KALWALL® TECHNICAL PERFORMANCE SUMMARY

1. WHAT IS KALWALL®

Kalwall®, developed and manufactured in the USA for over 50 years, is a highly insulating, diffuse light transmitting building panel system for use on walls and roofs. The primary component is a translucent structural composite sandwich panel formed by permanently bonding specially formulated fibreglass sheets to a grid core constructed of interlocking thermally broken extruded aluminium 'I-beams'.

The panels are factory pre-fabricated to the exact size and configuration for each project. Panels can be flat or curved, and opening or fixed glazed window units can be incorporated using the integral Clamp-tite installation system.

Kalwall's unique composition combines to reduce solar gain while at the same time maximising thermal insulation, and Kalwall diffuses light so efficiently that even direct sunlight is converted into even illumination with reduced glare. The panel is generally 70mm thick (100mm is also available) and by providing various densities of insulation the thermal resistance and therefore 'U' values can be varied. Kalwall is able to transmit large amounts of usable daylight into a space with relatively low levels of light transmission. Panels can be selected to transmit various percentages of light according to individual project requirements.

Kalwall panels do not appear completely flat. The face sheets made from a flexible material will be affected by temperature.

Kalwall has achieved European Technical Approval, ETA-07/0244, Please see under Section 7. Kalwall has been tested according to the procedures of EN13830:2003 – Curtain Walling Product Standard for CE Marking.

2. INSULATION & BUILDING REGULATIONS, PART L - U VALUES STANDARD PRODUCT

Three Densities Of Glass Fibre and Lumira™ Aerogel Insulation Are Available In The Standard Product Range. Insulation Values Have Been Assessed According To American Standards C-236, E 1423 And C1199 By An Independent Laboratory Certified By The American National Fenestration Research Council.(NFRC) The Insulation Values In This Document Are Given In Better Known UK And European Formats Not To Be Confused With American Documentation Which Uses ASHRAE Defined Bases.

INSULATION DENSITY	THERMAL RESISTANCE M^2		CIBSE NORMAL U VALUE W/M^2K			
			ROOF		WALL	
	NO BREAK	BREAK	NO BREAK	BREAK	NO BREAK	BREAK
*	0.19	-	3.08	2.86	2.74	2.57
A	0.46	0.62	1.67	1.31	1.56	1.25
B	0.65	1.11	1.27	0.80	1.20	0.78
C	0.83	1.61	1.03	0.57	0.99	0.56
D	1.21	3.37	0.77	0.28	0.72	0.28

The U value is calculated according to the following formula: $U = 1 / (R_{Kalwall} + R_{si} + R_{so})$

For alternative directions of heat flow and EEC defined exposure (BS EN ISO 6946), reference should be made to CIBSE Guide A – Environmental Design, Chapter 3, Tables A3.9 and A3.10.

BUILDING REGULATIONS PART L 2010:

Revised Building Regulations Part L came into force on 1st October 2010, replacing the earlier regulation L2 (2006) for Conservation of Fuel and Power. The revised regulation, as before, targets carbon dioxide (CO_2) emissions which must not be exceeded, for the whole building and services – heating, lighting, and air conditioning - based on a calculation procedure in the approved documents and a Simplified Building Energy Model (SBEM). The target carbon dioxide emissions are reduced significantly with further reduction envisaged in 2013.

The aspects concerning the limit for solar gain are $35W/m^2$ for the 6 m perimeter zone, including casual gains with strict limits on the luminous efficiency of lighting. This means the client may only be advised of the total additional level of solar gain for the Kalwall application.

For purposes of the regulation a Kalwall Assembly is required to meet the provision for windows or rooflights, and therefore considerable flexibility is possible because the product can offer much lower U Values, with very good solar performance. However it is expected that product U values lower than $1.5W/m^2K$ depending on the building size and shape will become necessary in practice, and it is essential to evaluate the influence of the sills, jambs battens and stiffeners, variations of internal grid dimensions and any glazed vision areas in the assembly, with the benefits of providing thermal breaks in these elements.

Structura UK Limited has developed an in house approved evaluation procedure (KALPUBPLUS) to determine the overall Assembly and Curtain Wall thermal properties to provide data for the architect and enable the design to meet the new regulations.

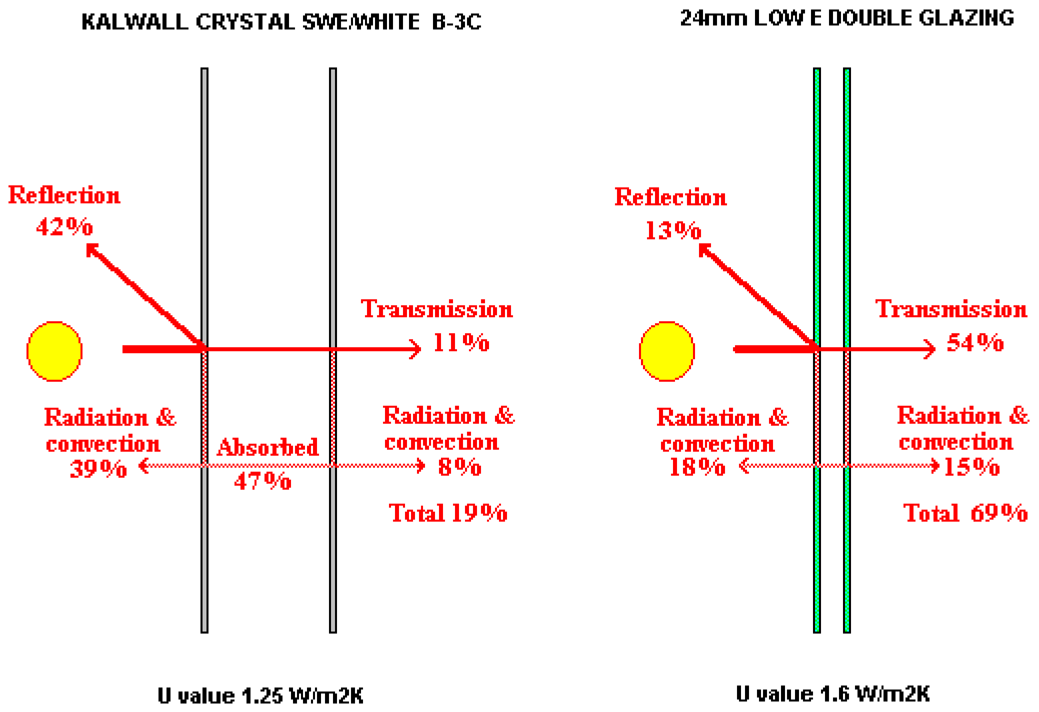
The new regulation retains a Section: Quality of Construction, which includes requirements for air tightness and permeability of the building envelope. This is subject to a pressure testing procedure, and measurement of leakage. If the requirement is not met remedial measures must be taken.

It is essential the responsibility for air tightness at the junctions between the Kalwall and the surrounding building structure should be established at the tender stage, and written in the subsequent contract.

3. Solar Control

One of the most important advantages of Kalwall panels compared with other conventionally used glazing materials is the ability to control heat transfer and solar gain. This is achieved by limiting both the radiation and conduction.

In the example shown a Crystal/White panel with 1.25 W/m^{2}K U value is compared with ordinary Low E double glazing with a U value 1.8 W/m^{2}K



3.1 Basic Solar Properties

The basic solar data from which all the derived design factors, such as the 'Solar Factors' and 'Shading Coefficients' are obtained is the transmittance, reflectance and absorption in combination with the thermal resistance. The essential measurement principles are given BS EN 410:1998 : *Glass in building - Determination of luminous and solar characteristics of glazing.*

The sum of the transmittance T, Reflectance R and the absorptance A is unity and therefore the solar properties are completely defined by the first two terms, which are those measured according to the standards. The measurements are done spectrally and thus the standards are also the basis of solar and luminous transmission as well as UV and colour.

Solar Data:										
	Air	Fibreglass			Lumira	Air	Fibreglass			Lumira
U Values W/m^{2}K	2.74/2.57	1.56/1.25	1.2/0.78	0.99/0.56	0.72/0.28	2.74	1.56/1.25	1.20/0.78	0.99/0.56	0.72/0.28
Thermal Resistance m^{2}K/W	0.19	0.46/0.62	0.65/1.11	0.83/1.6	1.21/3.37	0.19	0.46/0.62	0.65/1.11	0.83/1.61	1.21/3.37

Face Sheets		Solar Transmittance					Solar Reflectance				
Exterior	Interior	Air	Fibreglass			Lumira	Air	Fibreglass			Lumira
White	White	0.18	0.08	0.05	0.03	0.07	0.29	0.35	0.36	0.37	0.29
Crystal	White	0.26	0.11	0.07	0.04	0.10	0.29	0.42	0.42	0.45	0.29

3.2 Shading Coefficients

One of the most practical methods of determining the solar heat gain through the glazing of a building is the method that originated in the ASHRAE Handbook of Fundamentals. The principal advantage of this procedure is that proper allowance is made for the direction of the sun, the altitude and azimuth as it changes during the day and season on each face of the building or the roof. The basis of the method is to compare the heat gain with that through ordinary single 4mm clear glass.

