Momiji Seniors Centre, designed by Roy Matsui of Matsui, Baer, Vanstone, Architects, and is located in Scarborough at Kingston Road and Markham Road. It was completed in 1993. These buildings are interesting to consider as a pair, in that they were both designed to serve ethnic seniors. They offer housing, support services, and facilities to be used by the outside community. That these functions will evolve over time was specifically identified in their programs.

Both projects benefited from major commitment by their ethnic communities, and each has very complex underlying financing, being derived from both private and public sources, including the results of major fund-raising campaigns. This allowed the groups to undertake a level of independent planning which would not have been possible in a more government-dominated process.

Consideration of the formulas, and the methods of building aging, relative to these buildings can be undertaken. How have Suomi-Koti and Momiji’s planning processes attempted to ensure that the long-term value of their services remains high? A second matter, about the scrap value of the building and site, is a further variable which attempts may be made to influence. The third, regarding the ultimate scrap value of the site, without the buildings, may well be uncontrollable, except for the impact the building may itself have on the evolution of the surrounding community.

Momiji and Suomi-Koti are interesting because they are complex, and the impact of the aging factors were expected to be encountered early in their operations. This meant that they had to be dealt with explicitly during programming and design. Through their development processes, their boards gave careful thought about the longer-term functioning of their buildings. Buildings of other types might be similarly evaluated, relative to the classifications of aging processes.
Physical Deterioration

Most buildings do not fall victim to irreversible physical deterioration, and it is likely that neither Momiji nor Suomi-Koti will do so. Certainly, the physical aging cannot be ignored, but it is worth pointing out that the roofing and much of the mechanical equipment of Suomi-Koti have already been replaced, for reasons other than inherent deterioration. The redevelopment of the property through the addition of the nursing home floor, caused both the original roofing and the rooftop mechanical equipment to be disposed of within six years of the building's construction.

External Factors:

The external factors are much more interesting, far more dangerous, and open to considerable influence by the designer. How will these buildings diminish in value in the marketplace? A variety of possibilities exist.

Functional Obsolescence:

A major historical factor which has affected seniors' housing has been rising expectations. Over the past fifty years, seniors' housing has gradually moved from the house of refuge, through room and board type projects, to minimal apartments, and then on to larger sized units. The large numbers of bachelor apartments in the assisted housing stock in many cities have become increasingly difficult to market, and age limits have been lowered gradually to ensure full occupancy.

Changing market pressures might shift the nature of future demand. Accordingly, Suomi-Koti was built with a large proportion of two bedroom apartments, and even some three bedroom units, which exceeded the standards of the early 1980's. Is there a risk that in the future seniors will expect still larger units? Certainly the risk is there; however, risk is not certainty. One could equally speculate whether the decrease in acceptability of bachelor seniors' apartments would have occurred, had not the assisted housing programs concentrated on one bedroom units. This change accompanied higher levels of social spending, and higher levels of retirement resources. Will the Harris government cut-backs push smaller (hence cheaper) units back into preference? The trend could reverse itself, but over the first ten years of the Finnish project's life, it was best to have included the larger units.

More clearly, seniors' apartment buildings come to obsolesce through changes in their occupant age structure. Seniors' buildings contain the elements of their own evolution. This is not unique. Business writers refer to product life-cycles; the notion that a product will be born, grow, mature, decline, and ultimately die. In seniors' buildings, this internal change occurs very quickly, and even in such relatively new buildings as Suomi-Koti and Momiji, it is most
dramatic. Simply put, people age. Individuals who moved in aged 72, are 82 ten years later, and are becoming increasingly frail. Accordingly, these buildings must accommodate evolution because the in-situ users' needs change as they become more frail. Many of the buildings planned under tight government control, met the needs of their occupants when they initially moved in, but have limited capability of accommodating changing needs, often facing limitations both of built and of managerial natures.

In Momiji and Suomi-Koti, some aspects were incorporated specifically to allow evolution of the building and services. In Momiji, a substantial area initially seemed virtually without use, in spite of the names optimistically labelling the doors such things as “family physician”, “chaplain”, “dentist”, and “activities coordinator”. Now, only three years after opening, these spaces are intensely used - not necessarily as their labeled uses, but as specific needs have appeared, and ways of funding services have developed. This extra space has meant that the building is already comfortably accommodating changing tenant needs.

**Contextual Obsolescence:**
The contexts of such seniors' projects are defined both geographically and ethnically. A risk exists that long-term neighborhood drift might make the location of an ethnically-oriented seniors' building unattractive to the clientele. Furthermore, as immigrant groups become part of the general population, the possibility exists that over time, successive generations of seniors may have less interest in living within an ethnic context. These factors in themselves may not compromise the existence of the buildings; they might be sold to new ethnic groups, or gradually transform themselves into seniors' projects serving their geographical communities, all of which is dependent upon the buildings retaining a stock of valuable services.

**Aesthetic Obsolescence:**
Buildings are not objects of the moment, articles of fashion to be discarded after a few seasons of wear. Unlike ladies' fashion, the impact of buildings, and their use of resources, means that an attempt must be made that they remain esteemed for many years. How people will look at matters of design in the future is undoubtedly difficult to predict. It is important however. Whether people fifty years from now will want to live in the units may well be determined by their subjective opinion of the design.

Although design cannot but be highly influenced by its time context, both Momiji and Suomi-Koti look away from notions of design of the 1980's and 1990's. They look back to their respective ethnic roots, and attempt to celebrate them. The expectation during development was that in future years, they will not be regarded as obvious products of their decades, but will have a more timeless quality. One can hope that they will therefore remain valued, much as historically-designated buildings are esteemed, as well as being prized by their original sponsors.
CONCLUSIONS

No discussion of the impact of buildings on the environment is complete without some consideration of how long buildings last. The accounting profession in their presentation of the costs of business includes an allowance for the consumption of capital assets over time. Similarly, any consideration of the environmental effect of buildings needs to recognize a time factor.

Buildings are complex and substantial capital assets. Yet, relatively little consideration has been given to how they age and come to be destroyed. Most buildings are not demolished because they are irreversibly worn out, but fall victim to ongoing economic and social change. Architects control many of the variables which determine the life stories of buildings, so they should have regard to such factors in the original design of their products.

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FOOTNOTES:

1. Cowan (1965); pg 1395
2. Nicoletti (1968); pg 414

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Rooftops are a city's greatest untapped resource – acres and acres of empty space just waiting to be used! Imagine driving through your city's industrial parks and looking out over a sea of green instead of the sea of tar, asphalt, and gravel that now exists. Imagine looking out of your downtown office window and seeing a meadow of indigenous wildflowers instead of air handling units and roof vents. Imagine growing vegetables on top of your garage – the one that takes up most of your backyard! This vision, unbelievable as it may be to some, is not so far-fetched or so far-off, and the benefits can be incredibly far-reaching. In Europe, where sprawl is no longer possible, or desired, and where higher densities have made the environmental crisis more immediate, roof greening has been adopted as much out of necessity as out of a wish to beautify the urban landscape. In many northern German cities, by-laws now ensure that all new industrial buildings are designed and built with green roofs, and in parts of Switzerland, all new buildings are required, by law, to relocate the green space – taken up by the building's footprint at grade – to their rooftop; even existing buildings, some several hundred years old, flat roofed or sloped, are now required to green twenty percent of their roofscape.

Sod has been used as a roofing material in both Northern and Southern climates almost as long as man has been building buildings. Scandinavia and Iceland have standing examples of houses that are over three and four hundred years old, still roofed with wood, bark, and one or more layers of living turf; in Tanzania, grass roofs kept homes cool in the hottest of temperatures; and even Canada, not to be outdone, boasts the reconstruction of a Viking village on the Northern tip of Newfoundland, built entirely of stone and green turf, as well as a grass-covered fisherman's hut from the sixteen hundreds, at the fortress of Louisburg...
in Nova Scotia. Early settlers in the midwest United States and in the Canadian prairies built some of their first homes with walls of sod, and wooden roofs covered with prairie grasses.

Today, the technology for growing trees and plants on top of man-made structures is evident in every major city in North America – if you know where to look! Underground parking garages and shopping malls are often covered with lawn or landscaped courtyards, but because they are found at grade, passersby don’t think that they are walking on anything but “solid” ground. It is only when the separation between plant and ground becomes obvious that people start to take notice – and to question the sanity of both designer and building owner!

Green roofs can be divided into two distinct types – the vegetation covered or “inaccessible” roof, and the roof garden or “accessible” roof. Inaccessible green roofs are those where the vegetation acts just like another layer of roofing material. They are meant to be looked at, not walked upon, and therefore don’t need to concern themselves with exiting requirements, guardrails, or lighting. They can be installed on flat as well as sloped roofs, are low maintenance, and, depending on the climate and the amount of rainfall, can grow a variety of hardy grasses, wildflowers, mosses, and sedum’s in a soil layer as thin as eight centimetres.

Accessible green roofs, on the other hand, are essentially outdoor rooms, and as such fall under the restrictions of the Building Code, with respect to public safety issues. They are usually installed on flat roofs, for obvious reasons, with the vegetation either as a “carpet”, or in containers and raised beds, separated by areas of decking. Weight and the carrying capacity of the roof structure often play a greater role in the design of an accessible green roof due to the added load of people, containers, decking, trees, and deeper soil; installation and maintenance costs increase accordingly.

Regardless of the type of green roof one chooses, the environmental benefits of adding to the amount of biomass growing in an urban area are tremendous. Through photosynthesis, plants take in carbon dioxide and carbon monoxide and give off oxygen. Studies have shown that one hundred and fifty square metres of “plant surface area” (area of roof x height of the plant x surface area of the leaves and stem) produces enough oxygen for one person for twenty-four hours. Just imagine how much carbon dioxide, produced by commuters in cars, could be converted to oxygen if even half of the roofs in Toronto were greened! At the same time, the plants, through evapo-transpiration, would filter out airborne particulates, hydrocarbons, and sulfur, among others, thereby cleaning the air around them. Cities, with all of their reflective
surfaces and mechanical exhausts, are often referred to as heat islands; a layer of plants would absorb that heat and eventually have an impact on the temperatures, and the wind speed, during both the summer and winter seasons. And on a lighter note, just imagine the increase in butterfly, insect, and bird diversity that a downtown wildflower meadow or marsh would attract.

Stormwater runoff is also a problem that could be solved if we greened our roofs. Currently, with so much of the urban footprint paved over or built upon, rainwater has no opportunity to be taken up naturally by the ground. This is why we have had to create a complete underground drainage system to handle our stormwater runoff. Today, this system is overloaded, too costly to expand or upgrade, and — to make matters worse, when we have a particularly heavy downpour — overflows directly into the sewage system and then out into our lakes and rivers. No wonder Torontonians can't swim on their beaches in the summertime! On their own, green roofs — the plants as well as the substrate they grow on — would retain the rainwater long enough to decrease the load on the system and allow it to run off gradually; however, if you are involved early enough in the process, your roof could be specifically designed as a water catchment basin — you might even get a pat on the back from the Public Works Department in your local municipality! In Germany, there is a company that uses the marsh environment on its rooftop to cool and the clean the heated water from its mechanical cooling system and then recycles it back through their building. The possibilities are limitless.

On a strictly economic level alone, the returns on the initial investment are enough to make roof greening an option to consider. To start with, there are no land costs – you get the building plus the green space on top — two in one! — In fact, building owners can actually increase the value of their existing properties by providing their tenants — and their neighbors — with the added feature of a garden, or a beautiful view, or better air quality — and make a good impression environmentally.

The building owners could also cut their heating and cooling costs. Because plants and growing medium absorb heat, they act like an extra layer of insulation on the roof, keeping the building warmer in the winter and cooler in the summer. German studies have shown that twenty centimetres of substrate plus twenty to forty centimetres of dense grass cushion have the same insulating qualities as fifteen centimetres of mineral wool. This may not be much of a savings on its own, but when you take the following factors into consideration, a green roof really starts to make sense. With a cushion of warming air captured in grasses and plants of between twenty and forty centimetres high, the building could retain up to fifty percent of the heat typically lost through convection, caused by wind and

20 Year Old Rooftop Garden. Accessible Garden on Top of a Grocery Store. Germany (Growing Medium Grodan)
moving air along and over a conventional roof surface. Depending on the way the green roof is designed, the dewpoint could be kept within the layer of growing medium, which would eliminate the need for and the cost of a vapor barrier, and seen from the plants point of view, a warm building under the roof is absolutely necessary to keep the plant roots from suffering due to extreme temperature fluctuations in the winter, as well as preventing stored water and moisture from freezing, which could lead to drainage problems and membrane damage.

In a typical inverted roofing system, where the roofing membrane is protected by a layer of insulation and then that insulation is weighted down with a layer of ballast to keep it from floating away with the rainwater or blowing away with the wind, a layer of vegetation and soil could easily be used to replace both the ballast and increase the R value of the roof, if not replace the need for extra insulation entirely. Green roofing has also been shown to increase the life span of the roofing membrane itself, by protecting it from ultraviolet rays and extreme fluctuations in temperature, which can cause stress and brittleness, and by protecting it from punctures and damage, due to traffic and ongoing maintenance.

And then, if you were to add to that the possibilities for economical development through the growing of food or a cash crop or a plant which could then be turned into a value-added product in the building directly below, you have to wonder why green roofs haven't taken off earlier!

On a social level, green roofs also have much to offer. As well as providing for urban green space which is as safe and as accessible as the building on which it sits, a roof garden promotes a real sense of “city beautiful” and “pride of place”. In cities like St. Petersburg, roof gardening has dramatically increased urban food production, and in Toronto there are several community gardens that reside on rooftops. Roof gardens build community, as well as self-reliance; residents of apartment buildings who never meet in the halls, exchange seeds and stories in their roofgardens; children who cannot play on the street below now play on the roofs above; and downtown hospitals with roof gardens have seen the positive results that “horticultural therapy” (the interaction with green and growing things) has had on their patients.

So, now that you are convinced, what do you have to watch out for. The first and most important is the weight factor. If you are dealing with an existing building, this will probably be the limiting factor. Wet soil weighs one hundred pounds per cubic foot. Considering that most roofs are designed for a combined dead, live, and snow load of forty pounds per cubic foot, this
could be problematic. However, remember that many plants don't need twelve inches of soil for healthy growth; soil can be mixed with organic and inorganic matter to make it weigh less; and there are lightweight growing mediums on the market now, such as the rockwool pad from the Danish company Grodan, which can completely replace soil with no harm to the plants. Even if the roof itself is designed to carry only a very light load, the bearing walls, columns, and shear walls can take much heavier loads directly to the footings below. Consult with a professional engineer before you start.

Access and safety are also important considerations. Obviously, this varies depending on the occupancy of the building you are proposing the green roof for – restrictions are more stringent if the public is involved. Liability may also become an issue.

Keeping the drainage and access to drainage free and clear is a priority. This can be done by maintaining a gravel ring and filter cloth layer around roof drains and overflow scuppers, or by ensuring that any deck strapping or containers are aligned in such a way that they don't block the flow of water to the drain or eavestrough.

The compatibility of roofing types with the plants and growing medium you are going to use is also something that requires research. It is generally suggested that the two should be separated. For example, bitumen is a food source for micro-organisms as well as plants, and as such, any roofing product which contains bitumen is subject to root damage and penetration. Typically, the cross section of a green roof, starting from the bottom, includes the roofing membrane; a layer of filter cloth to prevent roots from penetrating the roofing membrane (if they happen to make it through all of the other layers); a drainage course of gravel or expanded clay pellets to allow water to drain from the roof; a second layer of filter cloth to prevent soil, growing medium, or organic matter from “eroding” or clogging the drains; the growing medium; and the plants. Studies indicate that after 5 years flat green roofs are more likely to suffer damage than sloped green roofs, but this is true whether they are greened or not; in any case, the vegetation and growing medium should be installed in sections for easy access should a problem occur.

Last but not least are the plants themselves! Climate, wind, rainfall, air pollution, building height, shade, and soil depth are all factors that will determine what can be grown and where. Climatic conditions on a rooftop are often quite extreme, and unless you are willing to irrigate, fertilize, or provide shading devices, your choice of planting material will be limited to hardier or indigenous varieties. Root size and depth are also important to consider – will the plant be able to stabilize and flourish in

Accessible Roofgarden
Mary Lambert-Swale. Housing Project, Toronto, Ontario.
ten centimetres or sixty centimetres of "soil"?; where have the plants been grown, and was it comparable to the conditions you will be subjecting them to? Typically, inaccessible roofs use mixtures of grasses, mosses, sedums, sempervivums, festucas, irises – plants that are native to drylands, tundra, and alpine slopes. On an accessible roof, with few exceptions, the choices are limitless. In Europe there are nurseries which specialize in providing plants specifically for green roof installations – here we are still experimenting. Consult a landscape architect or horticulturist for advice.

In conclusion, it has probably become obvious through the course of this discussion that there is no one way to design a green roof. There are as many different options for green roofs as there are buildings to install them on, people to install them for, and budgets to build them with. But it is the things that they all have in common which will help to make them a truly sustainable solution to urban greening and beautification. We hope it grows on you!

Monica Kuhn is a registered architect in Toronto whose firm, established in 1994, specializes in small-scale residential projects, permaculture design, and rooftop gardens. She is a founding member of the Rooftop Gardens Resource Group, and a frequent lecturer on the subject of urban greening and permaculture.

The Following are some of the many built examples of Green Roofs in Canada

1. The new Vancouver Public Library in Vancouver, British Columbia; Moshe Safdie, Architect, and Cornelia Hahn Oberlander, Landscape Architect

2. The Environmental Sciences Building at Trent University, Peterborough, Ontario; Richard Henriques, Architect, and Cornelia Hahn Oberlander, Landscape Architect

3. The Legislative Building in the North West Territories; Matsuzaki Wright, Architects, and Cornelia Hahn Oberlander, Landscape Architect

4. The Boyne School near Shelburne, Ontario; Doug Pollard, Architect, and Greg Allen, Environmental Engineer

5. Mary Lambert-Swale Housing Project in Toronto, Ontario; Building by Reich & Petch, Architects, and Garden Design by Monica E. Kuhn, Architect
6. Residence and Day Centre for the Y.M.C.A.'s Environmental Learning Centre in Kitchener / Waterloo, Ontario; Charles Simon, Architect, and MacKinnon, Hensel, & Assoc., Landscape Architects

The Rooftop Gardens Resource Group of Toronto is currently putting together an inventory of rooftop gardens and vegetation covered roofs in the Metropolitan Toronto area and would greatly appreciate any information on existing and proposed installations. Mailing address: The Rooftop Gardens Resource Group, c/o Monica E. Kuhn, Architect, 14 Sackville Place, Toronto, Ontario M4X 1A4

ACKNOWLEDGMENTS:

The ongoing research on the history, the environmental effects, and the technical details involved in the installation and maintenance of roof gardens and green roofs in Germany and Northern Europe. Some of the books I have drawn information from are listed below.

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The ongoing research conducted by various members of Toronto's Rooftop Gardens Resource Group.

The RGRG is a multi-disciplinary volunteer organization whose mandate is to create a rooftop gardening culture in Metro Toronto. To promote the concept of green roofs, the group offers the interested public a questionnaire and a series of information factsheets on various aspects of rooftop gardens, along with an associated consultants listing. A fledgling resource library is available for viewing through the city's Food Policy Council. As well, the group is involved in a number of pilot projects with the Toronto Board of Education, and their annual "Rooftalk" lecture series, in its third year, is hosted in conjunction with Ryerson's Sustainable by Design lecture series. For more information, please call Monica Kuhn @ (416)923-9034 or Mark Wronski @ (416)928-1712.
Passive Design:  
The Case for a  
Bioclimatic Approach

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Context

There is no question that human society is undergoing rapid change in nations around the world. In Ontario, presently faced with a revolution of sorts, it might be useful to take stock of shifting attitudes, to see how they might affect our lives for the present and future.

