Chapter 2:

SUSTAINABILITY AND CONSTRUCTION TECHNOLOGY: *AN ATTITUDE IN SUPPORT OF QUALITY*

"Sustainability" versus "Energy Crisis":

At first glance the cry "Sustainability!" reminds me of the classic fairy tale of the "Boy Who Cried Wolf". 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. Gasoline line-ups were an event of the past. Student and faculty interest in courses associated with energy conscious design technology showed a marked decline. Interest in Architectural Theory and History increased. The "Energy Crisis" was all but forgotten. The New York State Thruway may remain at 55 mph, but the speed limit on the Mass Pike is back up to 65 mph. Will "Sustainability" share the same fate?

The "Energy Crisis" had not disappeared, but rather some important technological changes in design approach had 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.[1] "Sustainability" is not a catchword or a passing crusade but threatens to be an enduring problem. Many quality aspects of our natural environment will disappear long before the need to be concerned with "Sustainability" will cease to be of central concern to the world community.

"Sustainability": It's Not a "Topic" but an "Attitude"

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[2], 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 that focuses on <u>Quality</u> and <u>Durability</u> in <u>Design</u> and <u>Construction</u>. 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.[3]

Implementing Through Technology:

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[4] 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.[5] 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.

Historically the field of Building Science Research and teaching was initiated as a response to the need to increase the performance of new building technologies and practices during the Post Second World War Period. Many new materials and methods of construction appeared during the Modern Period, followed closely behind by new types of material, building and envelope failures. Many of these failures, which were to become the primary focus of Building Science research during the 1960's, resulted from the inability of the new systems and construction practices to perform under local climatic conditions, resulting in deterioration of varying degrees. The performance criteria for Building Science that ensued focused on issues of durability against the forces of heat and moisture, and, issues of safety and health. The resulting decrease in building failures netted an improvement in architectural detailing and construction. Agencies developed during this period whose job it was to increase awareness about the importance of technological issues.[6]

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.[7] 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.[8] 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 relate to heating and cooling. Related environmental issues that sprung from difficulties associated with "tight" building construction gave rise to research on ventilation and air quality.[9,10]

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.[11] 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.[12]

"Life Cycle Costing" was created 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 attainment 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[13].

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[14], 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.[15]

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.[16] 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[17], 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.

Non Renewable Resources and The Embodied Energy of Materials:

The teaching of Building Construction naturally includes a discussion of the process of the material selection for structural systems, cladding and roofing systems and finishes. A comparison of products on the basis of the depletion of non-renewable resources has recently developed. The fight between the Wood and Steel industry over the residential framing market has brought this issue to the forefront. The Wood industry has had to assess logging practices, the devastation of old growth forests and the refurbishing of stock. The Steel industry has dealt with the notion of a non-renewable resource. The established criteria that forms the basis for the decisions associated with the material selection process has also come to include the issue of embodied energy. Embodied energy is defined as “the amount of energy used to manufacture, transport and install the materials in a building.”[18] By understanding the energy impact of materials, architects can begin to inform the material selection process to exclude the use of materials either that are characterized as “endangered”, or, based on their energy consumption.

Embodied energy can represent up to 30 years worth of the operating energy of a building.[19] As a result, material selection -- which is certainly central to the teaching of Construction Technology -- can have a substantial impact on the overall “Sustainability Rating” of a building. This impact can begin to parallel in importance architectural design decisions regarding Passive Design, HVAC systems and energy supply choice.

Building materials impact the environment through Global Warming, the production of atmospheric carbon dioxide and carbon emissions. The energy consumption associated with material production and transportation impacts the depletion of gas, oil and coal reserves. The burning of these fuels, coupled with the chemical processes to refine construction materials, emits pollutants and toxins into the air, as well as adversely affecting the ozone. The environmental impact of building materials has become a central research topic. This is not proving to be an easy task as the issue is extremely complicated. Government research institutes, aided by private practitioners are in the process of assembling data and reports in an attempt to clarify and simplify the decision making process.[20] As these are published the task of educating students and the profession will become more straightforward. In the meantime, creating an awareness is critical to ensure the ready absorption of eventual "fact" into the process of design.

