

Proposals of Building Designs using Highly Insulative Translucent Materials

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ABSTRACT

Multi-layers polycarbonate panels are naturally good thermal insulation materials. But their thermal insulation can be significantly improved if they are used in pairs, as in double glazing, and if the space between them is filled with a product aimed at blocking air movement but keeping a very visual transmittance. Such a product has been designed, with a U-value close from $0.65\text{W/m}^2\cdot\text{K}$. The final material is however translucent, and not transparent. It appears attractive to use it as a component of external walls or ceiling. This paper describes thermal and optical properties and possible use in buildings. A critical analysis is proposed to discuss the interest of this technology to reduce energy consumption in buildings.

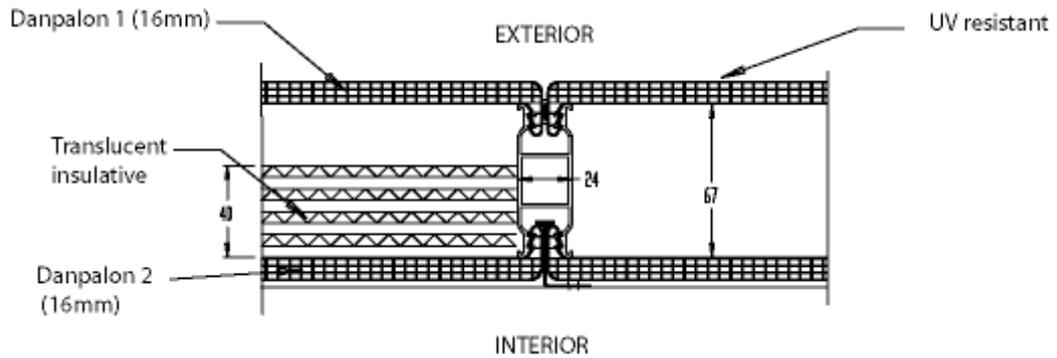
INTRODUCTION

Cellular polycarbonate panels have been distributed on the market since 1958. They offer an excellent mechanical resistance and can be used up to 120°C . They can be transparent or translucent, with various intermediate states. Today they are UV resistant (no yellowing) and could be recycled.

The company Everlite Concept has developed a whole range of cellular panels, referred as DANPALON®, with thicknesses of 8, 10, and 16 mm. It proposes a new product, Danpatherm®, consisting in two 16 mm thick panels separated by a space of 56 to 99 mm. This space contains a cellulose transparent material, with a thickness of 20 to 60 mm.



On example of façade design using translucent insulative polycarbonate material, seen at day-time and night-time (Cardiocéan Clinic in Pluiboreau, France (source: Everlite Concept)



Cross-section of Danpatherm® showing the central cellulose component between the two cellular polycarbonate panels 16 (40) 16 (source: Everlite Concept)

LUMINOUS PERFORMANCES

We have measured various luminous properties of the material in order to predict the final luminous environment that would be generated in buildings equipped with large areas of translucent insulative polycarbonate panels.

Luminous transmission

Material	Luminous transmittance of Danpatherm®	Luminous transmittance of double glazing 5(12) 5	Danpatherm® surface required per m ² double glazing supply same arrival of light
Danpatherm® + Green	0,15	0,80	5,3 m ²
Danpatherm® + Ice	0,22	0,80	3,6 m ²
Danpatherm® + Cristal	0,30	0,80	2,6 m ²

Table 1. Danpatherm® has a lower luminous transmittance than clear glass, suggesting an increase of glazed area by a factor of 2 to 5 to obtain the same luminous flux in the building.

Correlated Colour Temperature (CCT) of transmitted light

Danpatherm® is proposed with various surface treatments: Cristal (clear), Ice (diffusing) or Green. Other colours are available upon request. We have measured the Correlated Colour Temperature of light transmitted by the product under 3 types of exposures: two with real sky conditions to assess colour of transmitted light indoor, and one with an incandescent light source, to assess the aspect of the material at night time when seen from the outside. The results are shown in table 2. We observe that the ICE and surface Cristal treatments do not affect the colour, they can be considered as very neutral, with a very slight shift toward "Cool White Light". The green treatment leads to a significant increase of the values of CCT, leading to a cool but still acceptable indoor luminous environment.

