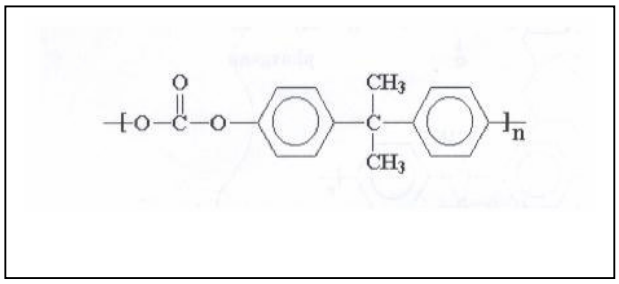
Rowad PC Manual

Polycarbonate



1.0 PROFILE

ROWAD Polycarbonate sheet offers the ideal combination of impact strength, cost effectiveness and energy efficiency. No glazing alternative can surpass **ROWAD** Polycarbonate sheet for superior all round performance. It's the right choice for almost any demanding glazing application.

ROWAD Polycarbonate sheet is as clear as glass and 250 times stronger. It's also 30 times stronger than Acrylic sheet - offering a margin of safety that no other clear glazing material can beat. With its inherent design flexibility, ROWAD can be cut or cold-formed on site during installation without the pre-forming and fabrication associated with glass or acrylic. It is lightweight and requires less structural support compared to all-glass systems, saving additional time and labor costs. Of course, its durability and energy efficiency add up to long term cost savings, too. From skylights and barrel vaults to educational and institutional glazing, the question is not why, but where is Rowad Polycarbonate?

1.1 Applications

Industrial

Machine covers
Machine guard/protectors
Lighting Fixture Signs
Electrical Insulation
See through elevators/lifts
Riot protection shields
Appliances
Signboards/Road
Chemical Reactors/Covers
Vending Machine
Medical Applications

Polycarbonate sheets in green house

Construction/Building

Covered walkways
Roof covers,skylight roofing

Partitions
Door and window panels
Noise reduction panels
Bus shelters
Green House Roof
Street furniture
Light domes
Design and display
Bill boards
Display items/frames/covers
Foldable displays
Panel board
Beer crates
Table top displays
Don't let material limitations compromise your design creativity - **ROWAD** sheet is designed to perform in a wide range of applications and meets all standard architectural specifications and codes

1.2 Rowad Polycarbonate offers the following protection and Specific Characteristics:

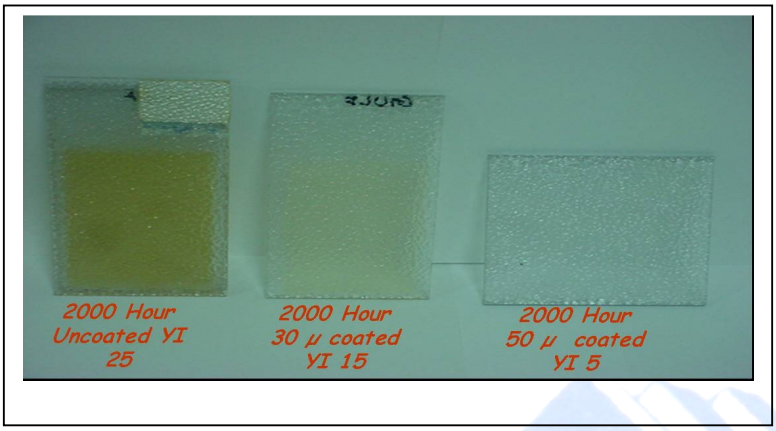
1.2.1 Impact Protection

Unsurpassed by any clear glazing product on the market, **ROWAD** sheet is hundreds of times stronger than plate glass and many times stronger than acrylic. This tough, long lasting material offers attractive protection in areas subject to high traffic, vandalism or burglary. It even withstands natural forces like severe wind, hail and snow storms.

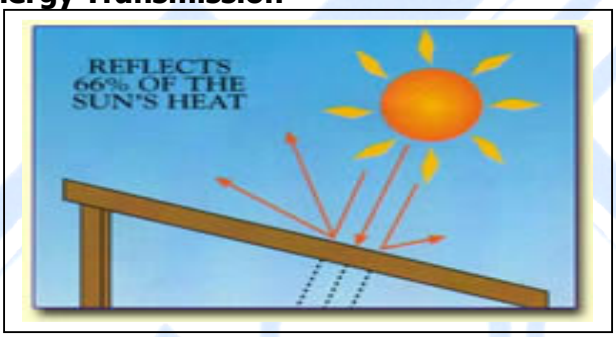
In fact, **ROWAD** sheet meets stringent state mandates for hurricane resistant glazing materials
ROWAD Polycarbonate sheet exhibits excellent retention of impact strength and stiffness at elevated and sub-zero temperatures
ROWAD Polycarbonate sheet has a continuous use temperature of 100°C on the positive side and -40°C on the negative side

1.2.2 UV protection

ROWAD Polycarbonate sheet is UV protected to give excellent durability to outdoor weathering and to resist the degrading effects of direct sunlight and other harmful UV sources.



1.2.3 Solar Energy Transmission



Where the intensity of direct sunlight is excessive, transparent bronze and grey grades of **Rowad** Polycarbonate reduce the light transmission to 66%.The specially tinted sheet cuts down the brightness of the sunlight to a pleasing level and helps reduce air conditioning costs during the summer months.Tinted sheet reduces the solar heat gain and therefore contributes significantly to greater comfort in both winter and summer.
The K-value of glass is 1.2 times that of solid PC sheet and is 1.7 times that of hollow PC sheet. So PC sheet can prevent heat loss and save more energy.

1.2.4 Sound Insulation

When applied together with existing glass and and an air space,sound transmission is drastically reduced.The sound deadening properties of **Rowad** Polycarbonate sheet are better than those of plate glass of equal thickness

1.2.5 Wind Resistance

ROWAD sheet rooflights can withstand wind suction loads of up to 1.2KN /m².The sheet thickness depends upon the wind pressure in the area concerned.

1.2.6 Chemical Resistance

Rowad Polycarbonate sheet has excellent resistance to acids, greases oils, saturated hydrocarbons and oxidizing and reducing agents.

