Conclusions 7.

Introduction 7.1.

This book is an introduction to advanced daylighting strategies for use in this millennium. For the first time, innovative daylighting systems have been evaluated on a comparative basis. The assessments, performed in real and scale-model buildings and in test rooms worldwide, show that the majority of the systems tested can produce potential energy savings when applied in the appropriate climates and on the appropriate orientations of a building.

A daylighting system should be selected according to climatic characteristics, e.g., the predominant sky type and the latitude at a building site. Actual energy savings depend on the daylighting system being designed as part of an integrated strategy that includes daylight-responsive controls. Careful integration of the daylighting system with the rest of a building's design should begin early in the design process to produce a high-quality work environment and provide building owners with a highly valued space.

The state of the art of designing daylit buildings in practise varies widely with climate and latitude. The design of buildings situated in higher latitudes, as embodied in typical design practise and building codes, places more emphasis on floor plans that are conducive to daylight admission where this resource is limited in availability. Buildings situated in lower latitudes, with an abundance of daylight and sunlight in most regions, must contend with the problem of cooling loads and therefore, in the past, have not relied as much on utilising daylight. Now with a renewed interest in reducing energy use and the improvement of working conditions, the use of innovative daylighting strategies is becoming a positive element in building design.

The advanced daylighting systems described in this book are intended to address the following challenges posed by traditional daylighting strategies:

- In predominantly overcast climates or in built-up urban areas, there is insufficient daylight flux to provide adequate interior daylighting.
- In some climates and orientations, poor control of glare from direct sunlight limits daylight applications.
- In hot and sunny climates, daylighting designs must manage sunlight to control cooling loads.
- There is widespread interest in extending the floor area that can be effectively daylit at a distance from windows and skylights.
- Given the ever-changing nature of tasks in buildings and the dynamic nature of daylight, design solutions that provide some degree of operational control are desirable.

These challenges shaped and defined the IEA SHC Task 21's Subtask A effort to study new technologies and designs that could address these needs. The study focused on both commercially available and experimental prototype technologies, so readers should verify the commercial status of any systems of interest. Current data on system costs and availability should be obtained from the appropriate commercial sources, some of which are listed in Appendix 8.6.

7.2. Performance

Participants of the IEA SHC Task 21 made a major effort to generate absolute and comparative performance data for innovative daylighting systems. A comprehensive set of test protocols was developed to ensure data quality and comparability (Appendix 8.5). Good comparative data were obtained for many systems in side-by-side testing with reference base cases under a variety of outdoor conditions. In some studies, occupant response data were also collected.

Although it was feasible to extend limited test room data to annual performance data, this was not always possible. Since the testing was carried out in different facilities in different countries, it was difficult to make comparisons between the data. In order to best utilise the results presented in this book and summarised below, a designer should carefully evaluate the performance data presented here in relation to the performance needs of a specific project. The "best" system for a particular project may turn out not to be useful for another project because of differing performance requirements.

The lighting energy savings potential of a daylighting system can be described as the system's capability to increase daylight as compared to a reference base case. The reference base case used in monitoring the daylighting systems in this project were either clear glazing or glazing shaded by venetian blinds at a specified tilt. Depending on the base case used and the sky conditions under which a system was tested, several systems demonstrated potential energy savings.

The main findings for each type of system studied are summarised below. The reader should refer to the appropriate section in the book for detailed information on each, taking into account the system's applicability and limitations.

7.2.1. Shading Systems Using Diffuse Light

Louvers. Fixed, mirrored louvers are designed principally for direct sun control. High-altitude sun and skylight reflected off the louvers increase interior daylight levels. Daylight levels from low-altitude skies (i.e., from the region of the sky approximately 10° to 40° above the horizon) are reduced. Fixed, mirrored louvers such as the "Fish" or "Okasolar" system can control glare but reduce daylight levels. They are a design option for shallow rooms in temperate climates.

Blinds. Standard venetian blinds provide moderate illuminance distribution. The optimum amount of slat closure is dictated by glare, direct sun control, and illumination requirements. Inverted, silvered blinds increase daylight levels if the slats are horizontal.

Automated Blinds. When an automated venetian blind is used to block direct sunlight and is operated in synchronisation with dimmable fluorescent lighting, energy savings are substantial compared to the energy used when a static blind is paired with the same electric lighting control system.

