Ontario Eco-Architecture

Submissions to the Ontario Association of Architects Committee on the Environment

Call for Papers for EnviroFest, May 1995
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From the beginning the Committee on the Environment (COTE) felt that a "call for papers" on environmental topics would serve a number of objectives all at the same time.

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

We wanted to reach members that had an interest and felt they could make a contribution either by way of example and case study; or conceptually in expressing innovative approaches, propositions or research.

We also wanted to stimulate and involve members, promoting the work and ideas of Ontario architects both within the Association and also more broadly to others.

The idea for a call for papers was first suggested by Rob McCrea then Council Liaison for the COTE. Rob had been impressed with some of the environmental publications of the American Institute of Architects (AIA) and felt strongly about promoting the work and expertise of Ontario architects.

But to what extent did it exist? Other than a small group of well publicized practitioners, who else was undertaking this work? After some discussion it was clear how useful the Call for Papers could be. So we initiated the process in the early Fall of 1994 with our expectations quietly held in reserve and we waited for the response.

Our hopes for an enthusiastic and interesting response were justified. We received a great many expressions of interest covering a wide variety of subject areas and approaches. Virtually all submitters were encouraged to develop their briefs into papers.

The papers contained within this publication represent a large percentage of the number
of 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 project was a success was given to Gary Pask. The tremendous effort involved in coordinating, discussing and working with each of the authors to produce this work is gratefully acknowledged by the Committee.

Similarly the Committee owes thanks to Barbara McLean who worked with Gary at each stage and took on the task of arranging and managing publication within the limited financial resources of the Committee.

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

It has been an exciting project to initiate and see reach this stage. The Committee sincerely wishes to thank the authors for their participation and efforts in contributing to the project.

The papers presented in this publication document a significant level of interest in environmental design issues. The content and ideas presented signal a noteworthy body of experience held by our community.

With the publication of the papers, we will have completed only the first stage of our ambitions for the project. We hope that the document will encourage architects to consider the many inherent possibilities in their work for greater environmental sensitivity, reduced ecological impacts and better performance.
Introduction

Gary Pask, OAA, MRAIC
Member
OAA Committee on the Environment

These papers or essays fall somewhat loosely into three themes: Materials and Systems; Projects and Case Studies; Education and Philosophy. Although we have conveniently dropped each essay into a category of sorts, on closer reading, you will find most of them comfortably bouncing from theme to theme. Each theme and essay, however, is equally important; they stand shoulder to shoulder, their urgency hailing our attention. Each one shows its stuff, what architects can contribute; indeed, what some architects claim clients expect them to contribute.

In the first theme, Materials and Systems, Peter Berton kicks off by narrating an adventure into wood, where his search leads him into a maze made more of pulp than old growth forests. Vince Catalli quickens the pace with the Ottawa two-step — balancing the dogma of a government program with the dancehall chaos of its applications. At the tag end, the team of Brent Day and Hitesh Doshi weave specific beginnings to choosing and specifying products from the fabric of friendlier roofing systems.

From houses to communities, the second theme, Projects and Case Studies, begins to spread some of the thematic seeds established in Materials and Systems. Linda Chapman's straw-bale house not only piggybacks a continuing, historical approach to energy efficiency, but also, significantly, applauds volunteer teamwork. Richard Williams essay on The Body Shop's new headquarters outlines, in a single project, effective energy-efficiency (including The Living Machine), use of natural light, reuse of materials, reduction of off-gassing materials — and all of this hand-in-hand with corporate functionality! Award-winning Phillip Sharp's description of his healthy-housing reveals much more than just his creative and investigative techniques. Between the lines, it asks moral questions that aim at the heart of the underlying principles ricocheting through our society. And speaking of values, Charles Simon's brand of holism applied to the planning and implementa-
tion of a YMCA camp extends the scale and starts to make sustainability feel at arm's length. Anchoring Projects and Case Studies is Luigi Ferrara's live/work regulations that guide us to "conserve, condense, and collapse" our designs with accountability that we, our clients, and our users can measure with some confidence.

Finally, in Education and Philosophy theme, Terri Myer-Boake proposes we start at the start — with education. Before we put our collective pencils in our mouths and dream our architectural dreams, perhaps a lesson or two in designing by the other 3 R's might green all of us with some profitable envy. Lighting up your psyches, Roberto Chiotti goes cosmic over the state of our souls as both architects and human beings, encouraging metaphysical ideas that promise to possibly lift you in quantum steps toward environmentalism and sustainability.

For me, working with the members of The Committee On The Environment — notably, Barb McLean, Neil Munro and Kristi Doyle — and the writers of these essays has been, above all, a lot of fun.

Not surprisingly, no two perceptions about the environment and sustainability, especially as they relate to architecture in Ontario turned out alike. And that's good! If, however, continuing along these lines, we work together building foundational principles and values, at least by consensus, then maybe, just maybe, we'll give those that immediately follow us a similar world to the one we were given. Or something concrete to build upon...

Enjoy these essays. Cheer their writers.

Go little journal!
Wood Products and their Environmental Implications

Peter Berton, B. Arch., OAA, MRAIC

Director
CA Ventin Architect Ltd.

INTRODUCTION

Manufacturers of wood products have taken up the cause of protecting the environment, each of them extolling the virtues of its products and its contribution to saving the planet. What is unclear to the specifier, is how manufactured wood products stack up environmentally against simple dimensional lumber. Does the fact that many manufactured products use waste (such as sawdust and chips) automatically create less impact on the environment? As architects we have no simple means of establishing the validity of the “green” claims made or how to weigh and compare the criteria.

Why are we interested? Apart from our own responsibilities as architects and human beings, clients are increasingly asking for information relating to the environmental performance of materials. It makes good business sense to know more about what we specify. In our own firm's case, we were retained to design an environmental learning centre which is intended partly as a “living demonstration” of environmental principles and their applications to school children. Instructors could point out various building parts or systems and demonstrate why they were selected and how they work, in relation to their environmental aspects, providing a building which in itself is an educational tool.

Because the building is in a rural location and the steering committee had indicated that
the building should have a non institutional feel, a palette of natural materials was selected with
the natural choice being wood as the major element.

So what methods did we have of determining comparative environmental benefits of vari-
ous wood products? Other than our own hard research – none. As a result, we undertook to
establish a knowledge base on the various materials we were considering.

Originally this paper was undertaken to see what could be unearthed for the use of archi-
tects who would like to have more knowledge of the materials they are specifying. It was not
intended to be an exhaustive comparison of materials as the length of the paper cannot achieve
this. It may, however, clarify this subject, and could be regularly updated and built upon.

Any act of building is inherently damaging to the environment. As such, it is impossible
to identify an ideal material or process. The intention is not to prove that one material is more
green than another. This paper is simply a discussion of appropriateness of a material for the use
intended. The specifier may want to use the ideas presented here to make their own evaluation.

The Process

In selecting materials that are prefinished, one might assume that these manufactured and pro-
cessed materials are less friendly than their natural counterparts, but perhaps this is not the case
in that durability, recyclability and other factors may outweigh the negative effects of the manufac-
turing process. This is an example of the complexity of ideas to be examined and discussed.
Some of the materials we considered include:

- dimensional lumber;
- natural wood siding and sheathing;
- plywood;
- waferboard;
- particleboard;
- MDF board;
- microlam/parallam;
- wood I's etc.;
- pressboard shingles;
- prefinished pressboard siding.

What is the best way to undertake the task? The first step is to establish various
criteria for making some judgement on which materials are appropriate to use in specific circum-
stances. Without being experts, we simply brainstormed and came up with the following list of
potential factors:
• forest resources depletion;
• manufacturing and transportation impact;
• energy consumption;
• presence of toxins or other by-products;
• durability;
• biodegradability;
• appropriateness of finishes e.g. stain on natural wood vs. prefinished product;
• recyclability;
• recycled content;
• cost;

These criteria basically come under five areas of the “cradle to grave” or life cycle analysis process. This concept is described under the following headings: Resource/extraction, process of manufacture, construction, use and post-use/disposal.

Once these areas were defined, we drafted a questionnaire and forwarded it with an explanation to 21 companies who manufacture relevant products including stain manufacturers (the list was randomly created using our catalogues, and a list of the companies we forwarded the questionnaire to is available on request).

**Wood Council**

In addition to the questionnaires, we contacted the Canadian Wood Council, Forintek, the National Research Council, the C.M.H.C., Forestry Canada, and others to see what information was available.

The Wood Council indicated that they knew of no existing related research, and that they primarily deal with dimensional lumber. They did get back to us after trying to find relevant information and would try to get us a report on a “sustainable forestry” research paper. It turned out that this was still in progress. But more on that later.

The NRC – Division of Building Research had no applicable information and forwarded us to Forintek. Forintek could only forward research if we know the name of a specific paper on the subject. They suggested we talk to Jamie Meil, who was doing Forintek’s comparative work on wood vs. steel, as well as Environment Canada, CMHC and NRC. Jamie Meil, Environment Canada forwarded us to Forestry Canada, who suggested Forintek and the Canadian Wood Council. CMHC referred us to the NRC. NRC did have some discussion on adhesives and preservatives, flame-spread ratings but did not refer to any specific research.

This perhaps will help to understand why the subject is so difficult to research.

After all this, we were contacted by John Burrows, the director of Technical and Education Services for the Wood Council. It seemed that now we had caused quite a stir as the Wood
Council had received queries from their members on the questionnaire, and the Council appeared concerned that we would be gathering information on our own. He urged us to “review existing information rather than create anew... to enlighten OAA members”.

After our exhaustive efforts to source existing information this was a welcome change. Furthermore, we did not believe we were “creating new information” by asking manufacturers to respond to a questionnaire on their products, but were compiling existing information. We subsequently received a package of materials from the Wood Council which included two parts of the nine part report on “Building Materials in the context of Sustainable Development”. This is an exhaustive and technical document using a spreadsheet format compiling life cycle data on lumber – not an easy reference tool for an architect.

**Questionnaire Response**

Of the 21 companies who were forwarded questionnaires, we received completed questionnaires from four with a handful of other responses containing industry literature regurgitated from the Wood Council. With this small response, it is difficult to draw conclusions, but what we did receive was helpful.

**Evaluating Wood Products and Environmental Performance:**

Given the range of positions taken by interest groups in the wood industry, it is important that architects gain an informed position on the products they specify. A widely accepted method of analyzing the process (and the one espoused by the lumber industry) is to separate the life of a product into its parts and assess each phase of its use to gain an understanding of the full range of impacts instead of focusing on one particular aspect. This is useful in selecting the appropriate material because the end user may place more emphasis on one aspect than another. For example, schools may consider air quality issues to be more important than, say, forest resource depletion and so on.

The five stages of the cycle are as follows:

1. Resource/Extraction
2. Processing and Manufacturing
3. Construction
4. Occupancy
5. Demolition/Disposal
We set out at the beginning to gain a better understanding of how to analyze wood products, we will therefore examine various product types in relation to the five stages of the life cycle.

Note that the wood industry generally supports this method of analysis because it draws some of the attention away from the negative aspects of resource extraction and distributes it over all of the stages of the process, where wood generally fares well against other materials - e.g. steel and manufacturing energy required. It is not our intention to compare wood to other materials but to compare natural wood products and manufactured wood products.

1. Resource and Extraction:
In the few responses we received to our questionnaire, the answers were often “not applicable”. I believe this often meant that they did not know, but in some cases the “method of extraction” question was answered in this way. The method of harvesting lumber is almost always “clear cut harvesting”. One could argue that manufactured products do not fall under this category because their sources are by-products but for the purposes of this paper we will assume that one of our major concerns would be forest resource depletion, and the central concept of “Sustainable Forestry”.

The most noteworthy item we have discovered in the research is that the development of Standards for Sustainable Forestry is underway. One question that Forestry companies have been getting asked increasingly by architects and buyers is “Does the wood we specify come from sustainable forests and how do we ensure this?” The forest industry has responded with the “First Standardizing national, voluntary guideline for sustainable forest management”. The CSA guideline – The Sustainable Forest Management (SFM) Guidance document (2808) – is scheduled to be ready in May of 1995. This document is apparently the first document which enables manufacturers to use a standard by which to measure their practices. This paper is not the place to describe how it works but its seven basic elements are stated as:

- Principles
- Planning
- Commitment and Compliance
- Public Participation
- Implementation
- Monitoring and Documentation
- Continual Improvement

Exactly what these elements mean is not clear in the CSA update quoted above, but the purpose of the standard will be to assure the consumer that “wood used to manufacture the goods they buy is derived from forest operations managed on an environmentally sound and sustainable basis as defined by representatives from a broad spectrum of Canadian Society”. This spectrum of Canadian society will consist of about 40%-45% environmentalist and general interest
groups and the balance evenly split between professionals, academics and producers.

The standard will form part of the "International Standard for Sustainable Forestry" under the (ISO) International Organization for Standardisation in which Canada's forestry industry is to be playing a major role. The organization is currently in the process of setting standards for an Environmental management program "The ISO 14000 standard" for all industries due out in 1997. Forestry Canada is taking a large part in creating an international standard because if the Canadian Industry sets high standards which only it follows it won't be competitive. The "ISO 14000 Standard" will provide a standard for comparison, which is extremely important for our export Canadian industry and which is under the scrutiny of an international market.

As previously stated, this paper is not the place to discuss the workings of the standard, but the CSA literature available to date on the subject is vague. Nowhere in the material does it explain what exactly sustainable forestry is. Perhaps this will be made clear when the document is presented in May 1995. From what I can understand sustainable forestry considers the effect of clear cutting on streams, fish habitat, soils and so forth. Whether or not lumber will be stamped is not clear, but it seems to be the goal. As an aside, an interesting experiment is underway in B.C. called the Mass Plot, where various types of harvesting are being studied. Checkerboard, clear cut, shelter wood (trimming out the strongest trees) and selective (thinning out the weakest trees) are all being examined for their effects.

There is also a school of thought which states that the amount we are getting out of the forests does not equal what we are putting in, in terms of burning of fossil fuel for extraction and processing. If this is the case then forestry and its current methods cannot possibly be sustainable because the environmental balance sheet does not add up. There is a very large difference between the way lumber is extracted now as compared to 75 or 100 years ago when logs were removed by a few men and a team of horses. Some say economics will derive maximum efficiency and therefore environmental sustainability, but if fossil fuels remain cheap then this cannot occur.

Manufactured products presumably use the by-products making some ecological sense. Many manufactured structural products such as laminated veneer lumber and parallel strand lumber use up to 50% less wood fibre than conventional framing systems, and they come from second growth forests requiring smaller trees that are often faster growing species such as aspen. Prefinished natural wood siding uses #2 and better lodgepole pine or balsam lumber - in other words not old growth forests. No information was returned to us for press board siding, but it is similar to MDF board which uses hardwood logs from New York State, in the case of the product made by Norbord Industries -one of the few respondents. Anecdotal evidence suggests the use of wood fibres as by-products of sawmill operations.

2. Processing and Manufacturing:
The architect/specifier is urged to carefully consider this stage. It is simple to ask the supplier for the information you need in the processing of materials as well as visiting the plant to watch the product being made - an effort which will be sure to spark more thoughtful questioning. While
architects may think this a time consuming effort, it should be considered a marketing endeavour because selected knowledge will be value added to the architect's services. Many clients will be interested in discussing and learning about the philosophical and environmental issues surrounding the selection of products.

The issues are outlined in the questionnaire but primarily energy consumption, effluent, packaging, transportation, on-line recycling and chemical toxins content should be examined. It appears that dimensional lumber is the least processed and packaged of any of the products. However, when control of waste and application of finish is under factory conditions, there is less waste and recycling is easier, because waste is uncontaminated and does not need to be transported back to the factory from the site. Many of the manufactured wood products are using 20 - 40% recycled material off the line.

3. Construction:
Part of my interest in this subject is related to design. Environmental consciousness must begin at the front end – not “out of the tailpipe” to use the words of William McDonough, the renowned environmental architect. Use, and reuse of materials has to do with how the product is designed, and we can change things if we let our needs and opinions be known to manufacturers.

Design and specification must include an analysis of how much waste the product generates. For example, brick walls generate very little wasted brick for a conscientious mason, as the increments are small enough to be used whole with little cutting, except in half. This occurs only if the designer has considered the modular brick size in the design, calculating coursing and so on. Wood is no different, particularly with sheathing and studs which come in standard sizes, but in architect designed buildings we are less likely to account for standard wood sizes as rigorously as we do masonry.

Adhesives used in MDF board, plywood and waferboard must be identified in light of worker safety and particulate matter, and off gassing. This will be further discussed under Use and Service Life below.

While the structural efficiencies in certain manufactured products are far better, they require a higher level of care and protection during construction. Most of these materials are susceptible to moisture delaminating and can lose their properties if they get wet – rendering them pure waste. Prefinished siding, particularly pressboard requires similar diligence in protection from surface damage.

Ease of construction and energy required for the placement of materials, such as cranes should also be analyzed. Heavy timber and glued systems may represent far higher embodied energy once in place as a result of fuel burned to place them.

