THE NORRIS COTTON BUILDING

"A LIVING LABORATORY IN ENERGY CONSERVATION"

A Living Laboratory For Energy Conservation

The Norris Cotton Federal Building, a new Federal facility in Manchester, New Hampshire, is a "living laboratory" for testing and evaluating methods to conserve energy in office buildings. The building was the first Federal building designed from the beginning with high priority being given to energy conservation. The building includes both recognized and innovative energy conserving technologies.

Traditional design concepts were examined during the preliminary planning stages. The analysis produced several unique features which were incorporated into the final design to achieve maximum energy conservation and at the same time provide a functional facility for the General Services Administration (GSA), which constructed the building. Therefore, the design of the building is substantially different from designs of conventional office buildings. At GSA's direction, the building was chosen as an "energy conservation demonstration project" for studying the effectiveness of energy conservation techniques in the design and operation of a contemporary office building.

The building is nearly cubical in shape, has two levels of parking garage, seven office floors and a mechanical penthouse. The requirement for heavier exterior wall construction has contributed to the building's design. There are no windows on the north side and the windows on the other sides are designed to reduce heat loss. The entire building has an area of approximately 176,000 gross square feet.

Evaluating the Unique Features

Among the significant unique features incorporated in the building are:

- small window areas to reduce heat loss, with special double glazed windows with venetian blinds built between the glass panes.
- massive exterior walls with the insulation on the exterior side of the masonry, between the masonry and facing panels to minimize the effects from outdoor temperature.
- a variety of interior energy efficient illumination systems.
- innovative energy-conserving heating, air conditioning, and ventilation systems which include heat pumps, heat storage and recovery devices, and liquid-heating solar collectors.

These features will be carefully evaluated and monitored by the National Bureau of Standards (NBS) for GSA and the Department of Energy (DOE). Data collection and analysis began shortly after the building was occupied.

There are six major areas being evaluated:

- Energy - heating and cooling
- Solar system
- Interior lighting
- User acceptance
- Window studies
- Economic analysis

Energy Analysis

The primary objectives of this task are to determine the effectiveness of the building and its systems in reducing the consumption of fossil fuels and to provide the necessary energy data required for the other tasks. A computerized instrumentation system has been installed to monitor the thermal performance of the mechanical and electrical systems in the building. This system continuously monitors more than 900 sensors located throughout the building. The sensors are connected to a computerized monitoring console located in a control room just off the main entrance lobby.

NBS is also studying the air and heat leakage characteristics of the building. The air leakage study uses an automated sulfur hexafluoride tracer gas technique developed at NBS. The heat leakage study is being done with infrared thermography equipment.

Solar System

There are four rows of flat-plate liquid solar collectors mounted on the roof of the building. The collectors, each row of which was made by a different manufacturer, total 377 m^2 (3900 sq.feet) of surface. The collectors represent the range of flat-plate designs currently on the market:

- single and double-pane glazing
- high-transmission glass
- plastic strip convection suppressor installed above absorber and below glazing
- metal absorbers with various surface coatings

The entire solar energy system is fully instrumented so that its efficiency can be determined and analysis of the solar system's performance can be made. Also, detailed tests are being made on each manufacturer's collector according to ASHRAE Standard 93-77[1]. This test, which is being performed using collectors not previously exposed to the environment, will provide a comparison for thermal efficiency requirements in the original specifications. Later, the exposed solar collectors from the Norris Cotton Building will be tested to determine the effects of weather and age on collector performance.

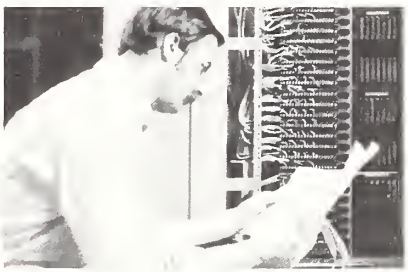
Interior Lighting

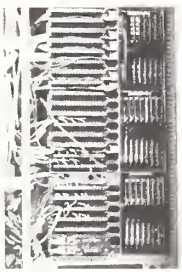
The Norris Cotton Building has different illumination systems on each floor that are being tested and evaluated for energy efficiency and visual effectiveness. The second floor, a testing area for natural lighting, has larger windows and photoelectric override devices to prevent use of artificial lighting if the natural light level is sufficient. The third floor has polarized lights. The fourth has high pressure sodium vapor lamps. The fifth floor has no overhead lighting installation, instead it has special office furniture with built-in lighting systems to illuminate work areas and to generate reflective light. The sixth floor has the same illuminating fixtures as the second floor, but it has less window area in the exterior walls.

User Acceptance

In evaluating the building's performance, NBS will also determine the occupants' reaction to the innovative design features. A questionnaire was developed to evaluate reaction to the building in general, reaction to the thermal environment, acoustics, lighting and windows in the building. The questionnaire was distributed to all employees in late March 1977. A second questionnaire was sent out early in the fall of 1977 to determine reaction following summer conditions.

The user acceptance studies will include the responses to questions concerning the occupants' acceptance of the different types of illuminating systems. In addition to questionnaire data, the researchers have conducted occupancy interviews and will have access to complaints filed by the occupants with the GSA Building Manager.





Window Studies

A previous study has indicated that there are three factors which contribute substantially to human satisfaction with windows: daylight, sunshine, and view[2]. One of the major innovations at the Norris Cotton Building is the use of smaller windows to reduce heat loss and heat gain. Yet very little is known about how building occupants react to reduced window sizes. The window studies will provide information on the effects of reduced window areas that will be useful for designing buildings with innovative window designs.

