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SUMMERTIME RESULTS FROM THE CLASS B PASSIVE-SOLAR PERFORMANCE-MONITORING PROGRAM

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SUMMERTIME RESULTS FROM THE CLASS B PASSIVE SOLAR PERFORMANCE MONITORING PROGRAM

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ABSTRACT

The DOE/SERI Class B passive solar monitoring program is designed to provide, at relatively low cost, accurate and consistent real-time estimates of building thermal performance, as well as detailed data regarding climate, indoor temperatures, and purchased energy needs. As part of this program, a microprocessor-based data acquisition system has been installed in each of ten passive solar houses in the Denver area, primarily to evaluate heating-season performance. During the summer, however, the monitoring systems are used to study the overheating tendencies of the buildings. Examination of the conditions that lead to overheating, using graphical and statistical techniques, will provide insight into the solar design practices that provide the most comfortable summer environment.

1. INTRODUCTION

The DOE/SERI programs for performance evaluation of passive solar residential buildings are being conducted at three levels of detail and expense. These levels have been designated as Class A, B, and C monitoring. The Class A program is the most detailed, focussing on the thermal processes that make solar buildings function. It is the most expensive approach and is being performed on very few buildings. The Class B program is the middle level of detail and expense. Its purpose is to produce accurate and consistent real-time estimates of building thermal performance, as well as detailed data regarding climate, indoor temperatures, and purchased energy needs. Because of its lower cost, Class B monitoring can be performed in a larger sample of buildings and climates, allowing the possibility of statistical analysis of building performance. The Class C program uses energy audit and utility bill analysis techniques to evaluate performance of a large sample of buildings.

In the next year, eighty passive solar buildings throughout the United States will be monitored at the Class B level. This report concentrates on ten buildings in the Denver area, in which the monitoring systems are in operation during the summer of 1981. Although the Class B program is designed for heating-season monitoring, summertime operation can provide valuable insights into the overheating tendencies of solar buildings.

2. THE MONITORING SYSTEM

The Class B monitoring program uses a microprocessor-based data acquisition system. Data is received on each of sixteen channels every fifteen seconds, and channel averages are stored on cassette tape every hour. In addition, daily and monthly performance factors are calculated in real time and then printed and stored on a daily basis. Physical and thermal characteristics of the building, such as furnace efficiency and solar aperture area, are measured at the beginning of the monitoring period and input to the microprocessor software.

The continuous measurements include horizontal and vertical solar radiation, outdoor temperature, indoor temperatures in five different zones (including sunspace and unconditioned buffer area), status of insulating shutters, and all purchased energy quantities, including space heating, hot water, air conditioning, fans, lights, and appliances.

During heating-season monitoring, real-time calculations include the major energy flows in the building: heating load, purchased space heating, water heating, internal heating, and solar heating. Also, the time is accumulated during which the interior temperature falls into a given 5°F "bin." This is a measure of interior thermal comfort and stability; if interior temperatures are spread across several bins, the environment is relatively unstable and sensitive to thermal fluctuations.

During the summer, temperatures of the various interior zones are the primary performance measures for passive solar buildings. The real-time data reduction program is modified to include a calculation of the daily temperature extremes in each zone. The temperature peaks are a measure of overheating. The days when the highest peaks occur can be identified from the daily print-outs, and the data for these days can be examined in detail using the cassette storage tape.

3. OVERHEATING MECHANISMS

Although passive solar buildings tend to be well-insulated, they are susceptible to excessive solar gains in the summer. The heavily glazed southern exposure, which of course provides heating in the winter, can create an overheating problem if insufficient shading, ventilation, or mass is available.

Of the ten buildings monitored in the Denver area, all have some direct-gain area, three have additional mass-wall area, and two have a sunspace. Each building has a different combination of shading devices and ventilation equipment, though several appear insufficiently shaded.

The sunspace systems are of particular interest, for although the living space is not directly penetrated by the summer sun, the sunspaces have large areas of unshaded tilted glass that will receive especially strong summer insolation. The extent of overheating in these buildings will depend on ventilation of the sunspace, and will be apparent from the rates at which the sunspace and the living space heat up on sunny mornings.

The thermal mass used for storage in most solar buildings can also prevent summertime overheating by damping out the effects of peak ambient temperatures and solar gains. The energy stored during the day can be removed if night-time ventilation is available. The effectiveness of the mass-ventilation combination will be apparent from the indoor evening temperatures, as insufficient mass or ventilation will cause excessive temperatures to build up late in the day.

4. DATA ANALYSIS AND INTERPRETATION

The summertime Class B monitoring has just begun as this paper is submitted. Results of the monitoring will be presented at the Sixth Passive Solar Conference.

A major goal of this project is to determine the relative extent of temperature and solar-driven overheating in order to gain insight into the design practices that provide the most comfortable summer environment. Detailed study of the data from peak days, with specific attention to the response of invidivual interior zones to ambient temperature and insolation, will indicate the driving forces for overheating. Also, statistical grouping of overheating occurrences as a function of ambient temperature and insolation, will indicate the conditions to which the building is most prone to overheating and suggest mechanisms to control these occurrences. Both of these approaches can be depicted graphically, allowing a visual comparison of the performance of different houses.

5. CONCLUSION

This work should provide insight into overheating phenomena in passive solar buildings. It also presents an opportunity to implement graphical and statistical data examination techniques that will be useful for heating-season monitoring as well.