CHAPTER VIII

SKYLIGHTS

8.0 GENERAL SPECIFICATION FOR SKYLIGHTS

8.1 MATERIALS

8.1.1 ALUMINIUM EXTRUSIONS

Extruded aluminium sections shall be fabricated from alloy 6063 or 6061 in temper T5 or T6 all in accordance with the latest edition of BS EN 755 - "Aluminium and its alloys – extruded rod/bar, tube and profiles."

The extruded section shall be of such quality and strength that the section properties of the load bearing profiles meet the requirements as laid down in section 8.3.

8.1.2 ALUMINIUM SHEET

Ancillary members such as sills, flashings, infill panels and the like which may be formed from flat sheet material shall be fabricated from aluminium alloy 1200 or 3004 or 5251 of appropriate temper all in accordance with the latest edition of BS EN 573 - "Aluminium and Aluminium Alloys."

8.1.2 TIMBER

Structural timber members where used should be of suitable strength material and comply in all respects with SANS 10163.

8.1.3 STEEL

Structural steel members where used should be of suitable strength material and comply in all respects with SANS 10162.

8.1.4 FLASHINGS

A suitable corrosion resistance, malleable sheet material shall be used for the forming of flashings, saddles and drainage channels at abutments, junctions and valleys.

8.1.5 GLAZING MATERIALS & GLAZING

8. 1.5.1 PLASTIC GLAZING MATERIALS & GLAZING

Plastic glazing material shall be ……. ***(Architect to specify)***

Minimum depth of rebate shall be 20mm.

Glazing shall be executed strictly in conformance with glass manufacturer's recommendations and all in accordance with the National Building Regulations Part N, SANS 10137, DSS SANS 10400, SANS 1263, and AAAMSA Selection Guide for Safety Glazing Materials.

8.1.5.2 GLASS & GLAZING

Glass/specialized plastic glazing materials shall be **........ *(Architect to specify)***.

Glazing shall be executed strictly in conformance with glass manufacturer's recommendations and all in accordance with the National Building Regulations Part N, SANS 10137, SANS 10400 and, SANS 1263.

A warranty is to be provided that the manufacturer of the laminated safety glass and/or the hermetically sealed glazing units warrants the product against delamination and colour degradation for a period of not less than 5 (five) years.

In case of structural glazing written proof is to be provided that all stages of fabrication and installation have been executed with disciplined quality assurance in accordance with the relevant part of SANS ISO 9000.

Structure using materials having in-situ applied finishes may not be used for structural glazing. Written confirmation of compatibility of structural sealant with extrusion surface, glazing tape and glass is to be supplied by the structural sealant manufacturer together with the regular relevant test reports regarding the adhesion of the sealant to the aluminium frame in accordance with ASTM/C 794-80 (Standard Test for Adhesion-in-Peel of Elastomeric Joint Sealants).

8.2. FINISHES

8.2.1 ALUMINIUM

8.2.1.1 ANODISING

All anodising shall be executed in strict adherence to SANS 999. ***(Architect to specify colour and anodic film thickness) i.e. 15 or 25 microns.*** A Certificate of conformance is to be supplied with each delivery that the anodised materials meet with SANS 999 in all aspects.

8.2.1.2 POWDER COATING

All powder coating shall be executed only by applicators approved by the specified powder manufacturers and shall be executed strictly in conformance with SANS 1769.

(Architect to specify type (Interpon D, Vedoc or other) and colour).

A guarantee of no less than 10 years is to be provided against peeling and discolouration.

8.2.2 TIMBER

The finish of the Timber structure shall be …….. ***(Architect to specify)***

8.2.3 STEEL

The finish of the Steel structure shall be ….. ***(Architect to specify)***

8.3. CONSTRUCTION

8.3.1 DESIGN

8.3.1.1 The Design wind pressure is ….. ***(Architect and/or Structural Engineer to provide)***

8.3.1.2 Hail, snow and maintenance loads are ….. ***(Architect and/or Structural Engineer to provide)***

8.3.1.3 The plastic, shrinkage and creep deflections of floor slabs is …. ***(Structural Engineer to provide)***

8.3.1.4 Tenderers are to allow for thermal movement due to an atmospheric temperature range of -10°C to 35°C. ***(Architect to confirm)***

8.3.1.5 The combined loadings as specified in 8.3.1.1 and 8.3.1.2 above shall be used in the selection of appropriate uniform loading.