Rowad Polycarbonate sheet is resistant to common household detergents and cleaners.
Rowad Polycarbonate sheet crazing occurs at high stress levels by low molecular weight hydrocarbons..Acetone and Xylene cause stress cracking even at low stress levels and their contact should be avoided.
Rowad Polycarbonate sheet is compatible with several building and glazing materials. However, the compatibility with individual chemicals has to be tested before used.
Polycarbonate panels are resistant to some chemical and products non-resistant to others. Resistance can be affected by the chemical concentration, duration of exposure, degree of pressure and temperature at time of contact**.**

The following chemicals are considered safe:		
Acetic Acid	Carbon Monoxide	Mercury
Ammonium Chloride	Citric Acid - 10%	Methane
Antimony Chloride	Copper Sulphate	Oxygen
Borax in Water	Ethyl Alcohol - 95%	Ozone
Butane	Ethylene Glycol	Sulphur
Calcium Chloride	Formain - 10%	Urea
Calcium Hypochloride	Hydrochloric Acid - 20%	Water
Carbon Dioxide	Hydroflouric Acid - 5%	
The following require caution:		
Cyclohexone	Glycerin	Sulphur Dioxide
Diesel Oil	Heating Fuel	Turpentine
Formic Acid	Jet Fuel	
Gasoline	Perchloric Acid-Conc.	
The following will attack polycarbonate:		
Acetone	Caustic Soda	Methyl Ethyl Ketone
Acrylonitrile	Chloroform	Perchloroethylene
Ammonia	Dimethyl Formamide	Styrene
Amyl Acetate	Hydrochloric Acid-Conc.	Toluol
Benzene	Hydroflouric Acid-Conc.	Sulphuric Acid-Conc.
Bromine	Iodine	Xylene
Butyl Acetate	Methanol	

1.2.7 Fire Performance

Although **Rowad** Polycarbonate sheet melts under intense heat or fire it makes no contribution to the growth of fire through flame spread. **Rowad** polycarbonate sheet softens at a relatively low temperature allowing fire,smoke and hot gases to escape as Polycarbonate is a self venting material

1.2.8 Design Latitude

ROWAD sheet is extremely ductile. It can be cut on site from flat sheet or cold-formed into curves that would be impossible to construct with laminated glass or acrylic. Forget about costly factory pre-forming and fabrication. With **ROWAD** sheet you can create cost effective, yet distinctive structures featuring dramatic expanses of curved glazing.

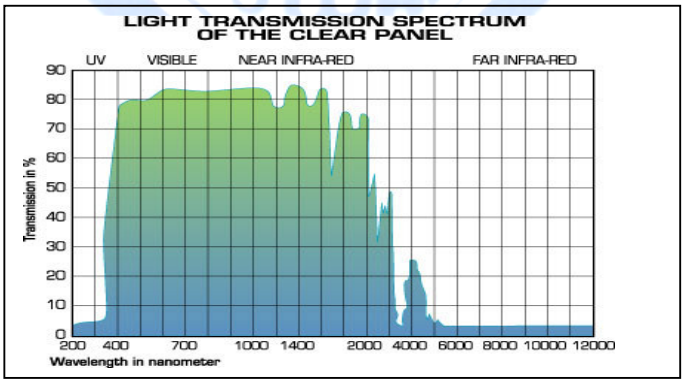
1.2.9 Cost Efficiency

The unique combination of light weight (half of glass) and high strength inherent in **ROWAD** sheet allows designs that require less structural support. Since **ROWAD** sheet can be cut and cold-formed on site, you save time and money that would normally be dedicated to pre-installation techniques like oven bending. And as **ROWAD** Polycarbonate sheet is much more durable than other material options, the cost of replacement becomes a less immediate (and less costly) concern.

1.2.10 Energy Efficiency

ROWAD sheet is a superior insulating material when compared to equivalent thicknesses of glass. Double-glazing and over-glazing offer even more energy savings. Over-glazing with a textured grade of **ROWAD** sheet adds visual security and enhances the appearance of industrial and commercial sites

1.2.11 Light and Energy Transmission



By allowing the transmittance of up to 90 percent of solar energy and 88 percent of visible light, clear **ROWAD** sheet is an excellent glazing material for a wide range of applications where clarity is essential. **ROWAD** sheet is also available in grey and bronze tints to help control heat gain, and a variety of privacy patterns for obscure glazing requirements

Light Transmission

Thickness	4.5 mm	6 mm	8 mm	10 mm	16 mm
Clear	82%	80%	80%	79%	78%
Bronze	42%	42%	42%	42%	42%
Opal	44%	44%	44%	44%	44%
Grey	42%	42%	42%	42%	42%
Insulation Values					
Thickness	4.5 mm	6 mm	8 mm	10 mm	16 mm
R-Factor	1.47	1.55	1.57	1.63	1.83
U-Factor *(BTU/hr/ft2/°F*	0.68	0.645	0.635	0.615	0.545

1.3 ROWAD Polycarbonate Glazing

Polycarbonate Glazing As Tough As You Demand.Think of all the places that you wish you could have put glass or acrylic in your designs, but could not due to the environment, building location, or material limitations. Now think of the demanding applications where glass and acrylic have been tried and failed; schools, psychiatric facilities, subways, bus shelters - the list is growing due to increased violence and vandalism. Think of applications where other plastics won't rise to the challenge. Now try **ROWAD** Polycarbonate sheet and make your designs a reality.
The family of **ROWAD** Polycarbonate glazing products, offer superior durability, unmatched design flexibility and structural integrity that easily surpass laminated glass and acrylic alternatives.

1.4 Allowance for Thermal Expansion

Rowad Polycarbonate sheet has greater linear thermal coefficient of expansion than other materials such as glass, steel and aluminium.Hence, care must be taken to allow for free expansion of the sheet to prevent bowing and internal thermal stress.Thermal expansion allowance must be made for both length and width of the **Rowad** sheets.
In practical terms it is necessary to allow 3.5mm/metre length and width for thermal expansion.

