RE-PRESENTING THE TRANSIENT ENVIRONMENT

The Building Workshop in Design with Climate

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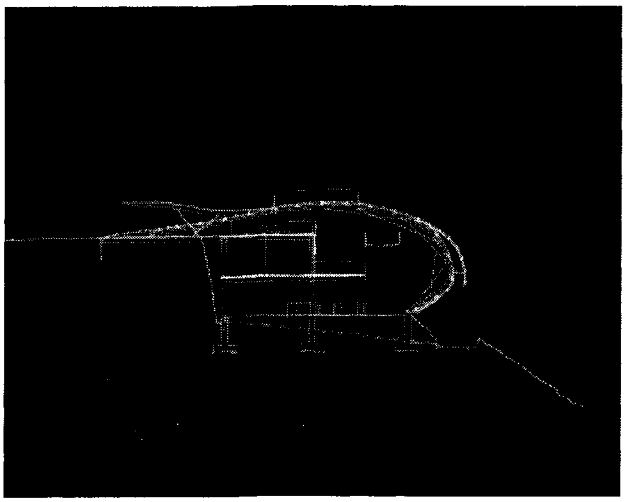

Figure 1: *Mansfield Dam Overlook*

INTRODUCTION

The Building workshop in Design With Climate is an advanced design architecture summer studio emphasizing the integration of climatic and ecological knowledge and computational methods into architectural design. The studio provides a focused course of research and design for architecture students in energy-efficient building, ecological impact, and climate-attuned architecture.

To provide for a pedagogical method to link ecological architectural theories to practice, the summer studio emphasizes, "hands-on" building workshops. These workshops ground knowledge in action and immediate experience. In this way students are able to evaluate the actual performance of design decisions. Hands-on learning seeks to re-establish the continuity and inter-relationship between the process of conceiving, making and using buildings and emphasizes the importance of making and thinking at the same time.

The objective for the Building Workshop is a hands-on investigation of building systems utilized to design and construct environmentally responsive architecture. Buildings systems integrate theories of; environmental controls, daylighting, water-use efficiency, waste management, smart buildings, and other low-entropy technologies that contribute to "green" architecture. The study of building systems also includes the principles, conventions, standards, applications and restrictions associated with the manufacture and use of existing and emerging construction materials and assemblies and their effect on the renewability of the environment. Our investigations suggest that progressive technologies offer solutions to the serious emerging challenges of energy efficiency and sustainable development and thereby become a strong design shaping force.

BUILDING WORKSHOP-SUMMER 2000

The inaugural Building Workshop in Design with Climate, during the summer of 2000 was focused on the integration of sustainable building systems at the scale of a small skin-load dominated building. The studio project was an off-the-grid Lower Colorado River Authority (LCRA) Visitor Center for Mansfield Dam at Lake Travis, located near Austin, Texas. The LCRA has provided public visitor centers at all its major dam projects starting with their early dams and continuing today as it upgrades all its existing dam facilities. The program for the Mansfield Dam Overlook Park Facility called for public parking, viewing decks, toilet facilities and display studios describing the history and operation of Mansfield Dam. The site for the visitor center is a parcel of land located high on a bluff immediately southwest of Mansfield Dam. The park property, approximately 8 acres is owned and maintained by the LCRA and has spectacular panoramic views of Mansfield Dam and across both upper Lake Travis and lower Lake Austin.

Along with meeting the personal needs of the visitors' the overlook facility was required to be built in a way that would allow the facility to be near self-sufficient (off-the-grid) and require little maintenance and not interfere with the day-to-day operation of the dam. The LCRA stipulated that proposed designs integrate sustainable building systems and planning principles into the design of the visitor center including but not limited to: energy conservation, design with climate principles, natural cooling, passive solar heating, photovoltacis, wind turbines, solar water heating, rainwater harvesting, on-site wastewater treatment, recycled and sustainable building materials, and computer controlled smart energy management systems.

To ground the students in the technical expertise required to achieve the requirements of the program the studio-teaching format utilized a coalition of sustainable building experts in a series of green building technology workshops. The technical experts included; Marc Richmond-Powers on Green Building, Marley Porter on Living Architecture, Stephen Gerdes on Rammed Earth, John Hoffner on Photovoltaics, Gareth Pollard on Rainwater Harvesting and Aerobic on-site wastewater treatment, Robert Anderson on Permaculture and Xeriscaping, and Pliny Fisk on Maximum Building Potential Systems.