TABLE 8.1: AAAMSA Test Performance Criteria

Test	Class Designation					Requirement
	A0	A1	A2	A3	A4	
Deflection (positive and negative) under uniform loading Pa (the design wind load)	600Pa	1000Pa	1500Pa	2000Pa	2500Pa	Maximum deflection 1/175 of span (2)
Structural proof loading 1.5 x Uniform loading	900Pa	1500Pa	2250Pa	3000Pa	3750Pa	No failure allowed
Water resistance under a pressure of x Pa	x=120Pa	x=200Pa	x=300Pa	x=400Pa	x=500Pa	No leakage when subjected to a flow of 0.05 *l*/s/m^2)
Air leakage through specimen under a pressure difference of 75Pa	y = 2	y = 2	y = 2	y = 2	y = 2	Not more than y *l*/s per m^2

(1) For fixed glazing y = 0,306 l/s per m^2.
(2) For spans greater than 4115mm, but less than 12,2m deflection shall be limited to 1/240th of span plus 6mm.

8.4 MANUFACTURE

8.4.1 Materials and workmanship shall be free from any characteristics of defects, which may render the finished product unsuitable for the intended purpose.

8.4.2 Skylights shall be fabricated to neat and weather tight construction and with secure and well fitted joints.

8.4.3 Hardware and fittings shall be removable without removing the frames from the structure and must be compatible with the adjoining materials.

8.4.4 Sliding members shall be constructed so that no metal to metal sliding contact occurs.

8.5 FITTINGS

8.5.1 Weathersealing shall be of materials that are compatible with aluminium and shall be such that any degradation, shrinking, warping or adherence to sliding or closing surfaces does not impair the performance of the installation.

8.5.2 Glazing beads, gaskets and glazing compounds shall be of materials that are compatible with the aluminium finishes, the glass and other glazing materials. Putty glazing is not permitted.

8.5.3 Hardware, bearing devices and fittings in general must be made of materials resistant to atmospheric corrosion and shall be of a design so as to be accessible for adjustment repair and replacement after the windows etc. have been installed.

8.5.4 Fastenings shall be of material which is compatible with aluminium and aluminium finishes.

8.6 INSTALLATION

8.6.1 The Skylights and Space enclosures shall be installed such that they are securely anchored, sealed and undamaged and meet in all respects with the performance criteria as set out in item 3.

8.6.2 The glazing material shall be installed strictly in accordance with the glazing material manufacturer's specifications.

8.6.3 The frames and glazing material are to be installed in accordance with the main contractor's building programme and the exposed aluminium is to be protected by means of low tack adhesive tape against mortar droppings and other non-mechanical damage.

8.6.4 Inspection of installed frames and glazing material shall, amongst others, be carried out according to the following criteria:

8.6.4.1 SCRATCHES AND BLEMISHES

This inspection will be viewed at a distance of three metres under normal lighting conditions, i.e. reasonable lighting conditions under which the project is normally viewed.

8.6.4.1.1 FRAMING

Scratches in framing are defined as being a mark on the surface which penetrates the powder coated, anodised or painted surface, thereby exposing the base material.

If visible when viewed from a distance of three metres under normal lighting conditions, the product may be rejected. Flaws/Stains, paint runs or other indication that mars the aesthetic appearance of aluminium which is visible when viewed from a distance of three metres under normal lighting conditions may cause the product to be rejected.

8.6.4.1.2 GLAZING MATERIAL

Scratches in the glazing material which will be acceptable are those which are under 75mm long in any area, and those which are longer than 75mm which do not encroach more than 75mm from the edge.

In laminated glass interlayer bubbles larger than 1.5mm diameter will not be allowed. Larger clusters or close spacing of smaller bubbles will also be disallowed.

8.7 QUALITY ASSURANCE

8.7.1 Prior commencement of any site work:

8.7.1.1 Obtain a copy of the appropriate AAAMSA Performance Test Certificate from the Manufacturer/Specialist Contractor supplying/installing the Architectural Aluminium Products.

8.7.1.2 Obtain a full set of detailed manufacturing drawings/manuals relevant to the installed products.

8.7.2 UPON COMPLETION OF ALL SITE WORK (AT HANDOVER)

8.7.2.1 OBTAIN THE FOLLOWING CERTIFICATES:

a) AAAMSA Performance Test Certificate
b) AAAMSA or SAGGA Glass & Glazing Certificate
c) AAAMSA Surface Finishing Certificate
d) AAAMSA or SASA Skylight System Certificate (when applicable)
e) AAAMSA Architectural Product Certificate (in the event drawings are not provided)

8.7.3 WARRANTIES

8.7.3.1 POWDER COATED SURFACE FINISH

Obtain a warranty, from an approved powder coater, that the powder manufacturer guarantees his product for a minimum of 15 (fifteen) years.