The many and varied reasons for change are hard to isolate with any certainty. But there can be little question that the impact of humanity on the eco-system that supports it, as well as all other species, is a major factor. It is almost two hundred years since Malthus, the English clergyman turned economist, published his “Essay on Population.” His central argument was that the produce of the earth had finite limits, set by the amount of land to grow food which set a limit to population. This contradicted the view of Adam Smith, in his “Wealth of Nations,” that increased population was good for the economy and people’s well-being (Roberts, 1990:645). These authors were, of course, writing in response to the change they saw around them in Britain in the period 1760 to 1830, an era now classed, with the advantage of hindsight, as the “Industrial Revolution.”

Today, in what some call the Post-Industrial, some the Post-Modern, era, the issues of
the growing influence of humanity on the globe have not gone away, but are cumulatively greater than ever, while the arguments as to their significance remain as similar and as intractable. Some see growth as being limited not so much by food, as Malthus did, since human ingenuity has been extraordinarily adept at finding ways to increase its production, but by consumption of non-renewable resources. The growth in consumption of minerals and fossil fuels since the early Industrial Revolution has far outstripped the growth of human population, and the even more rapid expansion of urban population and their consequent built-environments. All contribute to the cumulative impact on the Earth’s atmosphere, as evidenced by such phenomena as global warming and thinning of the ozone layer.

The questions of growing consumption are clearly relevant to architects in the more affluent countries, since they tend to set the technological standards that others follow. They are all issues affected to some extent by architects, and the types of human shelter that, through their design choices, they help to realize. If, indeed, the lifestyles we are helping to build are not sustainable and threaten our long-term survival, are there alternatives in the processes of architectural design? This paper suggests that there are. Those that address the levels of resource consumption and energy use to which our society has become accustomed are particularly relevant. One such alternative is the Bioclimatic approach that is the subject of this paper.

**Technical Foundations**

If the infrastructures providing energy for transport, construction and personal comfort and convenience to the residents of Canadian cities were to disappear, the cities would cease to exist, certainly as we know them. Existing urban systems are technical constructs widely separated from the natural environment on which, however remotely, they depend. In the short period since the Second World War, architecture has largely reflected the same remoteness from natural systems of existence. It may well be that, in the next century, the energy-dependent architecture of this period will prove itself an outrageous anomaly in the long history of architectural design: a time when architects abandoned reason and creativity to the dubious wisdom of their engineering colleagues. Systems more directly in harmony with the natural environment clearly offer attractive alternatives in energy consumption and life-style. They can reduce the reliance on synthetic technologies based on the consumption of the accumulated capital of millennia of photosynthesis stored in fossil-fuel deposits, or as some like to put it – raiding the bank!

Architects practicing today come to the profession with an education essentially of the post-war period whose heroes were the masters of the Modern Movement, and whose professors shared the same creed. It is unusual to find architects who do not understand the idea of the house as a “machine for living.” Accessibility to energy and ease of use is totally integrated
with the concepts of architecture. It was taken for granted, and without question, that modern buildings required energy; for pumping water, for cooking, for lighting, for climate control, heating, cooling, for transport and communication, and for the ever-increasing array of appliances, gadgets and conveniences that are the trappings of modern life-styles. They all consume energy with varying degrees of efficiency. Of course there is truth in the view of the necessity for energy in architecture. Perhaps little has changed in the concept of the "machine for living," and, if anything, it seems that our ways of using energy in building have increased in the computer age, rather than decreased.

But how do architects respond? How should they? How can they? It may be argued that the time-lag inherent in any professional education applies very much to the architectural profession. The technical foundations of the current practitioner's training has provided a pre-disposition to reliance on energy-dependent mechanical systems that can provide comfort in climates from the poles to the tropics.

This has permitted great freedom in the orientation and massing of built-form and in the choice and design of the building envelope. It may be seen as contributing to aesthetic liberation. On the other hand, since all architectural design represents, to some extent, a response to constraints, the recognition and acceptance of a range of obstacles represents the first level of design choices, that mould subsequent aesthetic considerations.

The accepted use of energy-dependent technologies in architecture therefore needs further examination, particularly in the light of the changes occurring in the ecosystem, and the human role in this change. Perhaps the first place to start is with the issue of comfort in buildings, since space heating and cooling are primary contributors to the use of energy in buildings: and it is here that the bioclimatic approach has something to offer.

**Design with Climate**

The architectural environment of just over thirty years ago was dominated by the great architectural works and philosophies by the giants of the late Modern movement. Architecture relied almost entirely on engineering technologies to achieve and control comfort. The conventional wisdom, that architecture was dependent on the consumption of energy, was accepted unchallenged, at least in the architectural circles of the Western world. But supporting this teetering edifice was a massive infrastructure for extracting and distributing the energy to make it work. Electricity was the essential ingredient, and still is. But the energy sources which produced it were taken for granted, as much by architects as by the general public. The easy, rather unquestioning, acceptance of this basic premise provides the foundation for a fundamental approach to design that influenced a couple of generations. It was one that became the core of architectural education and a foundation of the construction industry. Now enshrined, it has become glacially impervious to change.
The architecture of history is bound up with creative solutions to structure. Yet the environment in which architects now learn and work has become energy-based. It includes, not only the structural engineer, but also electrical, mechanical, heating and ventilating and other specialists. The situation begs the question of whether architects through unwitting, and doubtless well-intentioned, acceptance of the energy infrastructure, have abandoned a central, critical, crucial, element of architectural design to their engineering counterparts. As an extension, it might also be asked whether they should, through the use of appropriate design techniques, now claim it back to the benefit of the environment and their clients.

There is a less recognized, but contemporary, alternative to the high-profile Modern/Post-Modern mainstream of architectural procession. It also stems from the post-war period when energy-based architecture became the accepted norm. It was the work of those who sought lessons from the unfathomable well of inventiveness of ordinary people responding naturally, and with accumulated wisdom, to the challenges and the pleasures of their accustomed surroundings. They included writers such as Amos Rapoport and Victor Papanek, but perhaps they are best epitomized by the irreverent and irrepressible Bernard Rudofsky and his “Architecture without Architects” (1964). These authors posed no threat to the works of the then masters. But their unconventional focus introduced notions alien to the mainstream of architectural thinking and challenges. Most notably, they emphasized the successes of indigenous passive design in responding successfully to environmental conditions, without reverting to mechanical systems for comfort.

**The Bioclimatic Approach**

At roughly the same time, the Bioclimatic approach to architecture - of design with climate was developed by Victor Olgyay who combined the work of several scientific researchers to develop what he called a Bioclimatic Chart. In his fascinating book “Design with Climate” Victor Olgyay made a major, some might say visionary, contribution to the theory of architectural design. Despite its comprehensive nature, the book is surprisingly low-key and the bioclimatic concept easy to understand. In essence, it provides a means of comparing the biological needs of human beings for comfort, with prevailing conditions of climate. From this comparison it is possible to identify the design parameters that influence comfort in buildings. This “bioclimatic” approach gives the architect, if he or she is willing to accept it, a means of control over the “comfort” elements of architectural design, that have been so recently abandoned to engineering specialists.

But, it might be argued, life is already too complex, and time too short, to incorporate new considerations into the design process. How difficult is it to use this approach? The answer is that it is not. Olgyay’s basic charts from “Design with Climate”, indicate the use of a shaded comfort zone in the centre, the impacts of low and high temperature, and relative humidity.
They also show the need for corrective measures to improve comfort – the use of radiant heat if too cold, or the use of air movement if too warm or humid. They highlight opportunities for designers to arrange architectural form, orientation and detail to achieve the required conditions.

A brief assessment of climatic conditions, month by month, provides an essential base for alternatives in architectural design that, if not eliminating the need for energy consumption entirely, at least reduces it. At the same time there is the opportunity to re-introduce “delight” to Vitruvius’ troika of “commodity, firmness and delight.” It provides a base for passive design in architecture that has recently been enticed away from us by the magnetic attraction of machines. Cannot allure be found in the stars? Nowhere is the potential for change greater than in tapping the energy of our own star, the Sun - for light, and for delight. The tracking of the sun, again month by month, becomes a design tool, scarcely used in a technological society hooked on technical wizardry and energy consumption. Yet it provides a solution to at least some problems of heating in winter, and indicates the possibilities for passive shading in summer. Diagrams for North America are no further away than the nearest “Graphic Standards”.

Extensions of the bioclimatic approach provide for the translation of data to specific recommendations for design. They are based on a system for assessing whether any given climate is comfortable, warm or cold, at different times of day, and times of year. These were developed into a set of “Mahoney” tables, that give recommendations on building form, orientation, materials and element design. It is a simple, manual system. (Koenigsberger et al, 1973). Based, as it is, on numerical data, the bioclimatic approach is clearly amenable to computerization, and programs are in the process of development in Europe, though not yet available in Canada. (Tuschinsky, 1995).

**Reality Check**

Is the use of a bioclimatic approach to design realistic? One wonders how many architects in Ontario use the approach. Do many include at the very outset of their design process an assessment of climatic conditions, or the tracking of the sun? Do many include these as design parameters every bit as important as any other program requirements? If not, why not? Perhaps it is a function of time, perhaps a lack of awareness, perhaps a gap in education, or perhaps a combination of all these. Can such an approach be incorporated easily into the design process?

The answer from experience is yes. The author was introduced to this approach at the Architectural Association Tropical Department in the mid-1960s, and used it as the basis for design over 15 years in different countries overseas, as well as in Ontario. It is particularly appropriate in less wealthy nations with few energy resources, or in the energy-rich, but hot, Middle-East. There are numerous examples of how the principles have been applied, giving
pleasant conditions, and greatly reducing the requirements for energy consumption. Reality shows the approach to be clearly applicable in such environments.

**The Case for a Bioclimatic Approach to Design**

But returning to the question of whether this a realistic approach in Ontario, the answer must again be yes, for four reasons. These, it is suggested, make the case for a bio-climatic approach to architectural design. The first is that Ontario is affected by the increasing cost of energy, and the climatic change generated by the increasing consumption of fossil fuels as much as any other region. Problems in the atmosphere affect us as they do others. Yet they are the result of cultural, life-style, economic, and design choices.

The second is that in the economic downturn, increasing numbers of Ontario architects are exporting their services. It seems appropriate that design methods should be appropriate to very different economic, climatic and cultural environments. The bioclimatic method provides an easy route to ensuring that major mistakes are avoided.

The third is that in a world of easy communication and rapidly advancing technology, it is both prudent and possible to stay abreast of the field. Europe, with much higher energy costs than Canada, is taking many initiatives to reduce energy consumption in architecture. These take many forms, but a broad general sense of the direction may be gained from a recent conference for Teachers in Architecture. Amongst the numerous initiatives discussed, the bioclimatic approach to design ranked very highly, and in the concurrent exhibition all architectural projects were based on this method.

The fourth reason, last and certainly not least, is that this design technique is, to use current jargon, extremely “user-friendly.” It is approachable and easy for those with architectural training to grasp. It can be employed in whole or in part, depending on levels of understanding or inclination. It reveals a deeper sense of environmental context than the visual alone, allowing solutions that delight in sense of place, of site and of climate.

**Conclusion**

If the bioclimatic approach to design has not been widely used since its inception, this could be due to factors that may now be changing. These include a greatly increased awareness of the role of the environment in our lives, an economic downturn, and interest in better use of resources – of truly achieving more with less. There is the further concern of the world’s growing urban populations and built-environment and the stress that these will put on the eco-system. This combination provides an unprecedented challenge to architects. A bioclimatic approach to design offers some solutions. It is being used and elaborated in Europe. Why not here in Ontario?
Professor Middleton's research interests lie in the area of sustainability by design, based on over thirty years' experience in this general field. With a B. Arch from University of Toronto, he completed a year at the Architectural Association, London, gaining a certificate in Tropical Architecture. Half his career in practice and teaching has been in countries overseas. Almost all projects for which he was responsible were founded on principles of passive, climate-responsive design and use of regionally available materials. A planner with a Master in Environmental Studies degree, he also had central roles on multidisciplinary teams for Master Plans for universities and the new capital of Tanzania, and has undertaken independent consultancy on low-income housing in Canada and internationally. His own house, using passive design, has been operating off-grid for five years.

REFERENCES:


The Green on the Grand: Marketing Environmental Design

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Partner
Snider Reichard March Architects

In September 1994 we were part of a team which made a submission to CANMET/Natural Resources Canada for inclusion in the C-2000 Advanced Commercial Building Program. The C-2000 Program is a small demonstration program for high performance office buildings, developed and sponsored by CANMET, Natural Resources Canada. The emphases of this program are on energy and environmental performance, but criteria have been developed for a wide range of other performance parameters. The program was launched in 1993, and seven buildings have been designed, some of which are in, or approaching construction.

We proposed to build a 22,000 square foot office building in Kitchener, Ontario which would meet the key requirements of the C-2000 program; energy efficiency, minimal environmental impact, occupant health, comfort, and functional performance.

After review and evaluation of a detailed design submission our project became one of four projects in Canada to date to be authorized to proceed through to completion. Our project was the only “eastern” project, as all others were located in Western Canada.
The design goals for the project were:

- use less than 40 percent of the energy of an ASHRAE 90.1 building
- major electrical load reductions; which comprise approximately 60 percent of office building energy use
- a 60 percent reduction in annual carbon dioxide emissions relative to an ASHRAE 90.1 building
- no ozone depleting chemicals used to produce or operate building components,
- superior indoor air quality and comfort
- use of low environmental impact construction materials and practices

Buildings such as this C-2000 project require an integrated design approach. Rather than following the traditional architect led process we acted in this process as designers and facilitators simultaneously on equal footing with other team members. It was necessary for all the team members to set aside our preconceptions about the design process and our views of 'standard' office building design. Many design sessions were spent discussing a broad variety of design and technical issues with many sketches but no firm progress toward a final design. Building shape, massing, and orientation were discussed. Building systems were discussed. Building skin was discussed. Ways to maximum daylighting for a variety of office configurations were discussed, as were many other issues.

The builder/owner of the project, Ian Cook remained both enthusiastic and patient as the process continued. He willingly allowed various possibilities to be explored. We finally began a series of site plans, floor plans, elevations and sections similar to a more traditional design process. During this process, details were finalized and Ian indicated what could or could not work from a financial viewpoint. His concern, and ours, was to achieve the design goals within an affordable budget. In addition, tenants would be required before construction could be considered, as the market for new office space was very competitive.

At the time of our proposal the commercial vacancy rate in the Waterloo Region was 20
- 30 percent depending on location. It was therefore necessary to ensure that the building could be constructed at total lease rates (rent plus utility and common expenses) equivalent to current rates within the area and competitive within Southern Ontario.

Our project coincided with a change of philosophy of many commercial office tenants. It was no longer of primary importance to be located in a high-rise building in the city centre. This allowed the marketing and construction of a two storey 11,000 square feet per floor office building central to Kitchener and Waterloo within the developed portion of Kitchener but without the necessity of locating in the core. With sufficient land for surface parking we were then able to consider a building to be constructed almost entirely of wood, as opposed to the non-combustible multi-storey construction in urban cores.

All the wood in this project came from environmentally responsible sources. The small dimension lumber came from renewable Canadian forests. Our research indicated that all 2 x 4 and 2 x 6 material available in Ontario comes from 3rd and 4th growth woodlots (crop forests). This is not true for any lumber larger then 2 x 6 which comes from old growth forests. Larger structural members, sheathing and flooring came from wood chips and sawdust. In the case of oriented strand board these structural members are fabricated from nonstructural fast growing species such as aspen or poplar. Suppliers such as Macmillan Bloedel Ltd. have confirmed this to be true. As crop trees, they are preferable to larger species such as fir which require lengthy growing periods.

The wood frame construction, in addition to being a renewable resource provided a flexible low cost frame and allowed a highly insulated building shell. It was possible for the
The Green On The Grand building includes the following features:

- 28 percent of the water use of a conventional building designed to ASHRAE 90.1.
- No CFC’s or HCFC’s used to produce any of the building materials or operate any of the equipment,
- construction waste was reduced by 75 percent through a combination of reducing material requirements, reusing waste materials on site and recycling other materials,
- natural landscaping with drought-resistant native species, minimal grass areas and storm water retention pond,
- triple glazed windows with two low-E coatings, argon gas fills, silicone edge spacer and foamfilled fibreglass frames,
- spectrally-selective glazing that provides high visible light transmission and low solar heat gain coefficient,
- blown cellulose insulation made from shredded newsprint,
- gas-fired heater/absorption chiller that eliminates ozone-depleting chemicals and uses natural gas instead of electricity for the cooling cycle,
- use of the storm water retention pond for the building cooling tower eliminating city cooling make-up water and water chemical treatment system,
- displacement ventilation system (low outdoor supply and high exhaust) that provides superior indoor air quality,
- sensible and latent heat recovery of ventilation air combined with a cooling/ dehumidification coil and “free” reheat,
- heating and cooling by ceiling-mounted radiant panels instead of forced air to minimize fan power,
- continuous electric light dimming system for perimeter offices and interior offices served by clerestory windows,
- motion sensored walkway and signage lighting, and
- extensive use of recycled and formaldehyde-free and V.O.C. (volatile organic compound) free materials and finishes.

One of the most interesting architectural features of the project was providing as much natural day lighting as possible to reduce dependency on artificial lighting. Due to the high efficiency of the exterior wall construction we found it was possible to:

- Elongate the building plan which allowed for a maximum of perimeter offices and a minimum of interior spaces.
- Locate large windows around the entire perimeter of the building without adverse
heat loss or heat gain, (30 percent of wall area).

- Provide second floor high level clerestory windows to give natural day lighting to the core spaces.
- The second floor washroom areas and central corridor borrow daylight from interior skylights to the clerestory space.

Certain aspects of this project required the education and participation of the occupants. For example, if the tenants follow the intent of the lighting design, task lighting can reduce the overall lighting requirements by 25 percent. It was decided to provide operating windows around the perimeter of the building for individual fresh air control. This can cause balancing problems with the mechanical operating system, but was deemed to be of such psychological importance that it had to be included.

Many of the design concepts and materials used in this project were unfamiliar to Ian Cook and would be to most builders. Certain products, such as the windows (which came from Winnipeg) required special knowledge to obtain. Enermodal Engineering researched and obtained contacts for many of the products included in the project from a wide variety of sources. It is our hope that through this project and others, these products will become better known and accepted. Local manufacturers will begin to provide products (such as the windows) with comparable energy ratings.

Many contractors do not have the time or any direct motivation to research the variety of alternative materials and systems used in this project. This is an area where consultants can take a proactive role which may ultimately give their clients a marketing edge on their competitors.

During a lengthy building development process materials and systems were evaluated on performance and on cost. Some products were rejected due to higher costs but others, crucial to the goals, were included in spite of cost. Savings were sought elsewhere to offset these costs.

The resulting design met the goals of the C-2000 program and met the builder's goals of affordability and practicality.

The following chart illustrates that this project is not dramatically different from current construction on the basis of an elemental cost breakdown approach. The chart was prepared based on the following criteria so it could also be compared to the Means cost estimate breakdown for office buildings:

- Land and site servicing were not included.
- Parking lots, landscaping and all other site improvements to the building were not included.
- Major servicing costs were not included.
- The buildings are priced as finished shells with finished common areas and
corridors but without leasehold improvements.

- All mechanical ducted systems including supply lines in tenant spaces are included.
- Electrical costs are included except for tenant leasehold space.

We had constructed a 15,000 square foot, two storey, masonry, high quality office building in 1993. This building is included in the chart “Office Building A” for comparison purposes.

