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MASTER

TITLE PASSIVE SOLAR ANALYSIS AND DESIGN OF COMMERCIAL BUILDINGS USING DOE-2

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PASSIVE SOLAR ANALYSIS AND DESIGN OF COMMERCIAL BUILDINGS USING DOE-2

TECHNICAL ENGINEERING SUPPORT GROUP (WX-4)
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CONTRACT NUMBER W-7405-ENG-36

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PERIOD OF CONTRACT: OCTOBER 1, 1980 - SEPTEMBER 30, 1981

OBJECTIVES

The overall objective of this project is to develop passive solar design and analysis tools for commercial buildings. There are two specific objectives.

1. Develop passive solar/large thermal mass simulation capabilities in the DOE-2 building energy analysis computer program so that such systems can be analyzed in commercial building applications.

2. Perform case studies using DOE-2 to assess the applicability of existing design and analysis tools for passive solar applications in commercial buildings.

This work is closely coordinated with similar commercial building design/analysis tool and passive system development work under way at Lawrence Berkeley Laboratory (LBL) that focuses on the BLAST building energy analysis computer program.

BACKGROUND

The Technical Engineering Support Group (WX-4) of the Los Alamos National Laboratory has been closely involved with the development, documentation, and verification of DOE-2, including its earlier versions (Cal-ERDA and DOE-1), since 1976. In particular, we are responsible for the solar heating and cooling capabilities in the program and have developed and implemented an active solar system simulator in DOE-2. This active solar simulator has been under continual refinement, extension, and testing since then; the latest version is now in the DOE-2.1A program that was completed in May 1981.

As an extension of that work, since early 1976 we have been developing, testing, implementing, and documenting passive solar and large thermal mass modifications to DOE-2. The testing work has involved extensive validation studies using test cell, residential, and commercial building data.

Technical Engineering Support Group staff have emphasized the areas of analysis and design of passive solar system concepts in commercial buildings, and, in particular, the development of design tools for these applications. We also have considerable experience integrating energy conservation with passive solar design in large buildings. Because most architectural/engineering (A/E) firms have neither the time nor resources to develop these tools, the required system analysis, computer program development, and design tool development are appropriately being done at national laboratories.

Recently it has become increasingly apparent in the A/E profession that the most important passive solar and energy-related decisions for commercial buildings are made in the predesign phase where the energy problem for the proposed building is characterized and design indicators are determined. In response to this situation, Los Alamos has teamed with developers of four other building energy analysis tools (both manual and computer) in a predesign analysis study to demonstrate and evaluate how well representative analytical tools can provide needed predesign information.

SUMMARY

The following significant tasks have been accomplished. We have refined and fully documented the custom weighting-factor loads calculative method that was implemented in the DOE-2.1 program. This method allows direct-gain and night-ventilative-cooling passive systems to be analyzed using DOE-2. We have developed and tested a thermal storage wall model for DOE-2. This model treats vented and unvented storage walls using either masonry or water as the storage medium. It includes the effect of night insulation and selective surfaces. A model for attached sunspaces, atriums, and buffer spaces has also been developed for DOE-2. This model simulates interzone convection (forced or natural), and interzone conduction through massive walls.

We have completed a case study of Warner Hall at Carnegie-Mellon University in Pittsburgh, Pennsylvania, as part of the DOE Passive Solar Commercial Buildings Program. DOE-2 was used in an analysis of several passive solar and energy conservation retrofit options. The Los Alamos analysis served as a basis for comparison to a more limited (in time and budget) analysis done by the energy consultant for the retrofit project.

We also participated in a predesign analysis study, coordinated by the Solar Energy Research Institute, in which DOE-2 results were compared with results of four other analysis/design tools, ranging from manual to high level computer methods. The results will be documented in the design handbook that is being prepared under the DOE Passive Solar Commercial Buildings Program.

TECHNICAL ACCOMPLISHMENTS

We have achieved the following during the course of this project.

- Refined and fully documented the custom weighting factor calculative method in DOE-2.