The sustainable building workshops included field visits, material and building systems lectures, demonstrations and actual hands-on construction. The sustainable building technologies were formatted for design integration by utilizing a matrix that compared spatial design objectives with efficiency goals of maximizing the following systems flows:

1. Site and Building Design

A. Building orientation
1. Solar access and heat gain
2. Wind patterns
3. Views, circulation and access

B. Building Configuration
1. Surface area to volume ratio
2. Articulation

C. Microclimate
1. Typography and wind
2. Vegetation, xeriscaping, heat sinks, albedo and shading

D. Passive Solar Heating
1. Direct solar gain, indirect solar gain, isolated gain
2. Thermal mass and thermal lag
3. Passive solar water heating

E. Natural Cooling
1. Cross ventilation and Solar Induced Ventilation
2. Shading strategies
3. Evaporative cooling
4. Thermal lag and earth cooling

2. Water and Wastewater Systems

A. Rainwater harvesting
1. Roof collectors used for potable water
2. Impervious paving used for irrigation water
3. Aqua ducts, pumping and treatment equipment
4. Cisterns

B. Grey Water Systems
1. Holding tanks and primary treatment
2. Use for flushing water closets, or irrigation

C. Wastewater Treatment Systems
1. Micro-flush Compost toilets
2. Living Machines
3. Aerobic wastewater systems with solar stills

3. Power Systems

A. Low voltage and efficient light, pumps, fans, motors and smart appliances

B. Photovoltaic Collectors
1. Monocrystalline PV panels, thin-line PV panels, regulators, and invertors
2. Battery storage with stand-by propane generator
3. Utility interface

C. Wind turbines

4. Embodied Energy and Materials

A. CO2 balancing
B. Natural materials
C. Recycled materials
D. Recyclable materials
E. Engineered materials
F. Smart materials

During these sustainable technology workshops students were required to integrate green technologies into their design process. In requiring students to apply sustainable building systems to a design project the student gained a deeper appreciation for the design implications of the technology and retains a greater recall of that technology. The students also gain a better understanding of how the technology may be applied and what are the trade-offs or opportunities that may enhance a final design solution.

By disassembling the building and looking at specific sustainable building subsystems, criteria and options for sizing and selecting components is more easily understood. A system relies primarily on deductive reasoning for meaning and is designed and constructed in a rational manner. Creativity is involved in the design of a system, but the dominant force is logic.

Integration on the other hand is another procedure entirely. The dominant force in integration for meaning is creativity. The ability to evoke a new set of possibilities is essential. "The final integration that a building design becomes is an order that includes systems, but is rather a network that is complete when all the links between all the systems have been established" (Rush).

The students investigated the Richard Rush inspired theory of integration of sustainable building systems by developing their design schemes using large, 3/8" scale models. The large format models are large enough for the students to "see" and investigate building connections as well as to test the resulting implications of light and wind.

The intent of this analysis is to focus the students on the demand for building to meet precise dimensional and performance speci-

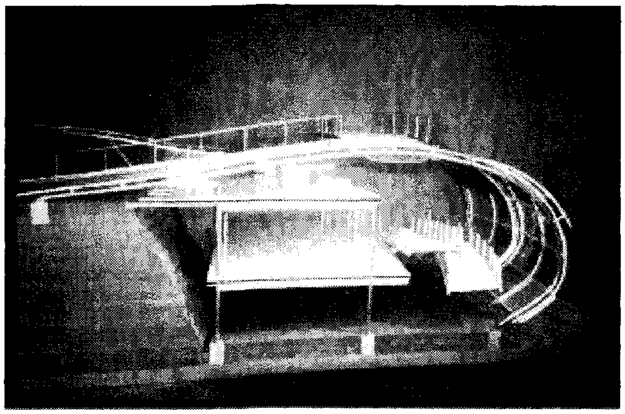

Figure 2: *An overlook scheme by graduate students Tae Hyeong Kim and Suk Yoon Kang utilizes translucent thin-line photovoltaics to enclose their visitor center. Daylighting illuminates visitor information studios, which are combined with wastewater Living Machines in marsh tanks all conditioned by solar-induced ventilation or passive solar heating and controlled by smart building computers. The roof of the center functions as a viewing platform and facilitates rainwater harvesting.*