Solar Heat Gain = Shading Coefficient x Solar Heat Gain Factor

In addition there is also a gain or loss due to temperature difference between the outside and inside environments given by:

Conduction Gain = U value x (Outside temperature - Inside temperature)
Conduction Loss = U Value x (Inside Temperature – Outside Temperature)

Shading coefficients are given in the following tables for both roof and walls. This is because the standard exposure conditions and direction of heat flow are different and there is a small but significant difference.

		Roof					Wall			
U Values W/m²K	3.08	1.67/1.32	1.27/0.80	1.03/0.57	0.77/0.28	2.74	1.56/1.25	1.20/0.78	0.99/0.56	0.72/0.28
Thermal resistance m²K/W	0.19	0.46/0.62	0.65/1.11	0.83/1.61	1.21/3.37	0.19	0.46/0.62	0.65/1.11	0.83/1.61	1.21/3.37
Density	-	A	B	C	D	-	A	B	C	D

Face Sheets		Total Roof Shading Coefficients *					Total Wall Shading Coefficients Total *				
Exterior	Interior	Air	Fibreglass			Lumira	Air	Fibreglass			Lumira
White	White	0.32	0.17	0.11	0.07	0.15	0.36	0.18	0.12	0.08	0.15
Crystal	White	0.40	0.21	0.13	0.08	0.21	0.43	0.22	0.14	0.09	0.21

* Corresponding short and long wave components of the total coefficient are provided on request.

3.3 Solar Factor or 'G' Value

As a basis of product comparison the Solar Factor or 'G' Value is often used by architects. It is also a requirement for harmonisation in the countries of the European Community. Glass manufacturers invariably quote this in their technical product literature though sometimes it may have another name. For example in the latest 'Pilkington' literature it is called 'Total Transmission'. In any event, it is the Solar Transmittance plus the fraction of absorbed solar heat that is convected or re-radiated by long wavelength heat transfer to the interior of the building.

U Values W/m²K	2.74/2.57	1.56/1.25	1.2/0.78	0.99/0.56	0.72/0.28
Thermal resistance m²K/W	0.19	0.46/0.62	0.65/1.11	0.83/1.61	1.21/3.37
Density	-	A	B	C	D

Face Sheets		Solar Factor				
Exterior	Interior	Air	Fibreglass			Lumira
White	White	0.31	0.16	0.10	0.07	0.13
Crystal	White	0.38	0.19	0.12	0.07	0.18

3.4 CIBSE Solar Gain Factors

These factors are used to enter the glazing solar transmission data in the CIBSE Admittance Procedure to calculate the thermal response of buildings to the solar load. The Kalwall factors given here correspond to the glass factors in Table A5.7 of the CIBSE Guide, Volume A, Chapter 5.

This procedure is used in commercial software favoured by many consulting engineers in the UK, for estimating air conditioning loads for design purposes and in plant sizing.

Kalwall Solar Gain Factors for CIBSE Procedure:											
U Values W/m²K		3.08	1.67/1.32	1.26/0.80	1.03/0/57	0.77/0.28	2.74	1.56/1.25	1.20/0.78	0.99/0.56	0.72/0.28
Thermal resistance m²K/W		0.19	0.46/0.62	0.65/1.11	0.83/1.61	1.21/3.37	0.19	0.46/0.62	0.65/1.11	0.83/1.61	1.21/3.37
Density		-	A	B	C	D	-	A	B	C	D
Face sheets											
Exterior	Interior	CIBSE Mean Factors : Roof					CIBSE Mean Factors : Wall				
White	White	0.26	0.13	0.09	0.06	0.12	0.29	0.15	0.10	0.06	0.12
Crystal	White	0.32	0.17	0.10	0.06	0.17	0.35	0.18	0.11	0.07	0.17

Exterior	Interior	CIBSE Alternating Factors Light Weight : Roof					CIBSE Alternating Factors Light weight : Wall				
White	White	0.23	0.12	0.08	0.05	0.11	0.26	0.14	0.09	0.06	0.11
Crystal	White	0.28	0.15	0.09	0.06	0.15	0.31	0.16	0.10	0.06	0.15

Exterior	Interior	CIBSE Alternating Factors Heavy Weight : Roof					CIBSE Alternating Factors Heavy weight : Wall				
White	White	0.19	0.10	0.07	0.04	0.09	0.21	0.11	0.07	0.05	0.09
Crystal	White	0.22	0.12	0.08	0.05	0.12	0.24	0.13	0.08	0.05	0.13

3.5. Admittance and associated properties

These properties are required as input data for the walls and other bounding elements of the building fabric in many commercial software packages.
Because the Kalwall panels are made of very light weight materials there is virtually no thermal inertia.

The Admittance* is therefore the same as the U value. The decrement factor f is 1.0, the surface factor F is 0.8 and the leads or lags indicated by the symbols ω/h, Φ/h and Ψ/h are zero.

**Reference is made to the CIBSE Guide Volume A, Chapter 3 Appendix 6.for the calculation of these properties.*

3.6 Atrium Roofs with Kalwall

Attention must be drawn to the design of naturally ventilated atrium spaces with continuous Kalwall roofs, and the necessity for ventilation at the highest point and should be at least 5% of the floor area.

4. LIGHT TRANSMISSION AND QUALITY OF INTERNAL DAYLIGHT

Kalwall provides a completely diffuse source of daylight whether or not the outside climate is overcast or there is sunlight. In this respect problems of direct sun glare, which happens with ordinary solar control glass, are avoided and thus no internal blinds are usually necessary. However when the sun is on the panels they themselves become very bright sources of light so if this excess of daylight needs to be overcome the product with the lower light transmission should be chosen.

In normal circumstances the light diffusing Kalwall panel provides a much deeper penetration of useful daylight into the space compared with ordinary glass. This is because the light is concentrated near the window with clear glass even when it has a higher light transmission.

4.1

LIGHT TRANSMISSION DATA		AIR	FIBREGLASS			LUMIRA™
U Values W/m²K		2.74	1.56.1.25	1.2/0.78	0.99/0.56	0.72/0.28
Thermal resistance m²K/W		0.19	0.46/0.62	0.65/1.11	0.83/1.61	1.21/3.37
Density		-	A	B	C	D
FACE SHEETS		LIGHT TRANSMITTANCE %				
EXTERIOR	INTERIOR	AIR	FIBREGLASS			LUMIRA™
White	White	20	14	8	5	12
Crystal	WHITE	30	20	9	6	15

4.2 DAYLIGHT PENETRATION

The cladding and roofing system overcomes the problem of how to transmit usable natural daylight into a building without the glare and shadows associated with traditional glazing, and thermo-plastic based materials, including polycarbonates. It is now specified for all types of building and is particularly popular for schools, sports halls and swimming pools where the diffused light is ideal for learning and playing sports.

Kalwall is quite different from other light transmitting products because it contains fibreglass, both as reinforcement and an insulant. The random distribution of the fibres completely diffuses the natural light, on clear and cloudy days. This in turn increases the depth of light distributed evenly within, with no glare and the stark contrasts of light and shade produced by conventional glazing. It means possible lower energy costs for artificial light, heating and air-conditioning and elimination of blinds, curtains or external solar control devices. For swimming pools, it means an enhanced ambience, privacy and improved swimmer safety by reducing veiling glare* from the surface of the water.

* Veiling glare – diffuse reflection of light from side glazing at the water surface hindering supervision of bathers under/in the water.

4.3 DAYLIGHT MODELLING

Advanced state of the art software enables a detailed interior daylight distribution to be modelled for any visual climate. A Daylight Modelling service is offered by Structura UK Limited which will assist the designer to choose the optimum choice of Kalwall products and their position in the envelope of the building, and prove, where necessary, the improvement which is achieved over conventional glass or polycarbonate glazing materials.

In parallel with thermal analyses provided with KALPUBPLUS software, information can be provided, helping the designer to meet energy use targets set by Building Regulations, including electric switching strategies for electric lighting supplementing the daylight, while meeting the rigorous requirements of Part L for heat loss, and air conditioning.

