"Sustainability", what does it really mean? Provide with nourishment; suffer; keep going, support or prove; all which can define sustainability, but doesn’t exactly answer the question. This word has been thrown around the design world for decades and is probably best if described as a continuous process of criterion for attitudes and practices. These processes of sustainability are primarily created from the minds and ideas of architects, developers, environmental activist, etc, and each of their opinions of what sustainability is or how they intend to carry out will by far differ from one another.

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Earth's climate is a fundamental part of our life support system. It shapes the way we can live on this planet. Yet, the way we live, work and play is inadvertently changing the climate. Human activities release air pollutants, most of them by-products of our use of fossil fuels — coal, oil and natural gas — to provide mobility, heat, industrial production, and wealth for regions which produce these resources. About 90 per cent of the world's commercially produced energy, and about 70 per cent of Canada's, comes from fossil fuels. The World Energy Outlook (OECD, 1998) forecasts global energy demand will grow by 65 per cent and CO₂ will increase by 70 per cent between 1995 and 2020, unless new policies are put in place. As fossil fuel use continues to rise, the consequences become ever more costly. Greenhouse gases from fuel combustion accumulating in the atmosphere continue to raise global temperatures. The increases are greatest in northern latitudes, including Canada. The effects of climate change are numerous and while we may have some benefits from warmer temperatures, we will also face a number of costs. A warmer atmosphere is more active, prone to weather extremes, such as floods, droughts and violent storms such as tornadoes and hurricanes. Warmer weather also brings ecological changes, moving species, including insect pests and disease-carrying organisms, further north. Hotter summers produce a variety of stresses and changes in the natural water cycle accompanying climate change will affect farmers, hydroelectric producers,
tourist operators and many others. Implementing sustainable development requires recognizing the connection among a host of actions, outcomes and responses. Nowhere is this more apparent than in the area of health and environment where quality of life considerations and life and death issues are frequently intertwined with the use of natural resources, and levels of social and economic development. Environmental hazards such as toxic emissions and contamination of air, water and food have long been known to be detrimental to human health, particularly during prolonged exposure and for more vulnerable groups like children or the elderly. Social conditions such as poverty and unemployment may worsen physical health and be especially hard on mental health and general well-being. Economic policies can result in negative social and environmental consequences that affect human health.

An overall general explanation for sustainability is the idea of environment prosperity, specifically the natural environment. Today we can say that our natural environment calls for drastic change in the way our society abuses its creations. Just the buildings that are built today derive one-third of their energy from fossil fuels. They use two-thirds of the electricity consumed in the United States and therefore, account for two-thirds of carbon dioxide emissions. They consume one-sixth of the world's fresh water and one-quarter of the world's wood harvest. While society has become accustomed and dependant upon the building shelters in which we live and work in and in return, the buildings are created out of nature's environment.
How do we know if we are moving toward a sustainable relationship with the earth? What tells us how we are doing? Many people are working on defining indicators so that we can judge where we are in our efforts to create a sustainable culture. Without a way to measure where we are, set measurable goals, and then measure our progress, it is difficult to know if progress is taking place. Indicators help answer this question and defining them sparks debate and increases awareness and understanding. With our current knowledge of the impact of the human species on the planet we can use a simple concept as an immediate indicator of whether we are moving in the direction of sustainability: is the population of the cultural unit (city, metropolitan area, state, country) growing? Until the answer is "no", this is the only indicator we need. This indicator is enough because we are exceeding the consumption level that allows most other species to flourish. We are out of balance with the natural world and on a course to eliminate all species that do not benefit humankind. Adding more people only increases the problem. Of course, the addition of an indigenous and primitive tribesman in the Amazon will have a far different impact than adding an American or Canadian or German - anyone in an industrial country. The latter has a far greater impact on the level of consumption and the area of the earth that is affected. Indigenous people also have trouble managing their population relative to the carrying capacity of their environment and they are increasingly affected by the global
economy. So, this indicator works for them also. The desire to grow is firmly rooted in our characters. Throughout our formative years and well beyond, growth is a preoccupation. To be able to crawl, to reach the water tap or to have our own way all require getting bigger. The residual urge to grow has been harnessed to stimulate the expansion of material consumption. The dilemma is that, while each of us wants to grow, collectively we have already grown to confront the limits of our planet. The solution has a well established precedent in each of our individual lives. For the most part, our physical growth comes to an end as we become adults. Physical growth is replaced by the development of our understanding, skills, relationships and appreciation of what life offers.