A Regional Approach:

As with other areas of Building Science and Applied Technology, such as Solar Design, thermal and radon gas requirements, the notion of Sustainability as it is applied to the various criteria for Architectural Design, necessitates a specifically *regional approach* for implementation.[21] 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.[22] This helps to prevent inappropriate technology transfer that may inadvertently undermine the integrity of the architectural project.

Having recently attended several Technology based Architectural Education Conferences, has served to reinforce the importance of a regional understanding of architectural detailing. At the ACSA Construction Institute in Rhode Island in July 1994, aspects of the audience came to life as topics ranged from "Dade County Regulations" in the development of standards pertaining to hurricane design standards, a discussion of changes in seismic construction requirements from the California contingent, complaints of ice dams and snow damage last winter from the Northeast which argues for increased roof venting, versus pending changes to eliminate eave venting because of the residential flame transfer identified in the Berkeley fires, and the installation of PV units and related solar design from the sun drenched Southwest. Many of the architectural construction texts that 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 that 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.[23]

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.[24] 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. Many people are unwilling to commit to living in tighter spaces near the city center to diminish the impact on our dwindling farmlands and decrease auto dependency. 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 cost 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. High labor costs make it uneconomical to recycle or reuse many construction materials. The labor to clean the nails out of dimension lumber used for formwork exceeds the cost of buying new lumber -- hence, the used lumber is usually designated as landfill. Consumers will readily use cheap inferior products versus durable quality products as the majority are not seeing into the future for an adequate secure distance to realize the overall cost and environmental benefits. Increasing difficulty in obtaining adequate landfill sites in close proximity to urban centers is becoming one of the chief motivating factors to select materials and products which have a longer life expectancy.

Teaching "Sustainability" through Case Studies:

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. Thoroughly discussed case studies provide an excellent means of supplementing existing construction texts by providing a means of highlighting issues of sustainability and regionality.

Sustainability through Quality design can be taught "positively" and "negatively"[25] -- each approach reinforcing the correct position of the other. *"Positive"* teaching relies on the constant illustration of the correct means of detailing and material selection. This may simply be an extension or reinforcement of current teaching practices. These tactics, we have found, are only partially successful in instilling good design practices in students. Students can quickly slide into poor detailing and selection practices if they are unaware of the severity of their consequences. *"Negative"* teaching can often make a more pressing and lasting impression on the importance of the issue, (as has always been found with "bad" commercials and "bad" PR). This approach relies on the use of case studies of building failures. The careful analysis and detailed post mortem of the technical failures of both ordinary and prominent 'hero designed' buildings is more 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 substandard material selection in buildings that are two to ten years old.

The continuing development and documentation of these case studies is essential to supplement existing texts on Building Construction that are sorely deficient in addressing regional concerns as well as general issues of Building Science. It has been found valuable both to present these case studies to students as well as to require their personal research and investigation of other instances. Involving the students in information gathering not only helps to increase their appreciation of the problems inherent with design and detailing from the point of view of Building Science and, but as well, increases the pool of resources for teaching if the product is well documented. It is useful to involve students in the research and preparation of cases, not only of buildings who have been time tested and either passed or failed, but in the speculative analysis of new buildings, recently constructed. Information can be gathered by students over a series of terms and years and the progress of the building can be followed. Students in subsequent classes can prove, disprove and build on the findings of previous years.

Conclusion:

The education 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 that 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,[26] daylighting considerations, use of PV[27], 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: The Issue of Embodied Energy.*** 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.[28]

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.[29]

7. ***Specify recycled materials.*** Be aware of the products which use recycled materials as these often save on the consumption of natural resources. Cladding 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.[30]

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.