4. Use and Service Life:
A major design issue today is air quality. In wood product selection, it is imperative to determine what types of adhesives and finishes are being used, as many MDF boards and plywood are still
using Urea Formaldehyde glues. These are well known irritants to those with respiratory sensitivity and therefore it was a definite concern in the design of our building, where school children will be sleeping. The issue of air quality is the subject for another paper (or ten) but it is a key part of the overall picture when considering life cycle analysis. The widely accepted substitute for urea formaldehyde is phenol formaldehyde whose constituent elements, when combined, render each other inert and minimize off gassing to below 0.05 ppm. This is very low when you consider that natural wood itself off gasses organic acids at quite a high rate. In any case, aged seasoned softwood is the best in terms of minimizing offgassing. Also, a general rule is to allow the products to dry out at least a month before going into service.

Maintenance is another tradeoff. The less maintenance then the less recyclable or biodegradable the product generally is. The length of time in my experience, between hand staining or painting of natural wood siding is up to 7 years. It is approximately doubled by most prestained materials under the warranties we have seen, and it is possible that these finishes may last longer. Some of the pressboards have a 30 year guarantee but this durability has yet to be proven in service. It is worth thinking about the service life of the siding substrate itself, assuming say 75 to 100 years. If you are only gaining a small percentage of the life time before restraining then the processing cost may not be justified. If less material is used in the long run there may be a case for its use. Check the amount of finishes used in premanufactured products to make your decision. If it is only twice what’s done by hand there may have been minimal environmental benefits in the long term.

5. Post Use Disposal:
There is nothing more biodegradable than natural wood. It is also available for recycling in other uses if cosmetic appearance does not matter and there is no rot. Even most of the premanufactured products – save for potential presence of toxins – will break down under conditions after repeated exposure to moisture. What becomes of the adhesives after decomposition? This is something I have not yet researched.

Current thinking is that if you use materials that are “of the site” then you are being as environmentally conscious as possible. That is – the materials were born there and they will die there. There is no transportation or processing. Natural materials such as wood certainly will score high in this area.

However, the question must be asked, why is it being disposed? Is it worn out? If so the object of design is to minimize the amount of product disposed of and maximizing reusability. And for that, as in preservation and conservation, ongoing maintenance is the key.

Conclusions
As a Canadian I have always had a passion for designing in a regional framework, using a local
palette of materials as opposed to what is designated by an International Style. But what I have really learned researching this paper is that we architects know very little and must add a layer to our thinking. I also realize that I bit off more than I could chew, as the subject is huge and it requires a more scientific approach than I can undertake. It does, however, propose a framework for thinking about building materials, and it could use much more detailed research. I believe a whole paper could be written about adhesives, for instance.

Our nation has been built on the extraction of natural resources for lucrative markets here and abroad. Money literally used to grow on trees. Our ancestors presumably thought the vast supply of lumber available would never end, and let’s hope this is true. The economic base and culture of our country is based on the extraction of raw materials – lumber, minerals and fish. The lumber industry appears to be acting in the direction of environmental responsibility, but I am suspicious from my experiences, that this may be lip service with a “business as usual” attitude. It is up to us as designers to become knowledgeable and continue to apply pressure.

My approach will be to continue to educate myself and try to understand which aspects of the life cycle are important for specific projects and clients. Other advice: do not squander the resource. Design responsibly and timelessly and avoid trendy approaches which reduce the useful life of the building. Remember that the wood industry’s main goal is to sell wood, particularly in competition with other products like steel. An architect’s main goal is to design responsibly, and the broader our knowledge and understanding the more effective we will be in getting the industry to change to meet our – the buyer’s needs. Press the industry for answers. Compile data. Question everything. There will never be a perfect answer and I expect the evolution to continue – but at least we will know more than most about the subject as should be expected of our profession.

I love using wood – it’s natural beauty is timeless, it’s both renewable and with proper care durable, and it is versatile and ultimately biodegradable. I hope we will be able to continue its use for years to come.

A detailed bibliography is available, as is the questionnaire that was forwarded. Thanks to Mary Ellen Johnston and Richard Williams for their research assistance and criticism.

Peter Berton, B. Arch., OAA, MRAIC graduated from Carleton University in 1979, and joined the Thom Partnership Architects the same year. In 1986 he became a partner in the Thom Partnership, and subsequently in the successor firm the Colborne Architectural Group. He joined the practice of C. A. Ventin Architect Ltd. in 1993, where he is now the Director of the firm’s Toronto Office. Mr. Berton has designed many projects in wood, including the Grandview Condominiums at Huntsville and the Pine River Outdoor Education Centre in Shelburne, Ontario.
List of Companies Questionnaires Were Sent To:

Wood Products
Cape Cod
Marwood Ltd.
Truswal Systems
Macmillan Bloedel
Pine Roof Ontario
Canexel Hardboard Division
Ram Laminating Products Inc.
Maibec Industries Inc.
Barrett Lumber Company Limited
Timber Systems Limited
Weldwood of Canada Ltd.
Trus Joist Canada Ltd.
Norbord Industries Inc.
Kent Trusses Ltd.
Malette Inc.
Jager Industries Inc.

Wood Stains and Coatings
Pratt & Lambert, Specialty Products
PPG Canada Inc., Coatings and Resins Div.
Marwood Ltd.
ICI Paints (Canada) Inc.
Para Paint Canada Inc.
Sico Inc.
Waste Not...
Architecture

Vince Catalli, B. Arch.
President
dESign consultants

A Brief Overview Of Today’s Profession

“it is quite impossible to consider the building as one thing, its furnishings another and its setting and environment still another . . . . All are to be studiously foreseen and provided for in the nature of the structure. All these should become mere details of the character and completeness of the structure.”

Frank Lloyd Wright, Architect
Organic Architecture

The current architectural profession is undergoing a re-evaluation of its future direction. Many factors have initiated this re-evaluation process. Tough economic times, computer technologies and an increased awareness of environmental issues are a sampling of concerns which are affecting and shaping today’s practice.

As architects, we contribute to the development of the built environment. Our constructed work does not stand independently from real world conditions and often includes social, aesthetic, design, economic, technical and environmental factors. The profession is continually expanding while at the same time increasing work load and performance expectations.

Presently, the construction industry is undergoing rapid changes towards an environmentally responsible approach. As an integral part of that industry, architects must begin to realize that they are not independent, but are rather a part of a larger system which must participate to help form environmental solutions.
Architects must begin to understand the true and total effects of their work. Cities, including architecture, utilize resources beyond their physical boundaries. According to William Rees, School of Regional and Community Planning, UBC, most cities appropriate from nature the ecological production of an area 22 times their size. The construction industry, and in particular new and existing buildings, use considerable amounts of energy. In fact 40% of all energy is used in the construction and operation of buildings.

The built environment also affects ozone layer depletion. A study conducted by the City of Ottawa indicated that 52% of carbon dioxide emissions are related to commercial and residential buildings. There are many more factors to consider such as indoor air quality, construction waste reduction, water conservation and an array of other concerns which can be directly linked to built environments.

These and other factors contribute negatively to our ability to sustain our existence. Architects, as prime consultants, must begin to take an active, more responsible role to design better, more environmentally friendly buildings. Current practices cannot and will not continue as they have, since new regulations, codes, standards, and changing public and business attitudes are facilitating a demand for change.

**Construction Waste Reduction**

Within the broad scope of the environment, the construction industry will need to pay special attention to the issue of waste management, and more importantly waste reduction. Many resources are utilized in the act of construction: transportation, building materials, energy and labour are some of the resources necessary to produce architecture. These resources are finite. Minimizing waste of resources is a necessary goal for environmentally sound architecture.

The construction industry is a large contributor of waste material which has traditionally been dumped in landfill sites. Today's reality, however, is that landfills are rapidly approaching capacity and many are subject to closure because they no longer meet strict environmental standards. The effect of this is that the total volume of landfill space is declining and the cost of disposing waste is increasing substantially.

Many argue that some regions do not suffer from the lack of waste disposal facilities - but when these facilities are viewed as a resource it becomes apparent that they are finite resources regardless of location. Landfill practices are short-term solutions which have been proven to fail by contaminating soil conditions and ground water sources. These consequences are hazardous to human health and well-being thus making landfill very controversial. Furthermore, replacing current landfills will be difficult due to land use conflicts in highly populated areas and public concerns regarding environmental impact. Indeed, several municipalities have already failed to find politically acceptable replacement landfill locations in their jurisdictions.
As a result, the federal government and the provinces, through the Canadian Council of Ministries of the Environment, has established a national goal of 50% reduction in waste aimed for disposal by the year 2000, using 1988 as the baseline year. Each province is addressing the issue in different ways. The 3Rs Regulations are Ontario’s method of encouraging better construction waste management and reduction practices.

Currently, construction and demolition activities amount to 25% – 33% of the total waste stream in Canada. In 1992, approximately 6.5 million tonnes of construction waste was deposited into landfill. During that same year Ontario contributed approximately 1.7 million tonnes of construction waste. (Chart 1) When you consider high tipping fees of $60 – $150 per tonne, waste management makes both environmental and business sense.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wood</strong></td>
<td>592,312</td>
</tr>
<tr>
<td><strong>Rubble</strong></td>
<td>423,080</td>
</tr>
<tr>
<td><strong>Paper</strong></td>
<td>135,386</td>
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<td><strong>Building Materials</strong></td>
<td>152,309</td>
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<tr>
<td><strong>Gypsum</strong></td>
<td>136,683</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>118,462</td>
</tr>
<tr>
<td><strong>Metal</strong></td>
<td>134,486</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1,692,718</td>
</tr>
</tbody>
</table>

(Source: Environment Canada, 1992)

**Reducing, Reusing And Recycling In Architecture**

The Ontario 3Rs Regulations insist on reducing, reusing and recycling of construction waste material. Up to now these concepts were seldom considered in architectural design. Consider a new way of architectural practice - what if architects always evaluated their own design approach to include building materials conservation, reusing and recycling opportunities? What if the requirements of 3Rs Regulations are factored in at the design phase and later at the construction drawing phase of a project? These issues and opportunities can be a part of the architectural plan. It is ridiculous to expect the contractor to resolve these items at construction since some planning and forethought is necessary for its success as a program. Each participant can make a contribution and evaluate their own processes. Just as construction activities require design input, similarly the notions of reduce, reuse and recycle in architecture requires the creative input of the architectural consultant.

In order to comply with the new regulations at the construction phase, architects must be aware of the requirements and incorporate waste reduction, reuse, and recycling of materials where possible. This does not preclude going beyond good intentions to develop ways to include the 3R's within the construction process as well.

Recycling is a catch phrase for the decade. As a process it requires the collection of goods which can be brought down to their raw material state and regenerated into other new products. The Blue Box program is an example of residential recycling, which has overwhelming
public acceptance as being “green”, while also being very simple and easy to perform. However, recycling requires considerable amounts of energy and is still dependent on traditional forms of production which have inherent environmentally unsafe consequences.

Reuse opportunities, on the other hand, are very different from recycling and can prove to be both better and less energy intensive. As an alternative, reuse is often overlooked and in many cases frowned upon. For example, the Ontario Building Code forbids the reuse of building materials, instead requiring new materials be used. Even if re-used materials are in perfect condition one can not legally reuse them in new construction. The rationale for this is the possibility that the quality of the material may have been damaged in the process of removal, and therefore might affect public safety. This protective outlook, however, should not be the limiting factor that prevents further investigations. Reuse deserves and requires more study.

Reuse can be understood in two ways: first, to use materials as they where originally intended; second, and more important, to use materials in a transformed state – different from their original purpose. This second idea motivated a design competition held in Ottawa. The competition asked participants to view used building materials as “raw materials” that can be utilized in an innovative manner to produce functional and aesthetic products and designs that are of higher value and thereby help divert waste away from landfill.

**Design And Creative Problem Solving**

"The norm is an arrest of learning, a manifestation of laziness of the eye."

Carlo Scarpa, Architect.

Architects have the creative ability to resolve complex building programs. This skill is unique to the construction process and can easily be transferred to other problem solving situations such as construction waste reduction and management. Realizing the potential of construction waste material is the key to effective waste management.

Recently, in Ottawa, a design competition was organized by the Ottawa Regional Society of Architects – Environment Committee, the Ottawa-Carleton Community Foundation, and the Ottawa Re-Store (a local, non-profit building-material reuse facility). The objective of the competition was to promote the value of used materials through the design of products that will increase the worth of these materials. In essence, participants were
asked to be innovative with the use of these materials as if they were “raw materials” yet to be shaped.

Architects and designers were asked to consider products that people would find useful and of greater value than the component parts. Participants were given free reign. The only restriction was to keep to a minimum the use of new materials, since the intention was to promote the use of used materials. Other considerations were to promote environmentally appropriate behaviour and go beyond good design, while keeping it simple and inexpensive.

A total of twenty-five submissions were received, among them furniture, gardening equipment, household fixtures and many other useful products. The winning submission was a chair with a perforated metal seat and legs made of polished copper and sandblasted ABS plumbing pipes (see Figure 1). Other honourable mentions included a fruit bowl that was once a hub cap, with engine valve supports coupled with candle holders and napkin rings made of car valve springs (Figure 2); sandblasted tin cans shaped to become dry goods scoops (Figure 3); a rotary dial phone transformed into a clock (Figure 4); and a children’s play castle made of corrugated cardboard (Figure 5).

These and other entries are examples of innovative reuse designs that exemplify highly creative problem solving skills. Architects have the imagination and technical knowledge to develop the reuse concept even further. Competition entries demonstrate only the beginning of a concept that will take stronger shape in the years to come.

Many other explorations are taking place which investigate alternatives to construction and demolition waste reduction. An example of this is de-construction technology which is the careful dismantling of a building such that as close as possible to 100% of the building materials are salvaged, reused or recycled. Pilot projects have successfully tested de-construction in Toronto, Halifax and Ottawa. Another example, are waste sorting
facilities that accept co-mingled construction and demolition waste. These facilities can recover from 80% to 90% of the waste by finding recycling and reuse opportunities for the waste material. With on-going research and testing, waste diversion strategies are becoming more and more economically viable and environmentally necessary.

Wasteful practices can no longer be overlooked. Architects can be leaders in the construction industry. We can promote changes to our wasteful construction and demolition practices. We can support reducing, reusing and recycling by recognizing the value of used materials while designing. Architects can help to alter wasteful behaviour and thus help to reduce the need to landfill.

Vince Catalli is president of by dEsign consultants, a firm which specializes in environmental and waste issues related to the construction and building management industries. He has organized a successful symposium on Ontario’s 3Rs Regulations and Construction Waste Reduction and a design competition which required participants to investigate construction material reuse opportunities through the design of new products. Mr. Catalli is a board member of the Ottawa Re-Store Inc. (a construction materials reuse facility), and chair of the Green Buildings Information Council Ottawa Chapter.
Evaluating Environmental Impact of Roofing Systems

Hitesh Doshi, P. Eng.  
Brent Day, B. Tech. (Arch. Sc.)

Ryerson Polytechnic University  
Department of Architectural Science + Landscape Architecture

Current Environmental Issues Affecting The Roofing Industry

With growing interest, awareness and regulations related to the preservation of our environment, the roofing industry has been seeking solutions on different fronts. The Canadian Roofing Contractor's Association (CRCA) is taking a number of steps to help contractors adapt to changing business and social climates. Hopefully these steps will encourage environmental stewardship in day-to-day operations. Since 1991 the CRCA has established an Environment Committee to address issues of concern to its members. CRCA's focus has been on the handling of the waste in response to and in anticipation of soaring landfill costs and imminent government regulations. CRCA has also continued to play an active role in emerging issues, such as dealing with CFC phase-out from insulation, improving the odiferous effects of hot asphalt, dealing with VOC's, and improving the durability of roofing systems through the better understanding of their performance. In addition they are currently supporting the efforts of Finoll Recycling Ltd., a company developing uses of old BLR roofing material.

North American leadership in roofing and the environment is being shown by the National Roofing Contractors Association (NRCA) and the Midwest Roofing Contractors Association (MRCA). In 1992 NRCA formed an Environmental Action Task Force charged with investigating waste disposal, recycling, and reuse of roofing materials. The MRCA also has similar goals, and continues to
look at processes for roofing material recovery and recycling. Their thrust is to address the alarming rate of increase of landfilling costs.

The findings of CRCA, NRCA and MRCA are that the present motivation among roofing contractors for environmental waste reduction is regulation or cost of disposal. In one survey, 73% of the contractor's surveyed indicated that they would recycle material as long as it was lower in cost or only slightly more expensive compared to disposal. A whopping 94% indicated that they would not recycle if the recycling costs were considerably more expensive than disposal costs. One of the conclusions of MRCA was that the major focus of material manufacturers and roof designers should be in developing materials and details that increase the durability of roofing systems. Also, roof assemblies should be detailed and specified to allow for easier and cleaner disassembly of systems at the end of their useful service lives so that materials can be more readily recycled or reused.

All the above work described above initiates from the requirements of waste disposal. Issues such as the extent of use of non-renewable resources, the damage to the environment from manufacturing processes, and the potential for roofs as alternate spaces remain unsolved. Designers are in the best position to integrate these environmental issues.

This paper describes a model called the 3R's+D Roof Model that was developed to provide a structured framework. It involves decisions needed on qualitative criteria for designing environmentally friendly roofing systems.