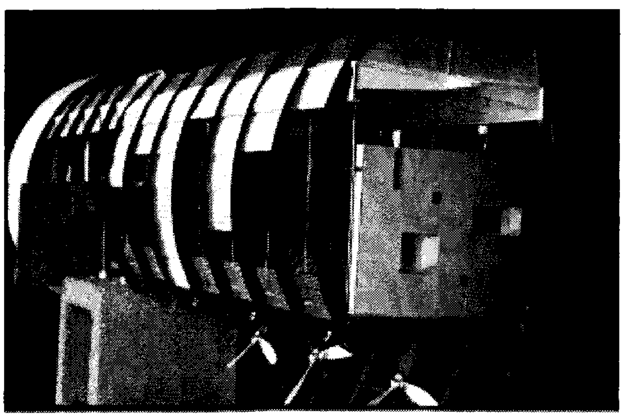

Figure 3: *A scheme by graduate students Paul Hanson and Cooper Schilling envisioned a lightweight structure attached to the bridge above the Dam. The structure is composed of aluminum truss frames recycled from a de-commissioned airplane hull. Solar induced winds flowing up the south facing wall of the dam power low-speed, Danish-made, wind generators hung off the wing of the structure. The wind turbines power lightweight aerobic composting units. These composting units are coupled with micro-flush toilets, which use only one pint of water per flush. Wastewater is treated by evaporation from a roof-mounted solar-still.*

fications. This process deals primarily with questions relating to the building fabric and the language of building systems. The students study the interrelationship of form and technique, and assemble and manipulate the building elements in serial composition. Form and function are symbiotically linked. Climate forms building shape and

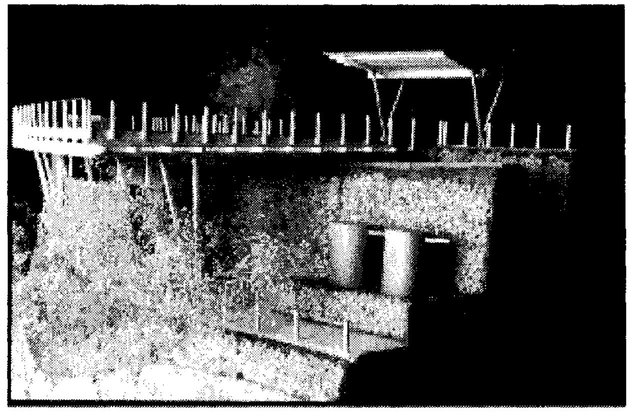

Figure 4: *A scheme by graduate students James Burdett and Chris Jones integrated their visitor center into the landscape. Gabbion retaining walls filter parking lot storm water run-off and enclose the visitor center along a pathway that connects the Dam to a viewing deck located on the roof of the visitor center.*

the building shape modifies the resulting microclimate. Using a pattern of desired spaces and building forms, students test design interactions with a resultant microclimate and context.

These three student projects describe the general tone of the projects submitted by the 24 students in the class.

The use phase of a building represents only one chapter in the energy life cycle of a building. The processing and manufacture of building materials incur enormous off-site impacts prior to the operation of the building. These impacts occur upstream during the mining, transportation and manufacturing life cycle stages of a building material. Upstream CO_2 can be up to 5 times greater than the direct emissions (for construction of the building) and 10-20 times greater than the annual operation (use) of the building all-depending on the life cycle of the building (Fisk).

The students presented an analysis of the building materials that would be used to construct their designs based on a Pliny Fisk-inspired methodology for CO_2 balancing of materials called the (CDIR) Carbon Intensity Ratio. The CDIR is defined as the ratio between the net upstream CO_2 impact (emissions minus storage) of a material and the weight of the material. A material with a positive CDIR is a net source and one with a negative CDIR is a net sink.

The students attempted to CO_2 balance their building designs by substituting low impact CO_2 materials for high impact CO_2 materials and/or by specifying high recycled-content materials.

CO_2 balancing brought a sustainable methodology to evaluating long-life high-embodied energy materials in comparison to short-life low-embodied energy materials. For example the students calculated the size of a fast-growing bamboo forest required to absorb the

CO_2 produced in making the concrete required for a mid-size dam like Mansfield Dam. Their calculations determined that a thriving bamboo forest (2.3 tons CO_2/acre-yr) would be required to be an area up to ten times the size of the entire 250 square mile Travis County and would require over four full years to absorb the CO_2 produced in the making the concrete in the dam. This large number is not surprising considering that, "within the building industry, the largest single material or product contributing to CO_2 emissions is Portland cement-based ready-mix concrete a figure that is 9% of total U.S. annual CO_2 emissions" (Fisk). On the other hand, if we assumed the dam would last several thousand years it would only take a bamboo patch a few square meters in size to balance the CO_2 produced in the manufacture of the concrete required to construct the dam.