<table>
<thead>
<tr>
<th>SYSTEM/COMPONENT</th>
<th>C-2000</th>
<th>OFFICE BUILDING A</th>
<th>MEANS 1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. General Conditions</td>
<td>5.4</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>2. Excavation</td>
<td>1.2</td>
<td>1.8</td>
<td>1.4</td>
</tr>
<tr>
<td>3. Foundation</td>
<td>7.4</td>
<td>6.8</td>
<td>3</td>
</tr>
<tr>
<td>4. Building Shell</td>
<td>14.5</td>
<td>±6.8</td>
<td>±2.8</td>
</tr>
<tr>
<td>5. Windows &amp; Doors</td>
<td>6</td>
<td>10.6</td>
<td>1.6</td>
</tr>
<tr>
<td>6. Roofing</td>
<td>2.2</td>
<td>3.3</td>
<td>1.9</td>
</tr>
<tr>
<td>7. Insulation</td>
<td>2.4</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>8. Exterior Walls</td>
<td>5.6</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td>10. Elevator</td>
<td>3.4</td>
<td>4.5</td>
<td>4.8</td>
</tr>
<tr>
<td>11. Finishes</td>
<td>2.2</td>
<td>12.6</td>
<td>23.1</td>
</tr>
<tr>
<td>12. Mechanical</td>
<td>29</td>
<td>12.6</td>
<td>23.1</td>
</tr>
<tr>
<td>13. Electrical</td>
<td>12.9</td>
<td>10.9</td>
<td>14.9</td>
</tr>
<tr>
<td>14. Contingency</td>
<td>6.8</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>TOTAL: 100</td>
<td>100</td>
<td>100</td>
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</tr>
<tr>
<td>COST PER SQUARE FOOT</td>
<td>67.09</td>
<td>66.71</td>
<td>71.83</td>
</tr>
</tbody>
</table>

Elemental Breakdown By Percentage

costs for the C-2000 project are higher than a simple rooftop application. It does however compare favourably with other systems that use a chiller such as the Means example. The C-2000 building has a fully ducted low volume displacement ventilation system and a full hydronic system. The utility savings can provide a reasonable payback for the increased costs from these systems.

We found the cost comparison of this project to other projects very encouraging. Notwithstanding some special discounting and other advantages given this project, we believe that other buildings constructed in a manner similar to this C-2000 project can be marketed successfully. As this is a demonstration project, it incorporates as many features as possible to achieve the program goals. A subsequent building would not likely include all the features and would then be somewhat less expensive.

The operating costs of the C-2000 project will be significantly below that of other buildings. These costs, as part of common cost, will result in a lower common cost component, (total
common costs for this building are estimated at $5.25 per square foot. Common costs are usually paid proportionally by the tenants at cost with a percentage management fee included. It is then not possible for the building owner to profit from the common cost component. As both the common costs and the rent are real costs to the tenant it will be important for the building owner to market the total cost of the rental space compared to the total cost of other buildings. In this way it may be possible to have a slightly higher base rent with a smaller common costs and still have a competitive total cost. In addition, the energy costs for this type of building should remain more stable. As energy costs increase this could then be used as a marketing advantage to tenants looking for long term leases.

Ian Cook is marketing this project with a net lease rate of $11.00 – $12.00 per square foot. This rate we are told by real estate agents is competitive for this product in the marketplace at this time.

We believe that tenants are becoming sufficiently concerned about their office environment (and the environment in general) that a C-2000 type approach can attract tenants as a marketing approach. Hybrid Turkeys, a global company, chose to take approximately one third of the space in this project specifically because environmental responsibility is part of their corporate philosophy.

Natural lighting and superior indoor air quality are real concerns for today’s companies. If our buildings can be cost competitive and provide these features we can slowly change the total office environment.

Working as consultants we were able to undertake this project and complete it successfully within a reasonable fee arrangement.

Funding for some additional fees was made available through the C-2000 Program. The bulk of this money was used to pay Enermodal Engineering for material and systems research as well as coordination of special systems during construction and the subsequent monitoring of the systems. However, some money was made available to us to mitigate the cost relating to a more protracted design process.
We found that we were able to work within our budget primarily due to the shortened drawing modification time provided by our cadd system. We believe that shortened revision time is the main strength of autocad drawings for our office. The second prime advantage is the ability to “copy” details, sections schedules and other data, either within the job or from other similar projects. This has allowed us to spend some additional time to work with our clients on material research and selection to make our buildings more environmentally responsible and cost effective.

The completion of the project and monitoring over the next two years will determine if we have achieved our goals.

If we have reached our goals we have done something remarkable. At a cost similar to a traditional building we will have created a building that consumes half the energy, uses 70 percent of the water and provides a superior environment!

Richard Reichard is a graduate of the University of Waterloo. He has been a partner in the firm of Snider Reichard March Architects for nineteen years. His practice includes residential, commercial and institutional projects throughout Southwestern Ontario. Innovative uses of wood construction are a particular interest. He was the architect of the Waterloo Green Home, an environmentally advanced house.

ACKNOWLEDGEMENTS:

Owner/Developer: Ian Cook Construction Limited
Ian Cook

Engineer: Enermodal Engineering Limited
Steve Carpenter/John Kokko
PARTIAL LISTING OF SUPPLIERS ASSOCIATED WITH THE C-2000 PROGRAM

A & T Industries
Product: Pond Liner

Accurate Dorwin Company
Product: High Performance Windows

Advance Transformer Co.
Product: Dimming Ballasts

Big Bear Services
Product: Recycling Services

Chicago Blower Corporation
Product: Blowers

Edgetech I.G. Ltd.
Product: Insulating Edge Spacer for Windows

Forbo Industries
Product: Linoleum

Frender Canada Inc.
Product: Rad Panels

Guillevin International Inc.
Product: Lighting

Haakon Industries (Canada) Ltd.
Product: Air Handler

HTS Engineering Ltd.
Product: Air Handling Unit

Kawneer Company Canada Ltd.
Product: Entrance Systems

Kieswetter Cartage and Excavating Company Ltd.
Product: Air Handler

Kohler Ltd.
Product: Toilet

Lackie and Associates
Product: Recycled Plastic Lumber

Nepitek Ltd.
Product: Automated Infra-red Faucets

Omniglass Ltd.
Product: Lineals for Windows

Plasti-Fab Ltd.
Product: Underslab Polystyrene Insulation

Ruttenburg Sales
Product: Lighting

Owens-Corning Canada
Product: Baseclad Insulation

R & D Energy Savers Ltd.
Product: Radiant Panels

SEL Recycling
Product: Wood Recycling

Sto Finish Systems Canada
Product: Exterior Insulating Finishing System - Acrylic Stucco

Stramit U.S.A.
Product: Straw Partitions
The Emerald Gate Project

Douglas Pollard B.Arch. OAA, MRAIC
Principal,
Douglas B. Pollard, Architect

Jiri Skopek A.A.Dip.,RIBA.,MCIP.,OPPI.,OAA
Principal,
Jiri Skopek, Architect and Planner

BACKGROUND

In 1994 CMHC and Canmet co-sponsored a national competition for innovations in high rise construction. The competition was specifically directed towards residential high rise projects that were to be built and monitored. Emerald Gate, a 130 unit non profit project for Strasser Developments was the Ontario regional winner.

The competition focused upon five prime aspects of high rise construction:

1. Building envelope durability...a pressure equalized rainscreen wall system was to be utilized.
2. Energy efficiency... the building was to utilize 55% of ASHRAE 90.1 design requirements (max).
3. Indoor air quality, ventilation and occupant comfort....fresh air was to be delivered to all rooms, upgraded standards of air quality were to be implemented.
4. Aesthetic, social and accessibility issues were to be rethought and advanced.
5. Environmental and resource conservation...A broad range of on and off-site considerations for waste, CO2 production, CFC and HCFC creation, resource depletion, site ecosystems, water management and building emissions were to be considered in the design process.

**EMERALD GATE EXCEEDED EVERY TARGET OF THE COMPETITION.**

Solutions employed were to be readily accessible to the construction industry. Their utilization and monitoring was expected to encourage builders to recreate them elsewhere.

**DESIGN OBJECTIVES**

It is the objective that the Emerald Gate project:

- Demonstrate the application and practicality of new building techniques and research findings from the point of view of the builder;
- Demonstrate the economic viability of environmentally conscious design solutions through savings in operating and maintenance costs;
- Maximize the environmental benefits and minimize the impact of externalities on and off site;
- Optimize the efficient use of non-renewable resources to preserve natural capital. This is to be achieved by the design of a building with a zero net fossil fuel demand;
- Create a building whose design, construction and operation will be adaptive;
- Accomplish the above without compromising the inherent beauty and delight of a well designed structure;
- Achieve performance of the building-as-a-system to provide safe, healthful, comfortable living space for initial and future occupants, in a shelter which abides by the principles of a "sustainable environment" and
- Export sufficient renewable based energy to be equivalent to the embodied energy required to create the building.

**SOLUTIONS EMPLOYED:**

The site for the project is a flat, treeless field on the north side of Steeles Ave.in North York, Ontario. An “L” shaped configuration was predetermined by an earlier planning process. This
offered an opportunity to address situations faced on many sites. The building is planned as one of a pair which form the major portion of a project containing 70 townhomes to the north. Steeles Avenue is a busy multi lane high speed road with bus service. Nearby Bathurst is similar and also provides neighbourhood shopping. The rest of the area is a mix of high rises and lower scaled residential developments.

**Interior Layout and Floor Plan**

The building is a stepped 11 storey, double loaded “L” corridor plan with its apex pointing southwest. This apex is rounded to reduce both the shading caused by right angles and turbulence which leads to sharper pressure differentials and greater water penetration, infiltration and exfiltration. To improve solar access the corridor was shifted off-centre (to the north and east), suites facing south and west made narrower and deeper, suites facing north and east wider and shallower. This manipulation, along with fully glazed sunrooms on the south and west resulted in almost equal solar penetration for all suites. Only two of the fourteen suites on a typical floor have no direct sun at some point on a (sunny) winters day.

The shorter dimension from the corridor to outside wall on the north and east permits the building stairs to span this distance and thus they too acquire full daylight. They then consume less electricity, are safer, more delightful to use, support plant growth, and with glazing on the corridor face, provide daylight to the corridor as well. Building amenity spaces, traditionally placed along the ground floor, were located on each floor at the inside corner of the “L”.

They provide daylight to the centre of the corridor, control the impact of exfiltration and infiltration associated with the elevator shaft (chimney effect), provide refuge during fires and most importantly reinforce the sense of community within the building. These amenity spaces are adaptive, being laundries (every third floor), meeting and hobby spaces etc. which convert over time to shared work at home spaces, communal dining spaces (meals on wheels), attendant care offices and possibly nursing stations.

The space recaptured on the ground floor is devoted to the lower floors of two storey family units, further reducing elevator dependency while increasing garden access. With the two storey shading/vine (food) supporting loggia they form a visual base to the building and add more “eyes on the street”.

It should be highlighted that the dispersal of amenities throughout the building, along with the enjoyable stairs further reduces elevator (power) usage. Elevators can regenerate power on their down trips but this technology is not utilized here.

Suite entries are recessed one metre from the corridor. These recesses, which serve at least two suites, strengthen territorial identification, create places for benches, shelves, changes in colour and texture of finishes to aid with visual and cognitive impairments, provide visual relief and subtle turning spaces for stretchers.
UNIT DESIGN

This paper does not permit a complete description of all considerations for the individual units. All units are, however, universally accessible and allow for future adaptations such as the addition of grab bars, lowering of certain counters and moving of some cabinets to create direct washroom access from bedrooms. Some suites are designed to allow the addition of a washroom without partition changes. A number of electronic aids were examined and the affordable ones are included to enable occupants to convert bedrooms and sunrooms to home offices and to manage their interior environment electronically.

BUILDING ENVELOPE AND ELEVATIONAL TREATMENT

The disposition of building facing materials is determined by a study of wetting and wind pressure patterns. Along the upper and vertical edges of high rise buildings a concentration of wind and pressure creates significant areas of wetting and water penetration and the greatest pressure differentials. The utilization of smoother materials (glass, metal, fibreglass) for faster runoff along with greater compartmentalization in order to create faster pressure equalization (the window mullions form the smaller compartments of the rainscreen wall) efficiently responds to these conditions.

The central portions of the building’s facade is formed of factory assembled 2750 x 6000 EIFS (exterior insulation and finish system) panels with preinstalled windows. The texture of the acrylic stucco finish and a choice of 2500 colours provides an ample design palette.

The windows are high performance, triple glazed, argon filled units with pultruded fibreglass frames. The glass is separated with silicone edge spacers and two of the surfaces are coated with spectrally selective low "E" coatings. The overall rating on the window is about .8 RSI. Pultruded fibreglass has a low conductance, much) greater strength (13X) than aluminum, the same coefficient of expansion as glass, is produced with vastly lower amounts of energy than aluminum, is made locally and with a plentiful basic resource (silica). Current codes dictate that the windows must be separated by one metre of non combustible construction. Thus they would be placed in situ on metal studs knee walls faced with a prefinished metal panel.

The EIFS panels that comprise much of the facade are made from acrylic stucco bonded to mineral wool “lamellas” which in turn are bonded to a “Densglass” substrate mechanically fastened to a steel stud backup. The entire panel is clipped to the slab edges, eliminating thermal bridging. Mineral wool, with its porous nature forms the draining cavity for the “drainscreen”. With its fibres running horizontally it bonds the outside layer to the substrate and improves compressive strength. The bonding adhesive is the air barrier and moisture barrier but is vapour permeable. The air barrier is completed with gaskets between panels. Only one layer of studs is required, it is further packed with mineral wool and faced with foil backed dry-
wall on the interior. The foil serves as the vapour retarder and as the true (accessible) air barrier. The adhesive on the substrate in this case was considered as a backup air barrier.

The wall has an RSI value of 5.6 and is roughly 225 mm thick. Mineral wool was favoured for this installation as it is made locally from recycled slag and rock fibre, is lightweight, self-draining, non-combustible, non-corrosive, non-petroleum based, does not use ozone depleting substances, is dimensionally and thermally stable over its life and extends the warranty on the wall to ten years.

Prefabrication achieves better tolerances, reduces waste, speeds up construction time, provides improved worker comfort and panel quality, reduces costs and temporary heat requirements, allows factory window installation which in turn reduces reliance on caulking.

Balconies are designed with grade supported light steel frames. This eliminates the significant thermal bridging inherent in cantilevered slabs and provides a means for vine support as part of the shading (and food or wine producing?) strategy. Balcony rails are widened to allow for potted plants and to serve as reflecting light surfaces. These details further enrich the facade.

**Energy Efficiency**

The systems employed are to be one hundred percent sustainable from renewable energy sources. The embodied energy required to construct the building is to be replaced over a fifty year life of the building by net export of electrical energy to the grid. In addition to greatly reducing the need for energy in the first place and to maximizing the performance of the skin, floor plan, ventilation, mechanical, electrical and waste systems the philosophy of the mechanical design relies on the interdependencies of the systems and the benefits they can provide each other.

**Ventilation System**

The system utilizes variable speed heat recovery. Fresh air is delivered to every room via high wall diffusers in the bedrooms and living rooms and is exhausted through the bathrooms directly to an exhaust riser. Kitchen exhaust is passive (range filter). One central unit, sized for high speed ventilation (5600 l/s) is operated at 3000 l/s for most of the year. This unit also provides 1600 l/s to lobbies and corridors and 1500 l/s to assembly spaces. Ventilation is balanced on the floors by constant volume supply boxes.

80% heat recovery is achieved through a desiccant wheel, a heat wheel, a heating coil, and evaporative cooling/humidification. The ventilation air load is further reduced with seasonal ice storage formed during the winter and used during the summer.
HEATING AND COOLING SYSTEMS

Most of the internal heating load is met with the air handling unit described above. Space heating and water heating are integrated, reducing capacity requirements.

The primary heating source is a bio-gas fired cogenerator which also produces electricity for this building and its sister building next door. Excess thermal energy produced can be exported to the adjacent townhouse development or the rooftop greenhouse or parking garage.

The small cooling load remaining is offset with evaporative rooftop spray ponding/night sky radiation and seasonal ice storage. Thermal energy from the cogenerator is used to generate the desiccant wheel during the cooling season. Humidification of supply air is achieved through moisture recovery from the waste air stream.

ELECTRICAL SYSTEMS

High efficiency fans, motors, lights and appliances accompany the reduction of requirements to make the on-site production of electricity practical. Most of the energy is produced by the cogeneration system supplemented with 250 m2 of photovoltaic panels producing 50 kw more during the peak load demand for air conditioning. There is also a substantial assist from a 75 kw wind turbine which might be placed at a distant site and fed into the grid or on the roof as it was drawn. When production exceeds demand the excess is stored in a battery bank for emergency and peak demand use.

BIOMASS

A methane digester converts biomass into nutrient, sludge and methane. The methane becomes part of the fuel source for the cogeneration system. The building could actually import wet garbage, treat it in the rooftop bio-regenerative waste treatment system, produce its own fuel and use the nutrient and sludge in its rooftop gardens and on site. The rooftop garden not only is a food source but assists in cooling the building.

SITE ECOSYSTEM

In addition to liquid waste treatment by its living machine the site will clean its own rain water through appropriate plantings, rock/plant filters etc. The site will be moulded and planted to maximize the benefit of summer breezes, especially as they blow across the retained rainwater, to protect from bitter winter winds, to utilize indigenous species which are drought tolerant etc. All grey water will be treated on site.
Waste

The project goal is a 50% reduction in household waste. This is be achieved primarily through waste stream separation and recycling. A recycling garbage chute will be installed, blue boxes located under the corridor benches and a program of pickup by residents will be implemented. “Garburated” compost will be treated in the living machine and digesters.

A full construction waste program with a similar 50% reduction target will be implemented. Separation, education and monetary incentives and penalties form the core of the program.

Accessibility/Adaptability

All suites and public spaces are universally accessible. The building was analyzed under the categories of fixed components, electronic components, adjustable components and components to be added or removed. Decisions on which solutions were appropriate were based on economics, the percentage of the population affected and the ease with which solutions could be adapted.

Certain items such as peepholes, switches and outlets, lever door sets and taps, textured floorings, glow strips, braille signage, nonglare, nonslip finishes etc. are to be installed immediately. Other items such as blocking for grab bars, handrails, benches, conduit for future “smart home” technology are provided for future adaptation. Adjustable items such as closet rods and shelves, certain counters, showers, etc are provided in all suites at the outset. Movable, removable items such as cabinets under sinks and full height cabinets that partitioned washrooms are planned so that certain suites can adapt further.

Public spaces receive the same consideration as the suites.

Commissioning and Monitoring

A full commissioning program of the mechanical and electrical systems as well as the building fabric was created.

Laboratory testing of the window units, EIFS panel with window, window wall system and their assemblies will be tested for water and air tightness, thermal and structural resistance.

On-site testing will include certain wall assemblies as well as three main roof elements...building envelope seal, greenhouse moisture retainer pan, and greenhouse enclosure.

The impracticality of commissioning the entire building envelope at once led to the solution of testing by compartments with special high capacity fans on a suite by suite basis.
Smoke bomb testing will identify air leakages.

Unique to the project is the monitoring of thermal and moisture performance after construction. Four locations on each elevation will be monitored with thermocouples and sensors to measure outside air and surface temperature, inside surface temperature and ambient temperature and relative humidity. Air pressure differential in the "drainscreen" wall will be monitored with external and internal probes.

The commissioning will include the methane digester, the living machine, the co-generator, the wind turbine, photovoltaic generation, battery bank, central heat recovery, ice storage and night sky radiation cooling.

**Design Methodology**

The holistic design solutions follow naturally from a holistic design process. The design team searched for the interactions, interdependencies, potential redundancies, benefits and resources that one aspect of the building could supply another. The interrelationships of the mechanical and electrical systems, the building envelope, indoor and outdoor air quality, lifestyles, behavioral patterns, the sun, wind and rain are consistently used as design determinants.

Just as in nature, the concept of waste is replaced with the concept of resource. Any building element that can't address at least three issues has a hard time making it to our short list. The by-products of one decision are used elsewhere. Community excess becomes our resource, our excess becomes the communities resource.

The design team consists of the developer, architects and landscape architects, mechanical, electrical and structural engineers, suppliers and manufacturers and specialized consultants.

Originally the competition was to be two tiered. At the conclusion of the first phase the regional winners agreed to cooperate during the second phase, to share the prize and to become each others resources (only in Canada eh?)and thus part of the team as well.

The initial submission described in report form the major directions the project was to take but no actual building design was undertaken. This part of the process involved numerous long and interesting meetings with all of the design team at once and concluded with the usual panic to meet the deadline. Without the deadline we would probably still be talking.

The full building design was created during the second phase. The design drawings were accompanied by a detailed report which included the results of various computer simulations. In addition some initial cost estimates, which identified a 5% capital cost premium, were done. Manufacturers and utilities were consulted on a regular basis.