The process of developing a wider variety of architectural design experiences goes along with our increasingly changing contemporary society. Society needs to place more value on the designs of architects. The building needs to explore more than the spatial requirements or meeting the minimum environmental and structural standards. Issues of user definition, urbanism, energy use, and ecological awareness are ways to socially experience a new design direction as our buildings become more than a sheltering device.

The environmental context is specifically confronted by the advances of technology by placing it more appropriately and efficiently into the design concept. Society is willingly becoming aware and concerned with the battle between our natural and manmade environments. Potential answers to easing the conflict lies on our social responsiveness to sustainable architecture and high technology. The combination of nature and manmade environments can allow architecture to explore more social and physical experiences of design with technology, making it one of the most challenging creative problems facing architecture.
The thought of what the design world may be like in twenty years is largely indescribable and unthinkably. Changes in our society and economy are due to the vast technological progress that we have made in the past ten to twenty years. With these vast changes, it has become apparent that we need to change our focus on some issues, which if not taken seriously now will later spell disaster. I am speaking of our natural environment and how it is continuously brutally destroyed by our rapid growth of the built environment. The interaction of the man-made environment with the natural world has become a profound cause for concern. Although it is almost a necessity for expansion of the built environment due to issues of population, economy, and culture, our society demands new solutions in design direction that offer a wider variety of experience to meet the needs of our changing contemporary society. Focusing on that which our society is concerned with and deriving a design process from those issues can be a challenging but creative problem for
architecture.

Technology has made such an impact on our society that almost everything in our daily lives is affected by some form of new technological progress. It appears only natural that the design world follows our society's trend of technology and uses new advances in materials and construction methodologies to enhance the built environment so that it may become friendly to the natural world. As there are a variety of environmental efficient ways to design the built environment, the construction of an exterior "shell" is the primary concern for this thesis. This exterior envelop of sustainable architecture does not call for the formation of earth mounds or the energy of our sun, but rather the need to primarily use technology in architecture design. Ornamentation and form are some secondary issues that will assist the environmental efficiency to its fullest potential. Technology in architecture can be used just as it is used in the medical fields, through the development of new materials that function at higher levels or new ways in which to construct/form an object. As our society undergoes rapid changes due to technology, the design world needs to pick up the slack with new ideas and thoughts for creating environmentally friendly buildings with technology, for technology in architecture can be useful in other ways other than greater structural capabilities.
Dr. Karl-Henrik Robert leads the Swedish endeavor in the creation of four fundamental principles of sustainability dealing with the natural environment. They are all based on science laws of aerodynamics for civilizations, sustainable civilization. His first sense states that fossil fuels, metals, and other minerals must not be taken from the earth at a faster pace than they can be re-deposited. It is easy to state that our current civilization is far from achieving this principle, but we may soon be coming up on a time when irreversible changes can occur. Robert's second principle refers to the creation of man-made productions and the fact that they cannot be produced faster than they can be broken down. Once again, there are limits to which these factors can reach before the consequences become irreversible. In his third principle, nature must not be diminished. Unfortunately, this principle has been underway since the beginning of existence, but only recently has it progressed to dangerous levels. Rainforest are dwindling constantly, our freshwater has become limited to around three percent of the total world's water. Our health and prosperity depends on nature's ability to regenerate, restructure, and reorganize into new resources, but it is up to mankind to control our own limits. Robert's final principle is a combination of the first three in that there must be fair and efficient use of natural resources to man-kimg. Meaning that humankind can meet its own basic needs in the most resource-efficient ways possible. Robert's principles are based on scientific research and data for a