Interior daylight levels are usually expressed and presented by the ‘Daylight Factor’ (DF), **which is the percentage of the horizontal diffuse illuminance available at any position.** Typical levels, which provide satisfactory daylight are usually in the range of 2% - 5% depending on the application. For example 2% at a depth of 3m from the glazing is the requirement for local education authority school classrooms. Not only does the modelling service provide the internal DF distribution but also a new concept called the ‘Daylight Autonomy’ (DA), which is the percentage of the time during the course of a year, the average daylight level meets or exceeds a target level in Lux, under both clear and overcast skies.

Daylight availability data is provided by CIBSE Guide LG 10 1999 reproduced in the diagram below.

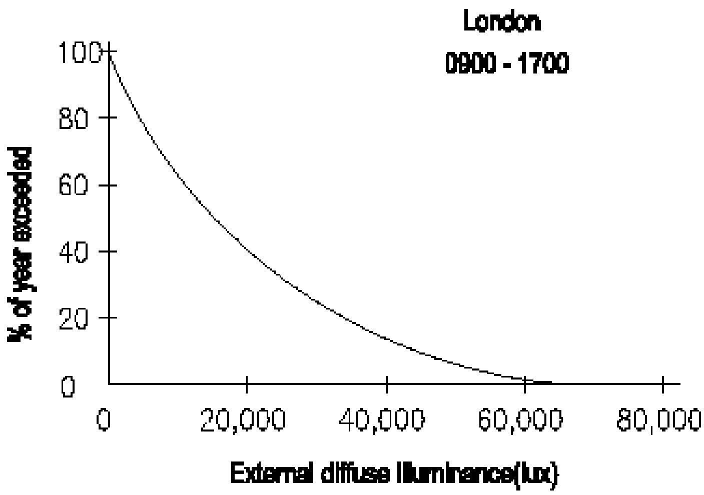
So for example: 10000 Lux is available for approximately 70% of the year between 0900 and 1600 and therefore for a 2% DF, 200 (viz 10000 x 0.02) Lux is available or exceeded.(Similar data is available in the EC publication ‘European Daylight Atlas’)

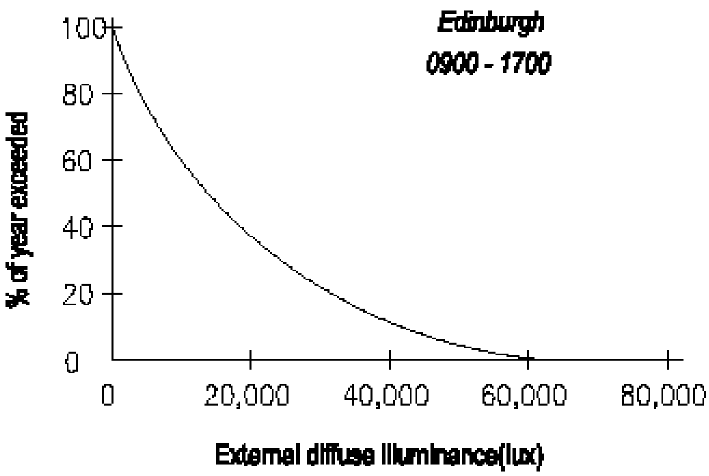
The Guide also gives advice on electric lighting switching strategies to save power and procedures to estimate savings.

The concept of Daylight Autonomy (DA) defined above, is used mostly in the USA. While there are no official guidelines, it is suggested that values between 40% and 60% represent worthwhile levels to achieve satisfactory daylighting in the building, where target lighting levels in various building types are given in the table below.

Recommended lighting levels for interior lighting - Lux (Illuminating Engineering Society)

Offices	500	Schools	700
Sports halls	300	Swimming pools	300



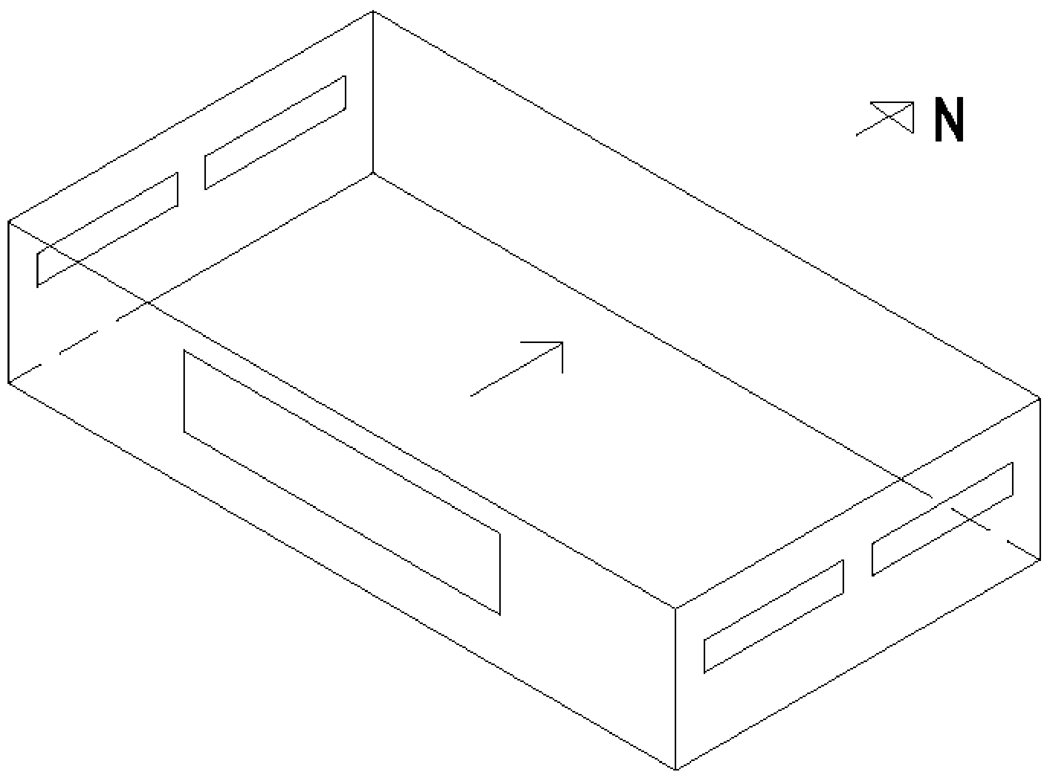


Percentage of a working year a given external horizontal diffuse illuminance is exceeded.

MODELLING EXAMPLE FOR SCHEMATIC SPORTS HALL

A typical side lit sports hall is shown below.

Fig 1.



Length 19.64m Depth 10.10m Height 8.7m

South Clerestory Length 10.10m Height 4.30m
Sill 3.00m

East/West clerestories Length 4.40m Height 1.36m
Sill 4.65m

Reflectances: Ceiling 70%, Walls 50%, Floor 20%

Studies were made for both Kalwall and polycarbonate in the clerestories. The crucial information demonstrating the improved more evenly spread daylight distribution is shown by the Daylight Factor at the working plane on plan in this case.

The Daylight factor distributions for a 20 x 16 grid are shown in the tables that follow. Also picked out is a key banded daylight shading pattern to help visualise the effect, with the denser shading for low daylight factors. Examination and comparison show that while the average Daylight Factors are very similar the variation is much greater with the polycarbonate clerestories.

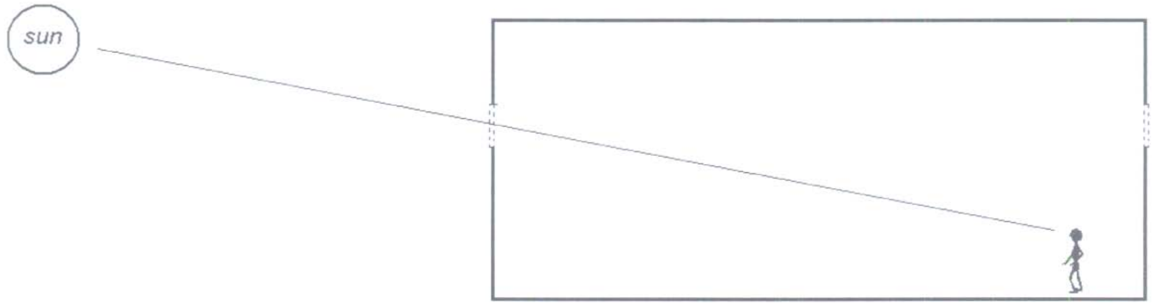
Another way to quantify the range is show by the Minimum/Maximum Daylight factor ratio and also the Minimum/Average ratio. Thus the Minimum/Maximum ratio is 0.09 with the non-diffusing polycarbonate clerestory compared with 0.22 for the Kalwall, and similarly the comparison of the Minimum/Average Daylight Factor is 0.18 with 0.35.

This is because most of the daylight falls first on the low reflecting floor with polycarbonate clerestories while for the totally diffusing Kalwall clerestories the light is spread evenly to all the interior surfaces including the high reflecting ceiling.