Subsequently, the students weighted very carefully the life-cycle cost of their building materials selections. For example a student team determined that the steel needed to construct their proposed design would have an upstream cost of 45,138 tons of CO_2, and the concrete needed would have an upstream cost of 21,918 tons of CO_2. In an attempt to balance these costs the student team used strawboard panels in the infill partitions in their design which have an upstream sink of –42,345 tons of CO_2. The net building would therefore be approximately 25 tons of CO_2 out of balance and would require the planting of 10 acres of Texas woodland (2.3 tons CO_2/acre-yr) thriving for one year to CO_2 balance their building.

BUILDING WORKSHOP-SUMMER 2002

The Building Workshop is offered every other summer term and for The Building Workshop in 2002 the School of Architecture has been chosen as one of fourteen Universities as finalists to compete in the 2002 Solar Decathlon. The Solar Decathlon is an intercollegiate design competition among student teams who will design, build and operate an 800 square foot totally solar powered home with a home office. The competition is sponsored by: the U.S. Department of Energy, together with the National Renewable Energy Laboratory, the American Institute of Architects and BP Solar.

The competition will take place on the National Mall in Washington D.C. where each house will be constructed and operated in 2002. The winner of the Solar Decathlon will be the team that can score the most points from ten contests that test the effectiveness of their design. These contests will focus on energy production, energy-efficiency, design, thermal comfort, refrigeration, lighting, communication and transportation.

The student team is developing a design using photovoltaic collectors that will capture, convert, store, and use enough solar energy to power all the energy for an entire household, including a home based business and the transportation needs of the household and business.

Given the fact that the competition brief implies a portable and temporary structure, the design project is intended to show how a mobile environment can be expanded and adapted to a specific site and then modified for the needs of a different site in another climatic zone. In the workshop the mobile environment is to be an Airstream trailer that has been modified to meet the energy and water-efficient requirements of the competition. Most heat and humidity producing household activities will take place within the trailer, which will contain the kitchen, bathroom, and laundry facilities.

In order to provide the remaining functions of the house, a modular and flexible building system will unfold around the Airstream trailer in response to the site with a flexible orientation to the sun and wind. The Airstream aesthetic will be carried throughout the building, since a streamlined design will enhance natural and solar induced ventilation.

The mobile utility environment will be transported to the National Mall in Washington D.C. and the unistruct structural/utility grid will be unfolded. The grid functions as the platform and superstructure for sustainable building systems.

The building will provide thermal comfort by primarily passive means through the following features: heat sink water bladder tied to a heat exchanger foundations, passive solar heating, wind pressure walls, and a solar attic. The water bladder will be cooled through night air flushing and will provide a thermal mass to stabilize the temperature swing of the building. Retractable extendable pressure walls will be used to optimize the ventilation potential of the local breezes by creating localized zones of high and low air pressure while in the winter being able to close up the building into a low surface area environment. The solar attic will induce ventilation through a stack effect boosted by the sun and the waste heat generated by a passive solar hot water tank mounted in the attic. Photovoltaic panels partially form the upper skin of the solar attic, which has ridge vents on the north side to exhaust hot air. Energy-efficient lighting, and daylighting contribute to the livability of the house, inside and out.

Approximately one-third of the photovoltaic panels are sized for the needs of the house and the other two-thirds of the photovoltaic panels provides the "extra" energy required to charge a street-legal, commercially available electric vehicle that is used to transport decathletes around town.

Communication is a key part of the competition. The team will have a web site, provide house tours and create printed materials that explain the design, engineering, and operation of the house as well as the products and technologies being showcased in the house.