Who is ultimately responsible for educating for Sustainability? It is an imperative endeavor that should be of central concern for ALL Architects, both practicing and student, Technologists and Designers.[31] 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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[1]Ledger, Bronwen. Architecture and the Environment: Where Do We Stand Now? Canadian Architect. June 1994. p.13
[2]Cole, Raymond. SBSE Summer Retreat 1994. Buildings and the Environment: Emerging Research Questions and Directions. Item 3.0
[3]Recommendations for the ACSA/AIA Teachers Seminar "Sustainability and Design". EASE Project.
"We need to have more stimulus/response cycles rather than just "a lecture over here and a do it over there"; they need to be made much more interactive, where you present knowledge, concepts and ideas; you act on them; you get results. There is a feedback cycle. This is not a private act; it has to be shared; it requires consensus, discourse and debate at each stage. ... We must break down the barriers between the studio and other parts of the curriculum."

[4]Durable Buildings Study: Performance and Durability of Building Materials. A&E Services, Technology Division, RD&D, PWGSC. July 1993.
[5]Allen, Edward. Architectural Detailing: Function, Constructibility,Aesthetics. John Wiley and Sons, 1993. p.1
"The experienced architect does not leave the answers to chance. Each detail, no matter how special or unprecedented, is designed in conformance with universal, timeless patterns that, given competent execution on the construction site, virtually guarantee satisfactory building performance."
[6]One need only examine the table of contents of the early issues of the "Canadian Building Digests" whose publication commenced in January 1960 by the Canadian Division of Building Research of the National Research Council of Canada.
[7]Moore, Fuller. Environmental Control Systems. Mc-Graw Hill, Inc. 1993. p.5
[8]Fraker, Harrison. Formal Speculations on Thermal Diagrams. Progressive Architecture. 4:84. p.104
"The principles and components of passive design, however, have physical consequences that go beyond technical performance. They can profoundly influence our perception of architectural space and our understanding of formal concepts. As we refine the technical performance of passive design prototypes, it is important that the designers begin to explore their latent formal content."
[9]Hutcheon, Neil B. and Gustav Handegord. Building Science for a Cold Climate. John Wiley and Sons. 1983. p.292
[10]Lischkoff, James and Joseph W. Lstiburek. Building Science Practice and the Airtight Envelope.
[11]Perreault, J.C. The Air Barrier: Construction Applications. Construction Canada 87(05).
"The road to an effective air barrier assembly was made out of apparent successes and baffling failures. The most significant reason for that ... was that we have been using the wrong material to do the job. This is not new, in fact there are hundreds of cases in construction history where failure occured because of animproper use or wrong choice of components."
[12]Quirouette, R.L. National Research Council of Canada. Building Practice Note 54. The Difference Between a Vapour Barrier and an Air Barrier.
[13]Moore, Fuller. Environmental Control Systems. p.4
[14]Branch, Mark Alden. The State of Sustainability. Progressive Architecture 3:93. p75
"Looking at the Life of Materials: The Croxton Collaborative developed this diagram to make architects aware of the life cycle of materials and the energy use within the cycle. ... The fact that energy use occurs in all (these) stages demonstrates the difficulty of "life-cycle assessment" of the financial and environmental costs of a product."
[15]Ledger, Bronwen. Architecture and the Environment: Where Do We Stand Now? The Canadian Architect. June, 1994. p.14
"The architect's individual contribution is to see that the building has the least possible impact on the site and that the form is responsive to the exposures. Working with the engineers they must create the most effective building envelope. The skin should be variable on a continuing basis, using sensors, louvers and, most important, superwindows. Buildings must also be designed for permanence instead of for replacement in 50 years. We must find ways of creating buildings that are as durable as the monuments of Rome. Recycling materials uses too much energy and produces too many pollutants to be the real answer."
[16]Forty Years of American Architecture. Recycling: Another Route to More Productive

Buildings. Architectural Record Reprint. p.58
The complete recycling of buildings, including renovation, re-use and use change, are able to prevent vast amounts of materials from landfill destinations, and negate additional energy costs to reprocess these materials into new usable end product.