8.7.3.2 GLASS

Obtain a warranty, from the manufacturer of the laminated safety glass and/or the hermetically sealed glazing units, against delamination and colour degradation of the products for a period of not less than 5 (five) years.

8.8 DESIGN GUIDELINE FOR ALUMINIUM FRAMED SKYLIGHTS AND SLOPED GLAZING

Sloped glazing includes the fenestration of skylights and space enclosures which are tilted more than 15º from the vertical. Sloped glazing systems should be inclined a minimum of 15º from the horizontal to insure proper condensation and water infiltration control and to minimize accumulation of dirt above horizontal or purlin framing supports. Systems inclined less than 15º from the horizontal may require special consideration.

All glazing materials are breakable. Failure may not be recognizable; breakage is usually sudden, sometimes unnoticed, and frequently for no readily apparent cause. Glass breakage from any cause is a probability function due to the minute individual characteristics of apparently identical panes. Sloped glazing installations may be situated above areas where people pass or work. This raises safety and liability considerations for the owner, designer, glazing and skylight manufacturer. Breakage can result from any of the following causes:

1. Excessive loading: wind, live, snow or concentrated
2. Impact loads from falling (i.e. hailstones) or wind borne (i.e. roof gravel) objects
3. Thermal effects generated within the glazing material itself (i.e. heat-absorbing tinted, reflective) due to inclined position
4. Inadequately designed glazing system which does not provide proper support, clearance and drainage
5. Edge or surface damage to glazing material during manufacturing, handling, installation or maintenance
6. Vandalism or destructive accidents
7. Effects of long-term weathering

Condensation, while generally not a factor affecting human safety, is an important consideration in the design of overhead glazing systems. Skylights and space enclosures should be mechanically designed (through the use of a guttered weep system) to control both condensation and water infiltration.

The use of architectural systems designed for vertical application must be discouraged as these systems lack the ability to drain condensation.

Aluminium is the material of choice for skylight construction. Aluminium is lightweight and can be easily extruded into the complex shapes necessary for skylight design. However the properties of aluminium must be clearly understood by the architect and engineer, and not based on the “steel manual” way of thinking.

For example, the stiffness of aluminium is one-third that of steel; an aluminium section can deflect three times that of an identical steel section under the same conditions without permanent deformation. An engineer or architect may thus question the allowable deflections of some aluminium-framed structures, when no damage whatsoever will result from these deflections.

The coefficient of thermal expansion is twice that of steel. Steel/Aluminium interfaces must be carefully analysed or serious connection problems could result. The effect of thermal movement can also impact on various support conditions.

Aluminium is anodic in nature and the potential for galvanic corrosion with dissimilar materials exists. Even though an interior space is considered a dry space, at times of high relative humidity there can be condensation on connections adjacent to steel or concrete curbs. Using a proven barrier between dissimilar elements can minimize this problem.

Also the heat of welding will change the temper of the aluminium alloy and reduce the allowable stress within 25mm of the weld area.

Engineers and designers are advised to consult the Aluminium Federation of Southern Africa for detailed information on maximum permissible stresses for aluminium alloys.

The vast majority of building designers and engineers' expertise is with steel and concrete structures. The basic engineering approach taken in the design of aluminium skylights is no different to that of steel or concrete, but many of the rules of thumb, or typical critical engineering considerations, are very different. The following section addresses these important differences. As each of these complex and often unique engineering problems cannot be solved within the scope of this document, the goal is to highlight these considerations as an aid to the design community.

a) DEFLECTION

Aluminium and most glazing materials have high strength but relatively low stiffness so deflection criteria are the usual controlling parameters in the selection of appropriate structural components.

Three items must be considered when specifying deflection criteria:

1. Excessive deflection can cause air or water leaks. As members shift or rotate, sealant joints may fail, mechanical joints may open, insulated glass edge seals may be overstressed, or gutter systems may fail to drain properly.

2. Excessive movement may lead to glazing breakage. Differential deflection may warp glazed panels or cause metal to contact the glazing material and induce fracture.

3. Excessive deflection can detract aesthetically from a structure.

The limiting of deflection as it pertains to skylights/sloped glazing has three basic considerations (See figure 9).

i) In-plane deflection

This deflection in framing members shall not reduce the glass bite to less than 75% of the design dimension and shall not reduce the edge clearance to less than 25% of design dimension or 3mm which ever is the greater. The calculation referred to in 4.1.2 above will meet this requirement. Careful location of the setting blocks is essential in order to prevent glass to metal contact.

ii) Normal to surface deflection

This deflection shall be 1/175th of the span of framing members up to 4115mm. For spans greater than 4115mm, but less than 12.2m deflections shall be limited to 1/240th of the span plus 6mm.