2.0 Properties of Rowad Polycarbonate Sheet

TYPICAL PHYSICAL PROPERTIES	ROWAD SHEET	UNITS	TEST METHOD
GENERAL			
Specific Gravity	1.2	gms/c.c	ASTM D792
Water Absorption	0.30	%	ASTM D570
Rockwell Hardness	M70-M78	Rating	ASTM D785
Oxygen Index	28	%	ASTM D 2863
Flammability, V-2 rating	1.48	mm	UL-94
Refractive Index	1.59		

OPTICAL			
Light transmission, 1 mm	89	%	ASTM D1003
Haze, 3 mm	1.0	%	ASTM D1003
Yellowness Index, YI (3yrs)	< 8	-	ASTM D1925
ABRASION RESISTANCE (AR)			
Taber Resistance, 100 cycles	0.6	%	ASTM D1044
Taber Resistance, 500 cycles	1.0	%	ASTM D1044
THERMAL			
Heat Deflection Temperature	132	°C	ASTM D648
Vicat Softening Point	148	°C	ASTM D1525
Thermal Index – Electrical Properties	100	°C	UL746B
Thermal Index – Mechanical Properties	120	°C	UL746B
Coefficient of Linear Thermal Expansion	0.065	mm/m°C	ASTM D696
Shrinkage	3.0	%	ISO 11963
Smoke Density, 3 mm	60	-	ASTM D2843
Thermal Conductivity	0.21	W/mk	DIN 52612
U – Value, 3 mm	5.49	W/m²	CEN 673
Shading Coefficient Clear	1.02		
Shading Coefficient Gray/Bronze	0.79		
Specific Heat	0.3		
MECHANICAL			
Tensile Strength, Yield	60	MPa	ASTM D638
Tensile Strength, Ultimate	72	MPa	ASTM D638
Tensile Strain, Yield	6	%	ASTM D638
Tensile Strain, Ultimate	125	%	ASTM D638
Tensile Modulus	2400	MPa	ASTM D638
Compressive Strength	73	MPa	ASTM D695
Flexural Strength at Yield	100	MPa	ASTM D790
Flexural Modulus	2400	MPa	ASTM D790
Izod Impact Notched (23°C)	65	KJ/m²	ASTM D256
Charpy Impact Notched (23°C)	40	KJ/m²	ASTM D256
Impact Resistance (Falling Weight)	62	Joules	ASTM F736
ELECTRICAL			
Volume Resistivity	>10(16)	Ohm.Cm	ASTM D257
Dielectric Strength	30	KV/mm	ASTM D149
Dissipation Factor (1MHz)	0.01		ASTM D150

3.0:FORMING

3.1 Cold Bending

The following procedures are recommended when cold bending **ROWAD** Polycarbonate sheets.

1 - The sheet should be cut to its pre-bending size with very smooth edges. Any cracks, saw lines or roughness on the edge may initiate a crack along the bend line when cold bending. If the trimming is done with a rough saw or guillotine, the surface must be smoothed around the bend line edge before bending

2 - Cut and bend the sheets with the polyethylene masking foil in place

3 - Bend the sheet at a relatively high speed

4 - To achieve the required angle, the sheet must be bent 20-40 degrees

more than the required angle. It is recommended to perform some tests with small size sheets before starting production.

5 - Bend the sheets with the upper side out (the printed side facing out) in order to reduce the chances of cracking along the bend line

6 - Textured sheets should only be bent so that the textured surface is in compression

7 - Colored sheets can show tint variations upon bending

8 - It is important to use tools that were designed for use with plastic sheets. Not all the standard metal tooling is suitable for plastic sheet

9 - It is important that the knife and anvil possess a good polished surface with no projections or splinters

10 - The knife should have a straight parallel profile with a rounded tip whose radius is 4-6 mm. A thicker sheet requires a larger the radius

11 - Take care not to squeeze the sheet between the knife and anvil when bending. Squeezing of the sheet will cause a non-esthetical bend and may induce high stresses, which may reduce the impact resistance of the product. Calculate the anvil span and knife thickness according to the sheet thickness so as to avoid squeezing

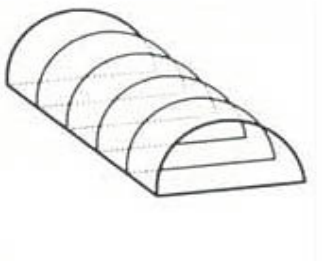
Rowad PC sheet can be cold formed into circular shapes for walkways etc.They may be cold bent with the minimum radius based upon the sheet thickness. As a guideline, the material can be radiused to 100 times the thickness: (R = T x 100)

Cold Bend Radii

Sheet Thickness (T)	Minimum Radius (R)
3.0 mm	300 mm
4.0 mm	400 mm
6.0 mm	600 mm

Arch Bends

Minimum bend radius for cold forming Rowad sheets in an arched application: 4.5 mm/550 mm 6.0 mm/600 mm; 8.0 mm/800 mm; 10.0 mm/1000 mm, and 16.0 mm/ 2400 mm



3.2 Thermoforming

This page describes various methods for handling and processing **Rowad** Polycarbonate flat sheets. The data is based on experience gathered by Rowad Plastic Co Ltd and other end-users of ROWAD flat Polycarbonate sheets

This information, while accurate to the best of our knowledge, should be regarded as a recommendation only, and no liability for the consequences of its use will be accepted by Rowad Plastic Co Ltd

ROWAD polycarbonate sheet can be thermoformed on standard equipment. Vacuum forming, free blown forming and line bending are the most extensively used processes.

While most standard forming techniques can be used, critical process modifications specific to polycarbonate are necessary to ensure uniform and repeatable formed parts.

Forming **ROWAD** Polycarbonate sheets should always be done when the formed zone is at a temperature above the Melt Temperature which is approximately 150° C. Any failure to do so will result in high internal stresses that might greatly decrease impact resistance and increase chemical sensitivity. Unlike other plastics, these internal stresses cannot be seen by the naked eye and can only be detected with the use of a light polarizer. Annealing can solve this problem in certain cases; however, the problems encountered in annealing make it complicated and inefficient.

3.2.1 Pre-drying ROWAD Sheet

ROWAD sheet must be dried before thermoforming because Polycarbonate absorbs moisture at a high rate. Trapped moisture forms vapor above 120°C, and the vapor expansion creates bubbles in the sheet

For best results and to reduce brittleness work over a warm mould of about 60 °C

Sheets of **ROWAD** should be placed in a dehumidifying air circulating oven for pre drying with approximately 25 mm separation between sheets. Oven temperature should be 120°C and monitored with controls. Recommended pre drying time periods are:

THICKNESS	**Time (Hours)**
2.5 mm	3
4.0 mm	6
6.0 mm	15
8.0 mm	24

A Note of caution - *Polycarbonate sheet begins absorbing moisture immediately upon removal from the pre drying oven. The rate of absorption is dependent upon the ambient humidity. For this reason, it is crucial to transfer the sheet directly to the forming machine as quickly as possible.*