A serious problem for non-diffusing glazing is Sun Glare shown schematically in Fig 2.

Fig 2.

Sun Glare with non diffusing polycarbonate/glass



On sunny days with low angle sun a person can lose sight of a ball in play against the bright sunlight. Because Kalwall is totally diffusing this doesn't happen, but with all non-diffusing glazing materials it will be a problem.

The only solution with the non-diffusing glazing would be to put a blind in place at these times, which would compromise the available day light and increase the use of artificial lighting.

In this particular example the west-facing clerestory will face low angle sun in March/April also August/September in the late afternoon 4pm – 6pm. Correspondingly the east facing clerestory at 6am – 8am, when the hall would probably not be in use. This is an orientation dependent consideration of good daylight design.

NON DIFFUSING GLAZING (POLYCARBONATE)

Daylight distribution as Daylight Factors, calculated for polycarbonate (non-diffusing) with same light transmission CIE distribution

1.17	1.70	2.07	2.17	2.17	2.20	2.07	2.10	2.10	2.10	2.10	2.10	2.10	2.07	2.20	2.17	2.17	2.07	1.70	1.17
1.22	1.87	2.29	2.39	2.39	2.37	2.29	2.27	2.27	2.27	2.27	2.27	2.27	2.29	2.37	2.39	2.39	2.29	1.87	1.22
1.28	2.05	2.53	2.65	2.63	2.57	2.53	2.48	2.48	2.48	2.48	2.48	2.48	2.53	2.57	2.63	2.65	2.53	2.05	1.28
1.35	2.25	2.80	2.95	2.90	2.80	2.80	2.75	2.75	2.75	2.75	2.75	2.75	2.80	2.80	2.90	2.95	2.80	2.25	1.35
1.38	2.42	3.03	3.22	3.20	3.10	3.10	3.08	3.12	3.12	3.12	3.12	3.08	3.10	3.10	3.20	3.22	3.03	2.42	1.38
1.42	2.55	3.23	3.47	3.50	3.43	3.45	3.47	3.53	3.53	3.53	3.53	3.47	3.45	3.43	3.50	3.47	3.23	2.55	1.42
1.45	2.65	3.40	3.70	3.80	3.80	3.85	3.90	4.00	4.00	4.00	4.00	3.90	3.85	3.80	3.80	3.70	3.40	2.65	1.45
1.48	2.72	3.53	3.93	4.10	4.23	4.38	4.50	4.60	4.63	4.63	4.60	4.50	4.38	4.23	4.10	3.93	3.53	2.72	1.48
1.50	2.77	3.65	4.15	4.43	4.70	4.97	5.15	5.27	5.33	5.33	5.27	5.15	4.97	4.70	4.43	4.15	3.65	2.77	1.50
1.50	2.80	3.75	4.35	4.80	5.43	5.90	6.18	6.00	6.10	6.10	6.00	5.85	5.60	5.20	4.80	4.35	3.75	2.80	1.50
1.47	2.73	3.72	4.42	5.07	5.67	6.20	6.52	6.70	6.80	6.80	6.70	6.52	6.20	5.67	5.07	4.42	3.72	2.73	1.47
1.40	2.58	3.55	4.30	5.10	5.87	6.48	6.83	7.03	7.12	7.12	7.03	6.83	6.48	5.87	5.10	4.30	3.55	2.58	1.40
1.30	2.35	3.25	4.00	4.90	5.80	6.45	6.80	7.00	7.05	7.05	7.00	6.80	6.45	5.80	4.90	4.00	3.25	2.35	1.30
1.13	1.95	2.62	3.13	3.70	4.27	4.65	4.83	4.93	4.95	4.95	4.93	4.83	4.65	4.27	3.70	3.13	2.62	1.95	1.13
0.90	1.48	1.91	2.20	2.44	2.69	2.83	2.88	2.89	2.89	2.89	2.89	2.88	2.83	2.69	2.44	2.20	1.91	1.48	0.90
0.60	0.93	1.13	1.20	1.13	1.07	1.00	0.93	0.87	0.87	0.87	0.87	0.93	1.00	1.07	1.13	1.20	1.13	0.93	0.60

AVERAGE 3.31 MIN/MAX 0.09 MIN/AVG 0.18

Key	
	> 6
	5 ~ 6
	4 ~ 5
	3 ~ 4
	2 ~ 3
	1 ~ 2
	< 1

KALWALL

Daylight distribution as Daylight Factors, calculated for Kalwall (diffusing) from Lux distribution in for a diffuse sky

1.65	1.97	2.32	2.42	2.52	2.66	2.70	2.79	2.79	2.81	2.81	2.79	2.79	2.70	2.66	2.52	2.42	2.32	1.97	1.65
1.73	2.15	2.41	2.57	2.79	2.90	2.91	3.00	2.97	2.95	2.95	2.97	3.00	2.91	2.90	2.79	2.57	2.41	2.15	1.73
1.87	2.32	2.64	2.76	2.98	3.05	3.12	3.14	3.16	3.15	3.15	3.16	3.14	3.12	3.05	2.98	2.76	2.64	2.32	1.87
1.92	2.32	2.77	2.89	3.10	3.21	3.27	3.31	3.30	3.36	3.36	3.30	3.31	3.27	3.21	3.10	2.89	2.77	2.32	1.92
1.99	2.41	2.78	3.03	3.15	3.35	3.47	3.45	3.53	3.60	3.60	3.53	3.45	3.47	3.35	3.15	3.03	2.78	2.41	1.99
2.05	2.52	2.85	3.10	3.32	3.42	3.64	3.60	3.68	3.76	3.76	3.68	3.60	3.64	3.42	3.32	3.10	2.85	2.52	2.05
2.10	2.59	3.03	3.34	3.57	3.57	3.73	3.85	3.86	3.98	3.98	3.86	3.85	3.73	3.57	3.57	3.34	3.03	2.59	2.10
2.14	2.68	3.07	3.45	3.69	3.87	3.92	4.18	4.12	4.27	4.27	4.12	4.18	3.92	3.87	3.69	3.45	3.07	2.68	2.14
2.08	2.53	3.18	3.59	3.69	4.07	4.17	4.42	4.41	4.52	4.52	4.41	4.42	4.17	4.07	3.69	3.59	3.18	2.53	2.08
2.11	2.58	3.17	3.64	3.93	4.16	4.28	4.41	4.57	4.75	4.75	4.57	4.41	4.28	4.16	3.93	3.64	3.17	2.58	2.11
2.04	2.63	3.18	3.52	4.04	4.35	4.53	4.68	4.83	4.90	4.90	4.83	4.68	4.53	4.35	4.04	3.52	3.18	2.63	2.04
2.01	2.61	3.10	3.37	4.01	4.30	4.79	4.89	4.98	5.07	5.07	4.98	4.89	4.79	4.30	4.01	3.37	3.10	2.61	2.01
1.84	2.39	2.88	3.20	3.84	4.25	4.65	4.62	4.86	4.97	4.97	4.86	4.62	4.65	4.25	3.84	3.20	2.88	2.39	1.84
1.66	2.20	2.68	3.09	3.60	3.94	4.26	4.52	4.53	4.56	4.56	4.53	4.52	4.26	3.94	3.60	3.09	2.68	2.20	1.66
1.41	1.89	2.32	2.73	3.07	3.47	3.70	3.68	3.79	3.93	3.93	3.79	3.68	3.70	3.47	3.07	2.73	2.32	1.89	1.41
1.13	1.56	1.86	2.03	2.24	2.40	2.35	2.44	2.53	2.46	2.46	2.53	2.44	2.35	2.40	2.24	2.03	1.86	1.56	1.13

