

ARCHITECTURAL DIVERSITY THROUGH CLIMATE-RESPONSIVE ARCHITECTURE

M.S. Zdepski

"The nature of a place must be explored. You don't plunk a building somewhere without the influence of what is around it. A building is the character of the place, the nature of it."

Louis I. Kahn, 1970.

ABSTRACT

During the past ten years, students in the third year of the New Jersey School of Architecture of the New Jersey Institute of Technology have been asked to address both the most technical and philosophical aspects of climate-responsive architectural design. They have considered energy consumption, visual and thermal comfort, and ventilation methods in the context of various architectural studio design problems. Through the use of microcomputer programs for analysis, students have been able to engage in repetitive cycles of thermal analysis and architectural design. Most importantly, the computer has encouraged experimentation of alternative approaches to form, material choices, and construction detailing while examining many solutions and preconceptions. This permits students to refine individual design approaches to reduce overall energy consumption and increase the thermal and visual performance of the buildings.

INTRODUCTION

One of the most fundamental characteristics of good architecture relies upon a detailed understanding of and sensitivity to the details of context climate and a sense of place that is specific to a building's site. Regardless of the technology or building's use, good buildings acknowledge their surroundings. The design and construction of buildings is the only activity that must be specific to the details of a particular place. Whether on a street corner, in the middle of a block, at the bottom or top of a hill, the site is a dominant architectural influence. Although we may construct identical functions, i.e., motels, hospitals, homes, etc., throughout the country, the variations in site and climate require different architectural responses. For buildings of small and moderate size, the site relationship is the most central influence upon energy consumption. Basic choices about orientation, wind protection, ventilation, solar access, shading, etc., simultaneously impact the energy ptilion of a building and its' architectural character. For this reason, information obtained from energy analysis is a direct test of the general design characteristics of a building.

Michael Stephen Zdepski is associate professor, School of Architecture, New Jersey Institute of Technology, Newark, New Jersey, and a registered Architect and Planner.

Rather than focus upon the extreme conditions of climate for HVAC system design (loads), or monthly energy consumption levels, each student is asked to study a building's performance under a wide variety of specific environmental conditions, including clear, cloudy, and average skies. Loads or yearly energy consumption data tend to orient the student designer to a micro-solution for reducing energy consumption dealing with insulation values, heating and air conditioning system choices, and scheduling only, rather than the more basic architectural choices available in the early stages of design. Studying seasonal variations, as well as varying daily weather patterns, is a direct and demanding test of the comfort and energy performance of the student's design. It results in a deeper understanding of the choices available in the design of a building envelope. The study of real days, which have different characteristics, challenges each student to respond appropriately with a dynamic architecture, producing morning-afternoon-evening as well as winter-spring-summer-fall building qualities. Generally it is possible to maximize the summer and winter average day thermal performance. To do so for clear and cloudy conditions as well becomes a much more difficult problem. In climates like New Jersey, with equal clear, cloudy, and average days, these studies are vital to adequately comprehend and respond to the energy/comfort issue. Students view architecture as a changing filter, which modifies the severity of climate for the comfort of man. The influence of shading devices, insulation systems, openness and enclosure, etc., has as great an effect upon the development of the architectural form and basic visual characteristics of the design as it does in proving the energy performance of the building. Through repetitive cycles of design and analysis, both the quantitative and qualitative aspects of architecture are combined.

Beyond minimizing energy consumption, students seek to provide cool, shaded, and pleasant places in the summer, rather than solely focusing upon peak gains or reducing mechanical system loads. Even the simplest thermal model, when adapted for actual climatic conditions, results in comfort/energy matters becoming a fundamental concern at the beginning stages of the architectural design process. Students have no difficulty in understanding that 50 degrees or 95 degrees Fahrenheit is an inappropriate interior air temperature for specific days of the year.

Because of the complexity of energy analysis and the high level of interaction between the many thermal variables, the computer becomes the necessary link in the design/analysis relationship. It acts as a consultant through which the student gains understanding, possibly even intuition, of the implications of the numerous architectural choices possible in complex environmental situations. It is the quick and interactive access to precise information about the student's own design that ultimately permits the student to ask the more fundamental questions about architectural quality, comfort, and energy consumption. The importance of internal gains, solar loads, insulation, shading, ventilation, etc., becomes a dominant vehicle through which the student approaches design. Totally glass buildings, equal elevations on all orientations, large isolated interior spaces become clearly undesirable. Rather than the technical information restraining the design solutions, as many would expect, into uniform approaches, the added information encourages a greater variety and more specific attitudes about architectural design. Although students are working with a common algorithm and identical climates, building functions, basic construction technologies, microclimates, and sites, the climate-building relationship proves sufficiently complex to provide a rich variety of possible design approaches.