better civilization, or a new civilization. Science may tell us the facts on how sustainability can be achieved, but it is not obtainable with today's society. In order to achieve what Robert has referred to as a "civilization that can fly", this current civilization would not be of existence. There are more real facts that need answered and a guideline in which to follow. Such a fact would be, where do we stand today or where will we stand in twenty years, and what these answers would be and in turn mean. With today's needs and population, was the world ever prepared for such and enormous responsibility? Accommodating the needs of mankind is out of nature's hands. Now it becomes important to control our actions in order to prolong the unfortunate deterioration of nature while increasing our benefits. There are ways to help or at least stabilize the effects that mankind has placed on the natural environment. Since buildings and construction accounted for the majority of our environmental problems, we can look at the architect and builder's roles in playing and creating a building. An architect is responsible for the design of a building. Today the architect is faced with a varied of options for designing an environmental efficient building. Using solar energy, day lighting, and the earth's surface are a few ways that an architect can use the natural environment with the built environment where both are taking and giving to each other.
This building is located in a dreary part of London and through the drama of its architecture liven the area. The building is a somewhat deliberate set piece of urban theatre with its provocative architectural statement. It is surrounded by dull civic-service offices and within reach of Westminster Abbey and the Houses of Parliament. It is laid out on a simple plan of two wings connected through a central circulation core. Within the core is a concave glass wall, dramatically suspended from a delicate network of stainless-steel materials. These towers help implant the building into the streetscape through exposing its inner working lift capsules' vertical traffic. The constant human action in the pivotal atrium and the lift capsules expression Roger's "long-standing concern with making buildings that contribute and respond to the life of the city." The way that this building reacts to the urban surroundings and the simple organization of circulation are two aspects of potential design criteria for my thesis project. The use of materials: stainless-steel rods and
Some of the main facilities include energy-efficient lighting systems, advanced energy technology windows, etc. The environmental energy technology division is a mission to perform research and development leading to better energy technologies and reduction of energy-related environmental impacts. The main facility, Lawrence Berkeley National Laboratory in San Francisco, develops technology that uses, converts, and stores energy closely at their information and research on energy-efficient systems.
This family owned business needed a flexible space that would allow for design development, offices, factory production and storage facilities, as well as being able to adapt to future construction. This building develops and refines themes of modularity and flexibility, which is a fascination of Grimshaw. The exterior metal cladding is highly flexible, designed so that standard panels, windows, and doors may easily be interchanged. These cladding panels are secured with anodized aluminum clamps fixed to mullions made from standard shelving uprights stiffened with flat steel plates. This type of flexibility in construction is one of the main design concepts behind my thesis. I intend to design a type of "paneling" system for the exterior that will be replaced as technology increases with better environmental solutions.
Energy efficiency was the most important priority in the design of the building. It is considered one of the most energy-efficient in the world. The bank has a dramatic appearance, both externally and internally. It is one of the most imaginative attempts at bringing together human and environmental concerns. Its walls slope to control noise and wind, there is no air conditioning, but rather a heat-recovery air-circulation system, and it contains a profusion of plants which are watered with purified rainwater fed from sculptures. Natural light is enhanced by the use of light-reflecting and dispersing materials in the window openings and work areas. One notable feature is the lack of right angles. The architects believe that these discourage creativity and harmony. I am focusing on the way that the architect used simple materials and geometry to solve several environmental issues.
Colorado has emerged as one of the premiere locations in the US for operating a high tech business. A strong Federal presence, good research universities, a highly educated and well-trained workforce, a State government focused on fostering a positive business climate, an exceptional environment, and a superior quality of life all contribute to attract venture capital to Colorado. Boulder, Colorado focuses on the fundamentals (infrastructure, housing, education, training, capital formation) to make their commu-
nities a good place to live and work. The aspects of their surrounding environment is also something the people of Boulder take great pride in preserving and nurturing the land.