[17]Bachman, Thaddeus,Sylvester. Simulation and Optimization in Architectural Practice. June 1992.

[18] Hastings, Phillip. Low Embodied Energy. Architecture and the Environment. Vancouver: 1992 RAIC National Conference. p. 103.

[19] Hastings, Phillip. Low Embodied Energy. Architecture and the Environment. Vancouver: 1992 RAIC National Conference. p. 103.

[20] Abrahams, Bob. The Environmental Impact of Building Materials: A Guide to Materials Selection. (First Draft) Young and Wright Architects Inc. May 1994.

[21]Branch, Mark Alden. The State of Sustainability. Progressive Architecture 3:93. p.74
"...environmental concerns...suggest a second look for historicism and regionalism in architecture. ...The New England center-chimney house, the Southwestern adobe dwelling, and the Texas dogtrot all have lessons for the green designer. Although advanced technology -- smart lighting controls, sensitive HVAC systems, and photovoltaic panels, for example -- is without a doubt an important component of the new green movement, architects are also becoming aware that we have spent too much time trying to conquer the environment instead of harnessing it. ... Pliny Fisk III ..."Think Globally, Act Locally"."

[22]Progressive Architecture. 4:84. Energy and Design. p.85, 98-103

[23]A Design/Technology Project that we are currently running requires students to examine and technically redesign the wall sections of "famous" modern architectural period pieces in light of current thermal and envelope requirements and practices to attain an understanding of the ramifications, both positive and negative on design, performance and detailing. The project will cross link the 2A Design Studio with Building Construction and Cultural History courses. Project review will include all disciplines and viewpoints.

[24]Cole, Ray. The BEPAC program in British Columbia for environmental certification for quality standards in industrial buildings. CANMET of Energy Mines and Resources with model Advanced Houses. The R-2000 house design program is being followed by a C-2000 program for commercial buildings.

[25]Lee, Tang. Learning From Building Failures. 1st Structural Steel Education Foundation Architecture Educators Meeting. November 27,1993.
"The present paradoxical situation of poor building performance in an age of unprecedented technological expertise can be traced to a lack of overall attention and understanding of the interaction between the environment and the building fabric. Learning and understanding about the principles of building construction requires more than memorizing facts. Understanding is best acquired through visualization and application of principles through an actual building failure investigation. ... By investigating a real-life problem, finding its cause or causes, and devising a solution to the problem, the students learn from other people's mistakes. Building failures become less mysterious and they become confident about designing buildings."

[26]Several computer simulation/optimization products are available in Canada and the U.S. for Simulation of Window Energy Performance. Window 4.1 from the Lawrence Berkeley Labs. CANME T is offering VISION, FRAME and WIN2000.

[27]Reynolds, John and all. Design for Photovoltaics Package. Available through ACSA.

[28]Cole, Ray. SBSE Summer Retreat 1994. Buildings and the Environment: Emerging Research

Questions and Directions. 2.0 Environmental Analysis of Materials.

[29]Where labor associated costs may make commercial recycling unviable, local low scale residential programs are being initiated to make available to the public, at low cost, salvaged materials from construction sites for use in private residential applications. A pilot program for this type of resale was initiated in Kitchener, Ontario and has been well received and apparently profitable for the business initiators.

[30]One need only to look at the current information available regarding the destruction of the Rain Forest, and the species in the United States and Canada that are rapidly being added to the endangered lists as a result of uncontrolled logging and land clearing practices.

[31]Recommendations for the ACSA/AIA Teachers Seminar "Sustainability and Design". EASE Project.

"...an ethical base for the profession needs to be agreed to and that it needs to include "sustainability" in its definition. ...Practice and education should work together in a partnership and in a compact."