The proper use of this model assumes that it will only be applied in comparing roofing alternatives which otherwise have similar performance in all other respects. We also assumed that environmental advantage of the roofing systems would not override the requirements of the roof to provide its primary function of thermal and moisture protection. In other words, given roofing alternatives that perform similarly with respect to the financial and technical parameters, which alternative is environmentally better? The model will also assist designers to evaluate their past designs to determine where minor changes can improve their environmental aspects.

**The Nature of Environmentally Friendly Roofing**

The following when considered together will provide the basis for the complete environmental evaluation of any given roofing system:

- The extent to which non-renewable resources are depleted.
- The sum of the impacts on the ecosystem from the production, use and disposal of the materials.

From the above it follows that an environmentally desirable roofing system will:

- Maximize the use of renewable resources and optimize the use of non-renewable resources. This would include maximizing the recycled content of the materials, selecting materials readily available in
nature, involving the least amount of manufacture, and selecting locally-produced materials thereby minimizing the total embodied energy of the materials

- Minimize the total impact on the environment of the materials throughout their lifecycle by eliminating those that contain known environmentally sensitive products; selecting materials that minimize the emission of greenhouse gases and avoiding those that are toxic or make use of toxic substances
- Be designed to maximize its life expectancy and thereby minimize the intensity of any negative environmental impact over time. Examples include selecting thicker sheet metal, incorporating better flashing designs, developing and using better membranes (arguably the most important component of the roof over its life span as it performs the most basic roof function — waterproofing) and making the system maintenance-friendly so that its service life could be maximized.
- Be designed so that at the end of its service life it can be disassembled and its components reused or recycled. Those components that must be landfilled should be designed so that they can quickly decompose and not contribute further to the existing large volume of waste. One example of a system that can be completely disassembled is a loose-laid, single ply, protected membrane roofing system.

An example of a roof that would seemingly satisfy these criteria very well would be a thatched straw roof or the roof of an igloo as illustrated in Figure 1 (see page 25).

Based on the above understanding of environmentally friendly roofing systems we have developed a framework that can be used by designers to evaluate the environmental impact of a roofing system.

**3R**’s+D Roof Model for evaluating the environmental impact of roofing systems

This method to establish the relative environmental impact of a roofing system looks at its performance in terms of the 3R’s – Reduce, Reuse, Recycle. It has to be recognized that despite every effort to reduce waste through the 3R’s approach some disposal is inevitable. Considerations to minimize the negative impact of disposal should therefore be an integral part of evaluating the roofs by this approach. It is for this reason that this model is called the 3R’s+D-ROOF Model. More qualitative data rather than quantitative data will be required for this model. It’s approach will be very familiar to those in the construction industry as it mirrors the concepts being put forward by the Ontario Ministry of Environment and Energy in its 3R’s regulations.

Additionally this model also takes into account the conservation of non-renewable resources and the negative impact caused from the manufacture of products.

**Table 1** (see page 28) lists the criteria to be used in this model. **Table 2** (see page 30) is a worksheet where different roofing systems can be compared. The use of this worksheet is self-explanatory. One way to use this model is to rate the different systems on a qualitative scale in Table 2. Designers may choose to use a weighting scheme that may emphasize one criteria over
the other. The weighted rating can than be added and the systems compared.

The tables are designed to allow the rating and weighting to be done at a system level rather than at the material level. Clearly the impact of all materials in a system have to be added in arriving at the total impact of the system for any one criteria. The model is designed in such a way that designers may, after choosing a system, use the model to see how they can improve their particular design to make it more environmentally friendly.

The following provides some background on the terms used in the 3R’s+D-Model.

Reduce
Reducing entails limiting the total amount of material used in the system during manufacturing, construction, maintenance and the end of service life. Reducing the rate of consumption of any resource causes a proportionate decrease in the rates of embodied energy and the pollution. At the end of the service life of the roof, less solid waste will go to landfill in a given period of time.

Reduction can be achieved in many different ways. The most obvious is to minimize the input of virgin raw material in the production processes of the various roofing components by maximizing the recycled content of the materials. It may or may not require less energy to use recycled material in place of virgin raw material, but is usually environmentally preferable as it conserves resources. An example of a class of roofing product with high recycled content is the various roofing felts produced by certain manufacturers who use recycled cardboard and rags and virgin wood chips as the main feedstock materials. Certain insulation currently available on the market also has significant recycled content.

A second method to reduce the use of roofing materials is to design the roof to be durable. If its life span is extended then the total mass of material required to provide the roof over time will be reduced.
Also, the mass of waste per unit time will be reduced. This may be achieved by paying careful attention to durable details, i.e. selecting systems and materials with longer life spans, ensuring good workmanship during installation, and following proper maintenance procedures.

The issue of roofing and reducing can be applied in a broader scope to apply to the building as a whole. The selection of the roofing system may have a direct effect on the mass of material required elsewhere in the building. For example, by specifying a lighter roofing system (less ballast, etc.), a designer may be able to significantly lessen the dead load on the structure and enable a lighter structure, with reduced mass of material, to be specified for the building.

**Reuse**

The concept of Reuse refers to a process where the material is put to use without remanufacturing. In theory, this may occur endlessly if there is no degradation in the quality of the post-consumer material. Reusing material lessens the requirements for virgin feedstock and, as above, has environmental value. Reuse can occur either at a manufacturing stage, construction stage or at the end of service life.

Reuse of material frequently occurs during the manufacturing process of some roofing materials, i.e., before they are applied on a roof. This typically occurs when scrap materials at a certain point in the manufacturing process, are reused. However, because of the increasing chemical complexity of manufactured roofing materials (in order to derive better performance from them), it is difficult or impossible to reuse some scrap material back into the same process because of the chemical change that has occurred. However some materials such as polystyrene foam scraps are being reused in the manufacturing process.

An example of reuse at the end of service life is the reuse of loose gravel in either a different roof or the same roof after re-roofing has occurred. Under some circumstances sheetmetal flashing can also be saved and reused at the time of re-roofing.

**Recycle**

Recycling as defined in this model refers to the production of a material different than the waste material being recycled and involves some reprocessing or manufacturing. In this way the waste becomes a feedstock of the new material. Technology is increasing the possibility of recycling waste in this manner and the biggest challenge designers face is in either using recycled products or in keeping up with the endless possibilities for recycling products.

One widespread example of this type of recycling is the processing of used asphalt roofing material (shingles and BUR) into various road paving materials. The most widely used product of this process is recycled gravel (with some asphalt still adhered to it) that can be used in the paving asphalt mix as aggregate or as a base for paving. Other products include road patch materials and various expansion joints. Currently this type of recycling is occurring in both the United States and Canada. In Ontario there is a facility to recycle waste from BUR in this manner.

One potentially significant form of recycling that is presently occurring on only a limited
basis is the incineration of post-consumer waste to recover a significant portion of its embodied energy. "Clean" incinerating technology is currently being developed that will burn the waste at very high temperatures and thereby reduce the emissions generated from the process.

**Disposal**

Any material that cannot be reused or recycled will have to be disposed. Disposal, as used in this model, accounts the extent of the material sent to a landfill site, and the extent to which it will be biodegradable without generating toxins into the ecosystem.

**Closing Remarks**

The main focus of this paper was to provide a framework to rationally evaluate the environmental impacts of different roofing systems. Other issues that are becoming important are related to the alternative use of roofing space e.g. as a garden. There is tremendous environmental advantage to this approach in terms of reduction in global warming, improved health, and reduction in storm water related problems. Designers should be aware of these trends and consider them in conjunction with the information provided in this paper.

*Hitesh Doshi teaches Building Science at RPU. Prior to joining Ryerson, Hitesh was involved in building science consulting for over 30 years. He continues to have a limited practice. Hitesh is currently Roofing Contributing Editor of Plant Engineering Magazine, and is on the Advisory Committee of Roofers with the Ontario Training + Adjustment Board.*

*Brent Day is completing his final year at RPU.*
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Explanation On Using The Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reduce</strong></td>
<td>Reducing entails limiting the total amount of material used in the system during manufacture, construction, maintenance and end of service life.</td>
</tr>
<tr>
<td><strong>Amount of recycled content in finished system</strong></td>
<td>Positive ranking should be given to systems that are made from non-virgin raw materials. Negative ranking should be given to products that make excessive use of non-renewable virgin raw materials. The higher the recycled content the higher would be the ranking for the selected system. The source of non-virgin raw material may be post-consumer recycled products or reprocessed material of the same kind.</td>
</tr>
<tr>
<td><strong>Amount of non-renewable resources used in manufacture</strong></td>
<td>Negative ranking applies to this criteria. The more the use of non-renewable resources the more negative will be the rating.</td>
</tr>
<tr>
<td><strong>Amount of emissions related to the manufacturing processes</strong></td>
<td>Negative ranking applies to this criteria. The more the extent of emissions and contribution to global warming the more negative will be the rating.</td>
</tr>
<tr>
<td><strong>Durability of system</strong></td>
<td>The total usage of materials for roofing over time is in direct proportion to the longevity of the roofing systems without substantial repair work. Roofing systems with higher durability will have higher ranking.</td>
</tr>
<tr>
<td><strong>Additional structural requirements</strong></td>
<td>Some roofing systems may impose greater structural loads than others. In this case where a roofing system results in a heavier structure negative ranking should be given. Positive ranking should be given to lighter roofing system that have the capacity to accommodate a roof recovery system at the end of service life.</td>
</tr>
<tr>
<td><strong>Amount of packaging waste</strong></td>
<td>Roofing that generates little or no packaging waste should be given lower negative ranking. Packaging material includes such items as corrugated boxes, plastic or paper wrapping material, and polis.</td>
</tr>
<tr>
<td><strong>Material size and shape related reduction in construction waste</strong></td>
<td>Every building will require some materials to be cut and fitted. Odd shaped buildings will have higher need for cutting and shaping than rectangular buildings. Since materials are normally shipped in pre-defined shapes and sizes there would be waste generated as a result. Materials which are more accommodating to the shape and size of the building should be given higher positive ranking.</td>
</tr>
</tbody>
</table>
Table 1 (continued)

<table>
<thead>
<tr>
<th>Reuse</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reusability of production waste</td>
<td>Reuse refers to a process where the material is put to use without remanufacturing</td>
<td>Positive ranking should be given where waste generated during manufacturing is reused. An example is waste extruded polystyrene insulation which can be reintroduced in the process as raw material.</td>
</tr>
<tr>
<td>Reusability of construction waste</td>
<td></td>
<td>Positive ranking should be given where waste generated during construction is reused. The greater the possibility of disassembling all the components of the system the greater will be the possibility to reuse or recycle some components. Roofing waste that is not clean cannot be easily recycled. Positive ranking should be given for ability to disassemble with higher ranking where all components can be disassembled.</td>
</tr>
<tr>
<td>Extent to which system can be disassembled into components at the end of service life</td>
<td></td>
<td>If the system can be disassembled some components could be reused at the end of service life. An example of this is ballast and insulation in a non-adhered protected membrane system. Positive ranking should be given where disassembled components can be reused with higher ranking for materials that can be reused at the same location.</td>
</tr>
<tr>
<td>Reusability of disassembled components without further processing at the end of service life</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recycle</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Recyclability of production waste</td>
<td>Recycling as defined in this model refers to the production of a material different than the waste material being recycled and involves some reprocessing or manufacturing</td>
<td></td>
</tr>
<tr>
<td>Recyclability of construction waste</td>
<td></td>
<td>Positive ranking should be given where waste generated during manufacturing is recycled.</td>
</tr>
<tr>
<td>Recyclability of disassembled components by further processing at the end of service life</td>
<td></td>
<td>Positive ranking should be given where waste generated during construction is recycled. An example is the use of adhesive containers that would be recycled.</td>
</tr>
<tr>
<td>Recyclability of system by further processing at the end of service life</td>
<td></td>
<td>If the system can be disassembled some components could be recycled at the end of service life. An example of this is the metal flashing. Positive ranking should be given where disassembled components can be recycled with higher ranking for materials that can be reused at the same location.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If the system cannot be disassembled but it can be recycled as a whole than it should be given positive ranking. An example of this is the BUR membrane which can now be recycled in Ontario.</td>
</tr>
</tbody>
</table>
Table 1 (continued)

<table>
<thead>
<tr>
<th>Disposal</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of waste at the end of service life</td>
<td>Where the material cannot be reused or recycled it will be necessary to dispose it.</td>
</tr>
<tr>
<td>Extent of Bio-degradable waste at the end of service life</td>
<td>Waste generated for disposal should get negative rating with higher values of negative rating for higher amounts of waste disposal.</td>
</tr>
<tr>
<td>Amount of toxicity related to waste generated</td>
<td>If the waste can be associated with toxicity than the system should be given negative rating.</td>
</tr>
</tbody>
</table>

Table 2

RATING SHEET FOR 3R'S+D ROOF MODEL

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rating</th>
<th>System A</th>
<th></th>
<th>System B</th>
<th></th>
<th>System C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RL*</td>
<td>W/L x RL**</td>
<td>RL*</td>
<td>W/L x RL**</td>
<td>RL*</td>
</tr>
<tr>
<td>Reduce</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of recycled content</td>
<td>+ or -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-renewable resources used</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions related manufacturing</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durability of system</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional structural requirements</td>
<td>+ or -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of packaging waste</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction in construction waste</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reuse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reusability of production waste</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reusability of construction waste</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extent of possible disassembly</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reusability of disassembled components</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recyclability of production waste</td>
<td>+</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recyclability of construction waste</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recyclability of disassembled components</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recyclability by further processing</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of waste at the end of service life</td>
<td>-</td>
<td></td>
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* RL - Rating  ** W/L x RL - Weighting x Rating
The Strawbale Project

INTRODUCTION

During a three day period in June 1994 over thirty people participated in the construction of the first completely loadbearing Nebraska style strawbale structure in Ontario. The modest 700 square foot studio building was constructed on a farm near Kingston. The 18 'oot by 26 foot structure has an open sleeping loft and adjacent covered carport. It used only 168 barley straw bales, including a 20% wastage factor. At $1.40 per bale the owner received a structural R-40 insulated wall for $235. A comparable double staggered 2 by 6 stud wall with R-40 fibreglass batts would have cost $1,032. This represents a savings of more than 400% for material costs.

Using dry tightly baled straw as giant building blocks allows us to turn an agricultural by-product into a useful resource. Straw is the highly fibrous stalk of any already harvested grain.

The environmental advantages of using this material for construction purposes in immense. Over 200 million tons of straw wastes are burned annually in the United States. In California 1.2 million tons of straw burned each year produce more carbon monoxide and particulates than all the coal fired generating stations in the state. If baled straw were used in place of wood frame walls for the average 2,000 square foot house approximately 42 trees could be saved. Using American statistics, all the straw left over from the annual harvest of major grains could produce 5 million homes each year.
**History**

Loadbearing strawbale construction is not new. Pioneer settlers in the Nebraska Sandhills developed this unique solution for shelter around the turn of the century. Thus we get the name Nebraska style construction for a building method where the straw bales alone take the attic and roof loads. Other types of strawbale construction use posts and beams or concrete mortar to take the structural loads. The advent of mechanized bailing equipment enabled Nebraskan farmers to turn prairie grass or crop residues into handy building materials. These were essential goods in an area of few trees and very sandy soil. Cement stucco, adobe or river mud was then applied directly onto the straw as finish. Many of these old straw homesteads, some almost 100 years old, are listed on the American National Heritage registry and are still in excellent shape.

The modern revival of this type of construction began in the American southwest with recent explorations in appropriate building technologies. There are now well over 100 completed modern strawbale buildings ranging from simple owner built structures to custom designed luxury homes. Straw from wheat, oats, barley, rye, rice, native meadow hay and even tumbleweed have been used for buildings.

Canadian statistics are sketchy, but we have at least six Nebraska style structures, several post and beam with strawbale infill walls and scores of a Quebec developed system using mortared straw and concrete. Canada Mortgage and Housing corporation performed loading tests of the mortared straw and concrete system in 1982. It was found to be more than capable of carrying residential loads. Recent testing programs at the University of Arizona and ongoing studies in New Mexico have shown strawbale wall construction to be fully capable of carrying residential loads without using mortared joints or concrete. From an energy perspective it makes sense to eliminate mortared joints which act as thermal bridges to leak out heat. Specifications for strawbale construction is expected to be included in a new draft amendment to the Uniform Building Code for the state of New Mexico. In Canada, permit approvals for Nebraska style buildings have required educating the local building inspector and a design prepared by a licensed architect or engineer.

**Energy Performance**

Straw bales are versatile. They can perform the multiple functions of load bearing structure, insulation, air barrier and stucco substrate. Straw bales are inexpensive, easy to work with and have excellent thermal resistance properties. Research at the University of Arizona found thermal resistance values for wheat and rice bales at R-2.6 per inch parallel to the grain and R-3 per inch perpendicular to the grain. The standard 18 inch wide straw bale gives an average thermal performance of R-40, double the Ontario Building Code standard for house construction. Straw is an
abundant annually renewable resource. It takes significantly less energy to produce straw bales than either standard lumber or concrete block. Material energy costs in British thermal units for R-50 straw is estimated at 3,400 BTU’s per square foot. (This was estimated using the costs of fuel to operate the harvesting and baling equipment.) Softwood per board foot comes in at 7,700 BTU’s, concrete per cubic foot is 96,000 BTU’s and R-50 fibreglass batts per square foot is 100,000 BTU’s.

