POLYCARBONATE SHEET IN SUSTAINABLE BUILDING DESIGN

BY JACK GOVERS

As nations seek solutions to reduce energy and resource consumption, the demand for innovative building materials that contribute to more energy-efficient building design continues to increase. More and more, designers and builders are seeking materials solutions that satisfy customer requests for green structures, meet evolving regulatory requirements, and achieve recognition through programs such as the Leadership in Energy and Environmental Design (LEED®) green building certification system.

Analysts are forecasting a global upswing in green building as more countries implement incentives for sustainable practices. The drive to reduce energy consumption to cut costs is one of the highest priorities in building and construction today. Based on average material costs, green-building materials represented approximately $14.5 billion in cumulative spending through 2010 and are projected to reach nearly $120 billion by 2030.[1]

Sustainability characteristics are not the sole justifications builders should use in choosing materials. The most relevant material innovations also bring other benefits, notably aesthetic improvements, design enhancements, and cost advantages, which allow architects and builders to create structures that are beautiful, practical, and sustainable. Buildings represent over 40% of the world's energy use and nearly a third of the world's greenhouse gas emissions,[2] comprising over $200 billion spent in heating, cooling, and lighting in the United States alone.[3] With so much at stake, building materials need to perform.

Polycarbonate (PC) multiwall and monolithic sheet products offer architects and builders many ways to potentially maximize energy efficiency and extend useful life, while also providing greater design freedom, enhanced aesthetics, and system cost reductions. Sheets can provide important sustainability benefits, including improved energy efficiency, reduced greenhouse gas emissions, a contribution to daylighting interiors, lighter weight to reduce the impact of shipping, and extended useful life to reduce resource usage.

MATERIAL POTENTIAL

How can PC sheet aid the design and construction of more sustainable buildings?

Design Flexibility

When creating a design on the cutting edge, finding a material that will make the idea a reality can be a challenge. PC sheet enables wide-ranging design freedom due to

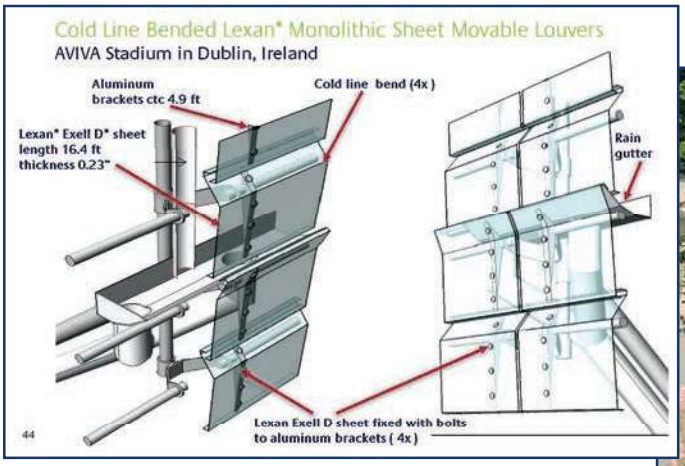

Figure 1 – Cold-line bent-sheet movable louvers.

Figure 2 – Aviva football (soccer) stadium in Dublin, Ireland.

Figure 3 – An example of cold curving.

Figure 4 – The South Railway Station in Shanghai, China.

an ability to be cold-formed and thermoformed without losing impact or weathering properties.

- **Thermoforming:** From opaque cladding panels to roof domes to louvers, monolithic PC sheet products are designed and manufactured in a diverse range of shapes using thermoforming, a heat-based thermoplastic shaping technique.
- **Cold-line bending:** PC sheet may be cold-line bent similarly to metal, using hydraulic press break/bending equipment. Large monolithic PC panels up to six meters (19.7 ft.) long were produced using the cold-line bending technique for the cladding panels of the Aviva football stadium in Dublin, Ireland (*Figures 1* and *2*). The bend improved the stiffness of the panel; and as a result, fewer support profiles were required to withstand wind gusts and snow loads.
- **Cold curving:** Some monolithic and multiwall materials can be cold-curved over curved support glazing profiles to suit many glazing applications such as roof domes, walkways, skylights, and architectural roofing projects *(Figure 3)*.