The traditional focus upon loads, or monthly conditions, gives few clues to the detailed characteristics of the buildings facade or formal aspects. It provides little insight into the conceptual aspects of design. It is important for students to ask questions about architecture that address qualitative aspects of the physical environment. What is the most pleasant space to sit in during a summer's rain? What kind of place is

most comfortable in a winter's cold, sunny afternoon ? Must a north elevation be differentiated from the south elevation ? In what ways are east and west elevations different ?

Regrettably, as our knowledge of thermal systems increases and computer models develop further, little progress is being made in analytical systems that directly assist in the development of initial and fundamental choices for building design. In the beginning, when the designer is seeking larger answers, more generalized concepts, and is dealing with conflicting situations, current energy software cuts the building into many small pieces: daylighting, heating, cooling, heat storage, shading, heating and air conditioning systems, weather characteristics, etc. Even linking together existing software to provide information of increasing detail through the design process is hampered by different analytical techniques (degree-days, solar savings fraction, bin analysis, hourly analysis, etc.). Each has its own data base, each giving a different view of the important variables to be considered in design.

Most software provides only raw data and is oriented to mid-design analysis. No software program has successfully made the bridge between analytical data and the graphic oriented world of architectural design. Because the larger issues, siting, room arrangement, building shape, etc., can rarely be reconsidered in the middle or end of the design process, energy analysis programs must assist the designer with basic choices early on, without the misleading information often associated with "rules of thumb" or energy budgets.

ANALYSIS AND DESIGN

Computers permit the immediate application of energy-related knowledge to what is generally a visually dominated design study. Given access to many types of information, heating, cooling, interior air temperature, ventilation needs, weather conditions, cloud cover, wind direction, etc., the designer can respond in a more holistic fashion, considering many influences, obtaining a sense of the entire problem, and developing an intuitive as well as technical understanding of climate responsive design. Early analysis, even if not highly detailed or accurate, leads to a greater insight and sensitivity in the development of pleasant places and buildings.

The reflection and experimentation is an essential part of all design. When dealing with the uncertain, always unique, and multifaceted considerations of energy in architecture, the computer provides a vehicle for the generation and evaluation of many design alternatives. Ideally the study of specific climatic events diminishes the abstract characteristics of building design in the architectural studio. Lines on paper, abstract ideas, conceptual models are tested by the needs of thermal and visual comfort. Although energy analysis is not a field assumed to have many visual physical design characteristics, the study of the climate-building interface has proved to be an area rich in traditional design ideas. It is a field encompassing a broad range of architectural concerns from color, shading, massive versus lightweight materials, site design relationships, etc.

PRESENTATION

Four student design projects, previously published by the Association of Collegiate Schools of Architecture as part of their Energy and Design Competition, will be presented. Two examples of each project are discussed, illustrating the diversity of architectural approach possible within an identical set of design determinants. Although all projects have similar energy consumption, they vary widely in physical and visual attributes.

The first project, "Wintergarden," illustrates the influence of extremely high mass construction, which creates a variety of interior spaces for plant propagation and display. Numerous identical interior spaces meet the needs of varying plant systems. Although the designs exhibit a highly structured and unified formal organization, variations in materials, colors, insulating systems, etc., at the scale of a room, result in an interior environment of extraordinary diversity, from arid to tropical conditions. The second approach differentiates north and south elevations and develops large interior volumes with a small surface to volume ratio. It relies upon cross-ventilation through the stack effect and the use of removable lightweight walls for the summer season.

The second project, "Woodworkers Shop," deals with the requirements of precise light and ventilation control. Daylighting models were also used as an analytical method. Each design responds to seasonal and daily weather variations in different ways. The first design admits light from clerestory windows, reflecting winter sun off interior ceiling surfaces. It controls light quality through the study of specific sun angles and reflections. The second design is oriented toward the overcast sky. Through the design of movable fabric panels, light enters the space from above or is shaded from the space during periods of intense sunlight. Throughout most of the year, the strategy focuses upon filtered sun or sky light. Although this design excludes direct sunlight under all but clear, cold winter days, higher levels of insulation and thermal mass result in similar overall energy consumption.