Strawbale structures look similar to adobe buildings. The thick walls with deeply recessed windows and knobbly plaster or stucco finish have a solidity and old world charm to them. A cement stucco finish on wire mesh seals the walls outside and plaster finishes them on the inside. A good stucco finish protects against the weather, rodents and fire. Surprisingly strawbale construction has fire ratings which exceed standard wood frame construction. Recent New Mexico fire tests showed that unprotected strawbale walls resist flame penetration for 30 minutes and stucco and plaster covered strawbale walls for over 2 hours.

Construction details

The 14 inch high by 18 inch wide by 34 inch long barley straw bales used for the Kingston studio were laid like bricks, without mortar, in a running bond on an 18 inch wide concrete grade beam. Steel reinforcing bars were embedded into the beam protruding up 24 inches to impale the first 2 rows of bales. Waterproofing was painted on the top of the beam in order to prevent water wicking up into the bales. The first row of bales have felt tar paper where snow may be resting against the wall. Subsequent rows of bales were stacked and pegged vertically to each other with one inch diameter willow whips. Wooden stakes, dowels, bamboo rods or rebars could also be used. Pegging the bales helps to keep them aligned and laterally stable until the top plate goes on. The large size and reasonable 40 pound weight of the bale building blocks means that the walls will go up very quickly.

After the last course, two 2 by 10’s were laid flat, nailed together and dowelled into the top bale as a top plate. The top plate provided bearing for the wood frame gable roof above. One eighth inch galvanized steel aircraft cables were then thrown over the top plate at four foot intervals. The cables were fastened to eyebolt anchors embedded in the concrete grade beam on either side of the strawbale wall. The cables were then tightened in place helping to compress and stabilize the walls. This is the method we used to connect the top plate back down to the foundation. The roof joists were 2 by 10’s at 16 inches on centre for a cathedral ceiling. Prefinished steel was used for roofing.

Construction proceeded at a breezy pace. The walls and half of the roof framing were complete by the end of day one. The adjacent post and beam carport and all roofing was finished by day three. A fast roofing system is important since the bales need to be kept dry.
throughout the whole construction process. In order to prevent growth of fungi, which rots straw, a maximum threshold of 20% moisture content should be achieved in the bales. Dry bales are easy to achieve if they have been barn stored for one winter prior to construction. Bale moisture reading thermometers are available through farm co-op suppliers to check levels before you build.

Once the roof was on, we allowed 4 weeks for the bales to settle and fully compress before the wire mesh and stucco were applied. Recent studies have shown that a much shorter settling period is sufficient. Testing is also under way to develop a means to fully compress the bale walls immediately after installation. This will enable the whole construction process to be a smooth uninterrupted flow. The wire mesh was tacked to the side of the top plate and stretched down to the nailer plate embedded in the foundation. The wire mesh was fitted tight to the straw bales with large staples made from baling wire.

The cement stucco was hand trowelled onto the one inch welded wire mesh in a base, brown and final coloured acrylic coat. It was a very labour intensive process taking 10 people 2 days to complete interior and exterior coats. Mechanically sprayed stucco, gunite or shotcrete systems would be great labour saving alternatives.

Strawbale construction is accessible. Community wall-raising using unskilled labour of all ages is very possible. Jumping down on and slapping the walls into plumb require no special tools or skills. Good carpentry skills, however, are crucial for setting up the corner bracing, preparing the box frames for windows and doors and framing the roof. The windows were kept narrow, one bale wide, to ease roof load distribution. We used 2 by 10's to construct the door and window box frames and set them on the outside edge of the 18 inch wide wall. This allowed 9 inches of straw on the inside of the opening to splay or curve the surface and allow more light into the interior. The lintels were flat 2 by 10's extending one half the width of each adjacent bale for bearing. The large 6 foot wide patio door opening has a built-up lintel. It consists of three 2 by 8's notched into the straw bales above it and bearing on the 2 by 10 door frame. All the frames were fixed into the straw walls with one half inch wood dowels.

The studio also used straw for floor insulation. A 6 millimetre polyethylene sheet was laid on top of a 6 inch compacted gravel bed. Half
bales of straw were then placed on the plastic and in between the floor joists giving it a value of R-20. Recycled spruce boards were installed for flooring. Six inch friction fit fibreglass batts were used to insulate the cathedral ceiling joists because they were faster to install than bagged straw. With a standard flat ceiling full R-40 bales can be placed on the ceiling joists in the attic space. These exposed bales can be coated with sodium silicate for extra fire protection.

**Services**

Similar to standard construction, the plumbing and electrical services are brought in below the foundation and come up through the floor. Underground rated electrical wiring, conduit or romex cable can be notched into bales vertically and run in between courses on the horizontal plane. Electrical boxes are installed in a horizontal course between bale rows. Foamed fire retardant or sprayed cement slurry behind junction boxes, lights and other potential heat sources can be used to improve fire safety. Plumbing pipes going through the bales need to be isolated in plastic sleeves in case of leaks. The easiest solution for plumbing is to box it into the interior partitions.

The super insulated structure is designed with maximum window exposure to the south and west. The carport acts as a windbreak on the northwest side. A vapour barrier was not installed in the structure so we could test the theory of breathable or moisture transfusive walls. Moisture readings performed on similar test structures have shown the interior of strawbale walls to dry out continuously over time. If required, an Ontario Building Code vapour barrier can be applied on the interior plaster with an acrylic vapour diffusion retardant paint. The exterior cement stucco acts as a moisture transfusive air barrier so that any moisture in the wall can be transported out of the wall. The exterior coating might also be sealed against moisture penetration in some potentially wet areas such as the base of the wall or at window sills with a clear non-toxic breathable sealer. The life span of a strawbale wall depends entirely on how dry you are able to keep it.

**Economics**

The greatest cost effectiveness of these buildings have been shown to be where they were constructed primarily by their owners. This makes sense since we know that about 50% of the cost of a house comes from the price of the labour. Careful material choices and donated labour allowed for a completed cost of $13 per square foot for the Kingston studio.

Canada Mortgage and Housing Corporation has done studies determining that the building envelope accounts for about 20% of the overall cost of a house. Simply substituting strawbale
walls for wood frame and brick veneer walls will not create an economic revolution in the affordable housing market. However, it will contribute to lower start-up costs especially in projects where "sweat equity" is factored into the financing. Lower life cycle energy costs as well as reduced pressure on our forest resources are side benefits worth considering. Using strawbale construction and building smaller and smarter will really make the big difference for affordability.

The environmental and economic problems facing the world as we approach the next century appear large and complex, but the answers are often embarrassingly simple. Sustainable design means using low cost natural materials, from local sources, with low embodied energy. Strawbales are the sustainable material waiting for our imagination.

Linda Chapman received her Bachelor of Architecture in 1983 from the University of Toronto. Since 1983 she has trained with various Toronto architects, working on a wide range of residential and commercial projects. After forming her own practice in 1991 her work has been focused on environmentally responsible design, co-housing and permaculture. Her Ottawa based consulting practice is currently working on several straw bale houses and the development of new sustainable building technologies.
"Our Dream – Welcome to The Body Shop Canada’s New Home Office

This building is the result of an ambitious dream: to create a home for our staff that is more than just a place to work. We want to inspire ourselves to be innovative, ambitious, and imaginative. We need a work environment that is innovative, ambitious and imaginative. This building is the result.

It loses less heat, spreads more sunlight, recycles more waste, re-uses more materials, and uses fewer toxins than a conventional building. It also celebrates our staff, our stores, our products, our culture, and our commitment.

It demonstrates that it is possible to incorporate environmental responsibility into a functional, affordable, and enjoyable workplace.

We hope our building is an example to other businesses of what can be achieved when you dream beyond the status quo.

Welcome to our home."

Margot Franssen,
President of The Body Shop Canada,

The Body Shop is an international retailer of skin and hair care products that are inspired by natural ingredients and traditional practices. The Canadian franchise, The Body Shop Canada, first
opened in 1979, experienced tremendous growth and success to the point where in 1991 they had outgrown their existing facilities – four industrial units on separate but neighbouring sites in Don Mills. The decision was made to bring everyone together under a single roof in a location nearby their existing facilities to minimize disruption to their 100 employees – the acknowledged backbone of a successful business. They also chose to recycle a building – a 35-year-old, 65,000 sq.ft. printing warehouse beside a railway track. This building would house production, warehousing, retail support services, communication, training, and administration. The new Home Office was to reflect The Body Shop's commitment to environmental and social responsibilities.

**Design Process**

The architects, The Colborne Architectural Group Inc., completed a preliminary assessment of the building and a design to quantify program requirements and determine their overall “fit” into the building. The next “mind-expanding” step in the design process was a two-day multidisciplinary design charrette.


All participants were given a tour of the Body Shop’s existing operation and the “new” building, and a copy of the preliminary design to communicate the building programme. Three groups were formed and for two days all were asked “to generate concepts and ideas that can be integrated into the design of The Body Shop’s new home office in a manner that ensures:

- It functions as a working model of environmental innovation;
- The overall design is both practical and flexible, providing the capability for both short term and long term technical advancement, innovation and expansion potential;
- Communication between individuals and departments is facilitated and a sense of community fostered;
- Our corporate values and culture are reinforced and deliberately expressed;
- Corporate environmental responsibility is demonstrated as practical, achievable and aligned with good business sense.”

At final group presentations, ideas ranged from a sod roof complete with grazing sheep to a method of treating sewage with plants in a green house. Interestingly there was a lot of similarity amongst the three groups affecting general planning, employee amenities, and quality of workplace, with most ideas being retained through to the final design.
SPACE PLANNING AND DESIGN

The planning was to make manifest The Body Shop's non-hierarchical office structure and non-traditional view of the workplace.

A system of internal “streets” form the main circulation spine running from the “front door” at Reception to the “back door” at the Cafeteria and garden fostering communication between departments, individuals and visitors. Displays lining the streets range from the latest products to the latest social and environmental initiatives, allowing various levels of interaction and participation.
The facility includes a full range of activities from national warehousing and distribution centre; product mixing and bottling facilities; to administration office and child care facility. Unusual adjacencies of different program elements were exploited to undermine the stuffiness of typical corporate head offices and communicate to all visitors and employees the full breadth of the company's operation – from source plants in the garden to the finished product on the store shelves.

"... kids [at the Home Office] aren't the only ones having fun. Employees in the "filling room" ... can peer through a row of interior windows into the very heart of corporate power, the boardroom. The brass can look back, of course. The same filling room can also be seen from the lobby, providing visitors with a picture of productivity.

Even president Margot Franssen's office, a cubbyhole off Inspiration intersection, is fully visible through a glass wall."

**Materials and Systems**

As the design was developed a set of criteria evolved for evaluating decisions on materials and systems, relating to The Body Shop corporate values.

Preferred materials would exhibit natural or recycled content, recyclability or biodegradability, and minimize environmental contaminants (V.O.C.s, CFCs, solvents, etc.).

**Paints:**

Virtually all paints and stains are water-based, 100% solvent-free on drywall and 75 to 90% post-consumer recycled paint on other walls. High performance coatings are 100% solvent free water-based epoxies.

**Drywall:**

Gypsum core has 20% recycled content and paper face is 100% recycled content.

**Sheet Flooring:**

Linoleum flooring, from all-natural sources including linseed oil, cork and jute. Installed with water-based, low-VOC adhesive.

**Carpet:**

The first installation in Canada of carpet made from 100% post-consumer recycled nylon, laid with a water-based, low-VOC adhesive.
Ceramic Tile:
Installed with low-VOC adhesives and grouts.

Rubber Flooring:
In exercise area, made from post-consumer recycled automobile tires.

Epoxy Flooring:
100% solids, solvent-free, low-VOC.

Cabinetry:
Constructed of medium-density fibreboard, 100% formaldehyde-free (made from wood fibre byproducts of lumbermill operations) with water-based adhesives and finishes.

Insulations:
All interior insulation and exterior wall insulation is CFC and HCFC-free.

Roof:
A new inverted roof system over the existing roof with most components loose-laid allowing easy repair and reuse.

Furniture:
Systems furniture was purchased refurbished to match existing systems.
Used wood boardroom chairs were refinished with water-based stains.
Garden benches are made from 100% post-consumer recycled plastic.

Glazing:
The Body Shop reclaimed a large number of double-glazed units destined for disposal.

Plumbing Fixtures:
Reclaimed from a hotel undergoing renovation in the neighbourhood and adapted to reduce water consumption.

Materials, once selected, were applied across the entire building base on use requirements, not on perceived status of the space – reinforcing the equality-based workplace attitude.

Systems and Building Components should be energy-efficient, environmentally responsible, and a demonstration of practical and workable technology. In examining building systems the payback period was developed as follows: under 3 years – do it; 3 to 10 years – most were incorporated; and 10 years and over – give careful consideration, with some being incorporated.

It became very apparent that there had to be very close fit between the system and the very specific nature of the building, its occupant and energy requirements, and its energy by-products.
No universal “ideal” systems were found but rather many were given very close scrutiny to find the specific combination appropriate to The Body Shop.

The Building Envelope:
The first and most immediately effective system decision was insulating the building! An inverted roof system (R20) and exterior insulation wall system (R12) put a “big sweater” on the building, reducing HVAC requirements by 30 to 40% The existing 10 inch masonry walls within the thermal envelope created a tremendous “thermal flywheel”. Existing glazing was retained and repaired where practical and replaced with the reclaimed glass elsewhere. Use of a sod roof or a roof pond for cooling proved too heavy for the existing structure.

The HVAC System:
Heat Pump System – The 22-zone closed loop heat pump system responds to specific occupant demands and varying solar exposure around the building. The closed loop allows “trading” of heating between zones - if one area is rejecting heat it goes into the loop to be used in an area requiring heat. (A common occurrence in a multi-use facility.) Excess heat goes first through a heat exchanger to pre-heat domestic hot water, and any remaining heat goes to a closed circuit cooler. Heat is provided by gas-fired boilers. This system featured a 3.5 year payback and annual cost savings of up to 25% over a conventional system.

Hot-Water Radiant Heating – A ceiling-mounted radiant valence system around the perimeter avoids interference with furniture. An in-floor radiant system heats the Family Centre. Radiant heating can provide good level of comfort while reducing actual thermostat settings.

Fireplace – The wood-burning fireplace in the Cafeteria is one of the most efficient on the market (90%) and features a catalytic combustor to virtually eliminate harmful emissions, and built-in blower to efficiently distribute the heat generated.

Ventilation – Fresh incoming air is filtered then heated by air-to-air exchangers reclaiming heat from exhaust air. All new exterior glazing includes opening windows, the most basic ventilation system of all.

Energy Management – A Direct Digital Control (DDC) system is the “brain” monitoring and adjusting the building systems. This allows a comprehensive view of operation and energy consumption.

Many other systems were explored by the team but ultimately rejected. Common reasons were: wrong “fit” between building demands/by-products and proposed system; high cost; low flexibility / acceptability within the current industry.

Physical site restrictions and the urban location eliminated use of groundsource or ground-loop heat pumps, and wind or solar power generation.

Co-generation using a small gas-fired unit to generate electricity and heat water with the rejected heat proved too costly with limited availability of equipment at this scale (space has been left for incorporation in the future).
Radiant Heating and Cooling coupled with Displacement Ventilation was rejected given constraints of existing building, high costs, office cooling requirements, and poor industry support at present.

Heat recovery from waste water was rejected as the heat is needed in the water to aid in operation of the Living Machine.

**The Lighting System:**
Lighting usually consumes as much as 30-40% of energy used within an otherwise energy-efficient office building. Energy-efficient lighting and day-lighting strategies would both reduce consumption and also reduce the cooling requirements.

Fluorescent Lighting – T8 lamps and electronic ballasts used throughout to reduce energy used by 34%, with the inclusion of PL lamps in specialty fixtures. Switches are zoned for easy use by occupants.

Daylighting – The arrangement of open office areas at the perimeter and closed offices to the interior with substantial glazing increased penetration of daylight. Light shelves along south wall of Warehouse bounce light deeper into interior. Sunscoop-design skylights are located throughout building, glazed with low-e argon-filled units. The Cafeteria has a north-facing clerestory – in normal sunlight conditions no artificial lighting is required.

Other items explored included light sensor controls but these proved costly and not necessary with an active staff program for energy conservation. In companies with low employee cooperation sensors would be advisable.

**The Living Machine**

One of the most provocative, and controversial components first discussed at the design charette is The Living Machine biological waste water treatment system. The system, developed by Dr. John Todd and designed for The Body Shop by Living Technologies Inc. is based on the ability of nature to handle its own waste.

Waste water from the building flows to an in-ground anaerobic tank to settle-out solids and vented aerobic tanks to strip-off gases. The water then moves through a series of vessels, each constructed with appropriate plants and animals to replicate a specific natural environment with its own cleaning properties – a pond, a brook, a marsh. The water then goes through a UV sterilizer and emerges “drinking water” quality. (As an essential safety feature there is a failsafe mechanism to divert water directly to the sanitary sewers in event of a system malfunction.) Many of the plant species used in the process are also source plants for Body Shop products – an illustration of closing the environmental circle.

Initially the water is being sent back to the municipal sanitary sewers during a testing
period. Ultimately water can be diverted to the linear Wetland in the garden and filter back into the earth, or water can be directed back into the building for non-potable use such as toilets - the biggest single domestic consumer of water.