DOE 2.1 (energy performance program) was run for the ASHRAE 90.1 base case build-
ing as well as Emerald Gate. Since DOE 2.1 does not truly recognize renewable energy sources we settled for a “load reduction” run which produced an estimated energy cost of 42% of ASHRAE 90.1 before the introduction of innovative mechanicals. This exceeded the competition target of 55% and was attributable to the improved envelope, heat recovery systems, energy conserving electrical and water fixtures, and high efficiency equipment selected. Monthly energy production costs were done on EXCEL spreadsheets.

After considerable refinement and dialogue RAIN and EMPTIED (wall performance programs) simulations were run on the drainscreen wall assembly. It performed excellently. (Since then the manufacturer STO has done extensive mockup laboratory testing. This testing supports or exceeds the initial expectations)

**Design Results**

The building was intended to be a 130 family, 11 storey non profit housing community. Due to the cancellation of the provincial program it remains unbuilt.

Otherwise it would now be a bright, sunny and happy residence for two hundred or so people supporting the larger community by accepting its wet waste, by exporting power, producing some food and increasing the local biomass (and thus oxygen).

It would support and provide community programs, adapt to demographic and economic changes in a single hop, be durable and delightful, colourful and cost effective. It would have accomplished this with minimal damage to our resources and environment, without producing toxins or much CO2, CFC’S, HCFC’S, and with minimal embodied energy and maximum building health.

The building would have taught us all a lot. By monitoring its performance and publishing the results its weaknesses and strengths it would have become an information resource for the entire building community.

It can still be built. Sufficient changes in rent legislation in combination with significant long term savings in operational costs could create the required financial feasibility. Because the building uses little community infrastructure, partial relief from levies and property taxes could also (possibly) be negotiated.

**Conclusion**

Emerald Gate exceeds all of the technical requirements of the IDEAS CHALLENGE, meets all of its own design objectives and demonstrates, that with today’s technology, it is practical to construct low energy, high health buildings.
It conveys the concept that when the interdependencies of nature and man are used as prime design determinants the resulting design is not only sustainable but immeasurably delightful, affordable and supportive of the human spirit.

It makes apparent the idea that the payback of sustainable development starts from the first moment of encounter and lasts for as long as we choose to remain on the planet.

What is not apparent is why we continue to develop in any other way.

**Jiri Skopek,** is a Toronto Architect, Planner and Environmental Consultant, who from the time he designed and built the first solar house in the UK, has been involved in the environmental field. He has won several architectural and planning competitions in North America and Europe for entries based on healthy buildings in sustainable communities. He holds a degree in Environmental Management from Ryerson University, and is the director of BREEAM Canada: a method for the environmental assessment of buildings.

**Douglas B. Pollard** graduated from University of Toronto Architecture in 1968. Since that time he has practised in Toronto, for twenty one years as a principle in his own firms. His practice focuses on small and mid-sized residential, commercial, institutional and mixed-use projects which demonstrate an intelligent use of finances, energy and resources. Many of his projects involve the user in the design process.

**Acknowledgements**

Engineer: Allen & Associates
Client: S & A Developments
Design Sponsor: CMHC
The Aberdeen Pavilion—A Case Study in Building Conservation

Kevin Deevey, B.Arch, Dipl.A.Tech., OAA

Principal
Kevin Deevey, Architect

"By much slothfulness the building decayeth"
(Ecclesiastes, X,18.)

INTRODUCTION

Every building has the potential of being immortal, but very few will last the lifetime of its occupant. Economic and political factors rally against the long term sustainability of most buildings. The possibility of readapting a specialized building program are often dismissed by the desire to build new and more convenient space. The burden of this kind of thinking is taken largely by the environment, by the demolition and subsequent disposal of obsolete building material, not to mention by the community at the loss of historic fabric. One factor that increases the decision to demolish is the inevitable dilapidation of most buildings.

There are two crucial practices that can avoid this eventual state. One is preventative maintenance: routinely servicing materials and systems in buildings before they fail, thereby extending the useful life of the building. The other, and the focus of this paper, is designing and constructing the building in a manner that it does not require extensive maintenance. The notion of solid, lasting construction has fallen out of favor, particularly since the general useful
life of a building is 30-50 yrs. The initial expense of using high quality, durable materials, along with the high cost of labour to assemble them in proven construction techniques, has meant that most modern buildings will rarely last the lifetime of their occupants. Exacerbating this problem is the lack of flexibility in given building programs. More often than not, the design is specialized and can't adapt to programmatic changes over time. The buildings ultimate fate is either a costly (fiscally and environmentally) retrofit or demolition.

**History**

The Aberdeen Pavilion was constructed in 1898 on the newly developed exhibition grounds on the outskirts of the City of Ottawa. The tradition of large exhibition halls had begun in Europe and America, most notably with the great Crystal Palace. The regional exhibition was the primary method of introducing new products and methods to a largely rural population. The requirement for large, column free halls spawned innovations in building technology evidenced in the Aberdeen Pavilion.

Designed by the architect Moses Edey, this 43,000 sq. ft. building combines an innovative use of bridge technology and standardized decorative sheet metal components. The structural framework, a series of pinned arch trusses was engineered and constructed by the Dominion Bridge Company of Canada. The decorative sheet metal “skin” of the building was a heavy gauge, zinc coated steel, stamped and textured to imitate fine ashlar stonework (fig.1). Although the building had the appearance of an eclectic, hand crafted Victorian Hall, it was in reality the product of an industrialized assembly line process.

The building was used extensively over its 100 year history, beginning as a showplace for the latest technological marvels. For a short time, the building contained an ice hockey rink; and was the home to the original “Ottawa Senators” hockey team. During the First World War, the building was refitted to accommodate the newly-enlisted on their way overseas. In the fifties and sixties the building was used to house livestock for the popular agricultural fairs of the period. Unfortunately, these changes, together with a lack of routine maintenance, deteriorated the building’s condition. By the early eighties, the building was infested with pigeons and considered unsafe for use.

In 1991, Ottawa’s City Council voted to demolish the building. This was met by strong opposition by regional, national and international heritage activists. In addition, council had to face an enormous price for the removal of pigeon excrement and lead paint during the demolition. Early estimates were pegged at over 1 million dollars, not to mention the burden this hazardous material would place on the environment.

Council reversed its position on the fate of the building and commissioned the firm of Julian Smith & Associates to prepare a restoration plan. After a year of planning and investigation, a contract was signed for more than 4 million dollars to restore the building. In considera-
tion of the national historic status of the building, more than 2.8 million dollars in grants was secured from provincial and federal agencies, leaving a relatively small burden on the local taxpayer.

**CONDITION**

Council's previous decision to demolish the building was not without some merit; the outward condition of the building was, indeed, a sorry sight. The structure is a huge monument in the south Ottawa landscape, easily seen from all directions. Considering the largely low scale commercial and residential quality of the context, this building is like the Titanic in an ocean of canoes. The building was often repainted, in the fashionable colours of the time, sadly these started to reveal themselves simultaneously. The huge windows, intended to illuminate the building in a time before artificial lighting, were all broken, mostly by rock-wielding passersby. The upper mezzanine windows, well out of the reach of any projectile, were summarily blown out by the local fire department practising their new techniques on the abandoned building. The interior of the building was not only lit by the windows, but also by a multitude of small bullet holes in the roof and the enormous endwalls. It seems that some agent of the city decided that this was the most effective means of dispatching the building of the pigeons, but clearly they gave little regard to the integrity of the building envelope. These conditions combined could at least give some substantiation to the idea of demolishing the building.

It was upon some closer inspection that the true nature of the building revealed itself. The general appearance of the interior was very discouraging: several decades of "improvements" had layered the finishes with partition walls, offices, concrete animal stalls, and several layers of mechanical services. Added to this debris was the infestation by pigeons and other small animals. After a serious cleaning of the interior, the potential of the building was very clear. This was truly a magnificent, light-filled grand hall.

The main structure, a series of pinned arch trusses, each assembled with riveted 4" L
sections, rising more than 40' from the floor of the pavilion, appeared to be badly rusted. In fact, under the accumulated dirt and years of paint, the steel was coated in an early form of galvanizing. Considering that the historic method of achieving this coating was to dip the steel into a vat of zinc, the protection to the base metal was considerable. The trusses suffered no undo deterioration over their long life. With regard to their strength, it was suspected that the trusses had fatigued over the years, but a survey of the existing truss profile compared to the original shop drawings completed a century ago, revealed almost no movement in the structure.

The foundations of the trusses were very early concrete piers. These had suffered, but were generally over-designed in the first place and had held up quite well over the years. The other foundations along the endwalls were of solid stone masonry and only required some repointing. The lower sidewalls, just under the bank of windows, had noticeably started to sag as well as having a substantial bow along their length. This initially was considered to be a serious settlement problem with the foundations. Further investigation revealed that their were no foundations whatsoever. Originally, these sidewalls were designed to be very light infill panels between the trusses, and, since they carried no load, they did not require a foundation. They might be considered a very early curtain wall system. The movement in the plane of the wall was due to snow being piled up against the building. The sagging was a result of fatigue in the window lintel. This exerted a force on the windows, and they pushed down on the wall.

The decorative sheet metal “skin” of the building appeared to be in a very deteriorated state. Similar to the trusses, this was largely a cosmetic problem. The metal work is about a 24 gauge zinc coated steel; beneath the accumulated paint, the protective coating appeared to be in perfect condition. Some rusting had occurred in locations subject to high abrasion from snow and ice movement, but otherwise it was still sound and undamaged. The majority of serious damage was located below the 6'-0” level, clearly caused by vandalism, accidental impacts and general neglect. In fact, much of the decorative ironwork at this level was missing altogether, exposing the wood frame or steel skeleton underneath.

Most of the glazing was missing from all the windows. The jagged edges of the remaining pieces did little for the building’s appearance. The windows were designed as a simple wood sash fixed into a wood frame. Measuring about 3’ wide and 8’ tall, they were divided into 15 separate lights. The wood frames were very robust and protected by a simple but effective metal flashing, and were in reasonable condition considering their age. The sash frame and muntin bars were largely intact but had weathered miserably over the life of the building.

Generally, it seemed that the building was in excellent condition, and apart from its pathetic appearance, the structure was sound and much of the original historic fabric was intact. This was certainly a case where the original architects design was for a high quality building requiring very little maintenance. A relatively large amount was spent on the initial capital cost of the building, but little was spent on the upkeep over the preceding generations. The prefabricated nature of the constituent parts allowed for good quality control, as well as
minimal labor costs in the final assembly. Considering that the program for the building had not changed (it was still to be used as a large assembly building) the building was a good candidate for restoration, with the emphasis on conserving as much of the original building components as possible.

**Conservation**

In this environmentally conscious age, the term conservation has come to mean the careful and selective use of our natural resources. The term has long been used in the architecture profession to mean something somewhat different but not necessarily at odds to its new intent. Martin Weaver in his text “Conserving Buildings”, offers the following definition for building conservation: "(it) can be defined as preservation from loss, depletion, waste, or harm... the field expanded to encompass the scientific preservation of a heritage of great and small older buildings for the use and enjoyment of our own and future generations."

Building conservation has become a complicated and disciplined field. There have been cases where the cost of conserving the original building material far outweighed the cost of simply replacing and replicating the original with a modern equivalent. In these cases the importance of the historical information was considered to be a priority over the more mundane economic factor. In the case of the Aberdeen Pavilion, it was realized that the conservation of the historic fabric made good economic sense, albeit the public was not going to receive a brand new building. The decision was to leave the scars and dents as a record of the building’s long history, as well as to maintain as much of the original historic fabric as possible.

As mentioned previously, the exterior of the building required only some cosmetic work. Much of the missing ironwork was replicated from examples on
other parts of the building. Similar traditional methods and materials were used in the construction of the new elements, assuring similar longevity and performance. The existing metal work had to be cleaned of its many paint layers. The problem faced in this task was the abundance of lead based paint. Current provincial legislation required the containment of any residue from the removal of these finishes, a Herculean task in the case of this building. The typical method of paint removal would have involved a light abrasive blasting; the problem encountered by this method was the creation of air born dust as a result of the blasting technique, and the possible damage to the protective zinc coating of the steel. A new system was tested and recommended for use on the building. Ice blasting was a cleaning system typically used in the removal of paint from commercial aircraft. Obviously, this was also a situation where it was desirable to remove the paint finish without damaging the integrity of the underlying material. It involved the use of a similar spraying technique as abrasive blasting, but a very fine mist of ice particles would be shot at the subject surface, producing enough abrasion to remove accumulated paint, but not enough to damage the material. The ice would melt on impact, and break the paint into manageable chips; the resulting stream of water would minimize the possible dust, and carry away the toxic material to be contained and disposed. This cleaning method worked magnificently, and was much appreciated by the workmen during the hot, humid construction days of July and August.

The windows were deemed to have outlived their usefulness and considering their condition were largely replaced. It was decided that the original design had worked quite well and a similar design was specified. The building was never intended to be a climate-controlled space, consequently their was no need to consider the insulating capacity of the windows; simple single pane lights were installed in the replicated sash using the same putty technique practised decades before. There was some consideration given to the thermal heat buildup and material degradation due to UV light; a low E type coating was specified for the new glazing. There had been some record of the windows being whitewashed during the summer to reduce the heat gain in the building; it seems that this small concession to modern technology has afforded the same, less drastic results.

Other small gestures were made to minimize the impact of the conservation program on the environment. The owners of the building expressed an interest in using the building during the winter. Insulating and heating the building was not economically feasible, nor practical, and would likely hasten the deterioration of the newly restored building components. A gas fired radiant heating system was installed. The theory with this system was that the occupants would be warmed by the radiation of heat from the ceiling mounted fixtures, in lieu of heating the space. This would effectively avoid condensation on the vast expanse of windows and allow for the building to remain cold at night and between shows.

The original floor of the pavilion was simply compacted dirt; when the building was used as a hockey rink, a concrete slab was installed. Over the decades, various alterations and some frost heaving had combined to severely damage the integrity of the floor. In an effort to
avoid breaking up 43,000 sq. ft. of old concrete, it was decided to simply resurface the floor. The surface was ground level, patched, and resurfaced with a colored elastomeric concrete topping. 

Clearly, the Aberdeen Pavilion has suffered a lack of maintenance over its years, but the original intent of the designer, to produce an efficient, high quality exhibition hall has lessened the impact of neglect by its owners. The attention to well specified materials and proper detailing have resulted in a building that has easily recouped its initial capital cost, and seems to be well on its way in paying back its restoration cost. The larger impact is in the less tangible areas; the building has avoided becoming another pile of rubble in a landfill and has made minimal impact on the environment and more importantly, stands as a reminder of an important architectural heritage.

Kevin Deevey is the principal of Kevin Deevey, Architect. Kevin has been employed by the firm of Julian Smith & Associates, Architects since his graduation from Carleton University's School of Architecture in 1991. Kevin has worked on many of Ottawa's historic buildings. He combines experience with heritage buildings with modern design to produce a contemporary architecture sensitive to precedent and history.

ACKNOWLEDGEMENTS

The success of this restoration project is due in large part to the work of Ottawa City Councillors, Jim Watson and Peter Hume, and the Mayor Jaqueline Holzman. 
Architect of Record: Julian Smith and Associates, Architects
Clerk of the Works: Anna Kozlowski
Structural Engineer: Adjeleian Allen Rubeli, Consulting Engineers
Mechanical Engineer: Smith and Anderson, Consulting Engineers
Electrical Engineer: Wood, Banani & Associates, Consulting Engineers
General Contractor: Tristan Construction
Reference


Footnotes

The Big Chute Redevelopment

John Paul Shelton, OALA, CSLA
Landscape Architect,
Ontario Hydro

ABSTRACT/SYNOPSIS FOR THE PROGRAM

ONTARIO HYDRO BIG CHUTE REDEVELOPMENT AND ASSOCIATED ENERGY ISSUES

- Questions related to energy efficiency, sustainable development and a biodiversity conservation ethic will form the basis of a new paradigm for planetary survival in the next millennium. We must shift from a culture of waste and indulgence to a culture of caring and responsibility. This culture must be based on an ecological systems approach to utilizing solar power through renewable energy technology.

- Whether we accept the new technology and/or how we integrate these “machines in the garden” will be central to our role in developing a symbiotic relationship between nature and culture within the Bioregion.

- Of the many tough questions we have to ask ourselves concerning future energy sources, decentralized, small scale hydraulics are an important part of the solution in a sustainable and energy efficient future. Big Chute works towards initiating a dialogue on nature and technology in our energy future.
THE BIG CHUTE REDEVELOPMENT PROJECT
SUSTAINABILITY – TURNING POLICY AND STRATEGY INTO ACTION

PROJECT SUMMARY

The Big Chute Hydraulic Generating Station (GS) was originally built in 1909 and later purchased by Ontario Hydro from the Simcoe Railway and Power Company in 1914.

Big Chute is a small run of the river plant situated on the Severn River approximately 140 kilometres north of Metropolitan Toronto. The station site is on the federal Parks Canada Trent/Severn Waterway (TSW) within a provincial Ministry of Natural Resources designated Area of Natural and Scientific Interest (ANSI).

The site is well known as the location of North America’s largest marine railway, operated by the Trent Severn Waterway, Big Chute is in the Heartland of Ontario’s cottage country, on the southern boundary of the District of Muskoka.

The strategic plan for Big Chute developed by special interest groups, is to maximize its potential as a tourist destination to the economic benefit of the region while preserving its unique historic, natural and cultural attributes.

Big Chute GS was the first station owned by Ontario Hydro and has remained largely unchanged since 1919. After 80 years of service the condition of the station had severely deteriorated and along with advances in turbine technology could more efficiently utilize available upstream flow. In May 1987, Ontario Hydro initiated environmental studies for the redevelopment of the station and in December 1990 received the necessary approvals under the Ontario Environmental Assessment Act and the federal Environmental Assessment and Review Process to proceed with the project.

The Big Chute Redevelopment Project involved the dismantling of a 4 megawatt (MW) station and the construction of a modern 10 MW station along with associated structures. A Visitor Interpretive Centre was created from a portion of the walls and surge tower of the old power house and the original generating equipment retained beside the new station. The new power house was built within the footprint of the old station to be architecturally reminiscent of the old building, but designed with large windows to facilitate viewing.

The redevelopment initiatives were prepared in consultation with all levels of government, local cottagers, resort owners, special interest groups and the general public who lent their support as site partners in the decision making process.

The purpose of the redevelopment, design and planning program was to integrate these new developments within the context of the cultural, scenic, natural and historic significance of the adjacent landscape setting by adhering to a ‘minimalist’ design and planning philosophy and the concepts of sustainable energy development, and biodiversity.

The site design features encouraged and enhanced the interpretive potential of the setting while improving the accessibility of the public to the power house, marine railways and the
Local/Regional Significance of this Tourism/Recreational Waterways

The station is located on the Trent Severn Waterway, an inland canal system that was initially conceived as a commercial transportation route between Lake Ontario and Georgian Bay. In 1915 the Canadian government built a marine railway (instead of traditional locks) to carry boaters past the gorge and over the height of land to allow them to journey up the Severn River.

A second larger marine railway was built in 1978 to handle the increasing boat traffic on the waterway. Over 10,000 boats pass through Big Chute each year making it one of the busiest and most photographed (Kodak records) lockstations on the system. The Trent Severn never became a viable commercial route but instead developed into a recreational waterway of national significance and is protected under the Heritage Canal Regulations of the Department of Transport Act.

Approximately 100,000 tourists visit the Big Chute site each year, peaking in mid-summer. Of these, approximately 35,000 are boaters who use the marine railway. Many of the boaters spend at least some of their time visiting the site while their boats are being carried over on the marine railway. Some 65,000 land based tourists (many are members of bus tours) have come primarily to see the marine railway.

For a variety of reasons, the Big Chute generating station - including location on a federal waterway, proximity to large urban centers, location within cottage areas, visibility to tourists, the aesthetically pleasing setting of the station on the water, and perceived heritage value of the station, a major component of the tourism interest in the area. TSW parks staff indicate that as many as 40% of the questions asked concern the powerhouse or associated structures, such as the power canal, winches, switchyard or sluice gates (technophilia-Thayer 1994).