There are two window designs in the building. The window area is approximately 12% of the exterior wall area on all the floors, except on the second floor where the area has been increased to approximately 30% in order to utilize the maximum amount of natural daylight.

The survey will answer some questions about occupant attitudes toward windows, but it will not provide quantified information about alternative sizes and shapes. To obtain quantitative information, a simulation study will be made using photography and scale models to provide additional data about the shape and treatment of windows. The results of the user acceptance surveys, particularly the positive and negative responses to the window designs, will be used to verify the responses to the simulation study.

Economic Analysis

The objective of the economic analysis is to determine to what extent the innovative design of the Norris Cotton Building is cost effective. A computation of the life-cycle costs associated with the building's design, construction and operation of the subsystems is being made. Then a comparison of the life-cycle costs of a comparably sized building designed and operated according to "typical practice" for the New Hampshire region will be made.

The Manchester firm of Isaak and Isaak, the building's architects, has prepared an estimate on the costs to design and build a comparable "conventional building." The architectural firm is working to gather detailed information on the mechnical and engineering subsystems costs that are associated with the energy conserving design of the buildings.

NBS will assemble the latest information on the capital operating, maintenance and repair costs of the building for analysis. Information on construction costs will be obtained from a computerized list of cost breakdowns on structure, and mechanical and electrical items that will be updated and published monthly for GSA and its contractors. In addition, operating, maintenance and repair cost information will be obtained directly from the GSA building manager and by NBS personnel conducting energy analysis for the building.

NBS Evaluation and Recommendations

Because the Norris Cotton Building contains many features that are not found in typical office facilities, it is equally important to learn how the occupants respond to innovations as well as evaluating the new engineering technologies. This evaluation requires an interdisciplinary team of NBS engineers and scientists with the assistance of consultants and other experts. The results of the tests and evaluations will be made public and will assist designers, builders, engineers and architects in solving and analyzing design problems for other energy efficient buildings.

The Design Team

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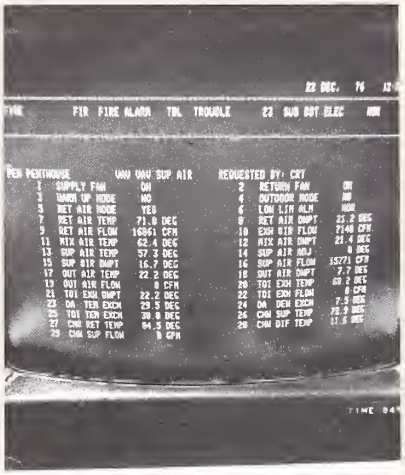
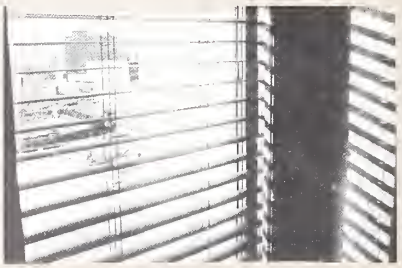
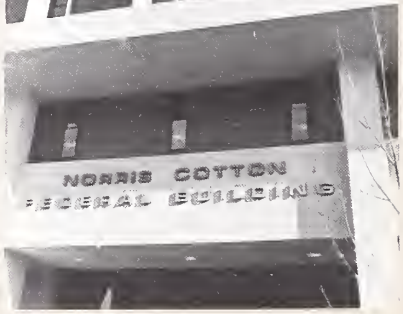
The firm of Isaak and Isaak was awarded the design contract by GSA in 1972. Other members of the team included Dubin-Mindell-Bloome Associates which served as energy conservation consultants; the GSA project coordinators from Washington, D.C., and GSA Region I staff, Boston, Massachusetts; structural consultant Rose, Goldberg and Associates; mechanical consultant Richard D. Kimball Company; and NBS, Gaithersburg, Maryland, which provided assistance on the design of the heating and cooling system based upon analyses of an NBS computer program.[3,4] Under sponsorship of DOE, NBS wrote the specification for and assisted in the procurement of a sophisticated instrumentation system for the building.

The Norris Cotton Building, which was dedicated on October 8, 1976, is being closely looked at by the entire building industry as a source for useful information which can be applied to the challenge for designing energy conserving buildings.







References

1. ASHRAE Standard 93-77, Methods of Testing Solar Collectors Based Upon Thermal Performance, ASHRAE 1977, New York, New York 10017. (For thermal storage devices, refer to ASHRAE Standard 94-77, Methods of Testing Thermal Storage Devices Based Upon Thermal Performance).

2. B. L. Collins, Windows and People: A Literature Survey. Psychological Reaction to Environments With and Without Windows, BSS 70, 93 pp., June 1975, National Bureau of Standards, Stock No. 003-003-01437-1, available from GPO, $1.55.

3. T. Kusuda, NBSLD, The Computer Program for Heating and Cooling Loads in Buildings, BSS 69, 398 pp., July 1976, National Bureau of Standards, Stock No. 003-003-01622-5, available from GPO, $4.60.

4. T. Kusuda, J. E. Hill, S. T. Liu, J. P. Barnett, J. W. Bean, Pre-Design Analysis of Energy Conservation Options for a Multi-Story Demonstration Office Building, NBS BSS 78, 64 pp., November 1975, Stock No. 003-003-01537-7, available from GPO, $1.25.

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