The system currently in place handles all the building's domestic sewage. Connections are roughed-in to add a system to handle waste water from the Production areas, currently under design.

The Living Machine is housed in a 200-foot-long greenhouse along the south wall of the warehouse allowing the thick masonry walls to assist in passive solar heating. This greenhouse with lush tropical plants and the sound of running water has become a favourite retreat for staff.

THE GARDEN

The landscape was treated as an extension of the facility and is equally expressive of The Body Shop's goals. The design started with the charrette and continues as each year another component of the master landscape plan is completed.

Restoration of the landscape supporting native flora and fauna:

The site is along a railway line, a natural seed and wildlife corridor. All landscaping is with native plant material incorporating rare or endangered plant species. Large areas of lawn are replaced with meadow grasses and wildflowers. Excavation material from the addition was redistributed on-site to create gentle berming and parking was reduced, allowing increased landscape area.

Recreation and education in the landscape:

Patios, play areas, a Flower Cutting Garden, apple orchard and bike shed, are provided for staff, kids, trainees and visitors. A Physic Garden, based on a medieval medicinal garden, featuring plant species which are sources for many Body Shop products.

The Linear Wetland:

This will accept site storm water and controls flow to allow drainage into the soil and evaporation. Careful planting including seed-laden mud from local wetlands helps increase habitat diversity.

A BUILDING FOR ITS TIME

The Body Shop's commitment extends beyond the building's construction into its ongoing life. There are many components in the facility that will continue to develop over time including a company-wide recycling program and a transportation program stressing car-pooling, public transit
and cycling. An annual company-wide environmental audit including energy performance of the building, checks the “other side” of the balance sheet. Their goals have been acknowledged by constant demand for tours of the facility and the receipt of three Financial Post: Design in Business Awards – Architectural Design, Environmental Innovation and Best-in-Show.

With overall costs at $62 per square foot for a total renovation The Body Shop's Home Office is a demonstration and a challenge to other businesses – this is the art of the “possible”. Business can balance both bottom lines – financial and environmental.

Richard Williams, B.E.S., B.Arch., OAA, MRAIC graduated from the University of Waterloo in 1981. In 1987 he joined the Thom Partnership and its successor firm The Colburne Architectural Group Inc. where he acted as Project Architect for the New Home Office for The Body Shop Canada. In 1994 he joined C.A. Ventin Architect Ltd. in their Toronto office. Current projects include the Pine River Outdoor Education Centre and the Historic Peel County Court House.
The Project Team

Architect: The Colborne Architectural Group Inc.
Partner-in-Charge: Stephen Quigley
Project Architect: Richard Williams

Mechanical Engineer: Keen Engineering Co. Ltd.

Electrical Engineer: Ellard-Willson Engineering Limited

Structural Engineer: Yolles Partnership Ltd.

Energy Consultant: Allen Associates Ltd.

The Living Machine: Living Technologies Inc.

Landscape Design: Garrison Creek Planting Company
David Orsini and Associates

Construction Managers: Cairn Construction Ltd.

Footnotes

1. Introductory welcome at the opening of the new Home Office, Thursday, October 14, 1993.
2. From The Body Shop brief to charrette participants.
Low-Cost, Multi-Unit Dwellings for the Environmentally Hypersensitive

Phillip Sharp, OAA, MRAIC, RIBA
President
Phillip Sharp Architect Limited

General Background and Objectives

Since World War II, some 50,000 new chemicals have entered the built environment. Health implications of these compounds (and their almost infinite combinations and permutations) have been inadequately monitored or understood. An increasing number of people are affected by “Environmental Hypersensitivity”, severe debilitation caused by exposure to airborne particulates, moulds, and chemical emissions. Most would benefit greatly from a home environment providing a respite from exposure to irritants. In time, this respite may enable them to lead more normal lives. Although research has lead to the construction of a number of custom homes, little has been undertaken on the design of low-cost, multi-family development. Yet, because of their affliction, the majority of the hypersensitive are in a low income bracket. To house them, and to obviate environmental illness generally, we must develop alternatives to the one-off remote dwelling.

This paper deals with a constructed prototype offering one such alternative, within a standard Ministry of Housing budget. The development is in Barrhaven, City of Nepean, Regional Municipality of Ottawa/Carleton, located at 45 degrees latitude with temperatures ranging from +86 degrees F in summer to -15 degrees F in winter. It is part of a non-profit community incorporating dwellings for the elderly, disabled, and others with special needs.

For the hypersensitive—all conventional construction practices were considered suspect.
The acute level of performance required that material selection be dealt with as an integral part of all design/construction issues including cost, planning, assemblies, mechanical/electrical systems, manufacturing processes, delivery and storage, site management, and occupancy and maintenance of the finished building. Contamination at any point in the process could be disastrous.

**Land Use Decisions**

Comprehensively planned walk-up apartments, stacked rowhouses, and hypersensitive units use 75 percent less land and servicing infra-structure than the equivalent number of detached family dwellings in the surrounding neighbourhood. Surface water is handled by swales, soak-aways, and ditches, eliminating regional storm sewer treatment. The location had no agricultural or ecological value. In the heart of a growing suburb, it is within walking distance of neighbourhood services, minimizing the need for motorized transportation. All existing trees were maintained. Additional planting utilized native species requiring less water and no chemical fertilizers.

**Societal Values**

The Church Housing Corporation is a potential catalyst for social and environmental responsibility, allowing many who would otherwise be institutionalized to lead more normal lives. Specifically, the Environmentally Hypersensitive units have focussed attention on chemical pollution. In taking care to avoid adversely affecting the hypersensitive, neighbours recognize the benefits to themselves and the ecology as a whole.

**Energy Efficiency**

Through compact planning, high insulation, airtight construction, and effective heating and ventilation, the building goes well beyond R-2000 standards. Electricity as the heat source avoids contamination from combustion. It draws on the Hydro-Electric power grid, but is ideally suited to heat pumps (as originally envisaged, but abandoned through a limited capital budget).
EMBODIED ENERGY

The extensive use of cement based products (concrete block and precast slabs), including cartage, involved high levels of embodied energy. However, this was offset to some extent by the virtual elimination of petro-chemical substances, simplified assemblies, reduced number of materials, (and the renewable nature of those materials), resulting in fewer manufacturing processes and site deliveries.

ECONOMY OF MEANS AND WASTE MANAGEMENT

Wherever possible, the building utilized one-part components to reduce materials and processes and, consequently, the potential for waste. None of the interior construction could be covered or hidden. This lead to dimensioning the entire building to unmodified component modules – from blockwork, board widths, and catalog windows to standard metal roofing sheets, with recycling in mind. Packaging waste was minimal. To avoid contamination from wrappings, major products were stored in reusable tarpaulins and delivered on site only as needed. With no basements, excavation was limited to perimeter foundations and slab on grade. Excavated material was reused for site grading with none carted off site. The very nature of this building dictated impeccable site management procedures. All petro-chemical and other volatile maintenance materials were banned in favour of non-allergenic, bio-degradable cleaning substances.

PRELIMINARY DESIGN STRATEGIES

From an initial assessment of the problem, we established the following strategies:

1. Site the building with good access to sunlight and open air, as remote from vehicular traffic and parking as possible.
2. Minimize the exterior envelope to reduce the area of insulation and vapour barrier required, (both particularly expensive in low-hazard materials). Super-insulate this envelope to conserve energy while allowing generous air changes.
3. Eliminate from the interior known potential irritants. Test all materials, on acutely sensitive volunteers.
4. Where undesirable materials are unavoidable (for performance or cost), isolate them from the interior and ventilate to the outside.
5. Eliminate basements, and crawlspaces as potential sources of damp and mould.
6. Eliminate wall cavities and all other dead air spaces in the interior structure where dust and mold can collect.
7. Provide balanced ventilation, heating, cooling and air cleaning systems to eliminate negative effects of the outdoor environment.
8. Mechanically ventilate storage and closets, as well as kitchens and cleansing areas.
9. Group services and appliances around mechanical rooms to reduce service runs. Expose plumbing and backs of appliances within the mechanical rooms for regular cleaning, and maintenance.
10. Provide ventilated cupboards to isolate off-gassing household items.
11. Use single-material assemblies with internal finishes.

**General Planning**

The owners required two one-bedroom, three two-bedroom, and two three-bedroom dwellings. The two and three bedroom units are planned as back to back two-storey rowhouses, with the two one-bedroom units being single storey bachelor apartments, one above the other, each with separate ground floor access. The resulting two-storey complex is almost square in plan consisting of six structural planning modules. On the second floor, plans interlock with the three-bedroom units overlapping the ground floor of the two bedroom units.
Detailed Unit Planning

For the purposes of this paper, we will examine a typical two-bedroom dwelling. One and three bedroom units follow similar principles. Individual dwellings are planned around the location of their own storage/mechanical rooms. Kitchens, laundries and bathrooms vent directly into these rooms where plumbing, appliance extracts, and the backs of major appliances are exposed for regular cleaning and maintenance, eliminating a major source of dust and mould.

Ground Floor
The entry lobby, under negative pressure, is an airlock to the dwelling itself and allows convenient changing from outdoor clothing, which is left in a ventilated closet before entering the living room. A hardwood cabinet/workstation with sliding glass doors on both sides separates the living room from the kitchen, and provides a mechanically ventilated dust-free shelf/cesk space for television, telephone and other off-gassing, dust-burning electronic devices, as well as for kitchen items and books. Contaminated air from the back of the refrigerator is evacuated by the duct serving this cabinet. A door accesses the rear of the refrigerator for regular cleaning, eliminating another source of dust and mould. Kitchen fittings are of solid maple "butcher-block" countertops on maple frames, with provisions for roll-out metal cabinets. A short hallway separates the kitchen from a laundry/half-bathroom.

The staircase with storage below, opens off the living room and leads to the second floor.

Second Floor
The second floor is planned around an open stair hall giving direct access to bedrooms, dressing room, bathroom and upper mechanical/storage room. Bedrooms are purely sleeping spaces. Clothes are stored in an open rack and tray system within a completely separate dressing room.

Heating and Ventilation
Each dwelling has its own self-contained systems to avoid any possibility of cross-contamination.

The primary system, ducted forced air heating, is served by an electric boiler, hydronic heating coil and a fan remote from supply and return air streams, all housed in the ground floor mechanical room. Return air, mixed with preconditioned fresh air, passes through filters capable of adaptation to meet specific needs. This clean, filtered air is delivered to the kitchen/dining room, living room, entrance lobby, and bedrooms, through one continuous exposed duct, suspended from the perimeter of the ground floor ceiling.

The secondary system consists of a heat recovery ventilator housed in the second floor mechanical room which exhausts foul air from the entrance lobby, storage areas, closets, laundry, kitchen, bathroom, glazed cabinet, and both mechanical rooms on a continuous basis to the out-
doors, through a roof-top enclosure. Continuous fresh air, drawn through gable end intakes, is delivered by the HRV, pre-heated and pre-filtered, to the return air duct of the primary system.

**Ducts in both systems** were acid-etched and washed to remove traces of oil resulting from the manufacturing process, and are demountable for periodic cleaning.

**Plumbing and Miscellaneous Mechanical Systems**

Plastic soil and waste pipes, used for cost reduction, are limited to the interior of the negatively-pressurized mechanical rooms and underslab installations. All other pipes and fittings are copper or plated brass. Domestic hot water is electrically heated. A central vacuum system, exhausted to the outside air, is installed in each unit.

**Electrical Systems**

Power is supplied to each ground floor mechanical room through below-slab conduit. As there are no conventional cavity stud walls, circuits are run in surface-mounted, wire-molds with baked-enamel finish. Lamp holders are ceramic, with glass globes or decorative light bulbs.

**Materials Investigation**

Rigorous objective selection criteria are hampered by the absence of medical identification of suspect substances; complex chemical combinations and permutations; lack of detailed specifications for many materials; unpredictability of recycled materials; and the minuscule quantities of emissions affecting the hypersensitive. Through precedent and subjective testing, some categories of toxins and irritants have been identified, including moulds, particulates, inorganic gasses, and volatile organic compounds. This led to the rejection of all petrochemical products; soft plastics, including floor coverings and polyethylene films; oil, latex or solvent based paints and sealants; caulking and adhesives; insecticides, herbicides, fungicides, and fire-retardants; softwood (sources of turpines and volatile acids); and products containing urea formaldehyde, including insulation, building papers, chip board, particle board, plywood and pressed board products, furnishings and carpeting. Materials containing phenyl formaldehyde proved less volatile but some subjects still reacted badly. Gypsum wallboard, (finished assembly and unfinished components) evoked adverse reactions in some subjects, possibly because paper coverings contained recycled material or fungi-
cide. Although surface treatments are available to retard emissions it is preferable to eliminate them at source. Natural-fibre carpets devoid of synthetic backings and chemical additives do not off-gas but still harbour dust and moulds, and are sources of irritant particulates.

**Materials Selection and Construction Assemblies**

We chose dense smooth-surface concrete block with polished in-situ and precast concrete slabs to achieve structure, one-hour fire-rating, an STC of 53, and integral finishes, in a single homogenous material. By eliminating all additives and conventional form-release agents, and treating exposed interior concrete with a penetrating solution of sodium silicate water-repellent hardener to prevent cement dusting, we had the beginnings of an affordable, benign, basic shell. At this point, the only undesirable materials were a polyethylene moisture and soil-gas barrier over polystyrene insulation both of which would be isolated from the interior by 4" of concrete.

We intended to leave the underside of the intermediate precast floor slabs untreated, but the soap solution used as a form-release agent reacted with steel forms resulting in a slightly stained surface. Ultimately we finished them with non-allergenic paint.

**Exterior Walls**

For exterior insulated walls some off-gassing and particulate-producing materials were unavoidable but acceptable if isolated from the interior. In collaboration with the contractor, we devised an 8" wood stud assembly with additive-free blown rock wool insulation restrained on the outside by a woven polyolefin air and moisture barrier, and on the inside by fire-rated gypsum board with aluminium foil backing exposed to the interior. Sealed with aluminum tape, the foil would provide an airtight vapour barrier totally isolating all offending materials. Foil and drywall screws were washed to remove oil films. A similar assembly was designed for the outside of the two load-bearing concrete block end walls, wrapping the entire building in a continuous super-insulated envelope which was then clad with prefinished hardboard siding. Windows are double-glazed units in metal frames with baked enamel finish. ‘Low-E’ units (incorporating metallic films) were rejected in favour of a wider spectrum of natural daylight since the occupants are basically house-bound. Porches, in-situ concrete with baked enamel steel posts and beams totally independent of the main structure, are linked only by a roof flashing without penetrating the air barrier.

**Roof**

To eliminate heavy petro-chemical vapours and formaldehyde emissions, given off by sun-warmed asphalt shingles on sheathing, from being drawn into the dwellings, the roof is prefinished sheet metal directly on wood purlins and trusses insulated with blown rock-wool, and a ceiling membrane of two layers of 5/8" fire-rated gypsum board, aluminum foil backing exposed to the interi-
or. As with the gable end wall assembly, this foil sealed with aluminum tape, provides an airtight vapour barrier isolating all contaminants.

**Interior Assemblies**
For interior linings and partitions we settled on basswood, an inexpensive fast-growing hardwood primarily used for paint stirrers, and popsicle sticks. We employed it as tongue and groove linings to the roof-space ceilings and gable-end walls, and as vertical 2" X 6" plank partitions in rebated and mitred top and bottom plates screwed directly to the ceilings and floor slabs. Staircases, kitchen fittings, and cabinetry are red maple. All wood components were assembled with mechanical fasteners or white glue only. Wood surfaces subject to wear or handling were finished with water-based verathane. In bathrooms, tub surrounds are preformed one-piece formica linings, mechanically fastened.

**Conclusions**
The lessons embodied in this project are applicable to housing environments generally. Elimination of pollutants leads naturally to simple, easily maintainable components and assemblies that evolve directly from the use of basic unadulterated materials.

This in turn leads to planning around modules inherent in such materials and assemblies, resulting in an economy of means which, combined with the necessity for impeccable site management, results in less waste and a concern for more sustainable development.

Control of indoor air quality inevitably calls for the application of energy conservation measures and more stringent envelope design.

Taken to its natural conclusion, serious consideration of healthy living environments, in the fullest sense, demands an attitude to design based upon first principles and not upon mere stylistic whim or superficial preferences.

It calls for the pursuit of an ethical lifestyle where “more” is replaced by “better” and “enough”.

*Phil Sharp maintains an Ottawa-based architectural practice specializing in non-profit and special needs housing. He runs a workshop on environmental issues at the School of Architecture, Carleton University, and is on the Technical Advisory Committee of the Canadian Manufactured Housing Association.*
**The Environmental Learning Centre – A Demonstration of Sustainable Design**

Charles Simon, OAA  
Principal  
Charles Simon Architect Inc.

**Introduction**

Sustainability is intrinsically an all encompassing concept, embracing the social, economic and physical realms. Stated in its most simple and ideal terms, it maintains that you take no more out than you put back in, you leave things no worse (and hopefully better) than you found them and you do not deprive one group to enrich another. Biologists are right to remind us that there is no waste in nature and all systems are inter-related and inter-acting.