During construction of the Trent/Severn Waterway, many lakes were developed and expanded to ensure year-round navigation. This resulted in the development of recreational properties and seasonal residences throughout this sublime waterway. Approximately 1,200 cottages are located in the Big Chute area and 2,500 property owners within a 5-kilometre radius (topophilia-Tuan 1974).
With the completion of regional road improvements, the new powerhouse interpretive centre, the landscape program, interpretive signage and new parking facilities; recent studies indicate that the site has a potential to easily draw over 200,000 visitors per year.

**Public Participation Process**

Ontario Hydro recognized the need for a comprehensive public involvement program in conjunction with the formal environmental assessment for the Big Chute Redevelopment. At the concept phase preliminary engineering studies considered redevelopment as one of five alternatives, the potential for impact on the public was significant. A larger capacity station could potentially alter river flow conditions and consequently the distribution of flows through the lakes in the area.

Due to the significance of the site, the public was very interested in the project, but a negative corporate legacy from past projects in the area added an element of inherent distrust (NIMBY/technophobia). Special initiatives were necessary to ensure that project planning involved the public and gained their confidence in the EA process.

This included the involvement of local government, municipalities and interest groups in information centers, site tours, workshops, public liaison committees and a media program throughout the definition and construction phases which allowed them to review and approve project activities, to become part of the environmental assessment report.

As a result, key issues and public concerns were identified early in the process, as follows:

- navigation
- ownership of flood rights
- shoreline access during construction
- fisheries and habitat enhancement
- heritage/cultural landscapes
- recreation
- resource use (potential conflicts with existing uses)
- integration and cooperation between regulatory agencies
- benefits to local business
- project communications

The continued use of, and commitment to co-planning/design activities with public involvement results in major long term benefits and a win-win EA process. The broader community views OH projects, such as the Big Chute Redevelopment, more favorably and so co-design/planning will remain an essential and integral part of the EA process (Schwass, Fowler 1993).
A Biodiversity Conservation Ethics

Big Chute is located in an environmentally sensitive area, the Big Chute Rocklands Area of Natural and Scientific Interest (ANSI). This area is known for its outstanding diversity of flora and is considered one of the most significant ANSI's in Ontario. The ANSI comprises 589 plant species of which 75 are regionally rare, 9 are provincially rare and of these 5 are nationally rare. The Rocklands is also home to the endangered Massasauga Rattlesnake and the Prairie Warbler.

To redevelop the station, Ontario Hydro had to undertake and limit construction of a small industrial project to a pastoral, parklike setting (the machine in the garden) while preserving the biodiversity (restore, retain and replace) of many environmentally unique and sensitive features of the Rockland (ANSI) adjacent to this park setting.

Every effort possible was made to protect and enhance the aquatic and terrestrial environments from the redevelopment activities to conserve biodiversity at the local level, including the following:

- installation of silt curtains (aquatic/terrestrial)
- tree transplanting and landscape restoration
- creating fish spawning habitat
- fencing to protect environmentally sensitive areas (ESA's)
- bioengineering for slope stabilization
- fish capture and restocking in the tail race pool
- wildlife habitat enhancement
- environmental monitoring/construction auditing for effects and compliance with legislation and EA report.

Environmental Assessment (EA) Act Approvals

In obtaining Provincial EA Act and Federal EARP approvals, Ontario Hydro had to address and resolve many diverse issues (i.e. erosion and sediment control, fish spawning habitat, flora and fauna, heritage concerns, navigational changes, increased flow rates, water quality and changes in water levels) related to the potential environmental implications of the project. It was from within this context that the visual impact assessment, landscape design and restoration became one of the key components to the many but important aspects of a successful planning, design, and construction program (see the Environmental Assessment Report).

In resolving the above issues Big Chute became the first OH generating station in Ontario to be approved under Ontario's Environmental Assessment (EA) Act and the first hydroelectric station in Ontario to successfully clear the federal Environmental Assessment and

Ontario Hydro has contributed to the development of environmental legislation, both federally and provincially, and is a recognized leader in the field of environmental assessment in Canada. Over 320 Ontario Hydro environmental assessments have been successfully approved since the enactment of Ontario's environmental legislation in 1975.

**ECOLOGICAL DESIGN: CHANNEL MODIFICATIONS AND NAVIGATION**

The Landscape Architect was initially brought into the project as an internal consultant by the EA Coordinator in 1988 at the planning stage to make recommendations on the visual impacts associated with shoreline modifications at Little Chute Channel downstream from the station.

At a community workshop, cottagers and local residents expressed their preference that the channel not be altered as it is recognized locally as a landmark, for its unique character and scenic beauty. They were concerned that the effects of the various channel modifications to accommodate the increased flow from a new powerhouse could significantly alter shoreline character through this restricted channel.

Little Chute could be difficult to navigate by large and/or underpowered craft and would have to be enlarged to pass the flows of a larger station capacity while maintaining existing navigation conditions. The proposed channel modifications were revised to address those concerns and after a month of intensive work, a detailed visual analysis was presented to the Public Liaison Committee at the Sheraton Centre, Toronto. The landscape presentation package included a 3-D computer animated model, video imaging and traditional renderings of existing and proposed shoreline character. As a result, the cottagers and stakeholders accepted the 10MW station capacity option preserving the scenic character of the channel and improving navigation. The visual impact assessment became part of the Environmental Assessment Report and was documented on the Big Chute Environmental Assessment Overview video.

By resolving the cottagers' concerns at the planning stage, the design recommendations and public participation process avoided possible delays and a costly hearing process.

**FISH SPAWNING AND HABITAT ENHANCEMENT**

Walleye habitat is the preferred sport fish species in the Big Chute area. Walleye spawning became a significant issue because walleye prefer flowing water for spawning and the proposed upgrading would alter flow conditions in the Severn River and Six Mile Lake.

Fish habitat is protected by the federal Fisheries Act which provides the Department of Fisheries and Oceans (DFO) with the authority to modify, restrict or prohibit any work or undertaking which is likely to result in harmful alteration, disruption or destruction of fish habitat.
The DFO requires that the proponent enter into a fish habitat compensation agreement which demonstrates that all fish habitat losses will be compensated with replacement habitat and that ultimately, there will be an overall net gain in fish habitat with the implementation of the project. (DFO-Policy for Management of Fish Habitat)

To mitigate the potential adverse effects on walleye spawning habitat OH proposed to operate the station according to a protocol referred to as the “Walleye Spawning Priority” operation which protect the habitat by ensuring minimum flows during the spawning period. (Min. flow spawn-50 m3/s, proposed Min. flow egg incubation 20 m3/s and water temperature). The result was an improvement in habitat conditions by reducing the frequency and duration of high flow situations (station capacity alternatives) which inhibit spawning.

To compensate for fish habitat loss, the creative use of rock from channel excavation was used to enhance walleye spawning habitat and provide structure for other fish species. Cobble sized rock was placed in near shore areas downstream of the station discharge to take advantage of current for spawning. In the Big Chute tail race pool, the bottom was graded and rock placed along the shore to enhance Bass spawning habitat.

These enhancements will result in net improvements in spawning conditions over existing conditions (J. Gee, 1993).

ARCHITECTURAL HERITAGE AND THE CULTURAL LANDSCAPE

Initially OH proposed to tear down the existing building to replace it with a new facility. Concern with this proposal was expressed by the Ministry of Culture, Tourism and Recreation (MCTR) stating that Big Chute GS “has tremendous historical significance from the standpoint of the development of hydroelectric power in Ontario”.

MCTR asked that OH assess the historical architectural value of the station and its fit within the cultural landscape of the local area and the region.

Through an architectural consultant and the public participation program it was concluded that Big Chute was particularly worthy of preservation with tremendous potential for interpretive opportunities.

The final station design alternative involved constructing a new powerhouse while retaining a portion of the old station, along with industrial artifacts and information displays to best enhance the interpretive potential of the site as an interactive people orientated facility, sensitive to the site’s intimate heritage significance. (J. Gee, 1993).
POWERHOUSE CONSTRUCTION AND ENVIRONMENTAL MITIGATION

Following the project review and approval by the Ministry of Environment and Energy (MOEE), design of the powerhouse was awarded by Ontario Hydro to a hydraulic engineering consortium and an architectural firm based in Toronto.

Due to the positive results of the visual assessment at Little Chute the Landscape Architect was invited by the EA Coordinator to assist the Hydroelectric group in their negotiations with the Trent Severn Waterway (TSW).

TSW had several concerns, one being that the crossing of the Old Marine Railway by the new Powerhouse Access Road would undermine the historic and visual integrity of this important feature. Another concern was that the rock filled intake jetties which divert the flow of water to the power canal would dominate the shoreline of the upper Severn River. After reviewing the details of the engineering drawings, the Landscape Architect prepared wire frame views and rough sketches of the proposed developments for presentation to TSW. TSW accepted the results in principle and the recommendations to mitigate the impact of the above through a landscape restoration program.

These design recommendations resulted in an estimated cost savings of $300,000 to the project by allowing Ontario Hydro to build a temporary bridge across the old marine railway and retain low profile jetties on the Upper Severn River.

In the Spring of 1992, the Landscape Architect’s role in the project increased as site planning issues and restoration details developed in the on-going design process. These site restoration and mitigation concerns were identified generically in the EA report and it became evident that a landscape design program was needed to resolve the overlapping requirements of the many partners and stakeholders in the project.

VISITOR INTERPRETIVE CENTER AND PARTNERSHIP

A request was made in the Fall of 1992 by the Manager of Big Chute to produce site restoration and redevelopment plans for Big Chute with the Landscape Architect reporting directly to the Hydroelectric Business Unit. Working closely with the Corporate Relations Officer (OH) and the Chief of Visitor Activities (TSW), an integrated thematic program for the Visitor Interpretive Facilities and Fourteen Interpretive Signs was developed.

In the Spring of 1993, a design concept and site restoration plan was presented to and accepted by the Severn River Big Chute Implementation Committee. The Committee’s mandate
is to enhance Big Chute as a multi-faceted, year-round tourist attraction of regional, provincial and national significance in support of the economic advancement of the area. Ontario Hydro encouraged working in partnership with the Committee. It is comprised of community representatives including the Ministry of Natural Resources, Township of Georgian Bay, District of Muskoka, Huronia Museum and Ministry of Culture, Tourism and Recreation.

By mid-summer 1993, final redevelopment plans were completed and reviewed by TSW before contracting for a Fall 1993 implementation under the Electrical Power Systems Collective Agreement (EPSCA).

**SPECIAL FACTORS RELATED TO SUSTAINABLE ENERGY DEVELOPMENT (SED)**

Under the direction of Ontario Hydro's new Chairman, Mr. Maurice Strong, the phrase 'Sustainable Development' was expanded to include the energy sector. Defined as meeting the energy needs of the present without compromising the ability of future generations to meet their own needs, this concept is now widely accepted and is part of Ontario Hydro's corporate culture.

The concept originated at the United Nations World Commission on Environment and Development in 1987 (Brundtland Report) near the time that the Big Chute project began was only then being widely debated. In 1992, Mr. Strong, then Secretary General of the Earth Summit (The United Nations Conference on Environment and Development) in Rio de Janeiro, reaffirmed the goal of establishing new and equitable global partnerships.

It is in hindsight that we recognize that the approach and philosophy of project team members was to do “right” by the environment (navigation/water quality/fish and wildlife habitat/architectural heritage and cultural landscapes/landscape restoration/visitor interpretive centre) in balancing Corporate policies, economic costs and technical constraints with community concerns so that Big Chute can be seen as one of the first manifestations of the guiding principles of Sustainable Energy Development (SED). (See Annual Report 1993).

The redevelopment of Big Chute makes greater use of the water resource (a renewable energy source) to produce electricity without compromising the ability of others to use and enjoy this resource (eco-efficiency) either now or in the future. Environmental stewardship at both the regional (macro) and local (micro) scale was factored into the project from early planning, to preliminary design through to final construction and continues with monitoring and the day to day operations of the facility. Thinking globally yet acting locally was indeed on the minds of the project design team in developing partnerships in the decision making process to find equitable solutions that the community can be proud of. (J. Gee, 1993)
INTEGRATING THE MACHINE WITH THE GARDEN

In an economic climate of austerity and fiscal restraint the site works managed to be innovative by cost sharing among the partners, using local materials, salvaging artifacts, preserving natural features, maintaining bio-diversity and enhancing the sense of place.

The redevelopment theme incorporates a 'Minimalist' concept which reflects the appearance of the Uplands Open Barrens vegetation and geologic associations. The 'Minimalist' concept is appropriate and in fact essential if one is intent on maintaining the identity of the regional landscape.

The redevelopment encourages visitors to participate in the landscape through all the senses to experience 'simultaneous perception' (topophilia). The power of myth and symbolism was consciously employed to assist the visitors on their journey throughout the site. Links with the past reflect the importance of maintaining a continuity with space and time. The redevelopment ensures that there are places where the intimacy and comfort of the visitor remains harmonious and sympathetic to the natural setting.

The redevelopment included the design of a central visitor courtyard to draw in and orientate visitors to experience the fascinating history and environment of the rocklands, marine railways and generating station. Fourteen interpretive signs convey through maps, photographs, computer images and text, the history of the site and the operation and technology of the station.

In the court yard, a rippling effect in the paving pattern emphasizes, subtly, the impact that water has played in the development of the region. Stone features set into the paving were selected for their special forms and colour as well as for seating. At a subconscious level these features could be seen as small islands in a stream (Zen) reflecting local character at the micro scale.

The courtyard is linked to the water front by the visitor welcome sign. Two of these signs are installed to greet boaters and motorists to the area. The sign was designed to highlight the many attractions and display the strong sense of partnership in the community. The peaked tubular steel frame supports the colourful sand blasted wooden face of the signs which attract visitors to the focal areas.

Seating and signage were designed and strategically placed, along with all the amenities, to accommodate people with disabilities, the elderly and children.

An overhead structure and shade trees provide the central focus in the courtyard and reduce the apparent openness of this space. The overhead structure is based on historical
precedence. Greek revival columns were used on the first homes of the demolished hydro colony. The fascia reflects the simple roof lines of the surge tower just behind the overhead done in the same classical manner of the era. A picture of the Hydro colony is shown on the interpretive panel in front of the overhead so the visitor can still make this link to the past.

From the courtyard, the visitor descends a slope to the powerhouse interpretive centre on a ramp beside the power canal. The ceremonious ramp and pathway (3.0m) consists of Muskoka Rose crushed granite, bordered with charcoal granite edging. To further integrate the site, Staghorn and Fragrant Sumac, Virginia Creeper and other natives were introduced to increase aesthetic values over time thus reducing the impact of the concrete walls of the power canal and the steel structures of the transformer switchyard.

At the bottom of the ramp, an underground stream was diverted to provide a water feature next to the pathway. Lined with charcoal granite cobbles and boulders, all of the stone was selected from the blast rock at Little Chute channel.

It is at this point in the pathway that the visitor is bathed in the sound of running water and enclosed by the mesic woodland clinging to the side slopes of the powerhouse. The visitor enters the informal realm of the lower terrace with dramatic views of the lower Severn and the tailrace pool.

The lower terrace is the most unique place on site due to the sense of enclosure and the presence of the salvaged penstock feature. This area is meant to be a rest stop before the visitor makes the final descent on the wooden stairway to the powerhouse complex where the sound of falling water has reached its climax. Visitors can relax on the one tonne granite chunks that line the top of the slope or use the benches nearby.

People are encouraged to walk through the penstock to get a feel for the scale of the old technology and of the water that once rushed through it. The penstock was left within the context of its original location and not placed directly on the walkway where there would be no choice or option for the visitor. Children like running back and forth along the walls of the structure while echoing inside. The
circle, as a symbol (Jung) formed by the penstock, presents the visitor with a strong connection to the subconscious mind and a window to the Lower Severn River.

The terrace is paved with Brussels Block, a new product that was chosen for its weathered appearance and the buff and limestone colours which match the old and new walls of the powerhouse. The area below the power canal was excavated to install the new penstock which required restoration of the side slopes. This area was back filled with quarry stone in a series of bench terraces for stability. To naturalize the slopes, a special product called Proposys, a soil amendment, was applied with a pre-emergent meadow mix and covered with Geolute, a biodegradable erosion control blanket to advance healing. Wild flower meadows and remnant prairie associations are common in the Barrens. Native shrubs are planted at the edges of the meadow and woodland.

The visitor completes the journey in the power house interpretative centre where free standing interpretive panels tell the “Hydro” story and explain the technology of the old and new equipment. The technology and equipment is laid bare for the public to experience (Thayer, 1994 - coming to terms with technophilia/technophobia) after being hidden from view and inaccessible for more than 80 years.

The tourists either return the same way or they make their way over to the old marine railway and the foundations of the old hydro colony where further signage was installed and pathway linkages improved to the new parking lot located on MNR Crown land.

Finally, a diversity of native trees, shrubs, groundcovers and vines (45 species and 500 plants) have been used to enhance and soften the impact of the new hydraulic structures and integrate the site with the Upland Open Barrens.

Large pines (15.0m) and birch were saved and transplanted before construction began and moved to the Spillway bridge where they have successfully established.

On September 28, 1993 the Big Chute Interpretive Centre opened with much fanfare within the local community. The ceremonies ushered in a new era with talk of partnerships and stewardship without compromising the needs of the future.

The Big Chute Redevelopment received the Hurontario Heritage Award presented by the Huronia Museum in Midland on February 19, 1994.

In “The Ecology of Commerce, A Declaration of Sustainability”, 1993, Mr. Paul Hawken writes: “Good design can release humankind from its neurotic relationship to absurd acts of destruction, and aim towards a destiny that is far more realistic and enduring. The urge to create beauty is an untapped power, and it exists in commerce as well as in society.” Mr. Hawken asks all designers to, “Be fun and engaging and strive for an aesthetic outcome.”

**Ecological Design and Restoration for a Sustainable Future**

Big Chute is an important example of a small scale renewable energy technology (RET) being
reassessed, upgraded and redeveloped to improve its energy efficiency and the need to move forward with ecological design at the local level for planetary restoration.

"The one general imperative that seems to summarize what we see when we survey the global ecosystem, paradoxically, is that we need to act at the local level, to use wisely and in sustainable ways the life supporting capacities of local landscapes for local purposes" (Lyle, 1985). Thus, and to paraphrase John Tillman Lyle, one person holding a shovel holds the key to potential community empowerment in restoring the ecological integrity of the bioregion. "Smaller might be Bigger."

Through the healing power of nature we need to reawaken the regenerative potential of every site to minimize the impacts of our developments within our communities and the ecosystem.

One needs to look no further than the work (living machines & solar aquatics) of Dr. John Todd and Nancy Jack Todd of Ocean Arks International and the Lindisfarne Association, Center for the Restoration of the Waters, to see the future. In their landmark publication "From Eco-Cities to Living Machines, Principles of Ecological Design.", they outline the emerging precepts of biological design as follows:

1. The living world is a matrix for all design
2. Design should follow, not oppose, the laws of life
3. Biological equity must determine design
4. Design must reflect bioregionality
5. Projects should be designed based on renewable energy sources
6. Design should be sustainable through the integration of living systems
7. Design should be co-evolutionary with the natural world
8. Building and design should help heal the planet
9. Design should follow a sacred ecology.