3.2.2 Forming Equipment

The thermoforming machine should be capable of generating and maintaining a vacuum of 50 cm. Mercury pressure throughout the thermoforming cycle.
Vacuum forming machines with infrared heating elements perform well for **ROWAD** sheet forming. Rotary and shuttle designs with automatic or semi-automatic controls are most suitable. Key features of this type for equipment are timer control accuracy, uniform heating sources and sufficient vacuum power. Single-sided heating has proven effective for **ROWAD** sheet in thickness up to 4.5 mm. For thicknesses above 4.5 mm it is recommended that dual-sided heating covers be used for effective radiation penetration

3.2.3 Heaters

Infrared cal rod, coiled nichrome or ceramic heating elements provide the best heating sources. Gas-fired heaters or convection ovens are not normally used with Polycarbonate. Uniform heating of the sheet is critical

3.2.4 Heating Cycle

Heating **ROWAD** sheet for vacuum forming requires heat penetration to achieve 180°C to 190°C. When **ROWAD** sheet reaches forming temperature, uniform "sag" occurs. The amount of sag depends on the size and thickness of the sheet. A 300 mm x 300 mm x 2 mm sheet will sag approximately 25 mm. A 900 mm x 900 mm x 4.5 mm sheet may sag 115 mm at the center. Once uniform temperature has been achieved, timers can accurately reproduce the condition, and part-to-part consistency can be maintained.

Procedure:

- Sheet thicknesses up to 4.5 mm can be heated from one side. Above 4.5 mm, two-sided heating is normally required to significantly enhance productivity
- Heat source is removed and heated sheet is forced over or into mold where vacuum is applied

Helpful Hints:

- **ROWAD** sheet "sets up" very quickly compared to other thermoplastics and can be removed from the mold in a short period of time.

Caution: *ROWAD sheet remains quite hot during this cycle and care must be observed when handling finished parts.*

Throughout the vacuum forming process, it is imperative that dust and dirt be controlled. **ROWAD** sheet has a static charge that attracts foreign particles which can create surface imperfections. Molds also attract dust particles and should be cleaned to avoid creating surface defects

3.2.5 Shading or Screening

Shading is often used to balance out hot spots in an oven for uniform temperature. Shading may also be used to control the sag of **ROWAD** sheet during heating

Procedure:

- Use heavy-duty metal screening to shade the major portion of the clamped sheet, leaving several inches along the edges unshaded to compensate for cooler areas
- Screens can be installed permanently or placed loosely above the sheet, depending on how much shading is required

Helpful Hints:

- Use slow heating. This is particularly important with heavier thickness in order to prevent gradient heating
- Allow heat to reach uniformity at the center of the sheet
- The heating rate may be reduced by lowering the heat intensity or by moving the sheet farther away from the heaters

3.2.6

Thermoforming Troubleshooting		
Problem:	**Possible Cause:**	**Suggested Solutions:**
Bubbles or blisters	Too much moisture in sheet	Predry sheet for longer time period Check predry oven temperature
Pinholes or surface marks	Vacuum holes too large	Use smaller diameter vacuum holes
Mark off	Mold surface too smooth Mold surface too rough	Vapor hone or use extra fine emery cloth to lightly abrade mold surface Polish out tool marks in mold surface
Surface defects	Sheet or mold has dust or dirt on surface Mold too cold	Clean off sheet and/or mold before forming Preheat mold
Sheet pulls out of clamping frame during forming	Sheet too cold to form	Heat sheet for longer time period
Non-uniform sag	Uneven heating	Check heaters Screen "hot" areas
Incomplete part formation detail	Sheet too cold Inadequate vacuum	Heat sheet for longer time period Check vacuum system for leakage Increase vacuum
Webbing	Sheet too hot Improper mold spacing	Reduce heating cycle Redesign mold Use mechanical assist

3.2.7 MOLDS

In general, male molds are more suitable for vacuum forming. However, other factors such as part size, finish and shape dictate mold design. Choice of mold materials should be determined by considering the length of the production run. For optimum cost-effectiveness, use the least expensive material that will take the entire run.

It is evident that thermal transfer is much more efficient with aluminum than wood. Wood, however, can be utilized for short-run projects.
ROWAD sheet tends to reproduce mold surface finish quite faithfully, even to the point of replicating wood grain in a smooth wood mold
Sometimes it is desirable to reduce the polish on a steel or aluminum mold by utilizing a vapor hone or bead blast. This is due to the fact that if the mold surface is too smooth, air entrapment can occur creating "mark off." For best results, use fine hand sanding on the surfaces. Sanding provides tiny channels for air evacuation to prevent air entrapment. This may have to be repeated on long production runs, as the sanded finish smoothes out from extended use
When constructing the mold, mold shrinkage should be a design consideration. Shrinkage for ROWAD sheet is 0.13 mm – 0.14 mm. The heating/cooling cycle and the type of vacuum forming equipment will also influence results.

3.2.8 Mold Materials and Mold Design

Polycarbonate allows the use of a variety of mold materials: wood, filled and unfilled polyesters, epoxies and metals
For prototypes and small production volumes wood can be used. For medium to large production runs, cold curing epoxies or Acrylics or those filled with Aluminum are recommended. Sometimes cooling channels in the mould are required for faster cooling cycles. It is essential during molding that the mould temperature is kept constant to ensure part consistency
Molds for vacuum forming need to take only 1 bar, so there is little wear on the tooling with low pressure of the material against the mold surface
Draft angles: Minimum 5-7 degrees or greater for ease of part removal from the mold
Radii and Fillets: Use generous radii wherever possible for more uniform walls and greater rigidity. On female tooling, use permanent corner fillets
Vacuum Holes: In order to form the sheet as rapidly as possible use sufficient holes for fast evacuation of air from between the sheet and the mold. In female molds, use air evacuation holes at all deep draw areas, especially around the mold perimeter where the sheet will be drawn last. To avoid marks on the molding ,0.5 - 0.75 mm diameter holes are recommended
Helpful Hints

- Keep the diameter of the holes small (approximately 0.4 mm – 0.8 mm diameter) to avoid marking on the sheet. Long, thin slots may be designed for air evacuation in female tooling
- Use vapor hones or fine sanded finishes
- Avoid sharp corners to minimize stress
- Avoid highly polished surfaces that can cause mark off
- Always preheat mold. Cold molds can create surface defects and/or

warped parts
- If mold temperature becomes too high during thermoforming runs, ROWAD sheet could stick to the mold. It is recommended that the mold temperature not exceed 125°C