The proposed site lies on the southeast side of Boulder just outside the city limits. The area is largely undeveloped and offers a remarkable opportunity to create a research facility that is both functional and environmentally sustainable. From a design point of view, the site offers a challenge for the designer with its great diversity in land elevation and aspect. The weather in Colorado (hot, dry, windy, cold, and snowy) will also give this research facility great opportunities to experiment with technology and the environmental systems.


**ABSTRACT**

This entire program is to bring awareness to the public through education and research about issues based on the environment and the effects our built society portrays. By having the program combine an environmental technology and research center with the University of Colorado at Boulder reaches out to a more diverse society of people. They are the experienced, intrigued, curious, and concerned people that understand the concern placed on our environment today. The program specifies research on exterior materials that may enhance our environment efficiency. These labs are used to test issues dealing with heat, cold, and moisture that is constantly being forced on the exterior of any structure. The educational program operates on the University’s guidelines for the environmental design and issues degree. The classrooms offer hands an experience along with distant learning capabilities to other universities around the world. Both of these programs combine the administrative program in a way to reduce the amount of space that would be used for separate programs. This is also another way to keep the tow programs together with information and activities. All of this is supported by a program that is to optimize the facility as a professional company and also a prominent environment for higher education.

**SCOPE**

The design purpose and goals of the program is to develop and deploy energy saving technologies, strategies and tech-
niques, and to improve process for designing, commissioning, and operating commercial buildings while improving the health, comfort and productivity of occupants. A second goal is to routinely and cost-effectively achieve energy savings at new and improved levels. The facility is intended to strengthen the state’s growing energy efficiency industry, providing jobs for companies in hardware, software, design and building services. This facility will become a museum in itself, housing the future of the exterior construction in environmentally friendly construction methodologies in architecture. With both public and private sectors of the building, the facility is open to all societies with an interest in the environment and technology. The building is divided into two main types of programs, a research facility and educational facilities. Both programs share a set of supportive facilities such as a library, exhibit hall, and lecture hall. This program comprises mainly of laboratories that study and research that delicate layer between the built environment and the natural environment. This facility is to be used as a training and experimental facility for the young and old; new and experienced on the materials that make up the envelop of a structure. The building itself is created through focusing on the concepts of EcoTech that embrace energy use and ecological awareness while concerning itself on the construction methodologies and exterior materials in order to create a flexible “shell” for an environment. The building’s exterior materials are to have the capabilities of being replaced as advances in technology take place to further enhance the built and natural environments. Ultimately the facility is to become a prototype of a new design style where the ideas of the environment and technology are prime design concepts; where architecture contains both permanence and transformation.

This research facility is located just outside the city limits in Boulder, Colorado. The large 300 acre site has just recently been purchased by the University of Colorado at Boulder for expan-
sion of their educational facilities. This site is easily accessible as it is directly next to the one interstate coming into Boulder. Most importantly, this site challenges the designer with its rough terrain and the fascinating views of one of America's most beautiful natural environments.

ORGANIZATION

The research and education laboratory facilities will be a federal government project for the University of Colorado at Boulder. The President and owner of the University pertain authority on all financial issues or any major development or deconstruction that might take place during this facilities existence. The Department of Research and Development will control all major activity of faculty and programs held within the Education laboratories of the facility. The science research laboratories are a branch of the National Environmentally Efficient Technology Development and will confine to the current standards that are proceeded through faculty and projects. The library is part of the University libraries at Colorado University. All remaining facilities with the Research and Education Laboratory is maintained and operated by the authorities of the University.

BUILDING CONCEPT

The facilities design will be looking at environmental systems in regards to the wind, sun, and light. Those design regards will be reflected towards the relationship of orientation on the site. By this, meaning North, South, East, and West. This will create a building
of four totally, possibly only three, different environmental systems, both in natural and mechanical ways. A close look will be taken into what type of geometry, organization, and technology will be needed to design a facility based on the amount of light, sun, and wind exposure from its orientation. The way in which natural materials will be incorporated into the design is an extremely important design concept. The users of this facility are to be able to experience nature at all times even when they are well within the structure.

BUILDING CRITERIA

The building is used as a research laboratory for developing new technology in environmentally efficient glazing materials. The building is designed with the opportunity to use its own envelop to conduct this type of research and also have the possibility to be able to exchange materials as newer, more efficient materials are always being developed. This will be able to keep this building up to date with technology and the type of research that is needed to be operating. The building needs to be able to meet the needs for equipment needed with the laboratories, in both the science labs and the educational labs. This facility is also to represent a style of transition from the natural to built environment. The building’s exterior envelope will be designed to create and ease of transition for both the users and the environment.