In a sense, with the Big Chute Redevelopment, we have come full circle from near the end of the industrial age when the station was first built out of the wilderness, to the beginning of the ecological age in reassessing our energy needs by pursuing more sustainable forms of energy production, development and use.
BIG CHUTE

An investment in sustainable development

"Sustainable development is a matter of economic survival in a world of finite resources and unlimited desire for growth... government, industry and individuals need to become even more efficient in the use of materials and energy... "

Maurice Strong
Chairman, Ontario Hydro
August, 1993

Paul Shelton is a Landscape Architect with “The Landscape and Architecture Office”, at Ontario Hydro. The Architecture Office provides a Corporate wide service to the Generation, GRID and Retail Business Units. Mr. Shelton is recognized for his expertise in regional planning related to visual impact and cultural landscape assessments, greenway and waterfront developments, as well as site design for energy efficiency. His present interests relate to applying Sustainable Energy Development (SED), Renewable Energy Technology (RET) and a Biodiversity Conservation Strategy through a holistic Land Management and Ecological Systems based approach to projects.
SYNOPSIS IDENTIFYING ALL PERSONNEL AND CREDITS AT THE DESIGN AND CONSTRUCTION STAGE

Owner
Project Manager
EA Coordinator(s)
Corporate Relations Officer
Project Landscape Architect

Ontario Hydro
Ian Lauchlan
Don Chubbuck, Jon Gee*
Richard Schwass
Paul Shelton

SITE PARTNERS

Parks Canada,
Director General
Wayne PaceyChief of Visitor Activities

Trent Severn WaterwaySuperintendent/Acting
John LewisChief Engineer
John Good

Ministry of Natural Resources Planner
Wildlife Technician

Sue Jorgenson
David Hawke

Public Liaison and CommunityLocal Cottagers, Resort Owners, Government Agencies, Implementation CommitteesSpecial Interest Groups

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Design Architect

Hydraulic Engineers
General Contractor
KST Hydroelectric Engineers,
Ellis-Don Construction Ltd.

Monitoring and Environmental Studies
Beak Consultants

Artist
Juliana Hawke
BACKGROUND REFERENCES


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LEAD International: Participating in the Search for Sustainability

Susan Reed Tanaka, B. Arch., OAA
Chief Design Co-ordinator,
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Environmental problems transcend the boundaries of both nations and professions. To better define these problems, individuals from across all economic sectors and from many nations of the world will have to meet and resolve the increasingly complex environmental challenges facing humankind. In 1991, an international organization called Leadership for Environment and Development, known as LEAD, was created for just this purpose. I am privileged to be one of 16 mid-career professionals selected in 1995 for membership in LEAD Canada.

LEAD was formed by an international group of concerned individuals with the aim of creating a global college of individuals with the knowledge, values and skills to help meet the challenge of sustainable development. LEAD International is a non-profit organization, based in New York, and funded primarily by the Rockefeller Foundation. LEAD Canada obtains additional funding from the International Development Research Centre, and is supported by the National Round Table on the Environment and the Economy. The LEAD program extends over a period of two years during which the participants, known as Associates, undertake a course of study which is designed to complement their professional activities. This study includes two national
and three international training sessions plus additional personal study projects. The international training is currently held in Costa Rica, Thailand and Zimbabwe.

In 1992, the First Cohort of LEAD International met; LEAD Canada joined in 1994 with participants in Cohort 3. I am a member of Cohort 4, and the other countries participating in my Cohort include: Brazil, China, The Commonwealth of Independent States (the former Soviet Union), India, Indonesia, Mexico, Nigeria, Pakistan and the states of Southern Africa. At the time of writing this article, I have completed one national training session and one international session in Costa Rica.

When applying to this program, I was convinced that all global environmental problems could be solved by careful implementation of engineered solutions, as the problems were already fully defined. In addition, I naively believed that Canada's role in the program was to mentor developing countries with our technological expertise. After all, if Canada is ranked by the United Nations as being the best place in the world to live on account of having the highest Human Development Index, what do we need to learn? Armed with this confidence and conceit, I arrived at the first national training session in Ottawa.

It's quite a shock to be submerged in a training session with professionals from outside of the design and construction industry. When we first met and introduced ourselves, I kept asking myself: “What do I have in common with these people, and why was I chosen to be a part of this?” I very soon realized that I had very little in common with the other Associates, and each of us had been asking ourselves the same questions. We were, in fact, chosen for the diversity of fields which we represent.

The other Associates in my Cohort have expertise in many areas including: law, economics, public service, advertising, food retailing, recycling, television arts, transit planning and industry. While fluency in English is a prerequisite for admission to the program, during the national session I had to learn to articulate concepts without using architectural jargon. I was surprised to learn that the other Associates blamed the design and construction industry for "over-development" in Canada. One Associate stated that "Engineers and Architects are great at solving problems, but they don't know how to define the problems at the outset". I argued that design professionals are usually brought onto a design team long after the Terms of Reference has been defined by the client. We were all reminded of Einstein's quotation: "a clever man knows how to solve problems, a wise man knows how to avoid them". Slowly as the sessions passed, I began to lose my faith in technologically engineered solutions; they were beginning to look more like clever solutions than avoidance of the problems. But what were these problems, and how could we avoid them?

Having read two thick text books a month earlier to prepare for the course, the training began with an overview of the issues and progress of sustainable development in both Canada and the world. We arrived knowing that the World Commission on Environment and Development (also known as the Bruntland Commission) has defined sustainable development as: "development that meets the needs of the present without compromising the ability of
future generations to meet their own needs". I was soon to learn that no one had any solutions for the problems of "sustainable development", and in addition, the problems have not yet been defined. I asked myself: "Who is responsible for writing these Terms of Reference?". It all seemed very depressing, and I remember thinking: "There's too much to be done, there's not enough time, and there's not enough people who care about the future".

Following our overview of Sustainable Development theory, we began to look at how Canadians use their natural resources. Still convinced that the real issues of sustainable development are the population growth problems in developing countries, I was shocked to learn that each Canadian, on average, consumes 25 times the resources of a person in a developing country, and in doing so, creates environmental waste which is affecting the quality of our air, water and soil. We Canadians, through luck, own a disproportionate share of the world's natural resources, especially energy. We are also one of the world's greatest producers of greenhouse gases, which result primarily from the burning of fossil fuels and wood.

In 1995, a report was released by an international panel of 2500 scientists who concluded that the earth has indeed entered a period of global climate change. While in part this change can be attributed to natural occurrences, the scientists attribute part of the changes to human activity. In addition, they warn of significant social, economic and environmental consequences unless a major reduction is made in emissions of heat-trapping greenhouse gases such as carbon dioxide. While I could easily imagine the environmental consequences of climate change, I hadn't yet considered the social and economic ones.

Each day we learned about new resources and new problems. Lectures were given in the following areas: agriculture, energy & minerals, global warming and climate change, pollution, aboriginal & arctic issues, common property, fisheries, economics, and introduction to round table processes. The sessions were presented intelligently and typically each topic had three guest speakers: one representing the environment, one representing industry and one representing social issues. I began to learn that none of the problems were simple, and that most were interrelated. While I was disappointed to learn about the failures of governing bodies to effect change, small examples of hope began to emerge at the grassroots level. For an introduction to international issues, the ambassadors of Barbados and Kenya presented their views on sustainable development issues to our group, and patiently answered our questions.

In November 1995, the Associates of Cohort 4 from around the world met in Costa Rica for the first time. Being the only "industrialized" country represented, the Canadians were briefed before the session to be patient, and not to control the processes. We were divided in working groups to study banana production and eco-tourism in the rainforest. My group consisted of 23 persons, with representatives from each of the country groups, and at the end of the session, we were to make a presentation and submit a report. Have you ever worked with 22 other people on a project? Combine the size of the group with the fact that English was the first language for only three Canadians and one South African. It was immediately obvious at our first group meeting that there were a lot of language and cultural barriers to overcome. I
was also to discover that punctuality is a relative concept depending on your country of origin.

After three days of lectures to familiarize us with the history, political framework and culture of Costa Rica, our group set off, in a bus, to travel from the capital city of San Jose to the Atlantic coast. When we reached the banana plantations, I was horrified to see the capital investment required for banana production. Banana plants require well-drained soil. The new plantations, lacking natural drainage, have great networks of drainage channels, some 7 metres deep. The cost to establish this drainage for one hectare of banana plantation is approximately 5 million dollars (US). Needless to say, there are not many local farmers who can afford this type of farming, and most bananas in this region are grown by multi-national companies.

The fruit is grown inside plastic bags, and the plants are tied with plastic strings for support; nemathacides and fungicides are used extensively to limit worm and fungi damage on the fruit. We were fortunate to witness the harvesting of the fruit which is picked green, washed, sprayed with preservatives and packaged within minutes of picking. Many of the workers in the processing plant were women, probably as young as thirteen. A full one-third of the fruit harvested was rejected and dumped for cosmetic reasons. Some of the bananas, although spotless, were rejected because there were too few in the bunch, or the length or curvature did not conform to the standard. Canada imports more bananas per capita than any other country, and it is our expectation of a "picture perfect" banana that causes this waste. I began to think about all those banana advertisements which I saw in my youth, and to question my own shopping habits. (I have been buying organic bananas since returning home and my children have been eating them with no questions asked)

After the banana plantations, our group continued on to Tortuguero National Park which is a primary nesting site for many species of sea turtle. A three hour boat ride through a system of canals allowed us to witness howler monkeys, spider monkeys, an iguana, a crocodile, and many varieties of birds and butterflies. Our diesel powered boat with its noise and wash from the engines was disturbing to all. Tourism was evidenced by the great quantities of plastic bottles floating on the canals. As most of the eco-tourism industry is also run by large multi-national companies, it was difficult to see how the quality of life has been improved for Costa Ricans by this industry.

Our Costa Rican guide told us a story about recent reforestation efforts. Government bureaucrats (of European ancestry) met with the indigenous people of an area to determine which types of trees to plant. Each group prepared a list of the local tree species which they would like to see planted. Amazingly enough, the first choice of the indigenous people was the last choice of the bureaucrats. Being surprised, they asked the indigenous people how their choice had been made. The elders explained that this type of tree, while unremarkable, produces a flower which attracts many types of birds, and they like to have birds near their homes as it adds to their quality of life. The story made me realize how, as a society, we undervalue those things that don't add to our gross domestic product.

We also examined the role of the International Monetary Fund who promoted the clear-
ing of land and the development of banana plantations in Costa Rica when loaning money. The Structural Adjustment Program, later implemented by the IMF to repay foreign debt, included a condition of reduced social spending. While Costa Ricans keep only a small amount of the total banana production revenue in their country (approximately 5 percent), in the long term, they are the ones who will suffer environmental degradation and a reduced quality of life through cuts in social spending.

Our group concluded in its report that “quality of life” needs to be defined in terms that are more than just economic, and that it's difficult to measure the real trade-offs that Costa Ricans have made for the banana production and eco-tourism industries. We were unable to define “sustainability”, but at the same time, we were able to easily identify what is “unsustainable”. We recognized that efforts towards short term growth, without regard for social and environmental consequences were questionable. Most importantly, the 23 of us worked together and learned how to ask more questions. We are still in communication with each other using the Internet.

I have now completed the first phase of my LEAD training and I still don't know what improves “quality of life”, but I've decided to continue asking more questions. I'm trying to be influenced less by attitudes of consumption, to use fewer resources and to produce less waste. These are all small changes, but in combination they represent a significant shift in my attitude towards everything I do. I may be optimistic, but I believe we are all capable of making changes to balance the social, economic and environmental challenges required of us. The LEAD Program has challenged many of my misconceptions about environmental issues. I am looking forward to the remaining sessions in the program, and to further discussion of the issues surrounding sustainable development.

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A Survey Of Sustainability And Passive Design Curriculum Development In Schools Of Architecture

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INTRODUCTION

A breath of freshness is currently revitalizing Architectural education in Canada and the United States. The focus of the Architectural Curriculum is beginning to look outward and beyond formal issues of “style”. Recognition of the impact of Architecture and Urban Development on our dwindling supply of natural resources for both construction as well as embodied and operating energy has necessitated a restructuring of the curriculum to focus on issues of Sustainability and Passive Design, not merely as appended “technical” topics, but as conceptually directive considerations in the formation of environmentally conscious design. Such courses are being offered on both a core and an elective basis, as well as the primary focus of “Design Studios”. Research and development in the field is beginning to recognize a new “Sustainable Vernacular”.

Although there seems to be much abuzz regarding the teaching of Sustainability to stu-
dents of Architecture, the current state of this teaching is not clearly defined. In an effort to understand the present condition of Sustainable education, I am conducting a United States - Canada Survey on the influence of “Sustainability and Passive Design” on curricular content and direction in Schools of Architecture. The purpose of this paper is to present a snapshot of the current status of Passive and Sustainable teaching; address issues in approach related to “regionality” — on both a geographic and climatic basis; and review preferred teaching resource packages, texts, videos and software. The current data is based on 78 responses out of 190 mailings, representing 60 schools of Architecture in the United States and Canada). Respondents are typically teachers of Environmental Control Systems and Building Technology.

The survey questions were based on five areas of concern:

A. General: The overall status of Sustainable and Passive Design teaching in the School and the perception of impending “change” with regard to this status.
B. Sustainable Design: More definitive information regarding actual numbers of courses being taught and the format of that teaching.
C. Passive Design: More definitive information regarding actual numbers of courses being taught and the format of that teaching.
D. Support Material: A bibliography of recommended texts and references, videos, software and resource packages for teaching, as well as information regarding computer platform preferences.
E. Active Systems: The teaching of PV systems and wind power.

![Fig. 1. Passive vs. Sustainable Teaching by Percentage of Respondents](image)

Analysis of Responses

General Questions

Although Passive Solar Design may be characterized as an aspect of Sustainable Design, the survey specifically requested separate responses to the topics of “Sustainable Design Teaching” and “Passive Design Teaching”. Whereas Passive Design teaching has been increasingly incorporated into the curriculum since the energy crisis of the mid 1970’s, specific “Sustainability” courses would seem to have been more recently implemented in accord with current environmental con-
cerns — the majority after the meeting of the World Commission of the Environment and Development in 1987.

The results of the survey support the notion that Passive Design teaching has been more firmly established in Schools. Data indicates that Passive Design teaching is solidly established in the majority of schools with 79% of respondents recording the topic addressed either to a "great or moderate extent". The same respondents noted the teaching of Sustainability to a "great or moderate extent" in only 51% of the cases. (Figure 1) When queried as to the School's intention to expand teaching in the area of Sustainable Design, 50% of respondents noted anticipated or planned curriculum expansion. (Figure 2) When queried as to intentions to expand teaching in the area of Passive Design, only 23% of respondents answered affirmatively, (some adding notes to the effect that they felt that their current Passive Design course offerings were significant and not in need of expansion).

**Sustainable Design Versus Passive Design Teaching**

The nature of the questions in the Survey was based on the assumption that Passive Design is viewed as an aspect of Sustainable Design. Of the survey respondents, 82% categorized themselves as teachers of Sustainable Design and 74% teachers of Passive Design. (Figure 3) Of those, 68% claimed to teach both Sustainable and Passive Design, 6.5% Sustainable Design but not Passive Design, 14% Passive Design but not Sustainable Design, and 11.5% neither. It was surprising to find that a total of 25.5% of professors separated the teaching of Passive and Sustainable Design. This attitude seemingly contradicts popular thought in research, publications and conferences that positions Passive Design as a significant aspect of the larger realm of Sustainable Design.

The status of development of both courses in Sustainability and Passive Design, as related to the number of offerings on each topic does not agree with the assessment of the General situation in part A — that is that Passive is more established than Sustainable. (see Figure 1) Of those completing this section (24% of respondents noted either no course offerings or left this section blank) there were 153 Sustainability offerings and 100 Passive
offerings. (Figure 4) Of the Sustainability related courses noted, a larger proportion are offered at an intermediate level. Passive courses seem to be offered equally at all levels of difficulty. These answers are very "grey" as not all respondents noted course numbers, and many noted that the same courses addressed both topics. This would support the notion that 66% of the respondents characterized their teaching as addressing both issues.

Course offerings in both Sustainable and Passive Design seem to be significant, but inconsistent from school to school. The University of Oregon and the University of Manitoba noted as many as 8 courses with Sustainability Content; twelve noted no course offerings. The average number offered by schools teaching Sustainable Design was 2.6 courses. The University of Manitoba noted 6 Passive Design courses; eighteen noted zero. The average number offered by schools teaching Passive Design was 2 courses. In many cases professors specifically noted that the same courses were responsible for addressing both Passive and Sustainable Design issues.

When querying the methods of teaching Sustainability and Passive Design, most faculty felt overwhelmingly that the issues were not being addressed in enough depth or with enough exposure in the core curriculum. The issues are normally covered within other courses in Environmental Control Systems or Building Technology, and exist as a series of lectures. Sustainability courses fared worse in terms of their coverage, with a high percentage of offerings noted as "marginal" or "indirectly addressed". (Figure 5)

Within the curriculum, only 78% of respondents included the teaching of Active Systems: with 66% teaching Photovoltaics (PV) and 41% teaching Wind Power. (Figure 6) Of the respondents who do not teach Active Systems, only 10% plan to teach PV or 13% to teach wind power in the near future. (Figure 7)

**Curriculum Materials**

Relevant, current, comprehensible curriculum materials are essential to teaching. The survey queried recommendations based on self compiled course notes, text, video and software references and teaching resources.

An excellent source of "self compiled" curriculum materials is found to be the Society of Building Science Educators reference library. Members contribute copies of their course materials, course outlines, project handouts and slides. These are available for free use to
members who need only pay for copying and shipping charges. A superb list of references is available through the Secretary Treasurer of the SBSE. The top used texts to teach Passive, and the Passive aspects of Sustainable Design are, in order:

1. Sun, Wind and Light by G.Z. Brown and Virginia Cartwright
2. Climatic Building Design by Don Watson and Kenneth Labs
3. Design with Climate by Victor Olgyay
4. Mechanical and Electrical Equipment for Buildings by Guinness, Stein and Reynolds
5. InsideOut by G.Z. Brown and Bruce Haglund
6. Environmental Control Systems by Fuller Moore
7. Heating, Cooling and Lighting

by Norbert Lechner

The most popular text on Sustainable Design is the “Primer on Sustainable Building” published by the Rocky Mountain Institute. The most significant lists of readings on Sustainable Design were submitted by Robert Pena and John Reynolds at the University of Oregon, and Don Watson at Rensselaer Polytechnic.

Energy and Passive Design software has seen some exciting additions in the last several years. The most frequently cited program, by far is Energy Scheming 2.0 (Macintosh) by G.Z. Brown of the University of Oregon. The second two most used programs come from UCLA for DOS platform: Climate Consultant and SOLAR 5.3. These were developed by Professor Murray Milne. Several new programs were released this year and show great promise.

“Spreadsheets for Architects”, a book and disk com-
Combination from Van Nostrand Reinhold by Leonard Bachman and David Thaddeus of the University of Houston, allows for easy add on of Lotus 1,2,3 for sun angle calculations (amongst other functions). Energy-10 (Windows), authored by Douglas Balcomb was issued for Beta-testing at the Passive Solar Energy Conference in July 1995. The program allows for complete energy analysis and design modifications for major building types based on TMY data. Ener-Win (Windows), by Larry O. Degelman of Texas A&M University was issued for Beta testing at the SBSE Training Session in August 1995. This program examines the whole building energy performance with simulation and prediction for retrofits.

Perhaps the most innovative teaching resource initiative comes from the University of California at Berkeley, Cris Benton, Project Investigator, in association with the Pacific Gas and Electric, The Energy Foundation and the U.S. Department of Energy, and the Society of Building Science Educators. Under the title "Vital Signs", a series of 12 energy and passive design teaching resource packages are being developed for wide distribution to Schools of Architecture in the United States and Canada. Seven resource packages were launched in August 1995: HVAC Systems and Components by Walter Grondzik (Florida A&M University); Health in the Built Environment by Tang Lee (University of Calgary); Whole Building Energy Use by Larry Degelman (Texas A&M University); Glazing Performance by Michael Utzinger (University of Wisconsin at Milwaukee); Interior Illuminance, Daylight Control and Occupant Response by Marc Schiler (University of Southern California); Dynamics of Solar Heat Gain Through Windows by Scott Johnston (Miami University); and, Measurement and Display of Thermal Performance of Buildings by Murray Milne (UCLA). All of the packages address theory, field protocols for various levels of student experience, assignments and additional references. Most also include software programs. The resource packages offer instructors in Passive and Sustainable Design an opportunity to add depth and hands on exercises to their current curriculum. For more information, Vital Signs has a home page on the Web.(6)

**Geographic and Climatic Analysis**

Based on the mapping of data from Questions 1 and 2, "Does your existing curriculum address issues of Sustainable / Passive Design?", a geographic tendency can be visualized. Passive Design receives more attention in hot-arid and hot-humid climates. Indeed a response from the University of Arizona stated, "living in the desert as we do, there is no choice but to teach
Passive Design!”. For Passive Design, the incidence of “great” is significantly higher in the west, filling in with “moderate” in the remainder of the west and south and extending northward, but with notably little attention to the topic in the northeast. For Sustainable Design, the incidence of “great” and “moderate” responses is also significantly higher in the west and south than elsewhere in the country.