Forming Guidelines	
Sheet Temperature:	
Typical:	180 °C - 210 ° C
Optimum:	180 °C - 190 °C
Mold Temperature:	98 °C - 125 °C

Straight vacuum forming in a female mold is recommended for low-profile parts where deep draw is not a requirement.
Drape forming over a male mold, usually results in better material distribution and depth-to-diameter draw ratios
Thinning of material in deep-mold cavities can be overcome by use of plug assists designed for fast penetration
Vacuum forming with snap-back, can reduce starting sheet size, aid material distribution and minimize chill marks
Air-slip forming is similar to vacuum snap-back except that heated sheet is billowed up and mold rises to meet it
Forming with billow plug, is often used to produce thin-wall items with depth-to-diameter draw ratios up to 1.5 : 1

3.2.9 Free Blown Billow Forming of Dome

Billow dome forming is utilized for forming dome shapes from ROWAD sheet and can be done with positive air pressure (free blown) or negative pressure (vacuum)

Procedures:

- Preheat all clamps and tooling (115 - 125°C).
- Pre dry ROWAD sheet in air circulating oven at 120°C
- Place ROWAD sheet in clamping frame of thermoforming machine
- Heat sheet until uniform sag occurs (180 - 210°C).
- Remove heat source
- Lower pressure box to seal air supply pressure
- Apply air pressure. Initial air pressure is high, and as dome is created, air pressure is reduced
- When overall height is achieved, maintain positive air pressure until part cools
- Be sure air source is properly filtered and uniformly dispersed for even formation of dome
- Utilize electric eye designs or micro switches to assure consistent

product
- When dome reaches electric eye, set height. The eye controls air pressure though a solenoid valve to control cooling.
- Remove and trim

3.2.10 Free Drawn Vacuum Dome Forming

Procedures:

- Place sheet in clamping frame of thermoforming machine
- Heat sheet until uniform sag occurs (180 - 210°C).
- Remove heat source
- Apply vacuum seal box and apply vacuum pressure
- Use electric eye or micro switch to assure consistency of depth of dome
- Retain small amount of vacuum pressure until dome sets up
- Remove and trim

3.2.11 Registration Forming

ROWAD is suitable for registration vacuum forming. Because the material is extruded, it is important to orient the sheet so that each part is screened and formed in the same direction each time. Materials should be specially ordered for this application. Dimensional stability tests indicate **ROWAD** is free form releases stress about 2-4% in the direction of extrusion and 1% across the extrusion web

3.2.12 Drape Forming

Simple contours can be achieved by drape forming **ROWAD** sheet. The sheet should be pre-dried, then brought to a forming temperature of 160 – 170°C in the oven

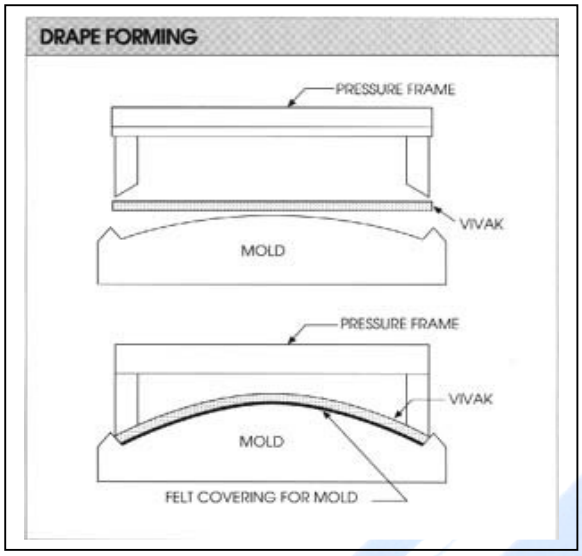
Parts are then removed and placed immediately over a male mould covered with felt.

This method can be utilized to manufacture a part requiring a simple radius of curvature such as face shields.

Mold material can be wood, fiberglass or aluminum covered with felt.

Procedure:

- Pre dry ROWAD sheet
- Bring to forming temperature of about 180 - 210° C in the oven
- Remove parts and immediately place over a male mold covered with felt
- Apply pressure until cool



3.2.13 Strip Heating ROWAD Polycarbonate Sheet

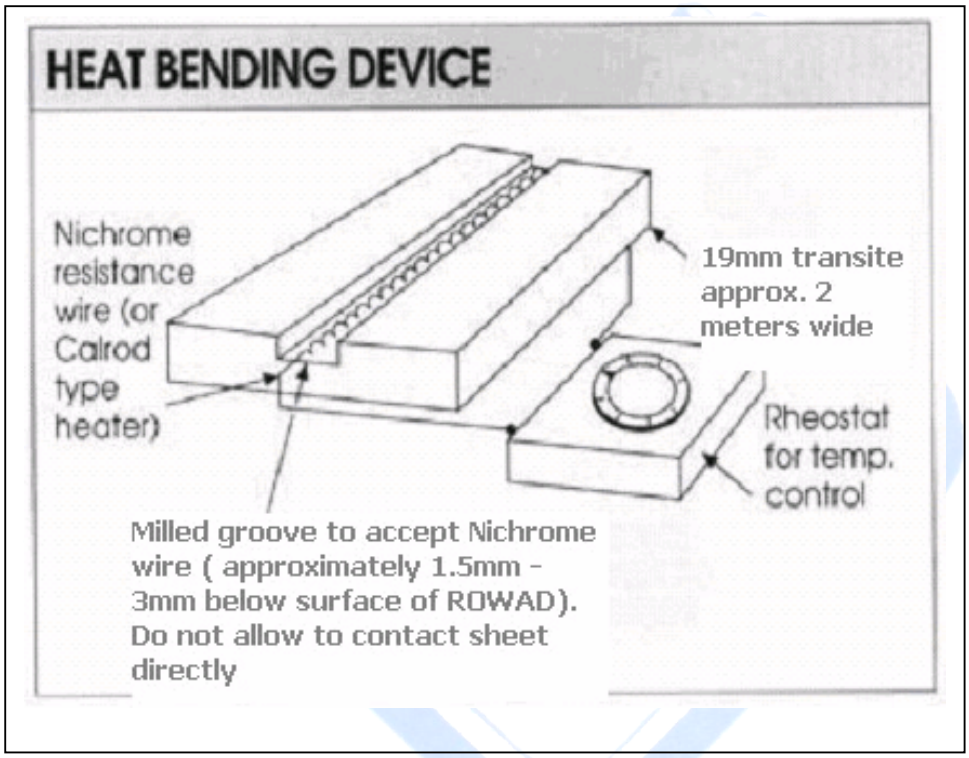
Strip heating or line bending is commonly used for producing localized angular bends in Polycarbonate. Generally, pre drying is not required for material thicknesses of 3 mm or less. On thicker gauges, pre drying can be avoided by back-routing or V-grooving the sheet to a 3.2 mm or less thickness.