For all of us, including architects, this requires a holistic approach to design, no matter how small the project at hand or how confined the program. As we approach the end of humankind's most environmentally disastrous century (and the much vaunted new millennium), architectural commissions which overtly call for true sustainability still appear to be as rare as hen's teeth. So it is important that we infuse our projects with those elements of sustainability which are practical, which enrich the project while safeguarding its budget, and which thereby add to a growing storehouse of ideas and technologies which may be drawn on as their relevance and urgency dawns on us.

That, in any case, has been the approach which my firm has pursued over the past twenty plus years.

And fortunately the urgency does appear to be dawning and leading to projects which call
for an increasingly holistic approach. An outstanding example is the master plan and building program for an Environmental Learning Centre commissioned by the Kitchener-Waterloo YMCA.

ENVIRONMENTAL LEARNING CENTRE

Background
The Environmental Learning Centre (ELC) proposes to incorporate the most comprehensive and ambitious physical embodiment of sustainable architecture and planning known to the client and its consultants.

The architect was brought in at a very early stage in the process to collaborate with the client in selecting a highly diverse team, exploring and clarifying objectives and program requirements, developing a master plan and identifying a first phase project (presently under construction).

Site
An existing camp set in 70 acres of strikingly varied landscape character on Paradise Lake, 16 kilometers from Waterloo. Some existing buildings have already been upgraded and retro-fitted to demonstrate a variety of energy conserving technologies and techniques, others will be either re-located to another site or demolished.

Master Plan
The following Core Objective of the ELC guides all decisions:

"To operate an integrated environment (of natural features, buildings, technologies and programs) which will gently encourage and inspire transformation in the lifestyles of all who visit and help them 'live more lightly on the earth.'

The entire site to be the teacher of environmental principles, to imbue environmental values."

A key proposition is that a thematic concept be developed for the site. Each area of development should respond to and heighten an awareness of the landscape character of that particular place. Also, in selecting design strategies and technologies, a variety of approaches to sustainability should be illustrated (it was recognized that the “experts” should not necessarily be the final arbiters of environmental correctness).

The first phase project includes the construction of two new buildings, the Day Centre and the Earth Residences, as well as associated site services and landscape work.
DAY CENTRE

Program and Site
Acting as the main arrival, orientation and information point for the Centre, it is appropriately located in a prominent central location at the high point of a gently south sloping meadow. It is planned as the one building which will command its site rather than blend demurely into it.

The three primary spaces are a Great Hall, a Resource Centre/Office and a Greenhouse. The Great Hall allows up to seventy people to assemble or provides a place for exhibits. The Resource Centre/Office will house up-to-date educational material on all manner of environmentally appropriate technologies and sources of information, materials or skills. And the south-facing Greenhouse will demonstrate a variety of natural processes described below.

Theme
The thematic idea for this building is that of the “natural building”, exploring a symbiosis between architecture and biology. Biota, mechanical systems and building design are fused to form a single interacting organic whole. The building is to function as both educator and demonstrator of up-to-date thinking on sustainable design, providing a healthy indoor environment and offering pointers to a possible new vernacular architecture.

Technical
The greenhouse provides passive solar heating in the winter, with warmed air ducted under the floor slabs and “topped up” when required by hydronic fins supplied by a high efficiency wood-burning boiler. The boiler also provides domestic hot water when the solar collectors inside the greenhouse require back-up heat. Summer cooling is effected through shading, passive vent stack heat extraction and a system of night sky evaporative cooling. The mass provided by walls, floor slabs and the greenhouse wetland and pond create a “flywheel” effect, absorbing and storing high inputs of solar heat and releasing it slowly. High levels of insulation to the exterior of the envelope combined with earth sheltering to the north and the use of sod roofs help keep the heat out in the summer and in during the winter.

The building will be connected to the electrical grid and it is hoped that in the future, when the legislation is appropriately amended, it will be possible to equalize the power generated either in this building or on the total site to that drawn from the grid. By returning to the grid the same amount of electrical power as is drawn, the site could ultimately be energy neutral.

Waste water (reduced to a minimum through use of water conserving fixtures and fittings) is cleansed by a “living machine” in the greenhouse, which uses as its final treatment visible biological systems (plants, snails, mollusks etc.) in a series of controlled associations ending in a miniature constructed wetland and a small pond. At the final stage the water is virtually potable and will either by re-cycled to the toilets or be returned to the water table. Rainwater is recaptured and stored in a cistern and treated by ultra-violet light prior to re-use.
Earth Residence

Program and Site
The purpose of the building is to replace some of the existing (outdated) sleeping cabins on the site and to provide associated program space and washrooms in an arrangement which marks a striking lifestyle departure in the provision of camp residential accommodation. Up to forty people will be able to sleep in rooms housing four or six people.

The site, while close to the entry road, is tucked into a Christmas tree plantation and behind a small perched wetland. As a result it had been largely overlooked in previous camp activities and most visitors' perceptions. Given the philosophy that the Master Plan should capitalize on and make legible each landscape/ecological component on this diversified site, the location suggested a very particular response to its particular setting.

In the longer term (when additional monies are available), it will be possible to approach the Residence by way of a boardwalk through the (educationally rich) wetland. The site is on a steep south-facing slope rising to the north from the wetland to the tree plantation and the highest point of land on the entire camp site.

Theme
This setting has led to the thematic idea of "design with nature", of fashioning a building which is in and of its setting. The building forms tend to be organic and to respond directly to the landscape forms, the views, the sun, the wind, the weather and the seasons. The building will be off-grid and rely primarily on passive natural processes. A more romantic notion of sustainability leads to fairly significant lifestyle implications and the acceptance that indoor comfort levels will vary with the external conditions in summer and winter and that they will be affected significantly by the users' active participation in drawing shades, opening and closing windows and doors, firing the heater, conserving hot water etc. Passive buildings require active users.

Technical
The first and most cost-effective strategy in the design of any passive heating and cooling system is the building itself. The north semi-circular wall is entirely buried in the ground and so protected from the north winds (which are further buffered by the tree plantation). 1.2m to 1.5m below ground, the earth is a balmy 4º - 10º C — the equivalent of moving the lower half of the north wall to Atlanta. The north section of roof is covered by an earth roof and all roofs and walls are well insulated.
A significant proportion of the space heating will be provided by passive solar gains through the south-facing windows in the sleeping areas. Summer cooling will be effected by cross-ventilation, the vent stack effect and trellises which also incorporate movable shades.

An unusually large, custom designed contra flow wood burning masonry heater will provide the residual space heat, as direct radiant heat in the Program Space and as hydronic heating in the washrooms. It will likely require firing no more than once every twelve hours, burning at exceedingly high temperatures which create virtually no pollution, and then the heated masonry mass radiates the stored heat for the ensuing day or night.

Solar panels will provide part of the domestic hot water with back-up provision by the masonry heater.

With no connection to the hydro grid, electricity generation will be through the use of photovoltaic panels, human pedal power (exercise bikes) and a wind machine atop the high point of the site behind the building. Electrical storage will be in batteries and a small diesel generator will provide back-up power if required. Its inclusion significantly reduces the number of costly photovoltaic panels and it is conceivable that it may not be required if restrained lifestyles and sufficient wind power are achieved.

Following the principle that there is no “waste” in nature, Clivus Multrum composting toilets will be used. These waterless toilets reduce all the contents to produce a nitrogen rich fertilizer which can be used as a resource. Greywater will be treated by the Waterloo Biofilter, a biological system developed by the Waterloo Ground Water Research Centre at the University of Waterloo. From this elegantly simple system the cleansed water will be returned to the soil by way of a simple trench tile bed.

**Materials Selection**

In addition to their thermal qualities, materials have been selected to optimize as far as economically practical those which are long life, renewable, re-used, re-cycled, non-polluting and/or which minimize the expenditure of embodied energy.

In the Earth Residence 100% of the structural and finish timber is re-used. Huge fir beams from a factory demolition in Hamilton were transported and a portable sawmill was temporarily installed on the site. This is owned and operated by a local Mennonite who was assisted by YMCA staff, and all the lumber was re-cut to produce large beams, 2 x 4's and even siding. The glulam beams, heavy timber ceiling decking and plywood were re-used. Concrete incorporates the maximum allowable re-cycled content. The floor finish is tile and carpet made from re-cycled plastic pop bottles.

The materials for the Day Centre are under re-review in light of the current availability of re-used products in readiness for a construction start this Spring. This highlights a fundamental
obstacle to the widespread use of re-used materials. At this time, the sourcing of materials, arrangements for transportation, re-working or re-cycling and the grading of structural components in a manner acceptable to the local building official all fall to the owner and project consultants. It is very time-consuming, expensive and plays havoc with timetables and the orderly organization of the construction contract. A lesson gleaned from building the Earth Residence is that central collection, sorting and grading centres are required if we are to re-use and re-cycle effectively and on a large scale in the future.

The site and landscaping design optimizes the use of native, low maintenance plants and re-cycled or re-used construction materials. A new parking lot is surfaced with 100% re-cycled gravel, tree spades have been used to re-locate scores of semi-mature trees, and grading and planting are contrived to provide an agreeable micro-climate, prevent erosion and ensure that rain-water run-off is returned unpolluted to the aquifer. Trees which are not suitable for re-use are mulched and used on the new pathways.

**Conclusion**

These first two buildings represent the first stage of a far-sighted initiative taken by an enlightened client who is dedicated to encouraging people “to live lighter on this earth”. Thousands of children (and many adults) will be taught love and respect for nature and hopefully realize that transforming lifestyles can be challenging and fun. By taking a leadership role within the national organization, the Kitchener-Waterloo YMCA has made a commitment to the promotion of environmental values and knowledge for many generations to come. The Environmental Learning Centre will offer people the only camp of its kind in Canada – and probably North America.

*Charles Simon, principal of Charles Simon Architect Inc., is an architect and planner, and is the only practicing architect to have been granted an honorary membership in the Ontario Association of Landscape Architects. His work has been widely recognized in energy efficient building, environmentally sensitive site planning and resource efficient planning. His inter-disciplinary training and experience has led to a wide variety of community and urban design projects.*
During the Industrial Revolution, the long standing tradition of combining the activities of living and working was slowly abandoned. Strict boundaries were drawn to separate dwellings from work places in an attempt to create healthy industrial cities. Today, the information technology enabled economy of the post-industrial city is allowing for new live/work relationships. Revisions to current city planning policies and fresh initiatives from architects and urban designers have spawned new live/work buildings and mixed use master plans.

Today's live/work buildings address many concerns which the environmental movement has identified as critical to achieving sustainable development. The recognition of the fit between the urban objectives of the environmental movement and the practical application of live/work have lead Ferrara Contreras Architects Inc. to outline a set of principles, which, when applied to architecture and urban design, become the tools for a sustainable urbanism.

Our firm's projects, such as our entry for the City of Toronto's Housing on Main Streets Competition, the live/work prototype House 1034 and the Springwood Homes' Smart live/work community, have explored the application of these principles in an effort to improve the quality of the built environment. The case study conducted by the firm for the Federation of Canadian Municipalities under the Affordability and Choice Today Programme, completed in August of 1994, expanded the scope of our research from architecture into urban design and planning. In this project we identified the requirements and outlined the method for establishing a streamlined
approvals process for live/work.

This case study, entitled "Home Occupation Scenarios: An Investigation of the Context for Live/Work Environments and their Regulatory Requirements" considered the nature of the changing domestic environment. It critically assessed the significant trends in architecture and urban design. It reviewed the urban design policies that regulate and restrict change and outlined means by which municipalities could streamline the regulatory requirements to support existing live/work situations while encouraging new live/work development.

The case study supported the premise that proximity between working and living places was desirable. It was ascertained that this land-use strategy reduced energy expenditures, limited the need for new infrastructure through an optimization of existing infrastructure, reduced the overall use of the automobile and eliminated the need for duplication of services. It presented the opportunity to redistribute uses which have been concentrated in the modern city leading to a more generalized and even urban fabric.

The firm, acting as consultant to the Town of Markham's Home Occupation Task Force, investigated the criteria for determining the acceptability of live/work in residential areas. Our firm was to monitor, report and improve on the process undertaken by Markham so that all Canadian municipalities might benefit from the case study.

Through the efforts of the Task Force, a process based on public consultation was initiated. With the support of a progressive planning department and a visionary council, a municipality-wide zoning by-law permitting home occupation was adopted and has been in effect since May of 1994. Home occupation is now allowed as-of-right in all residential districts of the town with performance standards as the main criteria in governing approvals.

We expect that this innovative approach to land-use planning and regulatory procedure will have a substantial impact on the Town. It will encourage better utilization of land and resources, support existing small businesses and allow for the development of new small businesses in live/work buildings.

The projected benefits include: a general reduction of car trips, a reduction of the wear and tear on existing infrastructure, more affordable and well utilized residential properties and greater lifestyle choices for the Town's inhabitant's. The case study became a vehicle to test new paradigms for urban planning as they impact land and resource utilization.

As the environmental movement has adopted the 3 R's of Recuce, Re-use and Re-cycle as mottos that will rehabilitate our environment, our firm proposed that in planning and architectural projects, professionals should think in terms of Conserving, Condensing and Collapsing. It is our view that these principles can be applied to the design of cities and buildings; with the result being a higher quality environment suited to the information technology dominated economy. As well, we envision social dividends accruing from urban structures based on live/work principles.

Conserving will encourage a prioritized approach to the preservation of land and buildings. It will establish special protection and designation of lands for environmental buffers, agriculture, urban areas and passive lands to support bio-diversity. Preservation, reconstruction and
regeneration should be the cornerstones of a building conservation policy. Conserving, as a strategy, will eliminate wasteful demolition of the existing building stock and will stress the need for the upgrading vs. razing of existing infrastructure. It will also encourage the adoption of new standards for the use, re-use and re-cycling of building materials, the optimization of resource usage, energy expenditure and building life cycle costs. Minimum life expectancies for buildings will also be regulated.

Condensing will discourage the physical expansion of the city and the consumption of farm land and natural habitats. It's implementation as policy will restrict urban sprawl creating centres with higher densities. It will encourage a concentration of functions within land parcels and buildings, optimizing the use of resources and energy. It will promote infill, adaptation and renovation of existing buildings and promote a proper balance of public and private space. Land values will be proportional to intensity of land use and taxation geared to reinforce the environmentally appropriate use of land.

Collapsing will eliminate unifunctional space. It will encourage shared-use facilities and support flexible and adaptable buildings. It will also mean the development of new 'aphysical' spaces that will provide services that can presently only be provided by physical spaces. The continuing expansion of certain aspects of our physical environment threatens our planet. The collapse of certain categories of physical space and the utilization of aphysical space in their place may improve environmental conditions. The implosion of the physical environment and the dispersion of the virtual city may be a key strategy for live/work and environmental planners.

How can these principles be implemented? In what way can architects and urban designers develop these tools?

Our firm has developed a new type of zoning which we have called Interface Zoning. It proposes a methodology whereby land utilization is determined by an analysis of Site Datum. From this analysis criteria are developed and performance standards evolved. Each parcel of land is considered within its environmental context and land use designations for each parcel are configured based on a philosophy of maximizing what can be made to come together in the city.

Interface Zoning has the following characteristics:

1. The redefinition of zoning away from prescriptive regulations to performance based standards eliminate unnecessary approvals processes which do not protect the public interest;
2. The encouragement of a variety of land uses per building parcel based on a systemic proportion derived from the Site Datum analysis resulting in development that is sustainable on its site and within its context;
3. The promotion of new building types and new approaches to combining land uses that result in more diverse, complete and holistic environments;
4. The fostering of a "blanket" approach to land use approvals utilizing Site Datum established by each municipality so that approvals are streamlined and economic use of land is equitable.
In the Town of Markham the implementation of these concepts was accomplished in a simple way and at a broad municipal planning level. The process was initiated by the Task Force. The firm completed an investigation of regulatory requirements, live/work trends and their urban design implications. Performance standards for live/work were assessed using site datum analysis and a 'blanket' by-law, the first concrete example of Interface zoning was developed.

The live/work by-law allows as-of-right for residents in homes, townhouses and apartments a maximum of 25% of their residential space for work/business purposes. It allows owners to employ one person on the premises and to receive a maximum of four visitors at one time. This is permitted provided that certain clear environmental standards are maintained. The by-law enhances the liveability and sustainability of Markham’s residential districts by permitting and legalizing home occupations without bureaucratic or costly approvals.

In this instance, the interface zoning approach is represented by the regulatory mechanism of the blanket by-law. It allows municipalities to create a framework for the multi-purpose use of residential lands and buildings. By focusing on what uses can be made to come together as opposed to how uses should be separated, this blanket by-law becomes a tool that follows the environmental policies of conserving, condensing and collapsing.

The by-law is based on performance standards rather than prescriptive standards. Environmental criteria such as: noise, green space, traffic impact, parking, access to sunlight, etc. determine zoning policy. The built environment is placed firmly in the centre of how decisions about planning the city are made. Rather than municipalities arbitrarily designating areas for live/work the use of performance standards allows for citizens to customize their live/work environments rather than standardize them to municipal regulations. The one-step zoning approvals process permits land uses as-of-right. Special approvals are only required if a performance standard cannot be met.

Our firm developed a generic blanket by-law as a resource tool for other Canadian municipalities to develop their own live/work zoning by-laws. It is currently being used by Vancouver, Calgary, Brandon, Selkirk, Regina and many others in developing their own regulatory framework.