- Completed the development of a thermal storage wall model for DOE-2 that treats vented and unvented storage walls of either masonry or water construction. This model is being implemented in DOE-2 by LBL and has been validated against measured data in Los Alamos National Laboratory test cells.
(See Figs. 1-2.)

- Developed a sunspace model for DOE-2 that allows modeling of attached sunspaces, atriums, and buffer spaces. This model is being implemented in DOE-2 by LBL and has been validated against measured data in a greenhouse test cell at Los Alamos and the greenhouse-residence unit of the Sundwellings Demonstration Center at Ghost Ranch in Abiquiu, New Mexico.
(See Figs. 3-4.)

- Completed a case study of Warner Hall at Carnegie-Mellon University in Pittsburgh, Pennsylvania, as part of the DOE Passive Solar Commercial Buildings Program.

- Participated in a predesign analysis study in which DOE-2 results were compared with results of four other analysis/design tools in the characterization of the energy problem for two test buildings. Design indicators were determined in addition to the annual energy consumption and cost by the end-use categories of heating, cooling, and lighting. This study indicated that a range of existing analysis tools produced the same general characterization of the energy problem, although the energy end-use component predictions differed significantly.

- Participated in the formation of the National Building Design Tools Development Committee being organized under DOE auspices to coordinate public and private sector activities in the development, evaluation, and dissemination of passive and active solar design tools.

EVALUATION

The first objective has only been partially achieved. Several important passive solar capabilities, mostly for heating, have been developed for DOE-2, but many others, particularly in cooling and lighting, need to be developed. Those passive capabilities now in DOE-2 have become widely used and have provided successful and accurate analyses of passive solar designs.

The second objective has been partially achieved also. The case study has shown that DOE-2 can accurately provide comparative energy and cost savings associated with energy conservation and passive solar retrofit options. In the predesign analysis study it was shown that, although DOE-2 can accurately provide needed predesign information, simpler tools can provide essentially the same information for many buildings at less cost and time for the designer. It is not yet known for which types of buildings the simpler tools are adequate.

FUTURE ACTIVITIES

Project Activities

Tasks to be completed later in this project include the following. Expected completion dates are in parentheses.

1. Develop improved evaporative cooling capabilities in DOE-2 (12/81).

2. Refine night-ventilative-cooling capabilities in DOE-2 (12/81).

3. Develop ventilative cooling through operable windows in DOE-2 (3/82).

4. Develop a rock bed model (for both heating and cooling) for DOE-2 (6/82).

5. Develop improved underground floor and wall models in DOE-2 (6/82).

6. Improve the glazing control options in DOE-2 (6/82).

7. Develop a roof pond model for DOE-2 (4/83).

8. Develop simplified design tools for passive solar commercial buildings (9/81 - 9/83).

9. Apply DOE-2 in a performance and economic assessment of commercial buildings retrofit options (9/81 - 9/83).

10. Continue to participate in the National Building Design Tools Development Committee (9/81 - 9/83).

Postproject Activities

By providing A/E firms and other design professionals with design/analysis tools appropriate for commercial buildings, passive and hybrid solar system designs will begin to penetrate the market. It is clear that passive and hybrid systems will not be applied to commercial building designs without the availability of user-oriented design tools. DOE-2 will be such a design tool for the more complex commercial building designs and will also be used to develop simpler design tools for the early phases of the design process.

PUBLICATIONS/REFERENCES

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3. J. F. Kerrisk, N. M. Schnurr, J. E. Moore, and B. C. Hunn, "The Custom Weighting-Factor Method for Thermal Load Calculations in the DOE-2 Computer Program," ASHRAE Paper No. CI-81-3, No. 3, presented at the 1981 ASHRAE Annual Meeting, Cincinnati, Ohio, June 28-July 1, 1981. To be published in the ASHRAE Transactions 1981, V. 87, Pt. 2.

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5. "DOE-2 Reference Manual, Part 1, Version 2.1," Los Alamos Scientific Laboratory manual LA-7689-M Version 2.1 (Lawrence Berkeley Laboratory manual LBL-8706 Rev. 1) (May 1980).

