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THE TUBULAR DAYLIGHTING DEVICE—A NEW OPTICAL DAYLIGHTING TECHNOLOGY

By Kate DeBellis, CSI, CDT, LEED AP, Solatube International Inc.

Sustainable—or “green”—building design is gaining momentum around the world, and both building owners and the design community are looking for new, robust and reliable sources for daylighting as alternatives to the use of electric lighting equipment during daytime hours. Fortunately, a new optical daylighting technology has emerged which uses advanced passive (non-moving) optics to harness and distribute daylighting into a building's interior spaces.

The newest technologies in daylighting can be found within the Tubular Daylighting Device (TDD) category. With the latest in product advancements, today's designers find that they are no longer bound by traditional daylighting methods and can bring the benefits of daylight to every occupant in the building easily and effectively with TDDs. A modern technology, the TDD behaves in a manner far different from that of its unit skylight cousin. While TDDs and unit skylights both provide daylight from a building's roof, there are more differences between the products than similarities. The standard TDD model is a passive system consisting of a transparent, roof-mounted dome with self-flashing curb, reflective tubing and a ceiling-level diffuser assembly that transmits the daylight into interior spaces. Tube diameters typically range from 254 to 559 mm (10 to 22 in.) with runs from as short as 152 mm (6 in.) to in excess of 27.4 m (90 ft). The most sophisticated TDDs allow multiple-story buildings to take advantage of daylight at every level, literally “ducting” daylight into any building, any space, anywhere in the world.

For the TDD to effectively bring daylight into interior spaces, sunlight capture must occur at the roof level. With various technologies used to harness daylight, TDD differences begin at the dome. Product technologies range from simple thermally-formed, clear plastic domes to more advanced systems that employ optics to control light collection. From the dome level, daylight is captured and then transferred through optical tubing, which systematically affects the daylight transport from the rooftop aperture to the ceiling diffuser. With an assortment of qualities in tub-

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ing materials, the overall goal is to maximize the ability of the light to travel down the tube, while minimizing the light lost during the transport.

The reflectance characteristic of the optical tubing surface must be closely examined, with high specular (mirror-like) reflectance being of the greatest importance. Specular reflectance determines how effectively each ray of daylight is transmitted through the TDD tubing system, with the higher the specular reflectance the better. More advanced TDDs offer optical modulation systems, allowing users to control

DID YOU KNOW...

Energy efficiency and daylighting are inherently linked. One of the most important energy considerations is the performance values of the glazing selected for your daylighting aperture. The key performance properties of glazing are U-value, solar heat gain coefficient (SHGC), visible light transmittance and air leakage rate.

U-value is a measure of the rate of non-solar heat gain and loss through the material. The inverse of U-value is the R-value. R-value measures the resistance of a material to heat flow. Glazing is measured in U-value while most other materials use R-value. Most glazing has U-values between 0.2 and 1.2. (the lower the U-value, the better the insulation properties).

light output, much like they would with some electric light models. These modern systems do not negatively affect the fixture's light distribution pattern, but can allow daylight's integration into robust lighting designs. The most advanced devices can be integrated into lighting controls systems for demanding multi-use environments, while others offer a wall-mounted rocker switch.

As with most advanced systems, the diffusion is the grand finale. All the components working in conjunction to obtain the highest quality daylight to the interior are only as good as the diffuser's final performance. Optical diffusers provide controlled daylight distribution in very precise ways. Light spread, color temperature and glare can all be greatly affected by the diffuser's specification. Varying lens technologies are available for TDDs, from basic prismatic designs to highly engineered Fresnel lenses. The choice of diffusion can be based on aesthetics or precise lighting calculations considering light spread and photometry. The diffuser selection for a particular proj-

ect is based on a number of criteria ranging from:

- type of space
- diffusion of light required
- static distribution patterns
- relative photometry

For the more advanced technologies, where relative photometry is available, the design of the TDD system uses the same tools and processes as those used for electric lighting. This allows the lighting designer associated with the project to design the daylighting system with ease, treating the TDD as if it were just another light fixture in the ceiling plane.

The TDD has made tremendous advances since it was first invented two decades ago. However, it has yet to reach its full potential, having only ventured into commercial markets within the last 10 years. As industry awareness grows and manufacturers continue to improve on daylighting technologies and product functions, it is likely that TDDs will continue to be designed into all types of structures, from schools to supermarkets, for years to come. ■

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AUTHOR—Kate DeBellis, CSI, CDT, LEED AP is territory manager for the commercial division of Solatube International Inc., a manufacturer and marketer of Tubular Daylighting Devices. With more than 10 years of experience in architectural design and construction, she authored the proposal for the expansion of the Construction Specifications Institute's (CSI) MasterFormat to include subsection 08 62 23 for Tubular Daylighting Devices. DeBellis can be contacted at kdebells@solatube.com.

TECHNOLOGY AND RESEARCH UPDATE

TOP LIGHTING: IMPACTS ON HEATING AND COOLING ENERGY USE

By Pravin Bhiwapurkar, PhD, Energy Center of Wisconsin

Daylighting, although not a new concept, is gaining popularity in today's energy intensive buildings. The continuous improvement of control systems for balancing artificial light with daylight has made daylighting more effective. However, along with the natural light, daylight brings solar heat into the space which affects heating and cool-

ing energy use. Additionally, skylight glazing can affect conductive heat gains or losses. This energy use changes based on a number of variables, including geographic locations, climate zones, glass thermal properties, wall color, texture etc. However, there are architectural design strategies that can be used to balance the energy effects of daylighting.

In order to understand the interaction of daylight with space heating and cooling energy use, the Energy Center conducted a simple comparative study of top lighting as part of an ongoing investigation. We followed ASHRAE Advanced Energy Design Guidelines for Small Office Buildings and modeled an office space without windows as our baseline. For the alternate daylit model, we added a single flat skylight equivalent to 3% of the roof area and included a continuous dimming system to control the artificial lighting based on the amount of daylight available.

In our models, daylighting saves lighting and cooling energy but increases heating energy needs in certain climate zones. The continuous dimming system reduced the amount of artificial light used in the daylit spaces, reducing the lighting energy needs. In addition, less heat from the artificial lights reduced the cooling load. In the heating season, this reduced heat from artificial lighting and conductive losses from the

space contributed to higher heating energy needs.

Good daylighting design means using strategies that address the climatic conditions of the building location. In climate zones with more cooling degree days, designers need to employ strategies that reduce solar and conductive heat gain while maximizing the availability of natural light. In contrast, daylighting strategies for climate zones with more heating degree days need to balance the heat loss from reduced artificial lighting and conduction with potential heat gains from daylighting.

There are top lighting design strategies that can balance energy benefits, energy penalties and natural light. These design strategies include skylight design, skylight area, orientations, and glass thermal properties. The Energy Center will be investigating the energy interactions of these and other strategies (i.e., illumination level and glare control). We will present these results in a simple graphical format for members of the Daylighting Collaborative on our website:

www.daylighting.org/tools.php.

Join the Daylighting Collaborative

If you'd like access to daylighting design information, new tools, trainings and the "Ask the Expert" forum, please join us by clicking www.daylighting.org/join.php.

Training Update

Coming Soon Online!

Daylighting Commercial Buildings

Michael D. Kroelinger, PhD, AIA, FIIDA, LC is Professor and Director of the School of Architecture at the University of Nevada Las Vegas. This online program provides the knowledge and tools needed to incorporate daylighting in commercial buildings.

This program will be presented through Energy Center University, the Daylighting Collaborative's professional education training partner.