The research our firm conducted also identified emerging trends driven by live/work and the key corresponding environmental concerns which municipalities must address in the future. The following is a brief summary of this research.

As access to virtual space is increased more people will be living, working and entertaining in their homes. We have identified these new building types as Imploding Houses. These are homes that accommodate live, work and play in one physical place and that are visited electronically and physically with greater frequency. This trend has the potential to radically re-invent the residential form as we understand it. We predict that imploding houses as collectors of the redistributed activities of the city will recast the functionality of the urban environment. We will see the evolution of the present villa suburban into a hybrid of a palazzo agricolo made up of very generalized spaces in combination with very specific spaces.

New Live/Work Streets that collect these Imploding Houses and accommodate microbusi-
nesses in residential settings will change the character of the city's residential streets. Idylic residential streets will now have to support new kinds of traffic and servicing while commercial streets will have to be calmed to support the daily activity of living and working. A new composite 'green' street with equitably designated pedestrian, vehicular and bicycle lanes, different parking and servicing requirements, wider sidewalks and tree-lined boulevards may need to be developed.

New multiple-unit live/work housing projects, which we identify as Live/Work Condensers will provide accommodation for people with common interests or people with specialized needs. These buildings will utilize specialized resources. Such condensers have been built for artists, the environmentally sensitive, the aged and the infirm. They are examples of new facilities that can combine communities of self-contained live/work.

Regulatory requirements that impose limits on the emerging aphysical city will have to be considered in response to negative impacts on the spaces of the physical city and the environment. While information technology can be of great assistance in the prevention of environmental degradation it can also enable conditions which could lead to the rapid deterioration of the built environment. A responsible and thorough understanding of the impact of the aphysical city on the physical city and a proper regulatory response to this impact will be required if economic and environmental crisis are to be averted.

The built environment at the end of the 20th century, is following a trend towards generalized rather than specialized structures. While, in our view, the expansive industrial city will be replaced by a more concentrated post-industrial city, the spread of new cities and the expansion of existing suburbs may not be easily halted. In fact new more aggressive regulatory approaches are required to deal with the human consumption of land. The 'no there, there' of the suburb may only be replaced by the post-industrial city with its physical and aphysical ecologies giving the psychic impression of 'an everywhere, everywhere.'

We believe that the application of Interface Zoning based on an analysis of Site Datum implemented through blanket by-laws and clear performance standards may just be the tools that will allow for the conservation, condensing and collapsing that will ensure a sustainable built environment.

Luigi Ferrara is a principal of Ferrara Contreras Architects Inc., a multi-disciplinary firm which was founded in 1989. The firm provides architectural, planning, urban design, interior design, industrial design, research and editorial services. Luigi is a member of the Ontario Association of Architects. He is editor of Perspectives: the Journal of the Ontario Association of Architects.
“Sustainability” versus “Energy Crisis”

Sustainability seems to have become the new archi-environmental catchword of this decade. The fervor of the crusade for a “Sustainable Environment” seems to recall a familiar time during the 1970’s when the words “Energy Crisis” caused highway speed limits to fall and solar design ideas to gain favor. But as quickly as the political furor over Watergate died down, and the capital and cultural boom of the 1980’s gained momentum, architectural concern over energy efficient architecture was virtually replaced by positional battles engaged in Design Style. Student and faculty interest in courses associated with energy conscious design technology showed a marked decline.

Some important technological changes in design approach had, however, taken place and been so thoroughly integrated into design and construction detailing and specification as to have become a non-issue. Perhaps the single most important change in Northern Architecture was the increased amount of thermal insulation now required by code. A fine thread of Technologically concerned Architects and Engineers maintained research, development and application of energy conscious design through the 1980’s and have re-emerged even stronger in the cause of Sustainability. Ecological and environmental concerns have expanded well beyond the issue of the consumption of non-renewable energy sources. The massive consumption of all natural resources during the economic boom of the 1980’s, both renewable and non-renewable, has placed a severe
strain on Global supplies and caused irreparable damage to our atmosphere. “Sustainability” is not a catchword or a passing crusade but threatens to be an enduring problem.

Canada with its sparsely distributed population and relative abundance of natural resources, still operates in a largely wasteful manner, and is only now addressing environmental issues with the intensity of interest and application required. In many respects, the legal framework is still lacking to press responsible environmental responses into service by architects and the general public. Urban sprawl still prevails due to an abundance of less expensive land on the urban fringe and a willingness to commute. Our deep recession has compounded these issues by slowing the building industry and commercial development to a virtual halt, and, significantly reducing capital expenditure and quality control on properties. Most architects and builders are grateful for any work and reluctant to press clients into additional costs for the sake of the environment. Budget is seldom available for voluntary environmental impact studies or additional capital expense to attain a user friendly low consumption environment.

“Sustainability”: It’s Not a “Topic” but an “Attitude”

Where it may be presently difficult to press the profession, the client and the architectural consumer into an environmentally responsible position, it is possible to instill a positive attitude towards Sustainability in the Architectural students of the 1990’s. The architectural applications of the principles of Sustainability require carefully considered limited consumption of those natural resources which we must use, and articulation that is carried out in such a way as to minimize wastefulness and promote longevity. It is not an argument against architectural development, but rather, because architecture and construction necessarily consumes massive amounts of materials and related energy, that the usefulness of those materials must be maximized.

Addressing the issue of Sustainable Architecture and Urban Design in the curriculum requires the adoption of an attitude that must permeate course content, from the most minute detail to the most general principles. An attitude must be nurtured in Architectural Design Education which focuses on Quality and Durability in Design and Construction. Sustainability cannot be “covered” by a single lecture or even an entire course. Conceptually it must be acknowledged in the broadest sense throughout the curriculum.

Implementing Through Building Science and Construction Practices

Technological issues related to solving the “Energy Crisis” expand quite naturally into research and practice towards a “Sustainable Environment”. The teaching of Sustainability in Building
Technology design and detailing choices can rely on an established "cause" for its instatement into the mandatory criteria for architectural design. Where Building Scientists currently have difficulty in controlling the wastefulness of continued urban expansion, we can present a reasonable and well established case for minimizing architectural consumption of materials by maximizing the effectiveness of their use. Here a serious argument can be made for Quality in architectural design, through detailing and the selection of durable materials in order to provide a long lasting product that will not require massive amounts of replacement and repair in the first five to fifteen years of its life span. Detailing and material selection are constantly addressed in the teaching of Building Science and Building Construction. Where we have always argued for Quality of product in the achievement of excellence in design, the notion of sustainability realistically and vitally extends and reinforces the idea as a means of minimizing the consumption of materials and resources by designing for longevity.

Teaching Building Science in the context of Building Construction methods and requirements within an Architectural Design curriculum, requires that Technology professors address numerous topics and criteria which are critical to the development of excellence in architectural design, from both overall and detailed standpoints. The degree of excellence achieved can be measured not only by the "Quality" of the Architectural Design and Concept of the building, but by the "Quality" in the detailing and construction of the building, and the ability of the building to "perform" and withstand deterioration over time. Building Science and Technology issues concerning Quality and Durability are a natural springpoint for a discussion about Sustainability and the impact that Technological choice and proficiency has in extending the life of the natural resources consumed by Architecture.

The Modern Period was marked by massive consumption and accelerated development. Many poorly constructed buildings of the 1950's, 1960's and 1970's have already been demolished and replaced. The movement towards design to conserve the energy associated with heating and cooling our buildings during the 1970's signaled the emerging concern in the modern building industry for the limitations of our environmental resources. Building practices as a result of research of this period served to increase the quality of construction, especially in the north where energy consumption and cost to the consumer continues to be a major issue. Solar design, both with respect to active and passive systems, not only involved Building Science and Construction detailing, but was necessarily integrated with the overall Design Concept. Construction and design quality was achieved by the geometric articulation of the building to access and maximize solar energy, the installation of increasing amounts of thermal insulation, using better insulating and sealed window units and reducing heat loss associated with exfiltration by sealing buildings. The architectural responses brought about by the "Energy Crisis" were narrowly focused on escalating energy costs as they relate to heating and cooling. Related environmental issues which sprung from difficulties associated with "tight" building construction gave rise to research on ventilation and air quality.

The reexamination of Building Science problems associated with moisture and exfiltration,
which occurred during the 1980's in Canada and resulted in the adoption of Building Code
changes calling for the installation of "Air Barriers", further increased construction and detailing
requirements in the building envelope as well as resulting in the development of new materials
and systems. For this type of construction to be successful, extreme care is mandatory both from
the point of view of detailing as well as constructing in order to eliminate all uncontrolled points
of Air Leakage in the building envelope. Its implementation resulted in higher quality construction
and the use of more durable materials.

"Life Cycle Costing" was initiated as a means to justify the extra expenses related to
increased thermal performance by identifying a reasonable "payback" period. Capital expenditures
to achieve superior performance through a better insulated and sealed building were justified
through "Life Cycle Costing" demonstrations which illustrated a net long term savings. Where the
"noble" cause for increased quality of construction and capital expense was to conserve energy
and "sustain our natural resources", the actual reason for implementation was often the attain-
ment of long term cost savings. The rapid rise in cost of all types of energy sources from the
mid 1970's to the mid 1990's proved many of the "Life Cycle Costing" figures more than correct
and suitably justified the expenses related to increasing the quality of construction and building
detailing.

Quality and Durability implemented in long-life designs will not only reduce overall costs
from a life cycle costing viewpoint, but reduce the long term impact on our environmental
resources by increasing life span of products and buildings, thereby decreasing the end amount of
material used. Where the boom of the 1980's in speculative construction could not successfully
argue for long term returns on investment due to a quick turnover of ownership, the slowing pace
of construction in the 1990's and the impending stabilization in the industry is building a product
which is not necessarily intended for immediate resale, and therefore can again begin to support
an argument for quality as supported by Life Cycle Costing and Analysis.

The environmental notions represented in the idea of "Sustainability" involve a broader
impact on the field of Architectural and Urban Design. The environmental impact of Architecture
and Urban Design can be measured not only in terms of the relationship of the built environment
to diminishing "natural" space, but also, in terms of architecture's consumption of our renewable
and non renewable resources, as well as our ability to recycle and make use of recycled products.
Awareness about these pressing issues has been heightened by the EPA's funding program for
Sustainability in Architectural Design, and demands a direct approach when addressing issues of
the impact of Architecture on our environment and its dwindling resources. Although many of the
urban or macro scale solutions to problems concerned with "Sustainability" are beyond the scope
of the effects of Building Science choices, as much of the game is won or lost at the outset by
design decisions regarding siting choices during the preliminary design stage, Building Science
can be involved in creative solutions pertaining to implementation on the detailed or micro scale,
which when multiplied by frequency of implementation, can make a significant difference to the
environment.
A REGIONAL APPROACH: USING CASE STUDIES

The notion of Sustainability as it is applied to the various criteria for Architectural Design, necessitates a specifically regional approach for implementation. This approach relates directly to the severity and type of the climate, availability of space for building, available technologies or materials, local building codes and regulations, and a relative sense of urgency (often imposed by the authorities having jurisdiction). Stressing regional considerations provides the student with a realistic and recognizable approach to handling problems. Identifying regional differences in performance requirements helps to refine technological content and define areas of appropriate use. This helps to prevent inappropriate technology transfer which may inadvertently undermine the integrity of the architectural project.

The use of case studies easily demonstrates how an architect who may be accustomed to constructing in California, for instance, however experienced, may make inappropriate or flawed decisions when transferring their design concepts to buildings to be constructed in the Midwest or Northeast. Quality in detailing and material selection needs to be addressed from a regional point of view via specific significant architectural examples. With the widely varied climate of the North American design context, from the problems associated with heat control in the south, to the severely cold climate of the north, rainy climates and coastal conditions, design must be justified and modified to account for the impact of the environment on architecture. Students need to understand the fallacy of approaching regional design with an inadequate response to specific environmental problems and limitations. Case studies can not only be used to highlight regional approaches, but used as a vehicle for design studies involving technological transformation to satisfy alternate requirements.

Many of the architectural construction texts which we ask our students to read fail to specifically identify regional issues. Much of the remainder of student design and technological information is absorbed from other “D”esign oriented books and periodicals. Style and detail which is either out of date or regionally incorrect is often inappropriately borrowed and blindly applied. Teaching Design and Construction in a harsh northern climate as I do, I frequently find students enamored with Southwestern architecture and heroes, struggling with thermal requirements, moisture problems and snow loading in an effort to appropriately re-climatize the building. Thoroughly discussed case studies provide an excellent means of supplementing existing construction texts by providing a means of highlighting issues of sustainability and regionality.

Students can quickly slide into poor detailing and selection practices if they are unaware of the severity of their consequences. The use of case studies of building failures, including the careful analysis and detailed post mortem of the technical failures of both ordinary and prominent 'hero designed' buildings is successful in catching the attention of students. It dramatically impresses upon them the inherent problems associated with improper detailing and material selection. Students are simply appalled to see mass deterioration due to improper detailing or sub-standard material selection in buildings which are two to ten years old.
Conclusion

The educative years are a perfect time to instill students with the ideals and morals imperative to sustain our environment. The moral appropriateness of Quality and Durability in Design and Construction will not be questioned in the absence of skeptical clients and economics. If we are able to instill students with a positive attitude regarding the inherent conceptual importance of Sustainability, we can succeed through small measures in creating Quality in Design.

The issue of Sustainability as it applies to Architecture and Urban Design demands that Building Science and Building Technology are given greater heed by Students and Designers because of the critical role that these fields play in increasing the longevity of our diminishing natural resources. If we examine the following eight concepts for Sustainability through Technological choice, we can easily identify a significant contribution to be made by educators in the field of Building Science and Construction. If Sustainability is embraced in the smallest scale of detail, its positive effects will multiply and permeate architectural development in general. A small pebble can ripple even the largest pond.

1. Specify products that have a long life expectancy. Substandard products which must be replaced in a short time create landfill and waste materials. Often these products are difficult to direct to recycling streams. (i.e.. windows, faucets, hardware, cladding, roofing)

2. Detail for durability. Even quality products can be badly detailed, resulting in deterioration and necessitated replacement.

3. Quality control in site or construction review. Ensure that the contractor is reputable and understands the intentions and warrantees or guarantees work for an adequate length of time.

4. Design to reduce energy consumption. This involves design with climate, orientation, understanding solar heat gain benefits and problems associated with fenestration, daylighting considerations, use of PV, proper use and design of thermal insulation, proper selection of heating and cooling systems, passive solar energy, mass thermal storage.

5. Low energy vs. High energy materials. Information is readily becoming available to carry out an educated analysis of building materials based on their overall energy consumption, from production to installation, taking into account the effects of recyclability.

6. Recycle materials. Require that site waste be streamed to take advantage of local recycling programs. Reuse formwork, strip nails and salvage, or make scraps and unwanted materials available to the public for their use as their labor may be less expensive.

7. Specify recycled materials. Be aware of the products which use recycled materials as these often save on the consumption of natural resources. Cadding and tile products are available which make use of recycled aggregates or marble chips which saves on the quarrying of new materials.

8. Avoid endangered species. Be conscious of specifying materials which are non renewable or whose harvesting endangers wildlife.
Where the overall design criteria for a project may not always be able to respond to urban issues regarding Sustainability, every building to be constructed or renovated can benefit by Quality Design for Durability. In this way all courses in Building Science and Building Construction taught in Schools of Architecture may positively influence the Sustainability of our Environment.

At present, teaching and research in the field of Sustainability and Passive Design in Canadian Schools of Architecture is lagging far behind their American counterparts. A significant number of West Coast and Southern U.S. Schools have entire Technology courses, Design Studios, research laboratories and faculty devoted to the teaching and promotion of Sustainability and Passive Design principles and applications. Although considerations of climate and regional vernacular may initially appear to favor applications in consistently warmer areas, the implementation of these objectives can significantly reduce the environmental impact of architecture in cold climates as well.

Who is ultimately responsible for educating for Sustainability? It is an imperative endeavor which should be of central concern for ALL Architects, both practicing and student, Technologists and Designers. Although the development of interest groups on the subject has largely sprung from technological sources, the Architectural application of the ideas of Sustainability is not specifically a Technological subject. As educators of Technology and Design, we have an immense responsibility through our preparation of future Architects. Through the ripple effect we are able, with our graduates, to eventually permeate the field of practicing architecture with a thoughtful and thorough approach to implementing the issues of Sustainability.

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As architects, we have come to recognize that we are facing an ecological crisis of alarming magnitude. Much worthwhile work is underway regarding how we can address the problems which this understanding brings into consciousness. However, the context in which these solutions are sought, remains for the most part based upon a world view driven by global economics and mechanistic technologies.

This paper offers a critical analysis of this position, seeking first to demonstrate how we as architects have allowed our creative processes to fall out of alignment with the creative processes of the planet, followed by the exploration of a functional cosmology which is rooted in an understanding of the earth as primary and the needs of the human as derivative. Finally, it examines ways in which architectural technologies can begin to function in an integral relationship with earth technologies within a bioregional context.

Many of the insights which I share throughout this paper have been deeply informed and influenced by the work of mathematical cosmologist Brian Swimme, and cultural historian Thomas Berry, both of whom are grounded in contemporary scientific understanding and inspired by the world’s great wisdom traditions.