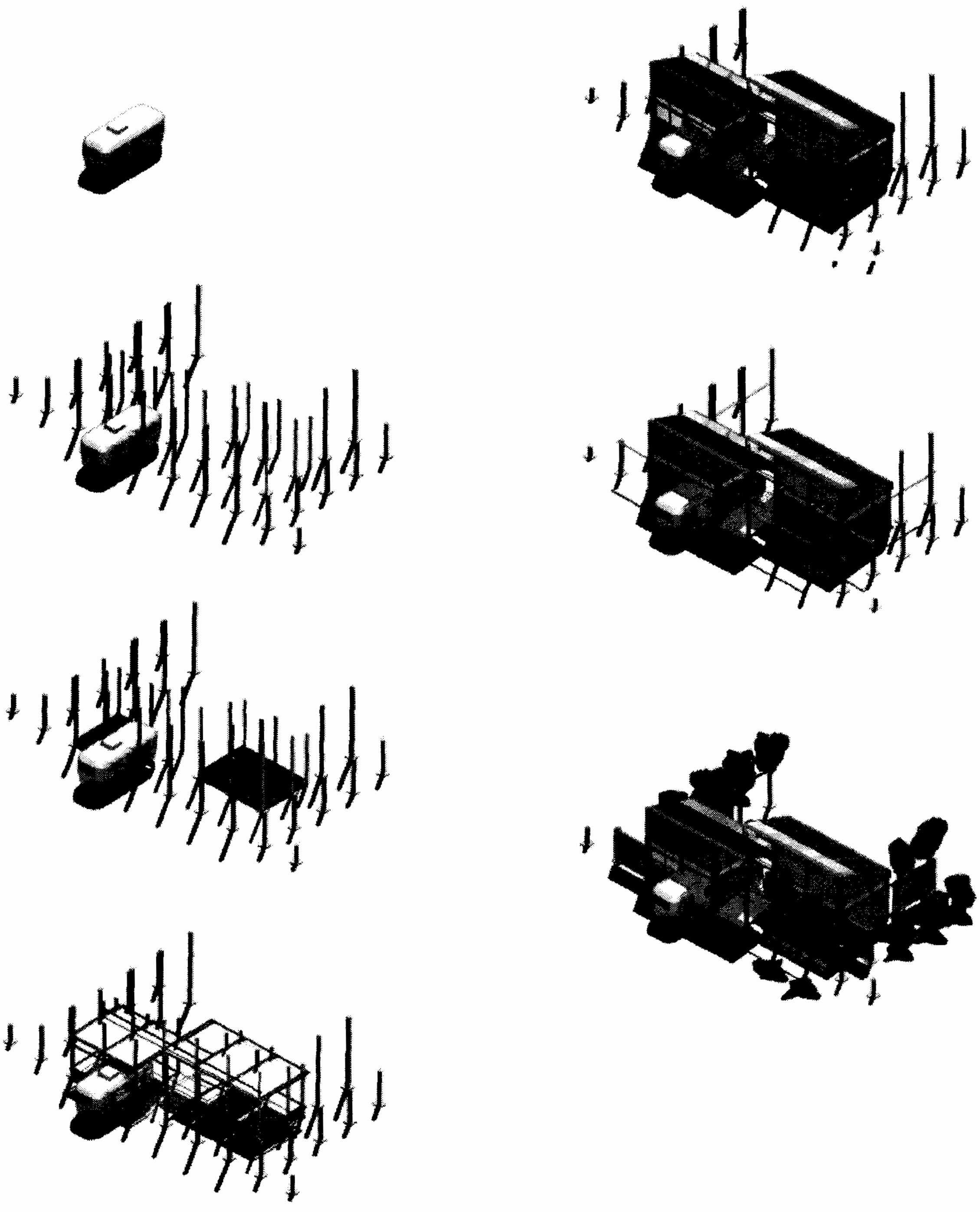

Figure 5: *The design for the Solar Decathlon envisions a flexible modular, reusable kit of parts that sits lightly on the land and forms the superstructure around a mobile utility environment. It features 1) low impact reusable foundation and anchorage system, 2) a column and beam structure that permits accessible utilities throughout the building, 3) floors, walls, and roof which are interchangeable structural panels, 4) carbon balanced components such that the upstream CO2 emissions in the steel is balanced by the net carbon content infill materials*

The students will conclude their study by monitoring building the performance and producing a post-occupancy analysis. A jury of architects will judge design, innovation, systems integration and aesthetics. The challenge of this contest will be to successfully integrate and synthesize design and sustainable building systems into a livable and delightful environment.

CONCLUSION

Through observation, data collection and testing students evaluate various design approaches. Post-occupancy analysis of material observed in built projects, along with comparisons to values derived by model studies, computer simulation and calculations, gives students an opportunity to assess whether the stated design intent has been achieved and to better understand how well design models predict the variety of ways occupants actually experience a building. The hands-on approach to the studio allows students to develop both know-how and know-why. This level of understanding is especially potent in the forum of the Building Workshop in Design With Climate in which disciplinary knowledge and interdisciplinary understanding take place.

NOTES

[1]Fisk, Pliny and Richard MacMath, "Carbon Dioxide Intensity Ratios: A Method of Evaluating the Upstream Global Warming Impact of Long-Life Building Materials," Center for Maximum Potential building Systems, Inc. 2000.

[2]Kurokawa, Kisho. "The Philosophy of Symbiosis: From Internationalism to Interculturalism," *Japan Architect*, Feb. 1982.

[3]Rush, Richard. *The Building Systems Integration Handbook,* The American Institute of Architects: Butterworh Architecture, Boston, 1986.