AVERAGE 3.22 MIN/MAX 0.22 MIN/AVG 0.35

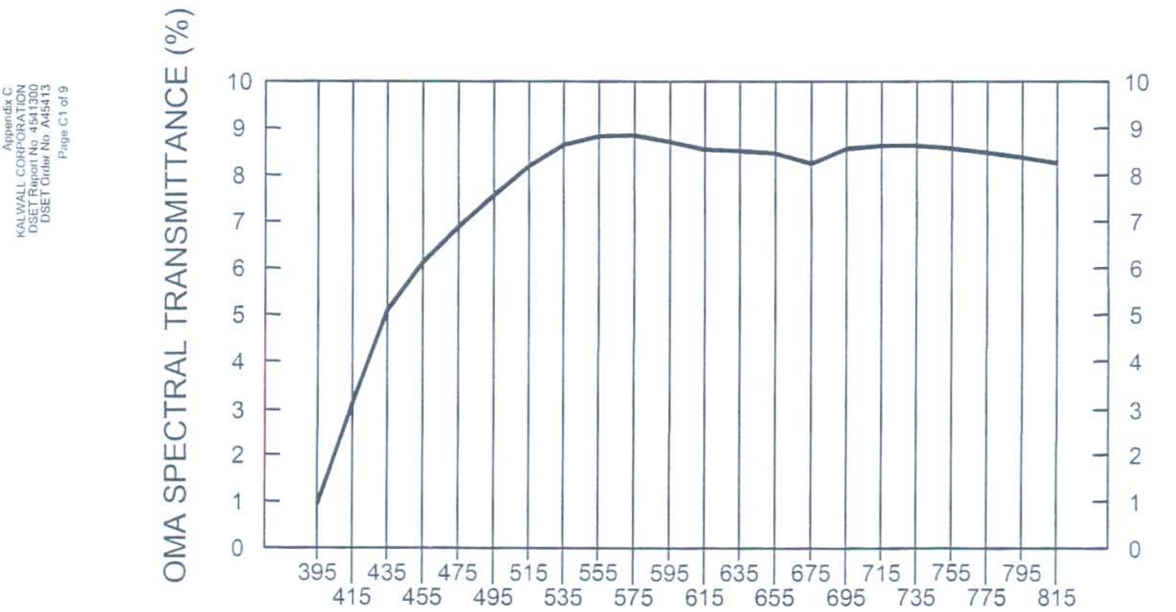
4.4 KALWALL DAYLIGHT MODELLING SERVICE

Predict and plan the proper use of daylight in the design of buildings by using Kalwall's Daylight Modelling Service. Please see www.daylightmodeling.com

4.5 SPECTRAL DISTRIBUTION

Below is a special transmission chart for a representative Kalwall panel. It is typical of all Kalwall panels in that there is no transmission in the harmful UV-B range (280 to 315nm). In the UV-A range (315 to 400nm) there is less than 1/10 of 1% transmission. In the visible range, there is a relatively flat, even distribution of all wavelengths.

SAMPLE – .070 WHITE / .045 WHITE



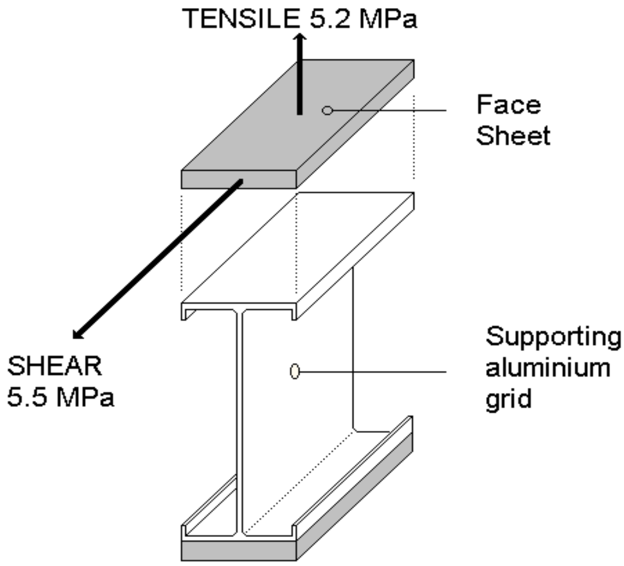
WAVELENGTH (NM)

5. BOND STRENGTH AND MECHANICAL RESISTANCE

The bond strength of a composite panel is important both for the initial structural performance and the long-term integrity of the installation. The long-term integrity of the product is borne out by many successful applications in USA under varied and severe exposure for periods exceeding 25 years.

Kalwall panels have been evaluated by ASTM bond strength tests detailed below, which are prescribed by quality control agencies in particular the - *International Conference of Building Officials Evaluation Service - (ICBOES).* The requirement is for minimum strength limits before and after prescribed accelerated ageing and exposure.

The ASTM test methods evaluate bond integrity for tensile and shear strength to 5.2 MPa and 5.5 MPa respectively (750 psi,800psi).



TENSILE TESTING: The requirement is 5.2 MPa minimum after ageing.

ASTM C - 297 "Tensile tests of flat sandwich construction in the flat plane" The requirements are met after two exposures to the 6 complete cycles of accelerated ageing.

ASTM D - 1037 "Evaluating the properties of wood based fibre and particle panel materials". This comprises the 6 cycle ageing requirements originally used for wood products but now is generally accepted for composite sandwich panels.

ASTM D - 1002 "Test for strength properties of adhesives in shear by tension loading" after the following five different exposure conditions:

1. Room temperature - approximates to un-aged bond strength of 3.7 MPa minimum.

2. Elevated temperature of 83^0 C - determines the capability under extreme heat to prevent structural failure:0.7 Mpa.

3. Accelerated ageing in accordance with ASTM D - 1037 ageing cycle to evaluate the long term strength: 5.5 Mpa.

4. Aged as in D -1037,tested at elevated temperature of 83^0 C - extreme temperature strength after ageing: 1.7 Mpa.

5. ASTM D -572,"Standard method of test for accelerated ageing of vulcanised rubber by oxygen pressure method" -severe exposure capable of rapidly deteriorating substandard materials in an oxidising environment at elevated temperature- : 65 Mpa.

In addition other independent laboratory tests have been made on Kalwall, as well as the successful experience of 40 years' successful projects.

MECHANICAL RESISTANCE

The mechanical resistance of the Kalwall panel is determined by a cycle of testing on full-scale panels in a 4 point bending test.

The ultimate failure load has been determined. **SEE ETA-07/0244, SECTION 7, PAGE 6**.

TYPE OF PANEL	VALUE
Kalwall 1.56	$2248 N/m^2$
Kalwall 1.25	
Kalwall 1.2	
Kalwall 0.78	
Kalwall 0.99	
Kalwall 0.56	

6. WEATHERABILITY

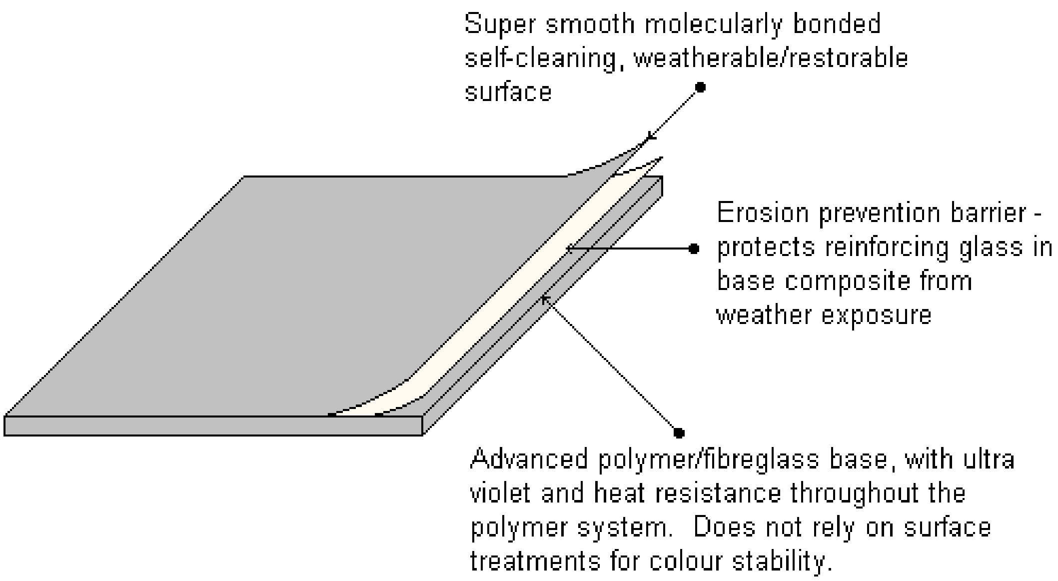
The major causes of degradation in commercial fibreglass reinforced polyester materials, polycarbonates and other thermoplastics is ultra-violet radiation, heat, thermal shock and weathering erosion. These conditions may result in the decomposition, colour change, cracking and crazing, loss of light transmission and 'fibre-bloom' of some products.

Kalwall, however, does not rely on superficial, sacrificial coatings, films, or 'gel coats' to protect the external face sheet. Kalwall's UV stability is built in to the full thickness of the outer sheet, so that unsightly yellowing and loss of light transmission is prevented.

In addition to Kalwall's excellent UV stability, the external face sheet is engineered so that the glass fibres cannot migrate to the surface or cause unsightly 'fibre-bloom'. This is achieved by the inclusion of a continuous glass veil erosion barrier under the surface of the sheet, which encapsulates the fibres.

The final weathering treatment to the external sheet is the inclusion of a low-coefficient of friction coating to enhance water and dirt run-off so that cleaning requirements are minimised.