The third project, "Country Club," approaches energy and climate responsiveness through basic decisions about functional zoning, building shape, site access, and circulation. One design orients all activities inward, in a controlled interior zone. Turning the building inward permits a high degree of light, ventilation, and heating and cooling control. Excess heat is exhausted to the exterior or moved to the perimeter portions of the building. The other design incorporates an exterior facade that changes dynamically to accommodate seasonal variations. The building opens to the site in the summer and encloses and shelters itself from winter weather.

The fourth project, "Music School," illustrates the widest range of solution from isolated tower, with two dominate east and west facades, to a low courtyard structure, turning inward. The tower design takes advantage of an east-west orientation for cross-ventilation through the elongated floor plan, minimizing solar gain and maximizing daylighting into every occupied space. Light shelves and shading devices strictly control solar gain while providing a sense of scale to the exterior elevation. The courtyard design turns all spaces toward a river view. Circulation space is located at the perimeter and is the path by which excess heat is distributed from one area of the design to another. As a "one room deep" building, cross-ventilation and daylighting are also maximized. The precast concrete construction is detailed to include substantial levels of thermal and acoustic insulation with large thermal mass surfaces in contact with the interior spaces.

CONCLUSION

During the past six years, architectural students have engaged in design and analysis projects, which utilize an energy analysis program based upon actual climatic events. The computer model has encouraged a greater variety of architectural approaches, increased willingness for experimentation in the basic principles of architectural design, and provided students with detailed and specific technical information. This has resulted in a high level of technical development not generally associated with mid-level architectural design studios. Although a highly simplified thermal analysis program, the basic concepts of energy conservation and climate responsive design have clearly impacted student's work and their understanding of architectural design.