Durability

As mentioned in the case of the Aviva football stadium, the strength of this material is already being put to the test internationally. In another example, the Shanghai South Railway Station in China (*Figure 4*) is one of the largest buildings in the world to use PC sheet. Its massive 55,000 m^2 (645,160 sq. ft.) round, transparent roof utilizes tai-

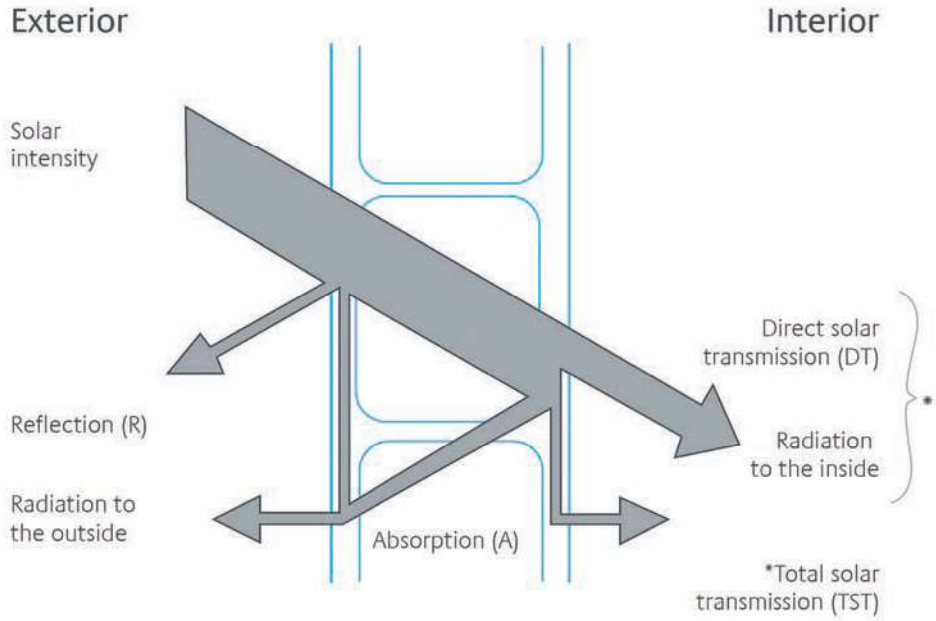

Figure 5 – The solar radiation reaching the sheet is reflected, absorbed, and transmitted. The greatest portion is transmitted, and the total solar transmission (TST) is the sum of the direct transmission (DT) and the inwardly released part of the absorbed energy (A).

lored LEXAN THERMOCLEAR™ multiwall sheet, which prevents penetration of UVA (long-wave) and UVB (short-wave) sunlight radiation and is virtually unbreakable—able to resist hail impact and withstand hurricane-force wind loads while at the same time allowing light into the interior.

On the other side of the world, Brazilian architects appreciated the material's durability when rough weather conditions hit their building site during installation. At the new Arena do Grêmio, a multi-use, 60,000-seat stadium in Porto Alegre, a violent windstorm hit as the LEXAN multiwall PC sheet being used for the roofing was only partially installed. The polycarbonate sheet remained undamaged due to its impact resistance and toughness compared to other materials such as glass. See *Figure 4*.

Aesthetic Light Management and Solar Control

Beyond its strength and shape flexibility, polycarbonate sheet can also enhance the visual aesthetic needs of a design requiring coloring options. However, the color options are not for visual benefits alone.

The color options for PC sheet contribute to light management. For buildings in hot climates or with south-facing features, polycarbonate sheet in white significantly reduces solar heat buildup, helping to maintain comfortable interior temperatures. The specially tinted sheet reduces the brightness of sunlight to a pleasing level, which can help minimize cooling costs in the summer.