Kalwall Super-weathering/Erosion Barrier System
The system that provides a superior performance that virtually eliminates maintenance



7. COLOUR CHANGE

ASTM D-2244 is the principal test method used in the USA to measure the colour change of architectural surfaces caused by weathering. The method allows colour scale choices to measure colour change. These scales vary according to the intent of the users. Since yellowing as well as darkening are the most noticeable effects of weathering on polymers, a scale designed to measure these changes is the most appropriate, such as the DE in 'Hunter' units.

Actual site weathering conditions require face sheet samples to be exposed to severe conditions for 5 years to be able to give an indication of site weathering effects over 15 to 20 years. Accelerated laboratory testing does not measure up to the severity of outdoor weathering. Kalwall face sheets are exposed at an inclination of 5^0-7^0 facing south in Florida. This angle provides the most severe weathering effects. ASTM D-1435, sometimes cited by competitors, which allows inclinations from horizontal to 90^0 is not recommended.

The principal climatic factors causing colour change are sunlight and heat.

Kalwall incorporates super weathering fibreglass face sheets which show no noticeable colour change after 5 years exposure to the South Florida sun. These sheets are manufactured with an exclusive resin formulation, which is only available from Kalwall.

Inferior grade fibreglass or thermoplastics may reply on gel coats, thin plastic films or high performance polymer laminate weathering surfaces. Innovative technology from Kalwall provides a permanent tough glass barrier in the exterior of the composite. This is a development of enormous significance.

Unlike other weathering surfaces the glass layer cannot be scratched, worn or weathered off.

In order to assess how little any colour change is and to show the improvement of the Super Weathering face sheet compared with other commercial GRP products, the following test was conducted. Three samples were exposed to the South Florida sun for between 3 and 5 years and then compared with un-weathered samples. The colour difference was assessed according to ASTM D-2244, giving the following results.

MATERIAL	YEARS EXPOSED	COLOUR DIFFERENCE-HUNTER UNITS	
		WITH COATING	WITHOUT COATING
Kalwall Super weathering GRP	5	3.0	3.0
Standard commercial GRP	3	3-4	>30

While 5^0 to 7^0 and 45^0 inclinations provide approximately similar total incident radiation in Florida 70 inclinations provide 25% higher levels during the hottest and their most onerous months of the year.

8. DURABILITY - AS ASSESSED IN ETA-07/0244, PLEASE SEE SECTION 7, PAGE 7

The mechanical resistance of the Kalwall panel has been determined by a cycle of testing on full scale panels in a 4 point bending test, according to §6.7 of ETAG 16 part 3 after 15 climatic cycles of ageing and compared with the initial value for the ultimate failure load.

PRIOR TO AGEING:

Ultimate load (N/m^2): 2248

AFTER AGEING:

Ultimate load (N/m^2): 2208

DURABILITY CLASSIFICATION

TYPE OF PANEL	CLASSIFICATION
Kalwall 1.56	Lifetime of 25 years
Kalwall 1.25	
Kalwall 1.2	
Kalwall 0.78	
Kalwall 0.99	
Kalwall 0.56	

9. IMPACT RESISTANCE

SOFT BODY IMPACT

Under soft load with a mass of 50kg, the panels withstands 900 Joules on 3 different locations (panel centre, in the node of the supporting grid and on the grid) at each panel side,

Note: Under soft load a mass of 50kg according to EN 1401 the panel withstands an impact height of 1600mm from each panel side.

HARD BODY IMPACT

Under hard body impact load with a mass of 1kg, the panel withstands 10 Joules applied on 3 different locations (panel centre, in the node of the supporting grid and on the grid) at each panel side.

IMPACT RESISTANCE

TYPE OF PANEL	VALUE
Kalwall 1.56	Soft body impact 900 Joules Hard body impact 10 Joules
Kalwall 1.25	
Kalwall 1.2	
Kalwall 0.78	
Kalwall 0.99	
Kalwall 0.56	

COMPARATIVE IMPACT RESISTANCE BY 2.9 KG FREE FALLING BALL TEST TO US STANDARD UL-972

In the US Free-falling Ball Test a 2.9 Kg, 90mm diameter steel ball is dropped on face sheet specimens 400 mm x 400 mm square. The ball is dropped repetitively from increasing heights in 300 mm increments until the face sheet tears or breaks. All impacts are based on 3 samples each impacted twice at the given height with no failures.

FACE SHEET	DROP HEIGHT Metres
Exterior High Impact	14.0
Interior B3C	6.0
Exterior SWC	3.6
5mm Tempered Glass	1.8

Kalwall systems have been approved by Dade County Florida for hurricane resistant walls and skylights having successfully passed the region’s large missile impact test.

APPLICATION

Whilst one can never say that Kalwall will not be damaged or broken under sustained attack, such as by vandals, standard thickness exterior sheet SW-E will more than meet the requirements of Euro code EN1401, and in addition it also meets the requirements of the American code US STANDARD UL-972.

However, Kalwall are able to offer an optional Exterior High Impact External Face Sheet, which is nearly four times as strong as the standard sheet (see US STANDARD UL-872 above).

This face sheet may be considered in areas where more than ‘normal day-to-day impact’ might occur.

Further when Kalwall is used as a roof panel system it will meet the requirements of imposed roof loads as stated in BS EN1991-1. In the USA Kalwall Roof Panel Systems for Skylights meet the Federal Occupational Safety and Health Administration safety requirements (OSHA) without the need for protective external screens or fixed preventative standard railings.

Also, Kalwall has been tested and approved as a Class 1 Roof Panel by Factory Mutual Research Corporation (FMRC), which includes tests for Roof traffic and hail damage.

10. AIR AND WATER PENETRATION AND STRUCTURAL TESTING

AIR AND WATER PENETRATION AND STRUCTURAL TESTING

As part of the CE Marking process, compliance with the requirements of this European product standard has to be demonstrated by Initial Type Testing (ITT) and Factory Production Control (FPC).

This entails initial testing of products by a Notified Body, a nationally approved test house "Notified" to the European Commission, and has been carried out by the Belgian Construction Certification Association. Results of the testing for are shown below:

Kalwall has been tested according to the procedures of EN 13830:2003 - Curtain Walling Product Standard

AIR PERMEABILITY:

Kalwall has been classified as **class A4** according to EN12152 Air permeability
Test results at 600 Pa : 1.19m^3/h pressure 1.37m^3/h suction

WATER TIGHTNESS:

Kalwall has been classified as **class RE$_{800}$** according to EN12154 Water tightness
Test results no water penetration at 800Pa

STRUCTURAL PERFORMANCE:

Kalwall has been tested according to EN13116 Resistance to wind load and achieved:

SUMMARY TABLE:

TEST	CLASSIFICATION/TEST STANDARD	LEVEL/CLASS
Air Permeability	EN 12152/EN12153	A4
Water tightness	EN12154/EN12155	RE$_{800}$
Resistance to Windload (serviceability)	EN13116/EN12153	1600 N/m^2
Safety	EN 13116/EN 12179	2400N/m^2

11. CHEMICAL RESISTANCE

Kalwall systems are resistant to most acidic or alkaline atmospheres. Environments usually considered to be corrosive such as paper or metal processing plants, seaside locations and swimming pools do not affect Kalwall sandwich panels or the Kalwall Corrosion Resistant Finish on the Clamp-tite System. Generally, any building atmosphere, where people are exposed, without the need for any protective clothing, can be considered to have no adverse effect on Kalwall Systems. Tests have been conducted according to ASTM D-543, *"Test for the resistance of plastics to chemical reagents"* for many common chemicals. Please contact Structura UK Limited for specific applications. The following information is required at the time of the enquiry:-

1. Identify the chemicals.
2. Identify the type of exposure which is anticipated:
   a) Vapour, liquid or solid.
   b) Continuous/intermittent.
3. Concentration of chemical in the atmosphere.
4. Operating temperatures in the exposed areas.

RELEASE OF DANGEROUS SUBSTANCES

The Kalwall panels comply with the provisions of Guidance Paper H (“A harmonized Approach relating to Dangerous Substances under the Construction Products Directive”, edition 2002) about dangerous substances.

12. THE FIRE PROPERTIES OF KALWALL®

FIRE POLICY

Kalwall is a unique product made from two specially formulated resin bonded glass fibre reinforced face sheets thermally bonded under pressure to an interlocking, aluminium 'I' section beam grid. Because of its structure, the product exhibits fire resistant properties exceeding any other translucent panels. The requirements of most building regulations for fire safety are well within its design capabilities.

Kalwall is a thermoset material, which unlike thermoplastics such as polycarbonate or acrylic material does not melt or drip in a fire.

EUROPEAN REQUIREMENTS

At the time of writing a process of European harmonisation is in progress throughout Europe in support of the Construction Products Directive (CPD).