There is significant agreement between the University of origin of authors of texts, software and Vital Signs Resource packages with geographic/climatic location and impression of achievement in the teaching of Sustainable and Passive Design. The University of Oregon, University of California at Berkeley, UCLA and the University of Houston have all been responsible for the production of important texts, software and teaching resources — and all rate their teaching of Passive and Sustainable Design highly.

**Conclusion: The Ultimate Question...**

It is critically important that Schools of Architecture increase the amount and depth of teaching of Passive and Sustainable Design. It is intended that the research content and analysis of this paper provide a better understanding of the current status of what is or is not being taught in Schools of Architecture as well as serving as a source for faculty who desire to expand Passive and Sustainable Teaching, or who are searching for resources, means and contacts to revitalize existing courses. Much hesitation in curriculum development is due to a lack of knowledge of what “others are teaching”. It is hoped that the dissemination of the findings of this survey will assist in filling that void. More detailed information regarding the survey data and resource sources is available through the author.

*Terri Meyer Boake, is employed full time as an Assistant Professor at the University of Waterloo School of Architecture since 1986. She is responsible for core curriculum development and teaching in the Technology Theme Area, including Building Construction, Theory, Design and Passive/Sustainable Applications and Principles.*
Footnotes

1 Young and Wright Architects, Toronto. The Environmental Impact of Building Materials. “The embodied energy of buildings can represent up to 30 years of operating energy...”

2 Vital Signs Curriculum Materials Project. “...buildings) account for more than one third of national energy use and over sixty percent of national energy consumption.”

3 In this instance Active Design Strategies are included under the umbrella of Passive Solar teaching. The survey does not at this point attempt to single out the teaching of Active Systems. I am in the process of issuing an addendum question to separate Active versus Passive Teaching.

4 These schools are: Arizona State University, Auburn University, Ball State University, Boston Architectural Center, California Polytechnic State University, California College of Arts and Crafts, Carlton University, Clemson University, College of DuPage, Florida A&M University, Iowa State University, Kansas State University, Kent State University, Laval University, Louisiana State University, McGill University, Miami Dade Community College, Miami University, MIT, Montana State University, New Jersey Institute of Technology, North Carolina State University, Oklahoma State University, Rensselaer Polytechnic University, Roger Williams University, Savannah College of Art and Design, Sonoma State University, Stevens State School of Technology, Technical University of Nova Scotia, Texas A&M University, University of Arizona, University of Arkansas, University of Calgary, University of California at Los Angeles, University of California at Berkeley, University of Cincinatti, University of Florida, University of Hawaii at Manoa, University of Houston, University of Idaho, University of Manitoba, University of Maryland, University of Minnesota, University of Nevada at Las Vegas, University of North Carolina at Charlotte, University of Northern Iowa, University of Oregon, University of Southern California, University of Tennessee, University of Texas at Arlington, University of Toronto, University of Waterloo, Virginia Tech, Washington State University, Washington University, Wentworth Institute of Technology, Widya Kartika University (Indonesia), Yale University

5 Society of Building Science Educators. For more information, contact Professor Leonard Bachman, College of Architecture, University of Houston, Houston, Texas 77204-4431, 

6 The Vital Signs Project. Contact Cris Benton at cris@ced.berkeley.edu
Environmental Education: Teaching Sustainability Through Design


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THE RISE OF ENVIRONMENTAL EDUCATION: ENTERING THE ECOLOGICAL AGE

The past decade has seen a dramatic increase in environmental awareness, particularly through the context of sustainability. In 1987 The World Commission on Environment and Development (the Bruntland Commission) gave us the term “sustainable development”. In 1992 the Earth Summit and its “Agenda 21” focused on issues of sustainability in ranging from global trade to power relationships to biodiversity conservation. Although still in their political infancy, environmental issues have come to play a more prominent role on Western government agendas. Sustainability has come to inspire hope as a response to the environmental crisis, and as such, it offers a promising new context for education.

Emphasizing sustainability, environmental education has become a new feature of many Canadian school curricula in the 1990s. At a recent conference of the Canadian Educators’ Association, the teaching of ecological principles was advocated as a core element of the curriculum, beginning as early as Grade Three (Dale, 1995). Sustainability and related concepts
such as ecosystem health are entering the educational program explicitly as a branch of social
studies, while ecology and environmental science join the core life and physical sciences.
Universities now offer post-graduate programs in environmental education, and teaching spe-
cialties range from political ecology to environmental law. Clearly, environment-centred edu-
cation is a priority for the 21st century.

There is no better place to begin educating for sustainability than within the school
building and site, both figuratively and literally. Through planning and designing innovative
schools and community facilities which are explicitly environment-centred, from the program-
matic features to the building materials to the site plan, we can literally “teach by example”. In
so doing, we begin the process of educating for ecological, economic, and social responsibility,
which are cornerstones in the foundation of sustainability.

This paper outlines an epistemology of sustainability and the guiding principles
derived for ecological planning and design. Using these principles, we focus on architectural
responses to environment-centred curricula as an emerging theme in educational programming.
Specifically, we discuss innovative approaches to ecological planning and design within an edu-
cational context. Two educational and shared-use community facilities are highlighted in which
the natural (non-built) and cultural (built) environments are implicitly and explicitly integrated
to demonstrate a planning and design philosophy of sustainability in practice. The ecological
planning and design features discussed include: educational programming elements which can
be designed and built into the facility to serve as teaching tools; landscaping and site planning
which takes advantage of natural ecological amenities; restorative/regenerative landscaping
techniques to create on-site environmental teaching elements; and building techniques and
materials selection which improve environmental quality (or maximize positive benefits) and
minimize negative impacts.

AN EPISTEMOLOGY OF SUSTAINABILITY:
GUIDING PRINCIPLES FOR ECOLOGICAL PLANNING AND DESIGN

Ecological design constitutes but one of a wide diversity of approaches to sustainability. In the
simplest sense, planning and design for sustainability requires us to follow Ian McHarg’s (1969)
premise to “design with nature”. Implicit in this approach is the need to re-connect the
management of nature’s household (ecology) with the management of the human-cultural
household (socio-economics). The reconnection of humans and nature and the recognition of
our interdependence is the essence of a systemic, holistic world view modeled after nature
itself. In this sense, understanding “nature as teacher” is the key to understanding sustainability.

The now much-maligned term, “sustainable development”, first popularized by the
Bruntland Commission (1987), emphasized technological sustainability rather than ecological
sustainability (Orr 1992) as a response to the environmental crisis. This definition focused on
meeting the needs of the present without compromising the needs of future generations, while the ensuing political emphasis was placed on the noun “development”. As World Bank economist Herman Daly notes (1991), this definition simply implies that continued and steady development is necessary to accommodate a growing population. It does not consider either the finite carrying capacity of the Earth, or the fact that natural systems do not and can not assume unlimited growth.

To create a more ecologically and economically meaningful definition for sustainability, Orr (1992) suggests 6 characteristics which effectively portray ecological sustainability, and which we believe, serve as useful guidelines for ecological planning and design. 1. Ecological sustainability requires the recognition that humankind is finite and fallible. Despite increased education, we remain limited in our ability to comprehend and manage scale and complexity. Furthermore, we risk serious consequences by operating at scales too large or complex for our limited comprehension. 2. Ecological sustainability can only be achieved through educated, empowered communities and a return to civic virtue. That is, a responsible, ecologically literate and active citizenry must work towards sustainability from the grassroots up. 3. Ecological sustainability is rooted in the past, in traditional knowledge which has co-evolved out of place, nature and culture, as much as it is in the acquisition of new knowledge. 4. Nature is a model for ecologically sustainable planning and design, not merely a set of limits. 5. With nature as a model for sustainability, we must recognize the need for decentralization and smaller scales of operation. (This relates to the first point, insofar as humans cannot successfully manage large scales or complex systems.) 6. Ecological sustainability requires the recognition of interconnectedness and a systems view of nature. An epistemology based on systems and meta-patterns or “patterns that connect” (Bateson cited in Orr, 1992) offers philosophical guidance in the pursuit of sustainability.

As planners and architects designing for ecological sustainability, we must practice Leopold’s (1949) art of “living lightly on the land”. To help us with this task, we subscribe to a set of ecological planning and design principles based on Orr’s (1992) six characteristics of ecological sustainability and similar to the thinking of McDonough (1992), Todd and Todd (1984), Van der Ryn and Cowan (1996) and others. Specific to our work in educational facilities, we emphasize three aspects of sustainability which we deem critical: Educational Excellence, Ecological Responsibility, and Economic Viability. The following section discusses these three domains of sustainability which serve as guiding principles for ecological planning and design.

**Educational Excellence**

The first guiding principle for the ecological design of educational facilities must be of course that they foster educational excellence. Beyond the necessary links to curriculum an programming, a design for sustainability must emphasize ecologically-responsible, small-scale and
locally-relevant learning. In an effort to educate a new generation of ecologically literate and responsible citizens, educational facilities must be designed in such a way that pupils learn the art and science of sustainability passively as well as actively. The building and site should facilitate active learning through its features and programming layout, while passive learning should be facilitated through the use and incorporation of natural features, ecological processes and appropriate (visible) technology. In this sense, the building and site should serve as a teaching tool. In ecological design, nature and technology should be made visible so that the design teaches us about and brings us closer to the systems that sustain us (Van der Ryn and Cowan, 1996). Thus, in the context of educational excellence, we advocate a design that is focused on an ecosystem perspective and the central concept of interconnectedness.

**An Ecosystem Perspective**

An ecosystem perspective calls for a recognition that the environment is “home”, resulting in an awareness and sense of place about the facility and site for users. This means that design ideas focus on using the site and its topography, natural features, cultural history, and location as design opportunities rather than constraints. In this respect, it is important to consider the watershed perspective. Specifically, the planners and architects, in collaboration with the client(s) and users, should ensure that the local watershed and surrounding bioregion are given explicit design consideration. In this way, we ensure that the facility fits into the local context, both culturally and naturally, and is respectful of both the site and larger watershed features.

**Integration of Nature and Culture**

In keeping with the principles of ecological sustainability, the design team should seek to demonstrate the principle of interconnectedness through integrating the natural ecological environment with the cultural and built environment. In doing so, we integrate the outdoors with the indoors and facilitate learning from the “outside in”. This can be accomplished by a variety of creative means and has distinct educational and quality-of-life advantages. For example, we advocate the maintenance and incorporation into the design of any natural site features. Existing woodlots, grasslands, or outcroppings can be used effectively as a means of on-site, outdoor education as “living laboratories” for the physical and natural sciences. Similarly, we can provide teaching and experimental garden plots adjacent to the facility which may also serve as regeneration/rehabilitation areas for native species. The outdoor component can be complemented indoors by the provision of (e.g.) indoor classroom composting units, and the use of green plants as air-quality enhancing agents. In these ways, the site becomes an educational amenity as well as an ecologically responsible development.
**Ecological Responsibility**

Ecological responsibility is a key guiding principle for educational facilities designed for sustainability. The model of nature and living systems provide the foundation for ecological design (see for example Todd and Todd (1984), Van der Ryn and Cowan (1996)). Using nature as a model requires adherence to the concept of resilience, which is central to nature and all living systems. In natural systems, resilience refers to the (flex)ability of a system to withstand and recover from disturbance, or to “expect the unexpected”. As Orr (1992) notes, design based on resilience is dynamic, flexible, adaptable, small-scale, resource conserving, culturally suitable, and technologically elegant. In practice, this requires the maintenance of natural linkages and processes and the use of low impact technologies.

**Maintenance of Natural Linkages and Processes**

Using a living systems approach to design requires sensitivity to ecological context and the maintenance of ecological linkages on the site. In this respect, we advocate naturalized landscaping and the use of teaching trails to supplement outdoor “living labs” and thematic garden. Similarly, we try to use the site’s topography to enhance rather than constrain design: e.g. nestling the building into an outcrop/escarpment to provide natural microclimates and unique habitats for teaching as well as conservation purposes. In this way, a variety of views and vistas incorporating the site’s natural relief are also integrated within the building. To provide low-maintenance (and low-cost) naturalized landscaping on the site, we specify (where appropriate): hardy, native or local plant species rather than ornamental/horticultural plant species; self-regenerating plantings such as perennial wildflowers/grasses rather than annuals; and use of existing woodlots/vegetation which may be buffered for outdoor education and wildlife habitat.

**Low-Impact Technologies**

Using nature as a design model calls for the use of technologies which are low-impact, which means that they should incorporate living systems where possible, be derived from or powered by a renewable resource, and should not produce pollution or toxic wastes. Living technologies include: Todd’s (1984) solar aquatic “living machine” for the treatment of on-site human waste, and “junglification” or “living walls” made up of indoor green-plants and aquatic organisms which maintain humidity and purify air. Renewable energy sources such as wind and solar provide not only sustainable energy production but also highly visible and informative teaching tools within and around the building. Furthermore, building specifications should emphasize non-toxic and responsibly produced/harvested building materials. Examples of such specifica-
tions include: low or non-VOC emitting carpeting and floor finishes; paints and finishes which are latex and oil-free, heavy metal-free, and non-PAH emitting; and native Canadian or plantation wood materials rather than tropical or clear-cut wild species. (See for example, the American Institute of Architects' Environmental Resource Guide, a regularly updated environmental materials/technologies information base.)

**Economic Viability**

In addition to the obvious demands of present society for economically viable design, designing for sustainability also requires economic viability. The key difference is that economic viability in the context of sustainable design is focused on longer time frames and the consideration of environmental costs and benefits. In this sense, ecology and economics are seen as compatible with rather than in opposition to the project (Van der Ryn and Cowan, 1996). This principle should really be termed "ecological-economic viability" to clarify that economic viability ultimately depends on ecological sustainability. Means of achieving economic viability for educational facilities include using resource conserving technologies and the creation of innovative business-education partnerships.

**Resource Conservation**

Resource conservation begins with the selection of a renewable energy source wherever possible. (See above section on Low-Impact Technologies) In addition, we may recommend the following routes to energy conservation which can dramatically reduce operating costs: optimization of the building envelope through (e.g.) high R-factor insulation and energy efficient windows; rigorous avoidance of internal heat gains through the use of daylighting-integrated lighting systems; specification (when used at all) of smaller and more efficient HVAC systems which can flex to accommodate changing loads; and the use of living walls. We also advocate the several water conservation techniques ("Best Management Practices") which can significantly reduce costs both on site and to the community at large. Storm water can be recycled through the collection and use of both site and hard-surface runoff as irrigation for landscaping, and/or the use of clear drain pipes from the roof so that the drainage process becomes a teaching tool. On-site storm water management can be achieved through natural filtration/percolation through vegetated buffer strips or a constructed wetland so that the runoff contributes to ground water recharge or landscape irrigation.
PARTNERSHIPS

In keeping with the collaborative community spirit necessary for sustainability, partnerships should be facilitated wherever possible between the educational facility and local businesses or government agencies. Furthermore, the development of shared-use facilities offers a collaborative means to achieve community goals. Through emphasizing partnerships among both financial supporters and user groups, a more economically and ecologically sustainable project can be achieved. Shared-use educational and community facilities (e.g. as highlighted below) use less land and resources, cost less per user, and provide a wider range of educational and recreational benefits to users than would individual facilities.

TWO CASE EXAMPLES USING AN ECOLOGICAL PLANNING AND DESIGN APPROACH FOR EDUCATIONAL FACILITIES ARE HIGHLIGHTED HERE.

THE HUMBERWOOD CENTRE (FIGURES 1 & 2)

The first case is the Humberwood Centre, a shared-use educational and community facility in Etobicoke, Ontario, which opened in January 1996. The facility is situated on the banks of the Humber River, adjacent to the Humber College Arboretum, and links two schools, a library, daycare and community recreation centres. As the winning scheme in a limited design competition, the Humberwood Development Centre was featured in The Canadian Architect (1994) and has since received much attention as an example of a successful shared-use facility. Designed in the spirit of sustainability, the Humberwood Centre's features are based on the notion of "environment as home", the concepts of integrating natural processes and linkages, and establishing a sense of place. The Humberwood Centre is one of the first truly integrated developments of its kind and incorporates a variety of innovative, educational, ecologically-responsible and cost-effective design features.

A Watershed Perspective: The Humber River forms a vital linkage with Toronto's waterfront. Situated adjacent to the river, the facility contributes, on a small-scale to a healthier waterfront through natural and cost-effective water quality enhancement on the site.

Educationally linked to the river, the facility demonstrates the dependence of community health on environmental health. Educational
landscaping and programming features help realize and enhance this critical linkage. Educational storylines, such as the history of the river, local people, climate, and wildlife habitats are incorporated into the landscape design. To celebrate the valley vistas, the building is sited to preserve existing treed areas, capture southern sun exposures and screen outdoor areas for improved micro-climate.

The Humber Arboretum and Nature Centre: The Humberwood Centre’s proximity to the Arboretum facilities allows for the exchange of creative educational and recreational programs. The facility has been designed to extend its structure and programs, not intrusively, but compatibly into the valley, inviting users to explore the Metro trail network and programs offered by the Arboretum. The landscape plan emphasizes the valley connection a pedestrian and bicycle trail system linking the east riverside to the west, the Arboretum lands, and the Metro Trail.

Natural Storm Water Management: Storm water from the facility’s roof and hard surface areas is collected and filtered naturally on the site. This is achieved through the “Habitat Corridor”, a primary structuring element, which provides both stormwater filtration and a symbolic transition of habitats through vegetation. Discreetly secured, the Habitat Corridor provides a rich landscape environment at building entrances. From public walks and classrooms, students can watch seasonally varied birdlife, changes in weather patterns, rainwater collection, and the effects of water on plants. Urban reforestation, using low-maintenance, native species includes upland plants, lowland thicket communities, and dry and wet meadows. Careful planting design has ensured complete visibility throughout the site. Existing woodlots and hedgerows require only minimal management yet provide an important river linkage. Storm water is polished off-site, in a series of small, constructed wetlands, where thick reeds and grasses do the final cleansing before the water is discharged overland towards the river.

Low-Maintenance Landscaping: Historic settlement and agricultural use have disturbed the site, providing an opportunity for creative habitat regeneration. Reflecting the Humber College Arboretum’s philosophy, we developed a cost-effective, ecologically-based regeneration plan of low-maintenance, non-manicured landscaping, based on enhancing existing woodlots and re-introducing native species (as above, the Habitat Corridor). This plan also provides the educational benefit of an on-site, naturally evolving diversity of habitats and associated wildlife, which reflect seasonal changes throughout the year.
THE ISLAND PUBLIC/NATURAL SCIENCE SCHOOL (FIGURES 3 & 4)

The Island Public/Natural Science School scheme is a finalist in a limited design competition held by the Toronto Board of Education. (At the time of writing this article, a winner had not been selected.) The proposed facility is a replacement school, on a new and highly visible site, that includes a shared-use day school and outdoor education/natural science school for the Toronto Board of Education on the Toronto Islands. The dual program for the school has operated for the past thirty years as a junior kindergarten to grade 8 day school for Island and Harbourfront children, as well as an outdoor education centre for the entire Toronto Board of Education system. The natural sciences program component is structured so that every Grade 5 or 6 student enrolled within the Board has the opportunity to visit the school for the period of one week, accompanied by their homeroom teacher, to study the unique ecology of the islands. Recognizing that existing facilities are dated and inadequate, the Board approved construction of a new school and intends to have the facility completed and operational by January 1999.