Procedure:

- Remove protective masking in bend area
- Regulate nichrome heat source to 170 - 185°C maximum
- Place sheet over heat source at bend area.
- Allow heat to soften material. Time depends on gauge
- Remove sheet and make desired bend on wood or heavy fabric-covered aluminum fixture
- Bend immediately - Polycarbonate sets up quickly
- Allow sheet to cool in fixture
- Some bends may require a degree of over bending to achieve desired angle after sheet sets up. Strip heating works best for relatively short parts - wide parts may warp
- Avoid bending short tabs on wide parts; warping may occur
- For thicker gauge sheet, use two-sided heating. (Repeated turning with one-side heating may also achieve sufficient heat penetration.)
- Thicker gauge sheet (above 3.2 mm) can be V-grooved to allow sharper bends

Strip Heating Troubleshooting		
Problem:	**Possible Cause:**	**Suggested Solution:**
Bubbles in bent area	Too much heat	Reduce temperature

Warpage	Part too wide for heat bending Heating not uniform Cooling not uniform	Heat from both sides to provide more uniform heat penetration Check for air drafts which may affect uniform cooling Do not try to bend short (under 25 mm) sections
Mark off	Heater is contacting plastic. Transite is too hot. Masking is not removed over sufficient area where heat is being applied	Lower heat source



3.2.14 ANNEALING

The use of optimum processing conditions minimize the internal stresses. But parts with high internal stresses should be annealed to avoid failure in service. This can be done by heating the parts evenly in an air circulating oven at 125°C for an hour for every 3 mm of the part thickness. Then the part has to be cooled slowly to room temperature, preferably in an oven with the doors closed

3.2.15 COOLING

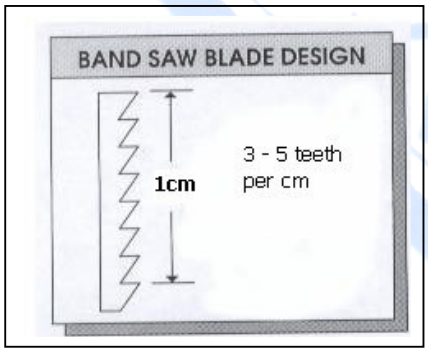
Cooling times are dependent on a number of factors such as ambient temperature and humidity, mould material, mould temperatures, cooling system, part thickness and its design. As Rowad sheets have high heat deformation temperature the moldings can be removed from the mould at 130°C without facing the risk of deformation

4.0 FABRICATING

4.1 Cutting:

4.1.1 Circular Sawing: A table saw or overhead panel saw is typically used for cutting Polycarbonate sheet. A circular saw blade with carbide teeth, utilizing the "triple chip" tooth design, is the preferred method. Blades for cutting 3 inch and thicker material should have three to five teeth per inch and the hook or rake angle should be 10-degrees to 15-degrees. Circular saws should be run in the speed range of 6,000 to 8,000 feet per minute.
When sawing thin gauge Polycarbonate, it is important to have a good supporting edge on the saw table with minimal gap between the saw blade and table-supporting edge. Care should be taken to ensure that tabletops are smooth and free from projections that might scratch or mar the sheet

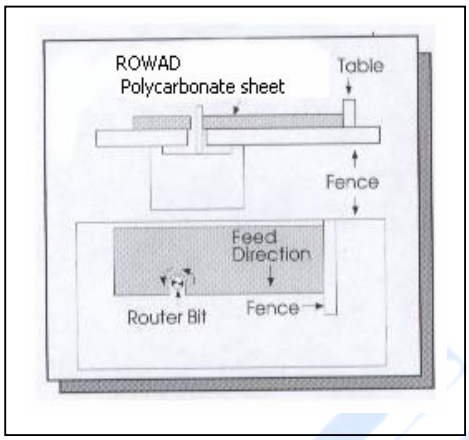
4.1.2 Band saws: Band saws are useful for trimming formed parts or irregular shapes. Band saws should be run at 2,500 to 3,000 feet per minute, and have eight to 12 teeth per inch. Coarser (larger) blades perform better with thicker gauge Polycarbonate sheet. Proper support of the part to be trimmed is important because vibration may induce cracking if the cut is not smooth
Band saw is used to cut formed parts or irregular shapes. Keep widths of 10 – 20 mm for blades. Cutting speed 20 – 25 m / min, blade speed, of 600 – 1000 m/min and tooth spacing of 1.5 - 2.5 mm is recommended



4.1.3 Jig Saws and Hack Saws : The most important consideration with type of cutting is support and clamping, particularly with the use of jig saw Blades having a tooth spacing of 2 – 2.5 mm are ideal with the emphasis upon low cutting feeds.

4.1.4 Routing: Routing produces a smooth edge on Polycarbonate sheet and may also be used to cut curved or irregular shapes. Routers with at least 1-horsepower motor and speeds of 20,000 to 25,000 rpm are preferred, used in conjunction with 1 inch to 1.25 inch diameter straight (fluted 2 or 3), carbide-tipped or high speed steel router bits.
The stock feed must be monitored closely as feeding Polycarbonate sheet at

excessive rates can cause vibration and cracking. It is important to feed the sheet against the rotation of the router bit and to provide a fence for sizing when making straight cuts



4.1.5 Shearing: Die cutting Polycarbonate sheet in gauges up to 2 mm thick is normally achieved by utilizing the following steps to calculate the required press tonnage:

F = (P x A)/2,000

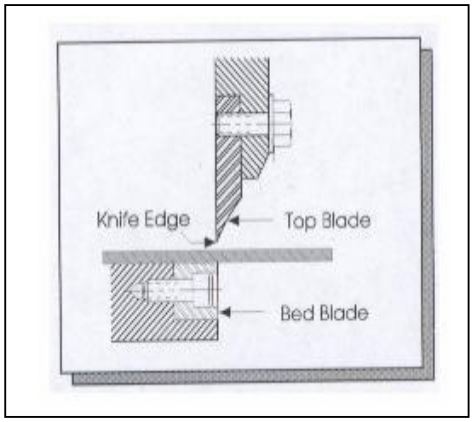
where F= required force in tonnage of the press, P=10,000 psi (shear strength of Polycarbonate sheet) and A= the sectional area to be cut

Steel rule dies mounted in a press provide good results. Use 3PT-thick (1 mm) steel to fabricate steel rule die-flush, or center bevel ground provides a clean cut. Facet ground steel rule is used to cut thicker gauge sheets, above 10 mm. Be sure the platens are parallel and that the backup pad is in good condition. Backup pads can be made from a variety of materials such as nylon, HDPE, etc.

