BUILDING ENERGY SIMULATION AND THE ARCHITECT

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ABSTRACT - This paper discusses the relationship of building energy simulation programs to architectural practice. It proposes some procedures by which the detailed input requirements of such programs may be alleviated during conceptual design. Means for procurring energy conservation products during detailed design through the use of simulation techniques are discussed. Finally the use of simulation during code compliance and in architectural research is discussed.

INTRODUCTION

In the dozen years since the first oil crisis, energy consciousness in the architectural profession has risen from obscurity to a place of predominance and has settled back again to a position of neglect. Excesses of advocacy during the times of gas pump lines have spurred a new profiligacy during this time of "oil glut". No matter that electric rates are rising alarmingly over much of the nation as expensive nuclear capacity is absorbed into the rate base, the architectural profession perceives that the energy crisis is over.

In the last few years, however, a revisionist advocacy has arisen which claims that energy conservation is good business. Taking its cue from the capitalist leanings of the nation's political climate, these individuals adjure the solar excesses of the seventies, and embrace the internal rate of return of conservation technology. Unfortunately for the architect, however, much of this technology falls into the engineering disciplines, leaving the architect, either for good or for bad; without much effectiveness in the energy area. Most architects thus feel that building energy simulation is completely irrelevant to their practice.

At the height of the energy crisis, a number of major building projects were designed utilizing vast numbers of parametric studies performed with mainframe simulation programs. Some of these projects include several of the California State Office Buildings, the TVA Office of Power, the San Jose Federal Courthouse. The parametric studies for these projects begain during the master planning phase by studing massing and orientation long before any details of internal organization were available. These studies continued, utilizing more and more detail as it became available from the architec tural design process. The energy simulation studies thus dominated the design process so that in many cases, the requirements of the internal occupancies and the architectural expression were subjugated to a single major energy conservation idea. In some of these buildings, the benefits of the energy conservation may arguably be outweighed by the negative impacts of the conservation idea on the functioning or image of the building.

SIMULATION IN PRELIMINARY DESIGN

The rhetoric of architectural energy consciousness, however, claims that more energy can be saved in the preliminary design phase than in all other phases combined. While this assertion may be correct, the nature of decision making in this phase is non-quantitative. The architect is juggling a great variety of factors, site factors, code and regulatory constraints, programmatic inputs and client preferences. Coupling these factors to general guidelines for energy efficient design is probably the best that can be hoped for in a balanced design effort.

Computer simulation can still be invaluable in preliminary design, even if it is not used for exhaustive parametric studies. The first task it can be used to accomplish is the setting of an energy budget and the determination of the investment potential for conservation in the building. These two goals can be accomplished in a single exercise. Prior to the start of schematic design, a "vanilla" code complying, and program encompassing building can be simulated. This simple building can provide the baseline for development of conservation and for code compliance in later design stages. A second simulation can then be performed on a version of the base building which has been developed totally for energy efficiency. This development can be exclusive any other concerns including first cost because the simulation will be used only to develop a minimum level of energy consumption that can be achieved at the specific site and with the specific program. The difference in calculated energy consumption between these two cases then becomes the greatest possible energy savings that can be achieved. Applying local utility rate structures to these two simulations yields the greatest energy cost savings that can be achieved. The client's economic performance requirements can then be reviewed to calculate a net present value factor that can be applied to the energy cost savings to yield the investment potential for conservation in the building. This number can then be installed as a line item in the construction budget for energy conservation items.

At the end of schematic design a simulation can be performed to determine what impact schematic design decisions have made on the energy consumption of the building. A decrease in the estimated energy consumption from the initial "vanilla " simulation may merit a transfer of budget funds from the conservation line item to other budget line items. An increase in the estimated energy consumption may indicate that some of the schematic design decisions should be reviewed in design development. Analysis of the energy end use components and load components on the simulation output can reveal sources of any changes in the estimated consumption.

The major problem experienced by architectural firms in using simulation programs in this manner is that simulation programs require extensive detail, particularly related to mechanical systems, which may not be available at this stage of design. As a result, a number of "Simplified Analytical Methods" and "Design Tools" have been developed which either incorporate assumptions about these details, or perform calculations at so gross a level as not to require details. Which such "Design Tools" may be of some use in making non-quantitative design decisions, their results can never be compared with those of a simulation tool.