Building, Site, and Island as Teaching Tools: The building and site are designed for active and passive study of natural and cultural heritage, learning for sustainability and the promotion of environmental citizenship, one of the Province’s Core Curriculum “Outcomes”. This is achieved through the use of the ecological and water quality monitoring areas, the energy and water conservation technologies, the thematic gardens and wetland area as outdoor “living labs”, and the building’s architectural reference to Island history. The Island effectively becomes the school as the classrooms extend past the walls of building to the landscape demonstration gardens, the maintained parkland and beyond to the Lake. The interior classroom design creates a whole systems view of the classroom environment through use of ceiling height, solar orientation, and windows for understanding solar energy, energy conservation and the physics of air motion. Furthermore, the clustered classroom design accommodates a variety of year-round learning situations including multi-age teaching, and team teaching opportunities. The “Common Ground” foyer and adjacent library provides for informal study and discussion, while encouraging development of social skills.

Promotion of the Toronto Islands’ Heritage: Promotion of the Islands’ Cultural Heritage is fostered through the preservation of historical and archeological sites, and architectural ref-
erence to Island history through school building forms (e.g. Common Room and Weather Monitoring Station as a lighthouse, and the Dormitories as a waterfront hotel/Park Pavilion). The building forms reflect elements of the existing school via roof lines, fireplace, classroom entrances to nature, and bay windows. The landscape plan re-establishes and enhances pedestrian connections through the Metro park system to facilitate waterfront and park activity, and formalizes a physical connection between inner harbour and Lake Ontario.

Protection, Conservation and Enhancement of Islands’ Natural Heritage: The planned landscape features are low impact, restorative/regenerative, low maintenance, and naturalized: e.g. classroom gardens, a constructed wetland, dunes, a butterfly garden, courtyards and play areas. Native flora and fauna are encouraged to re-establish themselves in specific areas of the site, and an in-place long-term maintenance plan assures sustainability of landscape design features and therefore, conservation of natural heritage.

Promotion of Environmental Citizenship and Stewardship: Stewardship is fostered through the use of naturalized/succes-sional garden plots which are designed with a specific educational purpose and theme: e.g. butterfly gardens, allotment gardens, a naturalization area, and demonstration wetland. The landscape plan and learning gardens are designed to convey appropriate stories about the islands’ cultural and natural heritage while functioning as a diverse and sustainable ecosystem. Students learn about sustainability and stewardship though active use and care of the thematic gardens as “living labs”, and through low-impact building technologies such as composting toilets. Similarly, ecological and water quality monitoring stations (indoors and outdoors) and linkages between gardens, maintained parkland and the Lake serve as educational programming features.

Low Impact Building Design and Technologies: The building is designed with proven renewable energy sources and ecological technologies. Features include a “living wall”, composting toilets, use of Lake water for heating/cooling, and passive power generation via a windmill. The living wall is an example of “junglification” or the use of indoor green plants which conserve energy, maintain humidity and improve indoor air quality. Water resources are con-
served through storm water recycling and collection/filtration of both site and hard-surface run-off in a wetland area. The building design also specifies non-toxic, low impact and native building materials, including sustainably harvested white pine logs.

**Low Operational Cost Through Resource Conservation:** Energy conservation reduces the present and long-term operational and environmental costs through optimization of the building envelope, avoidance of internal heat gains, and a “living wall”. Water conservation reduces operating and environmental costs while improving environmental quality and adding educational benefit. Recycled and collected water is used as irrigation for landscaping, and for educational purposes in the demonstration wetland with native landscape habitats. Low maintenance landscaping features (naturalized areas, wetland, gardens) reduce both ecological and operational costs.

**Affordability Through Partnership Commitments:** Partnership commitments arranged by the Design Team between education and business will facilitate ecologically responsible and economically viable features such as wind-generated electricity, computer and information technology, and the “living wall”. There has also been a provision made for a future Metro or Board interpretive centre and food services component in a highly visible location. As well, the design allows areas such as the Common Room, Dining and Lunch Rooms, General Purpose Room, Seminar Rooms to be available for private sector income-generating use as (e.g.) a conference centre or banquet hall.

**Closing Comments**

Conventional planning and design have effectively ushered in an era of environmental crisis. Traditional linear thinking, short-term planning and near-sighted design have resulted in the homogenization of heterogeneous landscapes, species and cultures, leading to a simplification of nature’s complexity and loss of diversity. We have created what Shiva (1994) calls “monocultures of the mind”. Yet the concept of sustainability offers renewed hope that we can respond with perhaps both intelligence and elegance to the environmental crisis. To do so, we must look to nature as our teacher, embrace its complexity, and model our designs on its systems. Ecological sustainability requires a fundamental re-education of ourselves and, for our children, a shift to environment-centred education. The education of an enlightened new generation must start from the outside in. It is our hope that an ecological approach to planning and design will facilitate this process at the heart of the educational institution.
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ACKNOWLEDGMENTS

The authors acknowledge and appreciate the efforts of the Design Teams for the case studies featured in this paper. For the Humberwood Centre, the Design Team was comprised of: Moffat Kinoshita Associates Inc. in joint venture with Zawadzki Armin Stevens Architects Inc.; Hough Woodland Naylor Dance (Landscape Architects); and Gartner Lee Ltd. (Environmental Consultants). For the Island Public/Natural Science School, the Design Team was comprised of: Zawadzki Armin Stevens Architects Inc.; Allen & Associates (Environmental Engineering), Earth Projects (Educational Environmental Consulting), and Todhunter Schollen (Landscape Architects).
REFERENCES


The Earth as Primary Educator

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Last year’s paper titled “The Earth as Primary Architect”, sought to address the ‘big picture’ by exploring the development of a functional cosmology that would enable architects to more effectively address the current ecological crisis by re-aligning their creativity with the natural creative processes of the planet.

This year’s paper continues that discussion, attempting to develop it one step further, evolving an understanding of the earth, not only as primary architect, but also as primary educator. The purpose of such an exploration is to discover how this new understanding of the larger context in which we practice our profession might influence curriculum so that architecture students will be prepared to deal with an enormous environmental task.

Once again, the paper draws heavily from the works of cultural historian Thomas Berry, and others, who are dedicated to achieving a mutually-enhancing, human-earth relationship.

The Role of the University as it Relates to Architecture

As architects, we find ourselves in a time of accelerated transition and change. Not only are we experiencing many changes on the technological level that affect how we deliver our services, but we are also facing major structural changes within the economic realm, both domestically
and globally, that are having a dramatic effect on our bottom line. Notwithstanding these changes, I wish to suggest that the most significant transformation affecting the future viability of our profession, and, indeed of the entire human venture, is occurring at the macro level of existence. What I'm referring to is what the cultural historian Thomas Berry recognizes as "the transition from the terminal phase of the Cenozoic age of the earth's geological history to its emerging Ecological age."

Unlike the Cenozoic age, which unfolded in splendor apart from any role fulfilled by humans, in the Ecological age nothing of major significance will unfold that humans will not be involved in. We are already witnessing the destructive effects of human activity on the ability of the planet to sustain its life-supporting systems. The likelihood of us securing a future for humans will primarily depend upon our ability to address the imperatives of human living while allowing the creative processes of the earth to flourish. In order to achieve this integration, Berry insists that it will first be necessary to acknowledge the earth as the primary self-nourishing, self-governing, self-educating, and self-fulfilling community. Furthermore, we must come to understand that universe education, earth education, and human education are all stages of development in a single unbroken process of creative evolution.

The role of the university, then, will be to serve as a centre for the creation and communication of a functional cosmology. This will prepare students for the necessary transition from the terminal Cenozoic to an emerging Ecological age, in which the human species co-habitates with the entire earth community in harmony and balance.

**Towards an Architectural Education for an Ecological Age**

It will be the task of all education, including architectural education to play a leading role in de-glamourizing our current myth of Progress, and to replace the entrancement of the modern/industrial world view with the entrancement of the possibilities inherent within the Ecological alternative. If we are to successfully address the ecological crisis that looms before us, students must be encouraged to think in ways that are different from the ways that created the crisis in the first place.

So far our education has focused primarily on the skills necessary for us to bring forth the natural resources of the earth and to shape these resources in a way that will best serve the needs of our western industrial society. And although this scientific/technological training has been tempered by cultural studies in the humanities, Berry claims that "education has not adequately provided students with the contemplative skills or imaginative capacities for dealing with numinous presence or with the aesthetic insight into the inner structure of reality."

Having employed a primarily reductionist methodology, we have excelled in examining the universe in quantitative terms by breaking it into its component parts. In so doing, we have forfeited an understanding of the universe as an integrated whole with a psychic-spiritual dimension.
as was understood by both primal peoples and even the classical/traditional human civilizations. We have learned to substitute an understanding of the other as ‘subject’ with a belief in the other solely as ‘object’. The excellerated exploitation of the earth over the previous few centuries is the result of such a limited world view.

However, more recently, the scientific community has come to a much greater understanding of the universe in its origin and development. And whereas the account of the Universe story is scientific, and therefore focused on its physical properties, Berry insists that it also has a mythic and symbolic significance because the story is beyond anything that rational intelligence can properly understand. “What is needed, however, is the completion of the story of the physical dimensions of the universe by an account of the numinous and psychic dimensions of the universe.”

The Universe is the only text without a context. Everything we know and learn ultimately defines itself reverentially within the context of the Universe. This is why an integral story of the Universe itself becomes the encompassing contextual framework for the entire educational process. According to Berry, “the sublime mission of modern education is to reveal the true importance of this story for the total range of human and earthly affairs.”

I would now like to accept Berry’s challenge and explore how an architectural education based on the universe story might unfold.

The role of the first course of a new architectural curriculum will be to present students with a functional cosmology based on the sequence of evolutionary phases of the universe story. Telling this lyrical narrative will provide the inspiration necessary for students to awaken the core of their own creativity. From the initial bursting forth of the primeval fireball, to the development of the galaxies, our own solar system, the planet earth, and ultimately all the elements necessary for the rich diversity of life that we know today, the story of the Universe reveals its ongoing creative process that we as humans continue to be a part of. As the great educator Maria Montessori so aptly states in her treatise entitled ‘To Educate the Human Potential’, “Human consciousness comes into the world as a flaming ball of imagination.” Through our human consciousness, we have become the self-reflective awareness of the Universe and as such are capable of recognizing, reflecting and acting upon the incredible beauty of the natural world that surrounds us as a result of this creative process. The Universe is the source of all creativity and because we are born of the Universe, ultimately we cannot help but be creative ourselves. Architecture in its sublime form becomes just one of the many celebratory expressions of this intimate understanding.

Telling the story of the Universe will awaken in students a sense of the mystery, awe and wonder inherent in its creative processes. Students will come to realize the need to re-align their own creativity with the creativity of the universe. Most recently, human activity has had a profoundly undermining effect on the ability of the planet to sustain the conditions required for this creative process to flourish. As Berry suggests, “This course, if related to the stars we see, the air we breathe, the water we drink, the food we are nourished by, the earth we stand on,
the natural life of the environment as well as the cities we inhabit, could evoke a profound sense of mutual presence of the student and the universe to each other." Accordingly, "the student could begin to appreciate something of our human responsibility for the destinies of the entire earth process, even of the universe process." Hopefully then, students will embrace the challenge of becoming participatory co-creators in the great work of the universe and come to fully understand both historically and personally, the significance of their role in creating the next phase of the story.

The Universe has a vested interest in their efforts to re-vision the future, so students need not feel overwhelmed by the task. A functional cosmology provides the origin and identification of values indicated by reality as we experience it. These values are manifested in the self-emergent processes of the universe itself. Berry identifies that the universe emerges as a process of "differentiation." From the beginning, the universe has articulated itself in unique, identifiable, intelligible energy constellations, or patterns. Each articulation is unrepeatable and irreplaceable. "From the iron core of the earth to the flower, from the eagle in flight to the human persons who walk over the land... each of these is a unique expression of the total earth presence."

The second value is "subjectivity". Berry believes that each individual reality carries with it an interior depth of being that not only reflects itself, but also resonates with the numinous mystery that pervades all the world. This quality he says, exists universally in all living and non-living beings but its activation in the human order provides the creative dynamics of the thinker, the poet, the scientist, the farmer, the educator, the architect, and every other role fulfilled by humans.

According to Berry, the most important is the third value which is "communion", since "every reality of the universe is intimately present to every other reality of the universe and finds its fulfillment in this mutual presence. The entire evolutionary process depends on communion." This value centered around the attraction of every physical being to every other physical being is manifest in a number of ways from its most elementary expression in the law of gravity to the most entrancing and intimate expressions of human affection. Our failure to fulfill this law of communion with the natural world is the reason for proposing a revised program of professional education that attempts to remedy that failure.

The universe story not only establishes the core values of a functional cosmology in which students can re-cover their creativity and participatory role, the story also remains the all-encompassing framework for the practical unfolding of the entire architecture curriculum. Within this context of the universe story for example, students will come to a completely different understanding and appreciation for the building materials that we as architects manipulate, form and mould into our creative design solutions. To reiterate from my submission last year, "This is because the universe story includes the story of copper and iron, of limestone and trees, of sand and water and the story of how each came into being in the evolutionary process of the planet. Out of their stories might come a renewed respect for their intrinsic value, that is,
an understanding of the sacred dimension and the recognition of the contribution to the development of our own species and to the ongoing role they play in sustaining life on the planet."

Cultural studies would also take on a whole new meaning within this context of the universe story and more particularly, the earth's story. According to Berry, in its evolutionary process, through the development of a vast complex of genetic codings, interrelated so that each depends upon all the others, the earth has, in a manner, taught itself the arts of life, an accomplishment of supreme competence. Even more remarkable, it has evolved a species that "is genetically mandated to invent a second level of its own being, a cultural realm, a realm freely developed in which the human gives itself its own identity in time and space and expands its activities in language and imagination and in that vast complex of activities that we indicate by the term 'human culture'. " We are genetically coded to think and to respond to our environment. How we think and how we respond is to a great extent dependent upon our cultural coding. Human education plays a primary role in the process of handing down our cultural coding from one generation to the next.

Not only does there exist today an incredible diversity of cultural expression on the planet, but also there has been a historical sequence of change in the cultural coding of the human, throughout its evolutionary development, which needs to be understood. Therefore, any study of culture must be expanded to include all the various phases of human cultural development: The Paleolithic phase, the Neolithic village phase, the period of the great religious cultures, the scientific-technological phase, and the emerging ecological phase. This would enable the students to see the continuity of their own personal development in the prior development of the universe, of the earth, and of all human history and thus, come to discover their personal identity in historical time and cultural space.

At each successive phase of cultural transformation, the human species has essentially 're-invented' itself. Each phase is characterized by its own creative energies and contributions to the development of our cultural coding. According to Berry, the student "could more easily appreciate the genius of the time when the languages of the human community took shape, when the religions and arts and social forms of the world were developed, when the great humanistic cultures were formed, when the elementary technologies were invented, as well as appreciate how the modern sciences emerged within the European cultural region, and the need now for a new adjustment of human modes of being and activity to the dynamics of the natural world." Of particular importance to the student will be how the architecture of each successive phase of cultural development provided a tangible and enduring expression of the era's understanding of the relationship of the human to the cultural and cosmic orders, how it helped to establish the boundaries between order and chaos.

A critical analysis of each phase of development would also put the student in touch with what the human venture has forfeited with the passing of one phase into the next and a sense of meaning and purpose for the historical mission of our own times. With the passing from the Paleolithic to the Neolithic we lost a certain intimacy with the wildness of our nature,
with the immediacy and interdependence upon the natural world for our survival and well-being. With the transition to the phase that brought into being the great religions and civilizations, with their large urban centres of culture, we lost another level of intimacy with our own human communities that was available to us in the Neolithic Village. With the dawn of the scientific-technological age we lost a sense of divine presence in the world and established the machine as the dominant metaphor for understanding the reality of things.

A mapping of the evolution of the universe on a simple horizontal line graph would demonstrate a continued creative development towards greater complexity and diversity through the formation of the galaxies, our own solar system, the planet earth and the entire range of life that has evolved in the last 4.5 billion years of earth history. A parallel line starting with the emergence of the human showing the evolution of culture, would begin to diverge at a point approximately 12,000 years ago and rise sharply away in a hyperbolic curve demonstrating that human cultural development despite its advances, has fallen out of alignment with our genetic coding and as such, with the ongoing core values demonstrated by the creative processes of the universe and the planet. What's more, students would see that this fall from alignment on the part of the human has dramatically impaired the ability of the earth's own creative dynamics to continue. Therein lies the imperative of the next transition from the scientific-technological phase of cultural development to the emerging Ecological age; that is, to re-establish the human within its natural context, which will require, as Berry puts it, to once again “re-invent the human at the species level”.

A course of study in cultural history then, would also have to address the possibilities and losses inherent in an emerging Ecological Age. As Berry suggests, it should deal with articulating the integral functioning of the biosphere, healing the damage already done to the earth, letting go of our addiction to progress as currently defined, and instead, bringing into being a renewable economic order by the integration of the human within the ever-renewing cycles of the natural world.

All professional education programs will need to deal with their own particular renewal within this context. For their part, it will be the responsibility of architecture students to deal with the issue of human habitat and by this I mean the entire range of built forms necessary for the functioning of the human community. At this year's conference on Designing for the Environment, guest speaker Paolo Soleri reminded us that “Human habitat is the most pervasive intervention of any species on the planet's ecosystems.” It may be helpful here to recognise that ecological issues are complex and perhaps cannot be understood through a single discipline. This may mean that in order to be an architect in the Ecological Age, it will be necessary to also have a working knowledge of other disciplines such as agriculture, solar technologies, forestry, land management, wildlife, waste cycling, and economics. By constantly seeking to broaden our context, we will hopefully begin to make the connections that illustrate the interdependence we depend on for a sustainable future.

Design studio will provide the forum for the further development and integration of all
the new insights that these other courses have afforded the student. The studio experience should allow the student an opportunity to leave the classroom and to discover “first hand” the spontaneities inherent in the design laboratory that is the natural world. According to Berry, “education must be a pervasive life experience.” Learning to observe nature with insight and to listen to her voices with care and respect, to allow one’s own spontaneities to be in dialogue with those of the natural world around us, will equip students with the knowledge and skills necessary to live well in a place. By developing intimate relationships with the soil, the rivers and streams, the natural features, and all the other living beings of a particular bio-region, students will come to appreciate the need to achieve harmony between human demands of habitation and the ecological processes that define the complex order of interacting life systems throughout the planet. In the words of David Brazier,

With each breath I am linked  
in a single orbit  
With the great forests.  
My out breath is their food,  
Their fills my lungs.  
Last year  
I was a tree  
And the tree was me.

With this approach, “ecological literacy” becomes the new foundation, the new reference for the development of a student’s design competence. “Ecological literacy,” in David W. Orr’s words, “is driven by the sense of wonder, the sheer delight in being alive in a beautiful, mysterious, bountiful world.” In order to sustain the hope and energy needed to survive the cultural transformation from the terminal Cenozoic to the emerging Ecological Age, it will be necessary to promote and nurture in the student this sense of the natural world’s numinous dimension. The interior landscape of the mind responds to the character and rich diversity of the exterior landscape. Therefore, the continued impoverishment of our outer landscape will reflect a corresponding impoverishment of our own imagination and creativity. We can only remain creative if the planet’s own creative processes are allowed to flourish.

In principle, we have explored a number of ways in which an architectural curriculum designed for the Ecological Age can evolve. It will be the role of educators to develop in more detail, the specifics of the courses taught and the studio problems offered. The underlying goals and/or tasks, however, should remain the same and deserve reiterating. In closing, the first will be to offer a critical analysis of our mainstream culture that has emerged out of the modern/industrial world view. The second will be to assist the student in developing a functional cosmology based on the universe story. The third will be to re-aquaint students with the natural world. Finally, it will be imperative that students come to recognise and fully accept the
responsibilities of their role in bringing about the Ecological alternative. Only then can we hope to maintain the viability of our architectural profession within a sustainable future.

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ACKNOWLEDGMENTS

Co-Editors: Gary Pask and Barbara McLean
Production Manager: Barbara McLean
Art Direction and Design: Reactor Art & Design Ltd.,
Shari Spier (416) 703-1913
Printing: The Printing House Limited

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