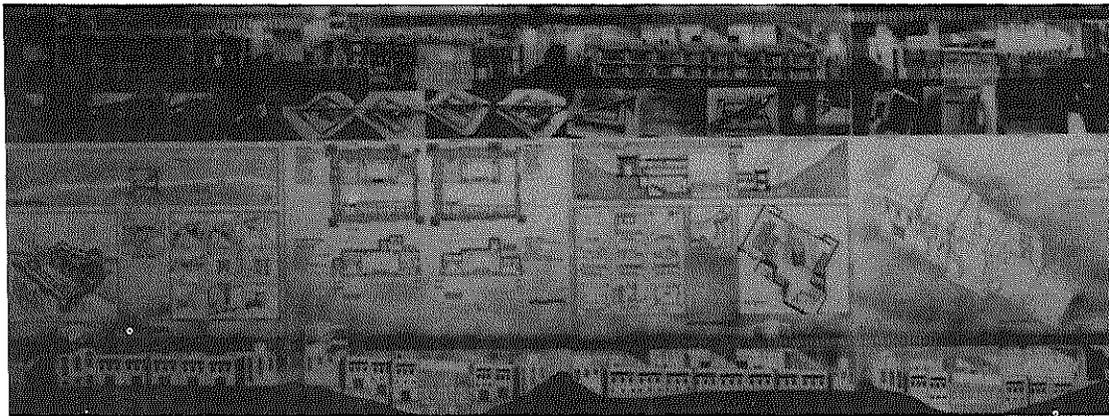


Figure 1. Music school, Emil Stojakovich

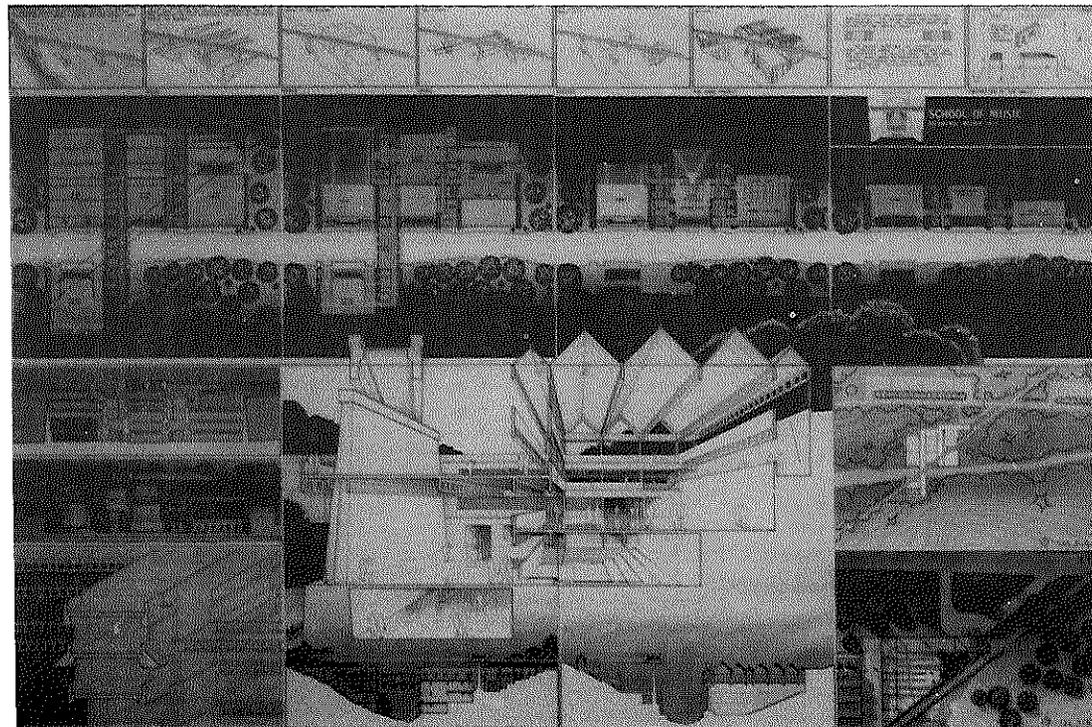


Figure 2. Music school, Greg Talmont

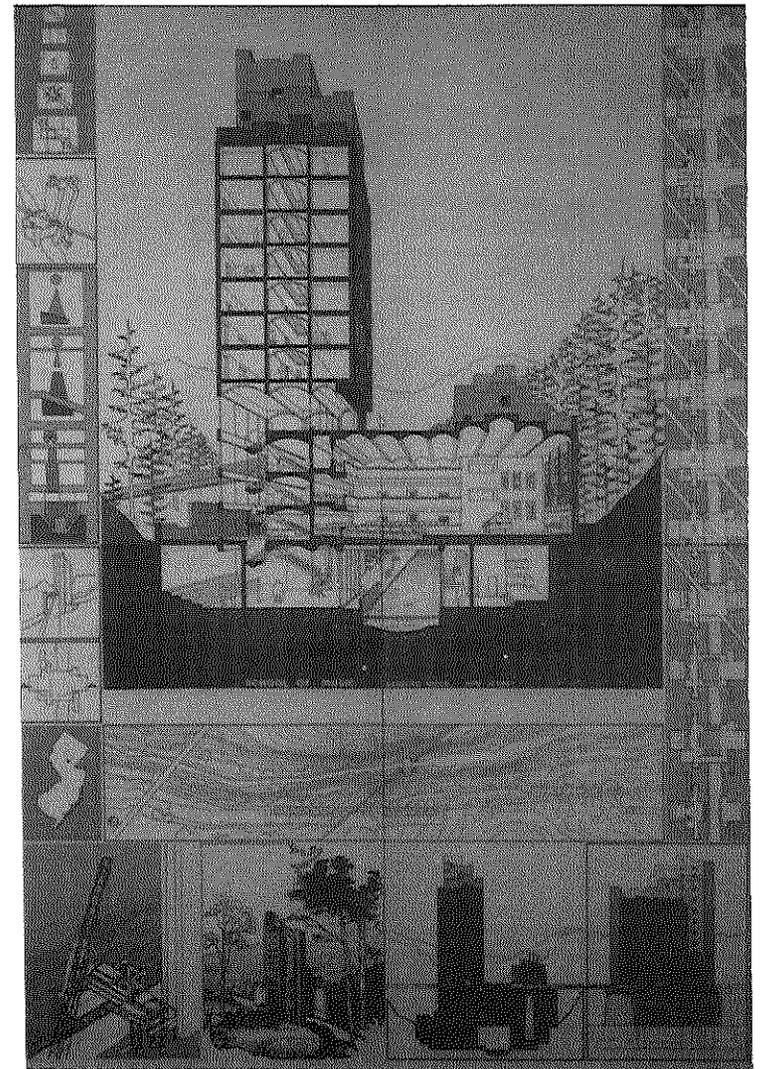


Figure 3. Music school, Joan Proofetta