Harmonised European classes have been developed for ‘Reaction to Fire’ performance and these have been adopted in the national regulations of EU member states. From the specifier’s point of view the Euroclass system provides a common basis for comparing the fire performance irrespective of the EU country in which they were made or tested.

Currently it is possible to demonstrate performance against either National or European standards, but evidence based on National standards can only be sold into that nation’s market and over the next few years will be phased out. European standards will supercede National standards and it cannot be assumed that if a product meets the relevant National Standards it will also meet the European Standards. In other words, testing must be carried out against European standards to achieve a European classification.

European ‘Reaction to Fire’ testing relates to fire performance in regards to the combustibility and ignitability of a material - its contribution to fire growth, lateral flame spread, heat release, smoke generated and the production of flaming droplets are all measured.

The testing is based on the tendency of the product to promote the conditions for flashover in a room. Euroclass A1-A2 and B products do not promote flashover.

The test specimens are representative of items that may be exposed to a growing fire, including:

- Wall linings
- Ceiling linings
- External wall surfaces

In England and Wales, the fire requirements for buildings are dealt with by Approved Document Part B of the Building Regulations. Requirements are expressed as a classification, for example:

- circulation spaces within dwellings may require European Class C reaction to fire performance
- other circulation spaces, including common areas of Assembly Buildings, may require Class B
- the external wall surface of a building over 18m from ground or less than 1000mm from a boundary may require Class B.

In addition to these classifications, the product is also tested for smoke release, which has been put into three broad bands - **s1** (little or no smoke), **s2** (quite a lot) or **s3** (substantial).

Some construction products can melt and ignite to form flaming droplets, which may initiate new fires away from the initial point of ignition. The classification system ranks the level of release of flaming droplets/particles as **d0** (none), **d1** (some) and **d2** (quite a lot). As Kalwall is a thermoset material it falls into category **d0**.

Kalwall achieves a Classification according to EN 13501-1 of:
Internal Surface: **B-s2,d0**
External Surface: **C-s3,d0**

Roof Classifications

Kalwall achieves an internal surface classification of **B-s2,d0.**
Externally, Kalwall achieves **S:AA** when tested to BS 476: Part 3, and Broof(t4) when tested to BS EN 13501 Part 5.

Practice in the United States

Kalwall can be specified as FM (Factory Mutual) Class 1 approved panels. Kalwall is listed in the USA by Underwriters Laboratory as a Class "A" Roof System. The U.L. #790 test procedure (ASTM E 108) includes tests for fire endurance, flame protection and spread of surface flame. This configuration of panels qualifies it for buildings which require a Class "A" Roof.(U.L. file R7878)In addition standard insulated panels will pass the Class "A" Burning Brand Test, according to ASTM E 108 (A.T.I. Report No 6566)

Factory Mutual Certification

Factory Mutual (FM Global) are a leading worldwide insurance company and research organisation involved in property loss prevention.

FM Research Standard 4411 certifies that the fire hazard of Kalwall has been evaluated for fuel contribution, surface flame spread within the core and susceptibility to radiant heat. Approved wall panels are considered Class 1 of limited combustibility, not requiring automatic sprinkler protection of themselves.

Kalwall can be specified as FM (Factory Mutual) Class 1 approved panels

Other information

Although Kalwall does not offer any resistance to the passage of fire the following information may be of some interest:

Tests were originally made in the USA (UL723/ASTM E 84) at Underwriters Laboratories. In addition the ignition temperature is 425^{0}C as tested in accordance with ASTM D 1929.This is significantly higher than with many other materials such as timber facings frequently used in buildings. It is also very much higher than sprinkler activation temperatures.
Standard Kalwall has also been tested over a period of 4 hours to a furnace temperature of approximately 650^0 C with the following results:

	🕐	🕑	🕒	🕓
Exposure time - hours	1	2	3	4
Interior face temperature - ^{0}C	660	652	650	668
Exterior face temperature - ^{0} C	212	203	207	207

The exterior face of the panel did not reach a sufficiently high temperature to ignite and although the resin in the interior face burned away, the fibreglass remained in place bonded to the grid, thus preventing the heat from reaching it. Tests on thermally broken panels perform in an identical way.

When ignition of a panel does occur in a fire its energy contribution is small, it remains in place unlike ordinary window glass, and does not melt or drip like thermoplastics such as polythene. In the USA will usually meet the N.F.P.A. definition of "Limited Combustibility”.

13. KALWALL ACOUSTIC DATA

INTRODUCTION:

Noise is unwanted sound, whether it originates from road traffic, or aircraft. It is a nuisance and causes annoyance, may impair working performance by distraction or in the long term may cause physical illness.

Kalwall has an important role in attenuating outside noise in many buildings.

MEASUREMENT:

The sound reduction is measured over the spectrum of frequency of audible sound usually from about 100 to 5000 Hz in third octave bands. It is necessary because of the complex nature of intrusive sound to give an accurate assessment. Traffic noise for example has a bias to the lower frequencies. In addition the ear is not equally sensitive over the spectrum and correction must be made to reflect this.

ACOUSTIC INDICES:

R_m Mean reduction. The arithmetic mean, or Sound Reduction Index, is measured over the third octave band range of 100 to 3150 Hz, reported in dB (decibel).

Rw Weighted reduction. R_m does not reflect the subjective response of the ear. R_w defined in BS5821:1984 is derived by comparing the measured sound reduction spectrum with a family of reference curves to minimise the adverse deviation over the 16 third octave bands between 100 and 3150 Hz. Numerically it may as much as 5dB higher than the corresponding R_m. It is very important to distinguish between these indices. For Kalwall it is about the same, but for glass 3dB higher.

STC Sound Transmission Class. This is the American version of Rw. It is derived in much the same way except the frequency range is 125 to 4000 Hz.

SOUND INSULATION:

The airborne sound insulation of Kalwall panels is summarised in the table below. All results quoted are weighted in accordance with EN ISO 717-1:1997.

Results marked with an asterisk were derived from laboratory tests carried out according to American Standard ASTM:E90 which is broadly equivalent to European Standard EN ISO 140-3:1995. All other results were derived from calculations.

Kalwall panel type denomination	Sound insulation rating (dB)		
	R_w	C	C_{tr}
Kalwall 2,74	23	-1	-5
Kalwall 2,57	24	-1	-5
Kalwall 1,56	31	-3	-9
Kalwall 1,25	31	-3	-8
Kalwall 1,20	31	-3	-8
Kalwall 0,99	31*	-3	-8
Kalwall 0,78	31	-3	-8
Kalwall 0,56	31*	-3	-8
4/16/4 double glazing (for comparison)	*31*	*-1*	*-5*
Kalwall with Lumira	34*	-2	-6
Kalwall 100mm panel	35*	-2	-7

All results quoted relate to test sample sizes of 4 m^2. The sample size used for the laboratory tests for Kalwall 0,99 and Kalwall 0,56 was 4 m^2. Test results for Kalwall 100mm panel and Kalwall with Lumira have been adjusted to account for tested sample sizes being between 7.4 m^2 and 2.2 m^2 respectively.

Panels of less than 2 m^2 area are likely to perform around 2 dB better than the values quoted in the table above. Panels of 10 m^2 or larger are likely to perform around 1 dB lower than the values stated in the table above.

Laboratory testing and calculations suggest that the internal framework grid centre spacing and grid pattern type may have a small effect on sound insulation (primarily at low frequencies). However, for the common Kalwall configurations noted in the tables above, the net effect in terms of R_w, C and C_{tr} is negligible.

FLANKING SOUND INSULATION:

Measured data from field tests in classrooms, together with calculations, show that Kalwall is capable of providing the following flanking sound insulation performance:

FLANKING SOUND INSULATION

Flanking sound insulation performance	$D_{nT(0.8s),w}$ (dB)	$D_{nf,w}$ (dB)
Horizontal	44 to 46	36 to 39
Vertical	48	40

Tests were carried out in accordance with EN ISO 140-4:1998. All results quoted are weighted in accordance with EN ISO 717-1:1997. Site conditions encountered during the tests indicate that the flanking sound insulation performance of Kalwall is actually likely to be higher than indicated by the test results.

The results indicate that Kalwall facades are compatible with achieving the classroom to classroom sound insulation requirements given in Building Bulletin 93.

It should be noted that the flanking performance is likely to be heavily dependent upon the detailing of the junctions between the Kalwall and the adjoining building elements.

SOUND ABSORPTION:

The sound absorption performance of Kalwall has been estimated based on calculations and reverberation time field measurements in classrooms:

SOUND ABSORPTION

Sound absorption coefficients						
Octave band centre frequency (Hz)						α_w
125	250	500	1k	2k	4k	
0.55	0.40	0.25	0.15	0.15	0.15	0.20

Octave band values and the weighted absorption coefficient have been calculated in accordance with BS EN ISO 11654. All calculations and assessments made using these estimated values should have due regard for the likely tolerances of the estimates.