In regard to solar control, the advantage of the material is that it allows in as much natural light as possible while blocking the infrared (IR) spectrum that carries heat. PC sheet can selectively absorb a large part of the near-IR spectrum of sunlight and significantly reduce heat buildup while transmitting diffused daylight. Either in monolithic or multiwall form, solar control IR sheet grades can help maintain comfortable interior temperatures and potentially reduce air-cooling costs in the summer. Annual energy savings for cooling and heating, according to the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), may total 15 to 25% with IR sheet when compared with double-pane glass. Over a year's time, IR sheet could save the equivalent of $33 to $53 per square meter (3.28 sq. ft.) in energy, while reducing carbon emissions. See *Figure 5*.

Insulation

Potential energy benefits are not limited to keeping heat out, but also helping to keep heat in. Compared to traditional glazing materials, multiwall sheet products can deliver exceptional thermal insulation to enhance energy conservation and reduce associated emissions. SABIC conducted scale-model energy consumption studies at the Welch Technology Center in India. Results showed that, depending on the gauge, a typical window- and roof-glazing application using solar-control IR multiwall sheet requires, on average, 25% less energy for heating during cold periods and air conditioning during hot periods. This contributes to an emission reduction of approximately 143,360-235,200 lbs. (64 to 105 metric tons) of associated greenhouse gases during a 30-year period of use.

With the interest in green building, the

Figure 6 – Amsterdam Arena in the Netherlands.

Figure 7 – Śląski Stadium in Poland.

potential benefits of regulating heat loss cannot be ignored. Approximately 20% of the European Union's total energy use is claimed by the household building sector, with heating and cooling claiming 90%.[4] In the U.S., 11% of greenhouse gas emissions come from home energy use.[5] Although emerging developments in heating and cooling technologies continue to be important in providing greater efficiency, material choice is also an important driving factor to substantially enable lower energy consumption.

Long-Lasting Qualities

Another important aspect of selecting a material is durability. Reinstallations are costly, time-consuming, and, most importantly, avoidable. Polycarbonate sheet has an excellent reputation for maintaining coloring and strength over time, even in stressful conditions.

For example, Amsterdam Arena in the Netherlands was Europe's first stadium with a sliding roof. An independent research organization, TNO Science & Industry, tested the properties of multiwall sheet from the roof of the Amsterdam Arena stadium after 15 years and found no significant change. The material suffered a minimal loss of 1.5% in light transmission and a small increase of 1.1 point in yellowness index, which complied with the product warranty and satisfied the builder's expectations. See *Figure 6*.

Installation Savings

When analyzing the sustainability of a building, the cost of construction is an important measure not to be overlooked. From transport to on-site breakage, financial losses and ecological impacts of installation can rise dramatically if builders select the wrong material.

Polycarbonate sheet offers weight savings of more than 50% compared to glass of the same thickness. Multiwall sheet delivers even greater weight savings. When compared with 0.23-in. (6-mm) wired glass, 0.39-in. (10-mm) LEXAN multiwall sheet offers a weight savings of more than 85%.

Lighter weight may lead to significant fuel savings in transportation, makes handling easier, and may contribute to lower overall labor and installation costs. Also, lighter-weight sheet products require less supporting structure (glazing bars, etc.), which reduces raw-material consumption.

A good illustration is provided by Poland's Śląski football stadium, which utilizes a specially designed sheet for the 462,848-sq.-ft. (43,000-m^2) freestanding roof. The 1-in. (25-mm) LEXAN multiwall product weighs 1 lb./sq. ft. (5 kg/m^2) and can sustain a wind load of 46 lbf/ft^2 (2,200 N/m^2) with low deflections at a sheet width of 59 in. (1,500 mm). It can also be used for much more demanding projects, as it can resist wind loads of up to 146 lbf/ft^2 (7,000 N/m^2) before collapsing. The exceptionally stiff sheet absorbs roof movements caused by thermal expansion and contraction as well as wind and snow load without the risk of cracking or breakage. Even at lengths up to 472.4 in. (12 meters), the material does not require intermediate support profiles. See *Figure 7*.