6. "DOE-2 Engineers Manual," in preparation by the Los Alamos National Laboratory, Technical Engineering Support Group (WX-4).

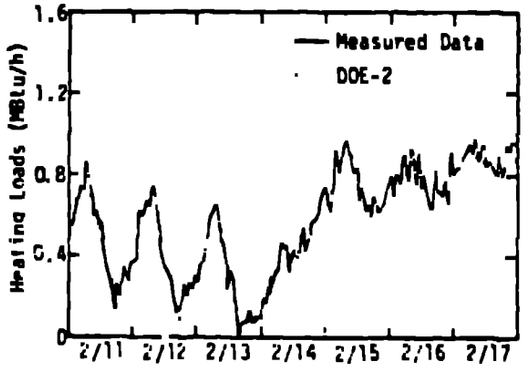

Fig. 1. Comparison of DOE-2 unvented storage wall model and measured data for a single-glazed test cell with a selective surface.

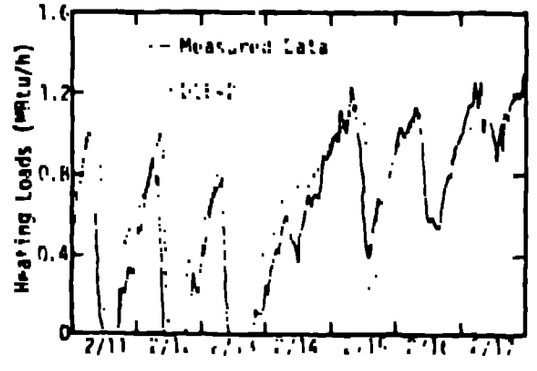

Fig. 2. Comparison of thermocirculation storage wall model and measured data from a vented test cell.

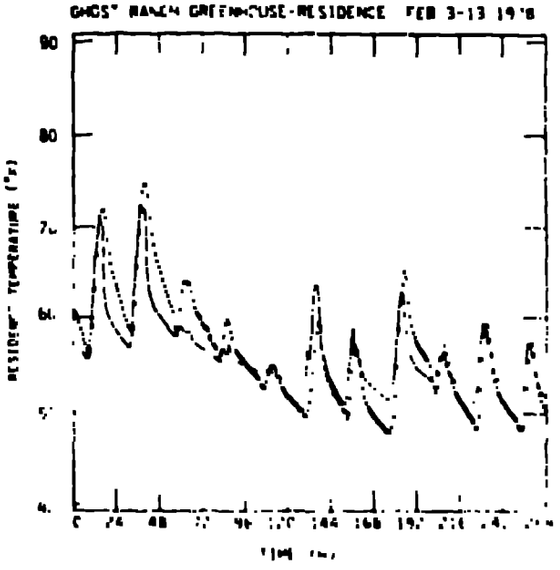

Fig. 3. Ghost Ranch Greenhouse, [illegible] at [illegible] measured, * - calculated [illegible]

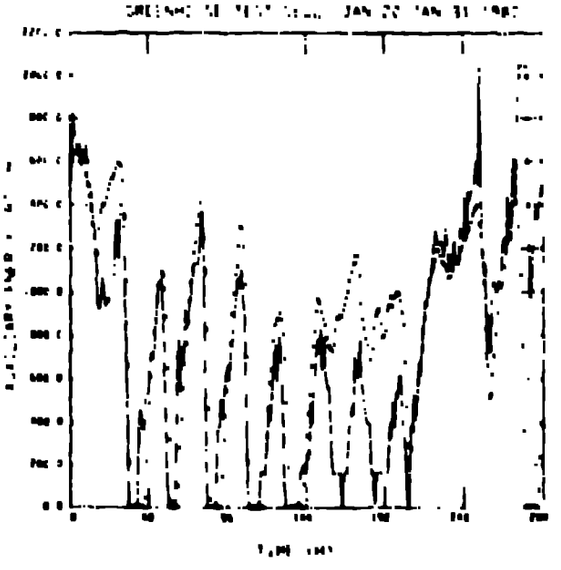

Fig. 4. Los Alamos Greenhouse test cell [illegible] measured, * - calculated [illegible]