Guillotine shear cutting is possible, but not recommended for thicknesses of more than 5-6 mm

as the cut edge will usually be rough and distorted

ROWAD Polycarbonate sheets are easily cut with wood-cutting saws. Avoid using high-speed equipment made for cutting steel, since the friction tends to melt the Polycarbonate



4.1.6 Laser cutting with industrial IR laser machines is possible. The cut usually looks burnt and internal stress may result due to high local temperature. When laser cutting, it is recommended to anneal the part at 130 °C for 1-2 hours

4.1.7 Water jet cutting with a properly tuned machine can give good results

4.2 Machining:

Polycarbonate is easy to machine. Special care should be taken to prevent overheating and melting due to high friction. If high turning speeds are used to achieve good surface quality, it may be necessary to stop the machine periodically to allow the part to cool. Sharp tools are essential in preventing friction heating

Suitable clamping is very important. Mechanical jigs and fixtures, or vacuum chucks provide a suitable clamping medium.

Forced air cooling is recommended for higher cutting rates. The use of cutting fluids to lubricate or cool the sheet is not recommended

4.3 Drilling :

Drills meant for plastics/metal are suitable. Standard high speed steel twist drills or drills with an angular wedged bit can be used for drilling **ROWAD** sheets. Carbide tipped drills can also be used since they retain their sharp cutting edge. Adequate clamping is required to reduce vibration and ensure a desired hole size. In case of deep drilling cooling with compressed air is required. Drilling should be done only at a minimum distance of 25 mm from the edges of sheets OR at a distance of 1.5 times the diameter of the hole. All holes must be larger than the bolt or screw or fixing to allow for thermal expansion and contraction.

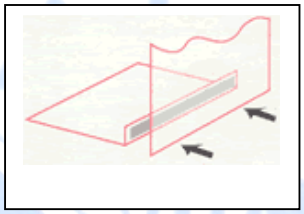
5.0 BONDING AND FASTENING

5.1 Adhesive Bonding

For small objects, where high-impact resistance is not essential, it is

convenient to use hot-melt adhesive guns. The best hot-melt is the Polyamide based type, though others such as EVA are also effective
For semi-structural, high-impact, outdoor weather resistant uses (bonding sheet edges in skylight domes to the frame or to another sheet, building aquariums, sealing car window frames, etc.), we recommend "Dow Corning" Q3-7098. Q3-7099, 3793 or "0tto Chemie" Novasil S-64 silicone sealants. These adhesives require no primer besides degreasing with isopropyl alcohol if the sheet surface is not clean. The adhesion to Polycarbonate is excellent and application with a 300cc tube dispenser is convenient. They bond Polycarbonate to metals, glass and other plastics, including Polycarbonate itself. The only drawback is that the adhesive is not available in transparent colors, but only in opaque white or clear .

For superior bonding strength, impact and tear resistance as well as high transparency. "Engineering Chemical" Polyurethane HE 17017 and HE 1908 are recommended. These are two-component type systems that are more difficult to work with than single-component adhesives. These should be used only where the highest mechanical and optical properties are required, such as ballistic glazing in which Polycarbonate and glass are bonded together.
For bonding flat sheet parts such as mirrors or small shelves to flat surfaces such as walls, doors, ceramic tiles etc., we recommend "3M" double-sided stick tape 4830. This is an acrylic foam adhesive that offers excellent adhesion of Polycarbonate to flat surfaces

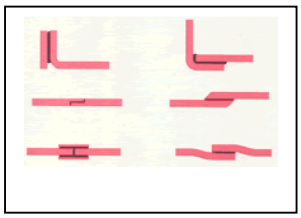


TAPE BONDING

There are many other adhesives that are compatible with Polycarbonate, but extreme caution should be used to avoid use of any that are solvent-based. Solvent-based adhesives can and do cause serious failures in critical places. Furthermore, it should be noted that some adhesive tapes of the pressure-sensitive type contain solvents or solvent traces which may cause stress cracking within months of application .
Our laboratory offers a testing service for those clients who wish to check if an adhesive is compatible with **ROWAD** products.

5.1.1 Welding is used to assemble opaque sheets only otherwise welding is not a preferred technique due to poor aesthetics. Hot air welding or ultrasonic welding are recommended for opaque sheets

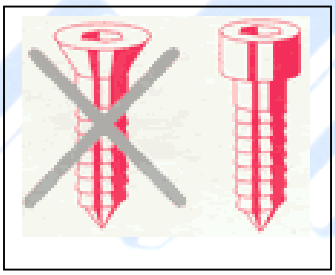
5.1.2 Lap joint and Butt joints of various kinds are possible with ROWAD Polycarbonate sheets



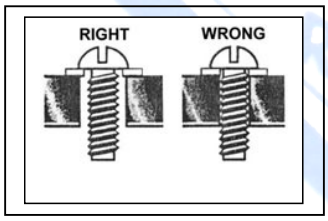
JOINING

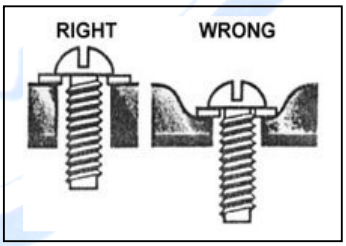
As the Polycarbonate sheets have higher coefficient of linear thermal expansion than metals and glass, enough allowance should be made while drilling holes to allow for expansion under fluctuating temperatures. Allow 3 mm on each side for expansion

5.1.3 Mechanical Fastening



Machine screws and Aluminum rivets may be used to join Polycarbonate sheet to other materials. To do so, drill oversized holes and use washers to distribute and cushion localized stress. Fabricators should be sure to consider the differentials in expansion factors for dissimilar materials. Also, be sure drilled holes are smooth and free from cracks





All types of nails and screws likely to cause stress cracking have to be avoided. Use of screws with chamfered heads must also be avoided as they cause stress cracking. Rubber or metal washers may be used. But do not over tight the screws. For plastic to metal joints, the head of the rivet should be against the plastic and the hole on the sheet should be large enough to allow for thermal movement. Rivet diameters should be approximately equal to the total thickness of the material and spacing should be between 5 – 10 times their diameter. Use of Aluminum, brass and copper rivets is recommended.