Material	CCT [K] Outdoor Measurement	CCT [K] Outdoor Measurement	CCT [K] Incandescent
Reference	4700	5350	2486
Danpatherm® + Green	4950	8550	3686
Danpatherm® + Ice	4850	5300	2308
Danpatherm® + Cristal	4800	5350	2593

Table 2. Values of measured Correlated Colour Temperature (CCT) of incident and transmitted light.

Colour Rendering Index (CRI)

This parameter characterizes the colour rendering of transmitted daylight, meaning its ability to render various typical colours without too much distortion. CRI = 100% means no distortion (it is the case with daylight). Typical indoor electric lighting installation offer a CRI value of 85 to 90%. The table below shows the CRI values computed from spectral measurement conducted on incident and transmitted light. The ICE and CRISTAL finishes do not affect the CRI values, but the GREEN will slightly affects rendering. This happens in the red region of the spectrum where the distortion of light is the highest.

	CRI %
Light source (filtered tungsten)	95,8
Danpatherm® + Cristal	95,3
Danpatherm® + Ice	95,0
Danpatherm® + Green	78,8

Table 3. Values of Colour Rendering Index (CRI) computed from spectral measurement of incident and transmitted light.

Glare control

A diffusing surface exposed to direct sunlight may become glary if the luminous transmittance is high. Typically, manufacturers of shading devices tend to offer solutions which maintain as often as possible the luminance of the window below 3000 cd/m², with an average comfortable value between 300 and 1500 cd/m². The luminance s obtain with Danpatherm® appear rather appropriate, with a reasonable luminance value, well adapted to the luminance distribution of indoor luminous environments.

Material	Luminous transmittance	Luminance (cd/m ²) under 8 000 lx (diffuse)	Luminance (cd/m ²) under 11500 lx (Global)	Luminance (cd/m ²) under direct sunlight 40 0000 lx
Diffusing Glass	0.6	1528 cd/m ²	2200 cd/m ²	11000 cd/m ²
Danpatherm® + Green	0,15	380 cd/m ²	550 cd/m ²	1900 cd/m ²
Danpatherm® + Ice	0,22	560 cd/m ²	805 cd/m ²	2800 cd/m ²
Danpatherm® + Cristal	0,30	764 cd/m ²	1098 cd/m ²	3820 cd/m ²

Table 4. Values of luminances (cd/m²) of the Danpatherm® product obtained under average illumination conditions in Paris on a vertical south facing surface.



Combination of translucent insulation and clear windows, University Library, Orléans-la-Source, France - Architectes : Lipsky + Rollet Architects.

THERMAL PERFORMANCES

We compare below values of U values describing the heat losses through a vertical panel between an indoor and an outdoor environment, per Kelvin degree

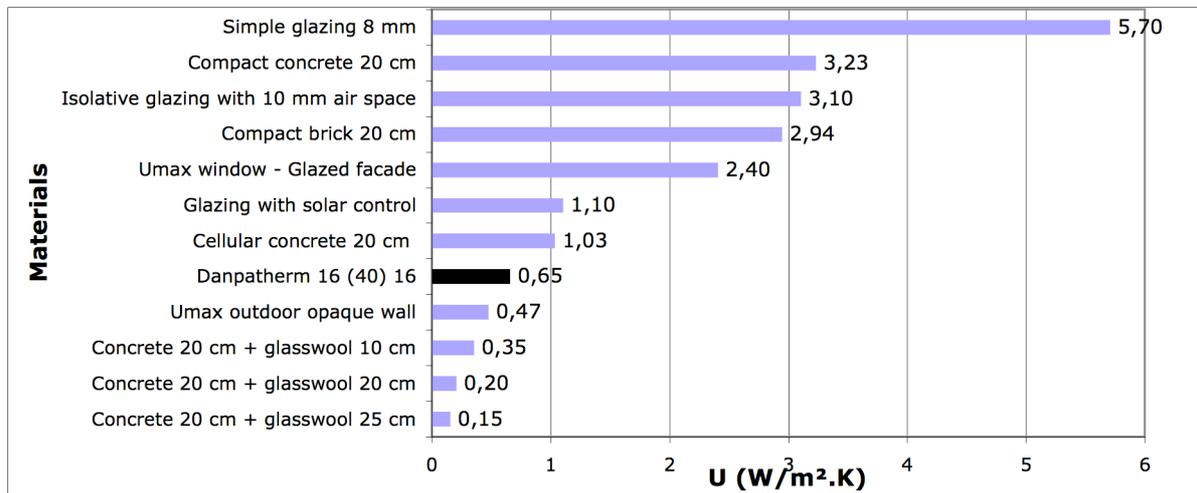


Table 5. Comparison of thermal insulation properties of various building envelope components (U value, W/m².K) . The Umax values are the maximum acceptable values of French Energy Code (RT 2000)

