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PASSIVE SOLAR DESIGN HANDBOOK* 3174A

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OBJECTIVE

As a component in an overall national objective of reducing the consumption of nonrenewable energy supplies, effective passive solar design of new construction and retrofits can play a significant role by reducing energy consumption in buildings. In support of this objective, a quantitative basis of passive solar design has been under development at the Los Alamos National Laboratory over the past six years. The objective of this program is quantitative information that enables a designer to analyze the energy consequences of design decisions. The current focus is the continued production of design handbook data to facilitate the incorporation of energy considerations as an integral part of the design process.

BACKGROUND

The basis of passive solar design analysis is computer simulation using numerical models that are validated against data collected from experimental buildings. Computer simulation is an accurate and versatile tool in design analysis, but many designers do not have access to the necessary computing equipment or engineering skills. Therefore, simplified methods amenable to hand calculation have been developed. The basis of simplified methods is a set of monthly solar load ratio (SLR) correlations. Such correlations were originally developed as a design tool for active systems.[1] Later the technique was adapted to passive systems and applied to thermal storage wall[2] and direct gain systems.[3,4] Data for these system types were incorporated in a systematic design analysis methodology in the Passive Solar Design Handbook, Volume Two.[5] The Handbook encompassed six reference designs, two each for water wall, Trombe wall, and direct gain systems. Subsequently, SLR correlations and associated analysis data were generated for 16 attached sunspace reference designs.[6,7] Meanwhile, continuing research has led to further developments in analysis data for direct gain,[8] thermal storage wall, and sunspace systems. These data, and extensive supporting information, are now being assembled in the forthcoming Volume Three of the Passive Solar Design Handbook.

SUMMARY

The Passive Solar Design Handbook, Volume Three, will update Volume Two by presenting extensive new data on the optimum mix of conservation and solar, direct gain, sunspaces, thermal storage walls, and solar radiation. The direct gain, thermal storage wall, and solar radiation data are greatly expanded relative to the Volume Two coverage. Optimum mix and sunspace information did not appear in Volume Two at all.

Volume Three will serve a continuing need in the design community for simple, yet flexible, design tools. The needed flexibility to analyze a variety of system designs is accommodated by the large number of reference designs to be encompassed--94 in contrast to 6 in Volume Two--and the large amount of sensitivity data for direct gain and sunspace systems--approximately 1100 separate curves.

Care has been taken to assure that the new data are compatible with that of Volume Two; thus, analysts should be able to incorporate the new data without major modifications of their methods. The result will be a substantially wider scope of application. The appendices will contain sufficiently complete reference data that Volume Three can stand largely alone as a primary source for passive solar design analysis.

An outline of the Volume Three contents follows.

*This work was performed under the auspices of the US Department of Energy, Office of Solar Applications for Buildings.

III. Low-mass sun-tempered buildings
   a. The concept of sun-tempering
   b. The reference designs
   c. Sensitivity data

Chapter 4. SUNSPACES
   a. Introduction
   b. The reference designs
   c. Sensitivity data
   d. SLR correlations
   e. Monthly calculation method

Chapter 5. MONTHLY CALCULATION METHOD

Appendix A. Volume Two Errata
Appendix B. SLR Correlations
Appendix C. Weather Data
Appendix D. Solar Radiation
Appendix E. Load Collector Ratio (LCR) Tables
Appendix F. Mass Sensitivity
Appendix G. Sensitivity Data
Appendix H. Glossary

TECHNICAL ACCOMPLISHMENTS

The following are more detailed descriptions of some of the major areas of new data to be presented in Volume Three.

- Chapter 2 will present information on the optimum mix of conservation and passive solar strategies in building design. Guidance will be available here on selecting the appropriate conservation level (wall R-values, for example) for a given location.

- Chapter 3 will present analysis data for nine direct gain systems consisting of three different levels of thermal storage capacity and three different glazing systems. The reference designs will be described in detail. Sensitivity data will be discussed with an emphasis on qualitative interpretations and general design rules useful at an early stage in the design process. The nine SLR correlations will be presented.

- Chapter 4 will present analysis data for 28 attached and semi-enclosed sunspace systems. The reference designs will be described in detail. Sensitivity data will be discussed with an emphasis on qualitative interpretations and general design rules useful at an early stage in the design process. The 28 SLR correlations will be presented and their application to the monthly SLR calculation method explained.

- Appendix B will present 57 new SLR correlations for thermal storage walls, including 15 water wall, 21 vented Trombe wall, and 21 unvented Trombe wall reference designs. The reference designs include various wall thicknesses, various masonry thermal conductivities, various glazing systems, and selective surfaces.

- Appendix D will present extensive new data on estimating the solar gains experienced by the various systems treated in Volume Three, the gains being an important variable required in the monthly SLR method of design analysis. The estimation procedure is based on the correlation of hour-by-hour solar radiation data from the typical meteorological years for 26 US cities. Two monthly correlating parameters are used, the mid-month solar declination, and the average monthly clearness ratio. The correlations enable a designer to readily estimate the total monthly solar radiation incident on glazing systems of various orientations, the radiation transmitted through 1, 2, or 3 layers of glazing material, and the radiation eventually absorbed in the building. The features that are new since Volume Two are the addition of the clearness ratio as a correlating parameter, which considerably improves the accuracy of solar gain estimates, and data on absorbed radiation, which are especially important for direct gain and sunspace systems.