The Glass transition temperature of Polycarbonate is –112°C. Hence, the Rowad sheet can also be used at sub- zero temperatures. As the sheet

surface is UV protected the properties of the sheet almost remain unchanged during the service life of the sheets even when exposed to direct sun light.

5.1.4 JOINT-PLANING

A standard woodworking jointer/planer is an excellent edge finishing machine for Polycarbonate sheet. Blades must be made from carbide or high speed steel. Fabricators are advised to avoid removal of too much stock on each pass; trying to remove too much material may result in a rough edge or cracked sheet. Usually one inch or less stock yields the cleanest edge. If smoother edges are required, wet sanding with a fine grit #200 sand paper is recommended

6.0 FINISHING: CLEANING AND POLISHING

For cleaning and degreasing before painting or bonding, use isopropyl alcohol (IPA). Apply with a soft cotton cloth or cotton wool. If the IPA contains water and water droplets appear after the IPA has evaporated, finish by wiping with a dry cloth. This method may also be used if any marks remain from the PE masking film .

For cleaning, dusting or polishing glazing, commercial spray cleaners, which contain specially designed waxes and solvents, are available. They leave a glossy, protective layer that is antistatic and dust repelling. The ideal maintenance procedure is to clean and polish the sheet every one to two weeks with a spray cleaner using a soft rag made from 100% cotton. Please consult with your local Rowad agent or representative for recommended preparations available locally .

It is possible to clean Polycarbonate with a soft cloth made from 100% cotton using a mild detergent and water. It is best to use mild dish cleaning preparations. Glass cleaning agents that contain Ammonia should be avoided, as they will damage Polycarbonate. Use of a mild detergent and water may result in a residue build-up. In that case, use the preferred alternative described above at least to remove the residue .

Under normal conditions, ROWAD should be washed on a regular basis with a mild solution of soap and warm water, using a soft cloth or sponge. To prevent water spots, thoroughly dry ROWAD sheet with a chamois or sponge. Do not use abrasive cleaners or sharp instruments such as razor blades or scrapers that may gouge the surface. For graffiti removal, organic solvents such as butyl cellosolve, kerosene, naphtha or mineral spirits work very well. Methanol, denatured ethanol and isopropyl alcohol are also excellent cleansing agents. It is important to rinse off the surface thoroughly after cleaning.

6.1 PAINTING

It is possible to paint Rowad Polycarbonate sheets with a variety of painting agents. Two-component paints such as Polyurethane or Epoxy-based paints

are usually compatible. We suggest that solvent-based paints be avoided, as most solvents and thinners may damage Polycarbonate. If, however, very rapid drying is possible and all residues of the thinner evaporate immediately, it is possible to use standard printing or silk screen equipment and paints. Most paint suppliers have standard paints which are compatible with Polycarbonate. In case of doubt, a compatibility test of a specific paint with ROWAD Polycarbonate sheets can be performed in our laboratory

6.2 HANDLING AND SAFETY

ROWAD Polycarbonate sheet is not scratch resistant and hence care has to be taken in their handling. The outer Polyethylene lamination film has to be removed only just before use to prevent scratches and dust accumulation. There is no necessity to remove the Polyethylene lamination film where thermoformable laminating film is used

Always store the sheets in clean, dry and cool places, preferably at 23°C and 50% humidity.

Keep the sheets always away from heat sources.

Try to follow the FIFO (First in first out) method to consume the sheet stocks

7.0 Rowad PC Sheet Glazing

Maximum sheet deflection – 50mm for large sizes and 1/25 of the width for smaller sizes.

The normal wind loads in Saudi Arabia is 1250 N/m², with extreme wind load up to 2000 N/m².

The Glazing factor tables are as mentioned below

Table (A) – Glazing factor in terms of sheet length and width

	Width							
Length	**250**	**500**	**750**	**1000**	**1250**	**1500**	**1750**	**2000**
250	A	A	B	E	F	F	F	F
500	A	A	B	C	D	E	F	G
750	B	B	B	C	D	E	E	F
1000	E	C	C	D	D	E	E	F
1250	F	D	D	D	D	D	E	E
1500	F	E	E	E	D	E	F	G
1750	F	F	E	E	E	F	H	I
2000	F	G	F	F	E	G	I	J
2250	F	G	G	G	F	G	J	J
2500	F	H	H	G	G	I	J	K
2750	F	H	H	H	H	J	K	K
3000	F	H	I	H	I	J	K	L
3250	F	H	I	I	J	J	L	M
3500	G	H	I	I	J	K	L	M
3750	G	H	J	J	J	K	L	M
4000	G	H	J	J	J	K	L	M
4250	G	H	J	J	K	L	M	M
4500	G	H	J	J	K	L	M	N
4750	G	H	J	K	L	M	M	N
5000	G	H	J	K	K	M	N	N

Table (B) – For Sheet Thickness

	Glazing factor													
Load (N/m²)	A	B	C	D	E	F	G	H	I	J	K	L	M	N
250	2	2	2	2	2	2	2	3	4	5	6	8	10	12
500	2	2	2	2	2	2	3	4	5	6	8	10	12	
750	2	2	2	2	2	3	4	5	6	8	10	12		
1000	2	2	2	2	3	4	5	6	8	10	12			
1250	2	2	2	3	4	5	6	8	10	12				
1500	2	2	3	4	5	6	8	10	12					
1750	2	3	4	5	6	8	10	12						
2000	2	4	5	6	8	10	12							
2500	3	5	6	8	10	12								
3000	4	6	8	10	12									
4000	5	8	10	12										
5000	6	10	12											

Calculation of adequate sheet thickness:
Wind Load is assumed to be 1250 N/m². Glazing factor is taken from the table for required length and width.

Example: For 2000 mm length and 2000 mm width the glazing factor from Table A is "J."

For the wind load 1250 N/m² and for glazing factor "J" the sheet thickness obtained is 12mm.

Note: Always take the next higher value if the required value is not found.

ROWAD CUSTOMER SERVICE is always at your disposal and feel free to contact us for any technical assistance