Danpatherm® panels offer thermal insulation properties which appear to be higher than most window components. Its U-value of 0,65 W/m².K is getting close from insulated opaque walls. It is also better than limits imposed by French thermal regulation (RT 2000) for windows and glazed facades.

Other thermal aspects

The Solar factor characterizes the total amount of energy (solar spectrum and no wavelength infra-red) transmitted by a panel exposed to the sun rays. With values below 20 %, the protection in summer is reasonable; It could however benefit from fixed or movable outdoor shading systems.

	Solar factor
Double glazing	0,74
Danpatherm® + Cristal	0,19
Danpatherm® + Ice	0,16
Danpatherm® + Green	0,13

Table 6. Solar Factor of various Danpatherm® products

Environmental aspects

The manufacturing of every kilogramme of polycarbonate requires about 4 times more primary energy (oil) than glass. Since the Danpatherm® product is lighter per square meter, this leads to a much smaller difference in inbedded energy.

Danpatherm's embedded energy is only 40% higher than glass per meter–square. In addition, the energy required for transportation is reduced, and Danpatherm® requires far less framing than glass, leading to a reduction of use of aluminium, which is a material with high embedded primary energy.

Matériel	Embedded Energy (kg crude oil / kg material)	Weight of product Kg/m ²	Embedded Energy Kg crude oil per m ² of product
Danpatherm® 16 (40) 16	1,68	9 m ²	15 kg / m ²
Glass 5 (12) 5	0,44	25 m ²	11 kg / m ²

Table 7. Weight of crude petroleum required per kg and per m² of final product
(Danpatherm® and glass source: Everlite et CSTB)

Polycarbonate is a product that can be recycled. In the manufacturing plant all waste is ground and mixed with the raw materials and included in the normal processing. At the end of the life of polycarbonate, the panels can be recycled and used for electric insulators and car components.

CONCLUSION

Transluscent polycarbonate panels such as Danpatherm® can contribute not only to the reduction of the energy required for heating buildings and also for its construction. Through the possibilities to adjust colours, it provides also opportunities to design innovative façades, with specific aspects at day time and night time.

However, great care should no taken on two domains:

The use of large diffusing surface in replacement of glass leads to an increase of penetration of solar energy under sunny conditions. This can be a serious problem for south and east facing vertical surfaces. In this case, it may be worth to investigate outdoor permanent shading systems.

Due to their low weight, the polycarbonate panels are not good acoustical absorbers. Use on building façade facing streets with heavy traffic could be a problem. Insertion of acoustic screens on the outdoor could be the way to add some correction.

Nevertheless, we can consider such a product as a way to combine the possibility of innovation in architecture with objectives of reduction of energy consumption.

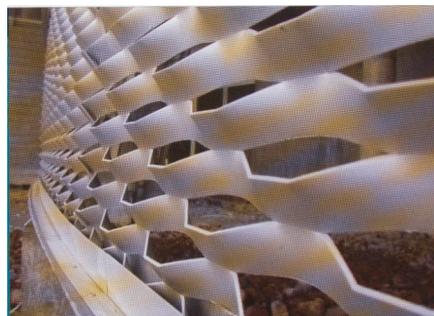


*Translucent polycarbonate walls with external blinds
(Gymnase scolaire à Pau, arch. : Nathalie Larradet)*

REFERENCES

French Energy Code, Réglementation Thermique 2000, Décret N° 2000 – 1153 du 29 nov 2000

Danpatherm® is a product of Everlite Concept, Danpal & Everlite-Concept, Z.I. des Radars, 6 rue Condorcet - 91350 GRIGNY, France, www.everlite.fr



*Various Metallic fixed solar protections used by architects in combination with
Danpatherm insulation*