Holographic Optical Element (HOE) Shading Systems. These systems provide efficient solar shading while maintaining daylight illumination. The current high cost imposed by the required tracking system may limit the applicability of HOE shading systems.

7.2.2. Shading Systems Using Direct Sunlight

Light Shelves. Optically treated light shelves are an improvement over conventional internal light shelves. Optically treated shelves can introduce adequate ambient light for office tasks under most sunny conditions.

Light-guiding Shades. Light-guiding shades increase daylight illumination in the centre of a space as compared with the illumination provided by conventional shades. Light-guiding shades are suitable for hot, sunny climates.

Angular Selective Skylights. Angular selective skylights are best used in low latitudes because these systems reject direct sunlight at high altitude and redirect low-altitude daylight into a room, controlling heat gains and at the same time providing additional illumination from the sky.

7.2.3. Non-Shading Systems Using Diffuse Light

Light Shelves. External light shelves use not only diffuse light but also distribute (diffused) direct sunlight. An external, upward-tilted (30°) light shelf can increase daylight levels at the back of a room. An internal light shelf will decrease light levels.

Anidolic Ceiling. This system, which has an exterior, sky-oriented collection device, has been shown to increase the daylight factor below the light-emitting aperture of the system at a 5-m room depth. It requires a blind on the collection device to control sunlight on very sunny days.

Zenithal Light-guiding System with HOEs. This system increases illumination in the depth of a room and reduces it near the window at orientations where there is no direct sunlight.

7.2.4. Non-Shading Systems Using Direct Sunlight

Laser-cut Panel. Similar to the prismatic panel, the laser-cut panel increases light levels 10 to 20% in the depth of a room, particularly in sunny climates. When the panel is tilted, substantially higher levels are achieved. Tilting can also reduce the glare factor.

Sun-directing Glass. Sun-directing glass increases illuminance levels in the depth of a room in sunny climates. The system depends on the incident angles of the sun and is best used in temperate climates.

In general, among the systems tested, some, such as the selective shading systems that reconcile solar shading and daylighting, can save significant energy. Non-shading daylighting systems that are located above eye level and redirect sunlight to the room ceiling, such as laser-cut and prismatic panels, can save considerable electrical energy but require detailed design consideration, e.g., specific tilting to avoid glare. Under overcast or cloudy sky conditions, anidolic systems perform well.

Automatically controlled blinds and louvers have proven to be efficient shading systems with much greater energy savings potential than static systems. Systems with holographic optical elements are promising but require further development to reduce cost and improve performance.

IEA SHC Task 21 Subtask A Achievements 7.3.

EA SHC Task 21 Subtask A: Performance Evaluation of Daylighting Systems has documented the potential energy savings possible with advanced daylighting strategies that manage the flow of light and heat. The task has also laid the foundation for ongoing research and assessment by establishing testing facilities to monitor new systems, measure their physical characteristics for software input, and to evaluate systems when they are installed in actual buildings. As a result of this work, manufacturers of daylighting products can now test new devices using proven methods, develop these products further, and assess their performance using post-occupancy evaluation procedures.

Future Work 7.4.

Although the work documented in this book demonstrates that improved optical systems can provide better daylighting performance, greater occupant acceptance, and increased energy savings potential as compared with conventional systems, the rapid and continuing advances in materials science and production technologies promise additional performance improvements as well as reduced costs and maintenance.

Beyond advances in optical components, however, critical elements of daylighting design still need to be addressed. These include the successful integration of advanced daylighting systems with daylight-responsive lighting controls, and the consideration of occupant response to advanced daylighting strategies. Two key focuses for future research are the development of a comprehensive understanding of occupant needs and preferences in day-lighted spaces, and the creation of models that describe the relationships among daylighting design parameters, occupant satisfaction, and control systems.

Past electric lighting energy savings mainly resulted from advances in the efficiency of lamps; future savings will be the result of using advanced daylighting systems and controls. Window and lighting system designs need to be integrated to maximise daylight while minimising cooling loads so that daylighting strategies can produce consistent energy savings. Cost-effective integrated design solutions are needed that have thermal impacts equal to or lower than those found in the best available conventional building designs. There is also the need for standards and guidelines to apply to these systems.

The work in this book is offered as a first step towards harmonising the needs of people with the advantages that technology can provide, and integrating the hardware and software elements of daylighting systems throughout the major phases of building life cycles.