- Appendix E will consist of LCR tables for 219 US and Canadian locations whereby a designer may estimate the annual auxiliary heat requirement for each of the 94 reference designs treated in Volume Three knowing simply the building LCR.

- Appendix G will contain a large amount of sensitivity data that describe the dependence of the annual heating performance of direct gain and sunspace systems on key characteristics of the designs. There will be approximately 1100 separate curves that represent the variation in the annual solar savings fraction as one or two design parameters are varied while the other design parameters are held fixed at their reference values. One example each of the direct gain and sunspace sensitivity data is shown in Figs. 1 and 2, respectively.

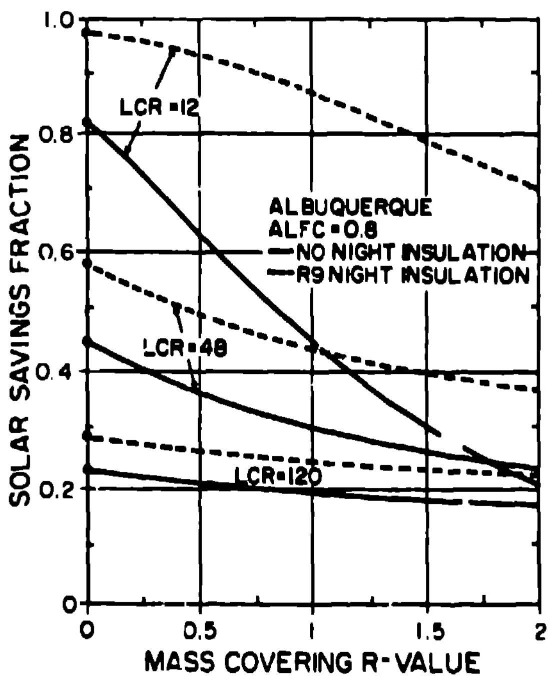

Fig. 1. Annual heating performance sensitivity in Albuquerque to the mass covering R-value for a double-glazed configuration with a mass thickness of 6 in. and a mass area to glazing area ratio of 3. The reference mass covering R-value is 0.

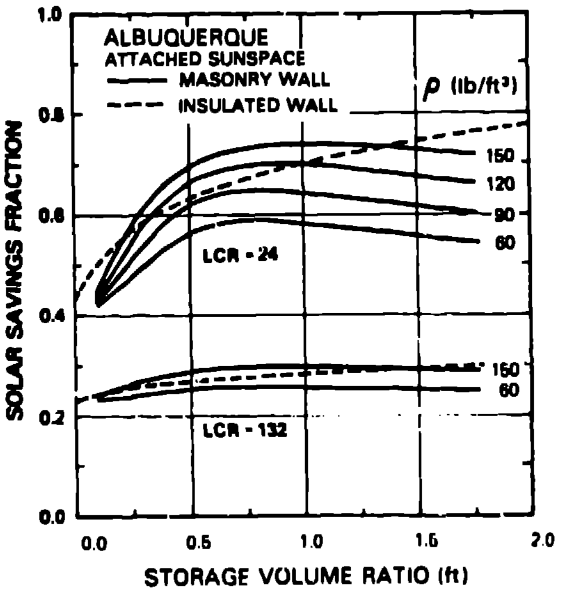

Fig. 2. Annual heating performance sensitivity in Albuquerque to the ratio of the thermal storage volume (ft^3) to the collection area (ft^2) for Geometry A with insulated end walls and no night insulation. Curves for both the masonry wall the the lightweight insulated wall configurations are included.

FUTURE ACTIVITIES

Quantitative design tools are a vital aspect of establishing passive solar technologies as credible and widespread alternatives to the high level of building energy consumption that presently characterizes that sector of the energy economy. Despite the significance of the step represented by Volume Three of the Passive Solar Design Handbook, there remains much more work to be done in this area. Some of the tasks that remain are listed below.

- More SLR correlations will be developed for systems already treated in order to provide analysis tools for a full range of typical design variations.
- Solar load ratio correlations and associated design analysis data will be developed for additional system types, including convective loops and thermal storage roofs.
- A more rigorous quantitative basis for the analysis of mixed systems will be developed. The most urgent need is for mixtures of direct gain and unvented Trombe wall.
- Passive solar heat to multiple-zone structures will be addressed from the standpoint of free convection through doorways.
- Rules of thumb will receive greater emphasis. Simple but accurate design principles that can be used very early in the design process are very important among builders who will not use more quantitative methods.
- Thermal comfort consequences of passive solar design will receive further development. Some issues of concern are winter temperature swings, summer overheating, and interzone temperature differences.
- The limits of applicability of the monthly SLR method will be further defined. Of particular interest is the method for accounting for internal gains, which can be an appreciable fraction of the total load in well-insulated residential buildings and in commercial buildings. Furthermore, the only essential difference between residential and many small commercial or light industrial buildings is in the size and schedule of internal gains.
- Summer cooling loads imposed by passive solar heating systems will be addressed. The emphasis will be on load control strategies such as fixed overhangs, operable shades, and ventilation. The objective is quantitative guidance in the creation of a balanced design in which considerations of winter heating and summer cooling are given their proportionate weights in the design process.

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