A far better procedure for preliminary design is to use some of the library capabilities and file management procedures to develop a set of defaults. These can be so configured as to allow an input stream to created by assembling a set of file agments, each of which contains a detailed description of the system or component involved. The automatic sizing options can be invoked so that the file fragments can be made generic. In this way, the results of the early design simulations can be compared directly with later more extensive studies to select components, materials and equipment.

SIMULATION AND DETAILED DESIGN

Simulation programs reach the apex of their utility in the detailed design phase. They can be used very effectively not only in selecting mechanical components, but also in selecting glazing materials, evaluating shading devices, establishing insulation levels and selecting lighting sources. Economic analyses can be based on the performance of specific products for which exact costs have been determined.

In conjunction with a pre-purchasing procedure, simulation programs can be used in the detailed design phase to compare and procure proprietary or dissimilar components or materials. A typical process might begin by furnishing vendors with a specification of the material or component. The specification may be open, allowing a number of means of achieving the same functional end. For example, the specification for a glazing system might include a color, an external reflectiveness and maximum values for U-factor and shading coefficient. A form would be filled out by each vendor which specifies the exact characteristics of the glazing system he proposes. This information would be formatted so as to be compatible with the simulation program component description format. This form then becomes a part of a formal submittal which includes a guaranteed price for the component. Energy simulations and economic anlayses are performed for each component alternative taking into account purchase price and operating cost differences. The client may then pre-purchase the most attractive alternative and, in the case of the conventional bid projects, assign the component to be delivered to a contractor yet to be designated. Components which are most effectively handled in this fashion include glazing systems and lighting systems.

SIMULATION AND CODE COMPLIANCE

Simulation has often been used in compliance under Section 10 of the ASHRAE 90-75 based state energy codes. In the past, this section has not been of tremendous interest to architects because the standard building to which the actual design is compared has the same architectural configuration as the actual design. The proposed revised version of ASHRAE Standard 90 replaces the old Section 10 with a new version which incorporates a "prototype building" to which the actual design may be compared. The "prototype building" is defined to have the same total floor area and the same number of floors as the actual design, with area being equally divided among the floors. It is assumed to be rectilinear with a 2.5 to 1 aspect ratio and with the long axis oriented north-south. Assumptions concerning mechanical systems are based upon the building type. For architects, this new methodology is of immense importance because architectural energy conservation opportunities are now of value in achieving code compliance. The prototype building, in fact, might well be the same building description described in the previous section as the "vanilla building" which was used to set the energy consumption baseline for budgeting purposes.

The performance path, described above, is outlined in Section 9 of the proposed Standard 90 update. It reaches a single metric for comparison of the prototype and actual building through a Building Annual Energy Cost Budget based on actual fuel costs at the site. Because energy costs, rather than energy consumption, are used as the metric, load shifting strategies, such as those utilizing structural mass for heat storage to reduce electric demand charges, become relevant to the code compliance process.

The proposed Standard 90 update thus dramatically increases the architect's participation in the energy code compliance process. Building energy simulation becomes the tool through which the impacts of architectural conservation measures are evaluated. Incorporation of certain no-cost architectural conservation measures such as solar orientation, glazing configuration, etc., will enable those clients who may be uninterested in energy cost savings either to incorporate energy costly amenities, or to substitute less expensive, less efficient components into their design while still achieving code compliance. The new standard should thus significantly increase the use of simulation tools for code compliance by architectural practitioners.

SIMULATION AND ARCHITECTURAL RESEARCH

Simulation remains an extremely important tool of research on energy consumption in buildings. The recent American Institute of Architects research agenda which stressed "whole buildings research" would rely heavily on building energy simulation tools to examine the interaction of building components in configurations more varied than can be found in existing examples. The various design handbooks and guidelines developed by the Development of Energy, Battelle, Tennessee Valley Authority and other funding agencies have made extensive use of simulation to examine the impact of conservation measures. These guidelines and similar reference materials become the most relevant input to the architectural design process during its early, non-quantitative phases. Simulation thus becomes an indirect input to these phases.

SUMMARY

Building energy simulation, while seeming the domain of the engineer, can have significant relevance to an architectural design practice. While extensive parametric studies may constitute overkill, proper utilization of simulation programs can offer significant benefits to the budgeting and design management processes. Building energy simulation will become much more important to the architect as energy standards recognize architectural design as a significant method of reducing energy costs. In a more indirect way, building energy simulation will continue to relate to architectural design as it is used as a tool to research energy consumption in buildings.