**The Big Picture: How Did We Get Here And Where Are We Going?**

The Cenozoic age in the geological history of the earth’s planetary evolution is described by Thomas Berry as the lyric episode of the earth’s story. It is the time after the extinction of the
dinosaurs when the great diversity of plant and animal life that we know today came to flourish. Sixty-five million years of creativity and fecundity brought the flowers and birds into being together with their myriad colours, fragrances and songs. During this period, the human too came into being as a distinct species. With time, language and culture emerged along with rituals that celebrated the surrounding beauty and diversity and which recognized the human's interconnectedness with and dependence upon the natural rhythms of the cosmological order. In a sense, through human consciousness, the universe could now reflect upon itself... could marvel at its wonders and mysteries. The earth was perceived to be imbued with life, to be a beneficent, nurturing mother. The father sun and sky were likewise seen to be beneficent and life-giving. The primal architecture of the time reflected this harmonious relationship.

With the transition from hunting and gathering of food to the cultivation of crops and the domestication of animals, the relationship of humankind to the natural world changed. A more active intrusion into the functioning of the earth's life forces began during this time as humans developed irrigation techniques, selected certain plant species and began cultivating the soil with tools. The great classical civilizations of history emerged in those fertile regions of the planet that were most consistent and dependable to supply their needs. The domestic, civic and religious architecture of these civilizations remained informed by the particular nature of the local bioregion and by a collective understanding of the relationship between humankind and the universe's eternal order. It was during this period of the classical civilizations that a sense of the pathos of the human condition emerged. While the phenomenal world was full of entrancing sights and sounds and fragrance and feelings, it also constituted a threatening reality to human life.

With the onslaught of the "Black Death" during the Medieval era, western consciousness further lost its sense of harmony with nature and came to live in fear of it. Traditional wisdom rooted in a deep understanding of mythic harmonies in the natural world eventually gave way to the search for empirical knowledge in an attempt to exploit and manipulate nature for the protection and benefit of humankind. The ability to transcend the human condition became of paramount concern to the scientific community. The universe was no longer perceived to be alive but was now understood in mathematical and mechanistic terms. Traditional cosmology became "mathematical cosmology". The disciplines of philosophy and theology were left to deal with the traditional questions concerning the role and meaning of humans.

With the coming of the Industrial Revolution and the widespread acceptance of Darwin's Theory of Evolution that placed the Human as the crowning glory of the evolutionary process, the Modern Era emerged. The understanding of natural selection based upon a cooperative relationship between a particular species and its environment became distorted. "The survival of the fittest" soon became the justification for an insatiable quest for economic wealth and power under both capitalism and socialism. The earth was seen solely as a resource to be exploited for its raw materials to fuel the engines of the economic enterprise. It also became the dumping ground for the waste products of these same industrial processes. The earth's ability to provide and absorb was assumed to be limitless.
Our current architecture reflects the deep cultural pathology of our times. The modern human adventure, particularly here in the western world, remains articulated and driven by a powerful myth deeply rooted in our collective consciousness. Thomas Berry and Brian Swimme have identified this as "...the myth of Wonderland, the Wonderland that is coming into existence by some inevitability if only we continue on the path of Progress, meaning by Progress the ever-increasing exploitation of the Earth through our amazing technologies." As architects, we are inextricably part of this human process which is quickly bringing to an end the Cenozoic Age of geological history. The complexity and diversity which has evolved over the past sixty-five million years of planetary creativity is being undermined at an unprecedented rate through human intervention. In our race to control and exploit the earth’s natural resources for the benefit of humankind, we have been blind to the fact that we are shutting down the very life supporting systems of the planet that we depend upon for our survival. Like similar addictive behaviors, our thirst for unmitigated production and consumption is accelerating the demise of the Cenozoic. We continue to believe in and trust that technology will find solutions to our problems. This is the denial of our addiction.

Certainly technological advances have made significant contributions to the human adventure. If it were not for the Space programme, astronauts would not have been able to see this blue-green planet in all its beauty and fragility and to recognize the earth as home. Perhaps we would not have recognized the ecological crisis and as a profession would not have a Committee on the Environment or be hosting an Envirofest. At the same time however, I fear that the increasing trend towards dependence on computer technologies in architectural practices today, while serving to expedite much of the design/production process, also serves to mediate us from our creativity in a very fundamental way. We have yet to recognize that our creative processes have fallen out of alignment with the creative processes of the universe and that we are in fact working against them and subsequently against ourselves. However, there is still time to change course if we are willing to respond to the many signals which are clearly indicating our contribution to the degradation of the environment. Our responsibility as architects is to actively seek out an alternative to the emerging Technological Age.

Towards the Ecological Age; The Earth as Primary Architect

The Ecological Age as defined by Thomas Berry into which we must presently move is “an opposed, though complementary age that succeeds the Technological age.” Our scientific endeavors have brought us to understand the governing principles which have directed the evolutionary process of the universe from the beginning of its explosive origin over fourteen billion years ago to the emergence of life and human consciousness here on the planet earth. Known as intuitive processes in the cosmologies of previous human eras, these creative principles are
now understood through scientific reasoning made available by quantum physics. That there is a story of the universe in its historical sequence of irreversible transformations in measurable time was never realized before this century. However, according to Berry, in order for the human venture to ensure its success, we must come to understand this story of the universe not just as a secular story, but as our "sacred" story.

We have come from an age where it is evident that a cosmological vision has been eclipsed in favour of a more mechanistic and reductionist perspective. And it is clear that this approach is pathological in the magnitude of its destructive methodologies and processes. But how do we extricate ourselves from the terminal Cenozoic era and emerging Technological age? How do we begin the journey towards the alternative Ecological age? How do we weave ourselves back into the web of life? What we need to do as architects, we must first do as humans. The real hope lies in our ability to re-establish an integrated sense of the whole, to redefine a cosmology based not upon an anthropocentric view of the human as primary but based instead upon a biocentric understanding of the earth as primary and the needs of the human as derivative. In order to do this we need first to examine the inner intentionality of the universe as manifested by its three creative principles: differentiation, subjectivity, and communion.

According to Thomas Berry, "differentiation" is the primordial expression of the universe. Out of the fiery violence of the "Big Bang" came radiation and differentiated particles that through a certain sequence of events, found expression in an overwhelming variety of manifestations. The universe is coded for an ever increasing, non-repeatable, biodiversity as exemplified by the incredible variety of life that has evolved on the earth. From its rich and abundant tropical rainforests to the stark beauty of its polar regions, the evidence of this tendency towards biodiversity is obvious. Humankind would not have appeared as a species if somehow the process towards increasing biodiversity had been allowed to shut down. As architects we cannot help but be creative because the universe is creative. Our role as humans and as architects must now be to reverse the imposition of our monocultural principles upon the world and to restore the earth's ability to continue its growth towards complexity and differentiation.

The second primary creative principle of the universe as identified by Thomas Berry is that of increased "subjectivity". Together, every reality that makes up a part of the universe is not just a collection of objects but is a community of subjects. As subjects, we all have an inner dimension, an interiority or inner reality which not only reflects the diversity that surrounds us but reflects the original bursting forth of energy at the beginning of time. Our creativity as humans and ultimately as architects is informed by the diversity of subjectivity that is allowed to declare itself around us. Any human activity which contributes to the impoverishment of the natural world will then inevitably contribute to the impoverishment of our sense of wonderment. With every species that becomes extinct, every mountain that becomes scarred by deforestation, every river that becomes polluted with our industrial wastes, the presence of the divine that inspires our creativity as architects is diminished. Our own ability to survive as a species will depend to a great extent on the ability of all natural entities on the planet both living and non-living to develop
their full potential apart from human influence as much as possible.

Thomas Berry's third creative principle of the universe “is the communion of each reality of the universe with every other reality in the universe.” As mentioned before, we are an inextricably related community of subjects. This genetic interrelatedness of everything in the universe to everything else means that the universe is in dialogue with itself as a community. “Everything is intimately present to everything else.” The original bursting forth of energy at the beginning of time contained all the elements necessary for the evolution of the universe up to and including human culture. The potential for music, poetry, dance, art and architecture existed as part of that original expression. This is why we are connected to the stars in the night sky and to all living and non-living realities on the planet, why they are deserving of our awe and reverence, and why we must celebrate them in our creative arts.

When our actions cause a living species to become extinct, or when our work is responsible for the destruction of a natural habitat, we are in fact destroying a part of ourselves. The universe in all its wondrous modes of expression is a celebration of the intricate dance of creation. As humans, and architects, the time has come for us to forfeit our role as exploitive dominators and to assume the more responsible role of participatory co-creators by re-aligning our sense of creativity with the creative principles of the universe and the planet.

We will be planning on a planetary scale and we must have a functional cosmology as our context for developing the necessary programme to achieve our goals. To assist us as architects, I will adapt as the basis of our programme some basic principles that Thomas Berry identifies as part of an agenda to achieving a mutually-enhancing, human-earth relationship.

Towards a Functional Cosmology

Before we can identify a new functional cosmology, we must first de-glamourize our current myth of Progress and replace its entrancement with the entrancement of the possibilities inherent within the Ecological alternative based on the universe story. This will be the only way to achieve and sustain the psychic energy necessary to proceed through the inevitable conflict resulting from the disintegration of the current unsustainable industrial infrastructures and emerge into the Ecological age.

It will be the task of all education including architectural education to play a leading role in achieving this goal. Through a critical analysis of the processes that fuel the myth of progress, students will come to understand the true costs of our privileged western lifestyles. As they come to fully comprehend the flagrant loss of habitat and species perpetrated by humans in the name of growth, they will experience a deep sense of loss. They will become sensitized to the fact than nature has its own unique, intrinsic and equally important values apart from those imposed by the human community. Ultimately loss is revelatory. Hopefully, our sense of reverence will return out
of this place of deep feeling and we will be able to, once and for all, let go of our anthropocentric ethic of dominance. Hopefully, what will come is a renewed advocacy for the voices of the earth community that for too long now have remained unheard only because as humans we have chosen not to listen.

Ours is a terminal culture. There will be much grieving, too, over the loss of "Wonderworld" and our addictions to over consumption which because of depleting resources can no longer be fed. Although the grieving process is an important component of our journey towards the Ecological age, it is not the whole story. Out of a renewed reverence for the earth and all members of its living and non-living community will come the desire for great celebration. The primary role of the human now will be to learn how to celebrate. All other members of the earth community are willing mentors. We need only stop long enough to pay attention to the everyday celebratory voices of the birds, the mountain streams, the wind in the trees.

As architects, it may be constructive for us to re-examine the architecture of primal peoples and that of the great classical civilizations as tangible expressions of their understanding of the universe and their role as humans. However, just as there is a need to replace our present dysfunctional myths, our intention is not to adopt the cosmologies of these previous civilizations. "The universe story is a one-time, multi-faceted, celebratory event" says Berry. We cannot go back, but must create our own cosmology to serve us for the venture that lies ahead. This new cosmology must put aside our tendency to place the human at the centre of the universe. Instead, it must adopt a bio-centric foundation which recognizes a new reverence for the other members of the earth community as integral to our lives as humans.

We cannot afford to be mistaken. Minor changes to our habits of consumption through re-cycling and conservation efforts will only marginally slow down the inevitable demise of our modern western industrial society. For architects, it will never again be "business as usual". In June of 1993, at the World Congress of Architects held in Chicago, members of both the International Union of Architects and the American Institute of Architects developed and signed an agreement known as the "Declaration of Interdependence for a Sustainable Future". Although this document still demonstrates a preferential bias towards the human, it marks a bold and significant departure for architectural enquiry and dialogue. As architects, it is not enough to articulate on paper what we profess. We must be willing to embody wholeheartedly in our actions as professionals and as members of the broader earth community what we teach and what we believe.

**Towards Human Technologies That Function in an Integral Relationship With Earth Technologies Within a Bioregional Context.**

Thomas Berry notes, "The spontaneities of nature need to be fostered, not extinguished. Nature has, during some hundreds of millions of years through numberless billions of experiments,
worked out the ecosystems that were flourishing so abundantly when humans and human civilizations emerged into being." It is only through sheer species arrogance that we submit the earth's ecosystems to our own technologies developed independently from and in direct opposition to the technologies of the earth for the sole benefit of humankind. It would be much more productive to invest our time in observing how the natural ecosystems of the earth function so that we can learn how best to exist in harmony with them. We have already said that the earth must be regarded as the primary educator, as the primary architect. Our building technologies must now be judged on how well they reflect the Universe's, and subsequently the earth's, guiding principles of differentiation, subjectivity, and communion.

The good news is that initiatives are being made by many concerned members of the profession. For example, the American Institute of Architects has compiled an Environmental Resource Guide. Similar comparative studies on building materials and real life cycle costing is being done here in Canada at the University of British Columbia. The OAA hosts the annual Envirofest and demonstrates its support for initiatives within the membership by sponsoring the sharing of ideas and information. In the meantime, others are asserting pressure on the manufacturing industry to come up with more ecologically benign materials, technologies and assemblies than those currently available. Others are attempting to improve energy efficiency standards in new and renovated buildings. The idea of "resource conservation" is finally becoming legislated. Whereas all of these approaches represent necessary first steps, they are somewhat analogous to the "Blue Box Programme" and are, in themselves, insufficient to redirect our present path towards ecological disaster.

Part of our responsibility as architects is to advocate for change in all areas within our sphere of influence. The decisions we make about the building materials we specify have far reaching implications, not only for our own bio-community, but for the bio-communities all over the world which supply, process, or manufacture them. With knowledge comes responsibility and accountability. There is no turning back. It is time to stop contributing to the degradation of the planetary bio-systems and start designing to improve the health and well being of all members of the earth community. It is time to restore bio-diversity...to re-connect humankind to the natural world...to restore balance.

To do so, we must also come to understand the meaning of "sacred place". I would like to suggest that every place is a "sacred place" by virtue of its existence in the universe. It is sacred by virtue of the fact that it will speak to us(subjectivity) in its own unique way(differentiation) of the numerous mysteries of the universe(communion), and because it participates in the celebratory, creative dance of the universe.

It is time for us to reconsider at a very fundamental level what it means to practice architecture in a place like the Greater Toronto Area, on the north shore of Lake Ontario, in the bioregion of the Great Lakes. Next time we are asked to design a building within our bioregion, before we bring preconceived ideas and biases to the design process, what if we were to first engage in a "vision quest"? What if we were to camp out on the site for an extended period of time so that
we can trace the effects of light and shadow as the sun traverses overhead, or witness the
dynamics of the wind and rain as they interact with the site's natural features? What if we were
to get intimate with the site...to feel the undulations and textures of the land contours beneath
our feet...to get in touch with the natural vegetation, with the composition of the soil, with the
voices of the living and non-living members of the property and the surrounding bio-regional com-
community that depend upon the site either for their survival or for their declaration of presence? The
immediacy of such an experience would undoubtedly sensitize us as architects to the many ways
in which the natural world speaks to our desire to find solutions to the human built environment
which are truly in harmony with the natural environment.

The understanding achieved by this first hand knowledge could then be supplemented
and greatly enhanced by research into the geography, natural history, geology, and biology of the
surrounding area. In the context of the universe story, these subjects could put us in touch with
the development of a site's unique characteristics over the millions of years of its existence.
Furthermore, we would gain essential insight into the very materials that we as architects manipu-
late, form and mould into our creative design solutions. 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 their sacred dimen-
sion and the recognition of their contribution to the development of our own species and to the
ongoing role they play in sustaining life on the planet.

Instead of focusing on computer technologies that ultimately serve to mediate our experi-
ence of the design process rather than to bring us more in touch with its intuitive aspects, why
not focus on the development of “low-tech” solutions which take their cue from the natural life
supporting systems of the planet and which respond directly to the natural rhythms and particular-
ies of a site and its surrounding bioregion.

Perhaps we should consider a building as though it had to function as its own self-sus-
taining eco-system. What are the real needs that must be accommodated by this building? Can
we do without air-conditioning equipment that requires extensive use of fossil fuels and which
depends upon ozone-depleting chemicals to operate? What then? Can we orient the building to
capture the summer breezes? Can we design “wind scoops” that direct and enhance the flow of
those breezes through the building or that naturally exhaust the excess heat within? Can we plant
trees that will create shade and reduce heat gain? And so on... This level of enquiry, together
with developing ways to receive and interpret the clues offered by the natural world around us are
where we need to devote our learning skills.

Hopefully, a renewed intimacy and sense of interrelatedness to nature will go a long way
towards recovering the poetic and cosmological dimensions in architecture which we so willingly
forfeited at the dawn of the Age of Reason. By adopting the values of differentiation, subjectivity,
and communion, we may come to fully realize our personal abilities and the unique contribution
that each one of us can make as architects to an understanding of creativity beyond our wildest
expectations... a creativity that has already been initiated by the universe in its original bursting forth of primal energy, and which continues to be demonstrated through its self-emergent processes in the natural world around us.

As architects, we have traditionally devoted our creative energies towards giving concrete expression to humankind's collective hopes, desires, and aspirations. As such, we have the potential to nurture and give expression to the dream of an emerging new Ecological age, based no longer upon an exploitive anthropocentrism, but instead upon a participatory bio-centrism in which the human species co-habitates with the entire earth community in harmony and balance.

It is time to re-enter the creative dance of the universe.

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ONTARIO ASSOCIATION OF ARCHITECTS

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