RAIN NOISE GENERATION:

Kalwall has been tested for rain noise generation under 'heavy rainfall' conditions in accordance with ISO 140-18:2006.

The resultant A-weighted sound intensity levels have been calculated and compared to the A-weighted intensity levels produced by other roofing materials.

Data for other materials has been obtained from BRE document (dated 2 December 2004) *'Building Bulletin 93 - Information on rain noise from roof glazing, polycarbonate roofing and ETFE roofing'* and the correction detailed in Section 3.1, Equation 1 applied to allow a direct comparison.

The table has been ordered in terms of increasing levels of rainfall noise.

SOUND INTENSITY

Element	A-weighted sound intensity (dB)
6/12/6.4 glazing	54.7
4R1 – Kalwall 0.28 (Lumira)	54.9
2R1 – Kalwall 0.78	60.1
3R1 – Kalwall 0.56	60.7
1R1 – Kalwall 1.25	62.5
Polycarbonate	67.3
ETFE Pillow	74.2

REFERENCE DOCUMENTS:

The following acoustic assessment and test reports are available upon request:

Document date reference	Authoring organisation	Subject
2010-03-05	Taylor Woodrow	**Laboratory rain noise sound intensity measurements** on a series of skylights for the Kalwall Corporation carried out to ISO 140-18:2006.
2009-04-03	Sandy Brown Associates LLP	**Estimation of EN ISO 140-3 sound insulation** of Kalwall panels. Performances based on data from ASTM:E90 laboratory tests and calculations using Insul and Winflag acoustic modelling software. Results weighted to EN ISO 717-1.
2009-02-13	Sandy Brown Associates LLP	**Estimation of Kalwall sound absorption coefficients** based on field reverberation time tests and calculations using Winflag acoustic modelling software. Results weighted to EN ISO 11654.
2008-12-22	Sandy Brown Associates LLP	**Flanking sound insulation field tests** in classroom to EN ISO 140-4. Results weighted to EN ISO 717-1.
2008-06-03	Architectural Testing Inc.	**Laboratory sound insulation tests** for 4” Kalwall panels carried out according to ASTM:E90.
2004-12-04	BRE	**Laboratory rain noise sound intensity measurements** “Building Bulletin 93 - Information on rain noise from roof glazing, polycarbonate roofing and ETFE roofing’ carried out to ISO/CD 140-18 (2004 draft version).
2002-02-02	Architectural Testing Inc.	**Laboratory sound insulation tests** for Lumira filled Kalwall panels carried out to ASTM:E90.
1997-08-07	Intertek Testing Services	**Laboratory sound insulation tests** for standard Kalwall panels carried out to ASTM:E90.

14. EXPLOSION VENTING

The FM-approved Explosion Venting Wall Panel systems function is to dispose explosive forces caused by an accident within a laboratory or manufacturing area. A building can withstand an explosion without collapsing roofs and floors, or other effects to structural integrity, if the forces of the explosion can be released.

Kalwall's Explosion Venting Walls, also known as "blow-out" or "pressure relieving", are designed to release from their mounting system should an explosion occur inside a building. After release, the panels remain attached to the side of the building and do not become dangerous falling debris. In some cases, the panels can then later be reinstalled.

Kalwall's Explosion Venting Panels are fully pressure release tested under **Factory Mutual Research Corporation Standard 4440 for Damage-Limiting Construction**. The Kalwall panels are not merely a component, but are fully approved as an integrated system.

The maximum size of a 70mm thick panel is 1500mm x 4600mm and a maximum weight of 12.2kg/m^2.

15. ANTI-TERRORISM APPROVED SYSTEMS

Kalwall have used their experience in manufacturing hurricane resistant systems to take explosion absorbency and high flying debris protection standards, to introduce systems which will give protection against bomb blast.

Typically, the various components of a building fail once they are subject to the forces of an explosion or impact. Once freed from their static positions, they become deadly projectiles. In a blast scenario, this is the major cause of injury or death, not the shrapnel from the explosive device itself. Kalwall transfers the force of an explosion to the superstructure of the building, distributing it in more non-lethal directions while protecting the occupants. Reducing or eliminating flying debris increases the survivability rate.

Kalwall Corporation's "Blast-Resistant" technology allows natural daylight into the occupied space of a building, while still providing a significant degree of protection to those inside from the hazards of airborne debris following an explosion. The unique composition of Kalwall structural panels, combined with additional restraining components, demonstrates equivalent or superior performance to the stringent UFC 4-010-01 DoD and GSA Anti-Terrorism Standards for building designs.

Applied blast loads from one to six psi and varying durations were tested on several configurations of Kalwall panels, including the energy-efficient, thermally broken models. While the panels were damaged at the higher blast loads, no flying debris was generated and the panels were retained in the opening.

It is worth noting also that because Kalwall is not transparent, building occupants are not visible from the outside making them a potential target.

16. Factory Mutual Corporation Approval

One of the world's leading commercial insurance companies and loss prevention experts, with its own Approval Standard Systems for products and services.

Factory Mutual's rigorous test regimes are designed to enable international clients to confidently specify FM approved products worldwide knowing they will meet, and often surpass, local Building Standards.

Kalwall has been tested and meets the following FM standards.

FM 4881	Class 1 Exterior Walls
FM 4411	Building Insulations (Class 1 Fire Standards)
FM 4440	Explosion Venting Construction

17. MISCELLANEOUS PRODUCT DATA

WEIGHT:

Dependant on panel layout and size there will be slight variations in the weight of Kalwall panels. Thermally broken fibreglass filled panels will generally weigh no more than 16kg/m^2.
Lumira filled panels will generally weigh no more than 22kg/m^2.

THERMAL EXPANSION:

The Kalwall sandwich panel coefficient of linear thermal expansion is 2.23 x $10-^5$ / C.
A 2 m panel will expand approximately 2mm when the temperature rises by 40^0 C.

DISTRIBUTED LOADS:

The ASTM E-72 test reported by NH Materials Laboratory Inc. reports tests undertaken at the Kalwall facility in 1997. These tests were made on a roof section 12ft x 5ft (approx 3.6m x 1.8m). The section was loaded at the quarter points with loads increasing up to 4500lbs (approx 2000 kg). Deflections were measured at the mid points of the long side. The maximum load applied converts to a uniformly distributed load of 4.3 kPa (kN/m^2).

Three different products were evaluated all with the same or similar results, namely that structural integrity was sustained during the tests. It can be safely assumed that the BS requirement of only 0.6kPa is met with a wide margin.

18. Quality Control

As part of the European Technical Approval and CE Marking Process, compliance with the European product standard has to be demonstrated by Factory Production Control (FPC). This entails audits by a Notified Body and has been carried out by the Belgian Construction Certification Association.

The Factory Production Control (FPC) is defined in the Construction Products Directive as a control system to be introduced by the manufacturers to monitor their production, to ensure that the required product characteristics are achieved and maintained consistently by the output. Every aspect of this control system should be documented in a body of written policies and procedures, and as such is an integral part of the QMS.
More information on the general requirements of the FPC is set out in the Construction Products Directive.

For more detailed information please see Section 7, European Technical Approval, ETA-07/0244, Section 7, Pages 8, 9 & 10

19. DESIGN RULES AND APPLICATION RULES

DESIGN RULES

The design rules are in the Kalwall material and take into account the calculation of deflection and stresses in line with the specifications of the project.

On the basis of the wind loads and horizontal loads, the calculation of the deflections and stresses are done in the I-Beam and the imposed allowable deflections are verified.

The calculations are done in line with the Euro code 1, EN 1991-1-4 and the national annex of the country in which the panels are installed.

20. MAINTENANCE

All current Kalwall Systems standard exterior faces are full thickness, colour stable, and include a permanent glass erosion barrier and a self-cleaning surface. Normal rainfall will keep Kalwall free of dust and dirt. A periodic wash with soapy water and a clear water rinse is recommended. The Kalwall Erosion Barrier prevents erosion caused fibre bloom.

As the face sheet weathers, the full thickness resin retains its colour. The reinforcing fibres are contained within the sheet. The weathering surface will lose its sheen and become matt. While no coating replacement is required, original face sheet lustre can be restored following these guidelines:

15 to 20 years on north and east vertical exposures.
12 to 20 years on average exposures.
10 to 15 years on roofs and intense sunlit exposures.

Kalwall Weather seal #85, a transparent coating will, if applied within the above times, restore the original lustre satisfactorily.

PLEASE ALSO SEE SECTION 7, EUROPEAN TECHNICAL APPROVAL, ETA-07/0244