CONTEXT CRITERIA

The building's context will be closely monitored by the standards that are held by the University of Colorado at Boulder. The specific architecture style that dominated the already existing main and east campus is characterized by the use of field stone and red roofs. Placing this facility on a site owned by the university will help this facility to become part of the community and environment in a more friendly and appreciated way. This site also sets forth a variety of views of one of America's most famous landscapes, the Rocky Mountains. The site offers a challenge to the designer with the largely differences in its contours.
The idea behind this thesis was to look at ways of building efficiently in order to obtain a more environmentally friendly environment through sustainability. There are several ways a building can obtain sustainability by following a set of guidelines, but I wanted to look more closely at the functions of the buildings and how that may be used in order to obtain a state of sustainability. I looked at issues that pertained to the earth, water, and sky and how materials interact with these concepts and what materials are best represented or would best represent them in ways that are accepted by users in a functional way. I wanted the main design aspect to focus on the circulation of the building as I feel movement is a primary way to experience a structure and the way that it interacts with its surrounding natural environment. Another strong key in the design process was trying to create ways that the users were able to connect with nature at almost all times, whether that be through viewing or walking through a natural environment. I also wanted to create the feeling
that the building was growing from the earth and was just another layer created through nature. I looked at ways of creating layers structurally for protection and also to create layers through imagery. This was in order to make an easier transition between the natural environment and the built environment that I was creating. Geometry of the current circulation of Boulder's road system as well as the geometry of north, south, east, and west was a primary design aspect in the process of organization.
The plane of the building was separated to increase the function of circulation and the function of private spaces versus public spaces. The laboratory rooms were the hierarchy of the facility and therefore were placed in the center of the building. The labs were orientated around such issues as the sun and wind. This was in order to obtain maximum research data from the actual, ever-changing and unpredictable nature itself.
Some of the strongest design issues in the project came with the way in which the solar patterns, wind patterns, issues of moisture, and the social issues with people and movement. The wind patterns of Boulder Colorado primarily come from the south and are considerably weak compared to other parts of the United State such as Chicago. Boulder lies along the 40 degree latitude. The solar patterns follow an angle from north to south of 26 degrees to 74 degrees and from east and west of 30 degrees beyond the median to 31 degrees above the median.
The plans, sections, and elevations are to follow a unique layout as to how the exterior envelop interacts with the outside world that they connect to. The long corridor represents the important of circulation through the three main parts of the buildings. The hierarchy height as well as the layers of protection through the structure. The arched canopies are to address the sky and the materials of the exterior walls are to connect with the surrounding landscape. Materials of the surrounding area of Boulder were the primary materials used throughout the building.
The floor plan is laid out is such a way to optimize function of use and circulation. It is also organized along the ideas of public spaces versus the private spaces in order to gain control over the amount of use and energy that is placed into certain areas as they pertain to the time and amount of use. The supportive area consist of a library, lecture hall, and cafe as the primary spaces along with spaces of networking the facility and storage. In this area is also a large atrium style area for seating, gathering of groups, or just relaxing. The laboratory consist of offices for twelve scientists and six main labs that area separated along the orientation of their function. The labs consist of moisture, temperate, solar, wind, and tinted glazing specialties. The education facility contains nine classrooms and ten teachers offices. There is also an administrative office here for the entire facility. All of the separate facilities are connected through a long corridor that corresponds to the main circulation road that runs through the heart of Boulder.
The elevations and sections of the building help to see the integration of the exterior layer into the natural environment. The elevations depict height variations in order to call out the importance of what is to be held in that area of the building. The corridor stands out at the highest as it is considered the hierarchy of the facility for movement throughout the separate spaces. The central focus of the facility is seen in the middle of the laboratory. This is to call out the important of the labs and their function in this building. The arched canopies help to address the sky in a light and natural way. The corridor itself if constructed of several layers of protection through structure. The first layer consist of simple glass panels to break away from the separation of the natural environment to the built environment. This way the users are constantly confront with the aspects of nature as the move throughout the building. The next layer is the structure to create the corridor and the final layer of the canopy addresses the sky while also providing a sense of protection to the users as that is what we are accustomed to. The laboratory area is also placed over a body of water. This is to help bring all aspects of nature to the users through interaction, weather that is just walking over it or getting outside to wade your feet in it or go ice skating in the winter. The building also is built from natural field stone and has two different sizes and colors to represent the layers of depth in the building as would the natural world through layers of earth.
The long linear corridor is a reflection of the circulation system that already exists by the main interstate that runs along the site and down through Boulder. The corridor is the only piece of construction that connects all three buildings: education, laboratories, and supportive. This helps to maintain energy use and efficiency throughout the building.
Through the corridor is the supportive facility of the building. It shows the layers of stone that is used on the supportive and educational facility. The two different stones represent layers within the building as they are built. The top layer is a field stone brought to the site of Boulder that is lighter and smaller and the other is a field stone that is darker and larger than the other.
The canopy lies over the corridor and rotates slightly at the center over a large open area of the house. The canopy acts as a sunshade for the interior, providing shade and reducing glare. The canopy is made of a lightweight material with a solar screen to give maximum reflection of the sun's heat and the sky above.
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I have learned several aspects of sustainability in architecture through this project. Not just in the ways of constructing sustainable, but also the effects that are created upon the environment. There was also a lot of information to gain as far as attempting to design a facility of such a large size and one that dealt with scientific instruments. As I look back upon the issues and statements of this thesis, I feel that I have touched just the beginning of a extremely long and complicated topic of sustainability and the several different ways of obtaining a more efficient, healthier environment. This thesis dealt with a broad sense of topic, therefore making sense of details and pin-pointing conclusions of design was difficult. More information towards circulation, laboratory layout, and the connection between the built environment and the natural environment was needed in order to make a more clearer sense of this thesis topic. This thesis also needs more attention brought to construction and details of material interaction with the connections between the separate buildings and especially with the main corridor. More information towards issues of mechanical and exactly how issues of reuse with the existing water and daylighting issues will be expressed. While the thesis ideas and positions are strong, I have only touched a bare minimum of what this project could become as a new standard in construction with sustainability.
BACKGROUND

RESEARCH QUESTIONS

CONCEPTUAL ISSUES

DESIGN REFLECTION

PROGRAMATIC ISSUES

SITE DESIGN, RURAL TO...