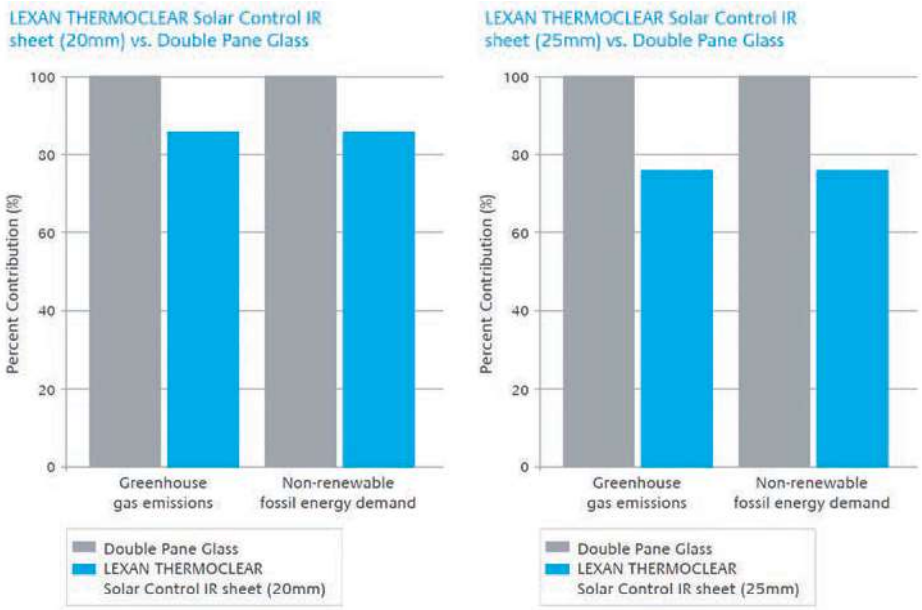

Figure 8 – This figure compares greenhouse gas emission and fossil energy demands during production of a glass-based system vs. LEXAN multiwall sheet.[6]

Considering the Full Life Cycle

To build a truly sustainable building, the materials and building design combine to minimize the overall cradle-to-cradle environmental impact across the life cycle. In one particular example, multiwall polycarbonate sheet with IR absorption technology results in 15-25% lower life cycle greenhouse gas emissions than double-pane glass. These graphs (*Figure 8*) compare the greenhouse gas emission and fossil energy demand through production, installation, and building use for one ASHRAE design case. While actual performance will depend on local climate, window thickness, facing (north or south), window surface area, and other factors, these results are indicative of the benefits of careful consideration of materials and design.

Future Applications in the United States

Figure 9 – BBVA Compass Stadium in Texas.

Figure 10 – SABIC Building in Massachusetts.

To date, multiwall sheet has been very popular internationally for large construction projects. While the United States' building industry has also begun using this solution, there is potential for growing innovative use.

One of the first examples in the U.S. to use multiwall PC sheet is the Houston BBVA Compass Stadium. The material's nine-wall configuration delivers a high level of thermal insulation for energy savings, and the 39.4-in.- (1,000-mm-) wide panels—twice the width of traditional panels—reduced installation time and labor to support tight construction budgets. See *Figure 9.*

On a smaller scale, SABIC's Pittsfield, Massachusetts, site (*Figure 10)* features its own monolithic PC LEXAN sheet product for roof lights and façades, with the aim of reducing solar impact. Both products used in this project have a unique, proprietary, UV-protected surface that resists outdoor weathering while offering excellent clarity, with light transmission values of 75% to 87%, depending upon the thickness of sheet. This unique protection ensures long-term optical quality under intensive UV exposure and maintains the superior toughness of the PC material in comparison to other thermoplastic glazing.

Cost-efficient and flexible in its design capabilities and versatility, polycarbonate sheet is positioned to help meet the demand for energy-efficient buildings constructed with sustainable products. As the next great architectural challenges arise, the use of polycarbonate sheet will likely increase, and new material innovations will undoubtedly emerge to meet the needs of the industry.

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