Due to the flexibility and breakage resistance of most plastic and composite panel glazing materials relative deflections as high a 1/100 of the span can be considered for their supporting structure. Consult knowledgeable material suppliers and manufacturers.

iii) In plane racking

Racking requires careful investigation in order to assure that glazing does not come in contact with metal and that edge engagement is not compromised. Racking occurs when a force causes a rectangular skylight panel to shift out of square. Differential support settlement or deflection and lateral loads cause racking.

As many skylight geometries lack conventional diagonal bracing the structure may not have the stiffness to resist racking. There is little doubt that fixing glazing panels do help stiffen a structure and reduce the effects of racking. However, quantifying this benefit has proven extremely difficult.

Creep and compression set in gaskets, fabrication and installation tolerances, as well as thermal movement considerations, necessitate caution. When racking is a concern, consultation with knowledgeable manufacturers is recommended.

b) SIDEWAY

Sideway, or story drift, as it relates to aluminium skylights is not specifically addressed by any standards, although it occurs in most freestanding frames. The objectives of the proper limitation of excessive sideway are identical to that for deflection; to limit glazing breakage, leakage, and visual impact. Again careful consideration must be given to both in-plan and out-of-plane sideway, as well as differential sway caused by varying spacing or end conditions that may cause racking or warping of glazing.

Differential drift or sideway of aluminium framed skylights due to lateral load between any two points of a continuous glazed frame should be limited to the difference in height/160 for glass or height/100 for non-glass glazing materials. The designer should specify the absolute maximum differential drift. Figures 8.1 to 8.5 depict the deformed geometries of several typical skylight forms.

Glazed ends of freestanding frames can pose complex detail problems if sideway is large. End details must transfer transverse load into the system and still allow the primary frame to sway. When improperly designed, differential sideway will lead to warping and possibly breakage in the glazing material. Consultation with knowledgeable manufacturers may be appropriate for details of this nature.

c) CONNECTIONS

When analysing an aluminium skylights, connections account for the vast majority of engineering documentation. Assumptions made in the general frame analysis must be coordinated with the design of the connections. As custom shapes are the rule rather than the exception, most connections must be engineered from scratch.

Moment connections are commonplace in aluminium skylights, yet are often not scrutinized as closely as they should be. The elastic method for design of eccentrically loaded fastener groups is the most widely accepted in aluminium construction.

The development of high-strength steel bolts has led many designers to utilize the concept of friction connections in steel design. Aluminium would seem to be a natural for this technique the coefficient of friction is quite high. However, skylight components are typically pre-finished, therefore this justification becomes suspect.

Furthermore, aluminium and stainless steel bolts are not capable of the high torques required for friction connections. Friction connections should not be counted upon in the design of aluminium framed skylights.

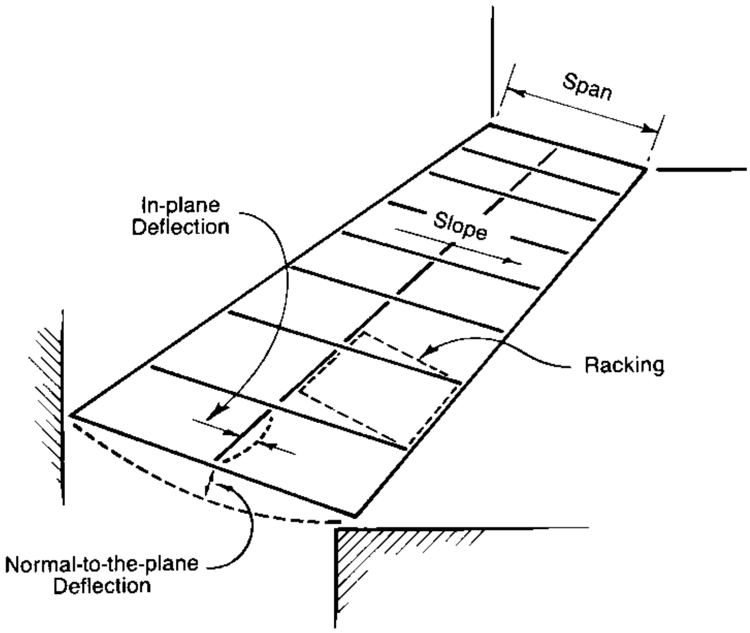

Figure 8.1: Deflection Considerations of a Single Slope Skylight

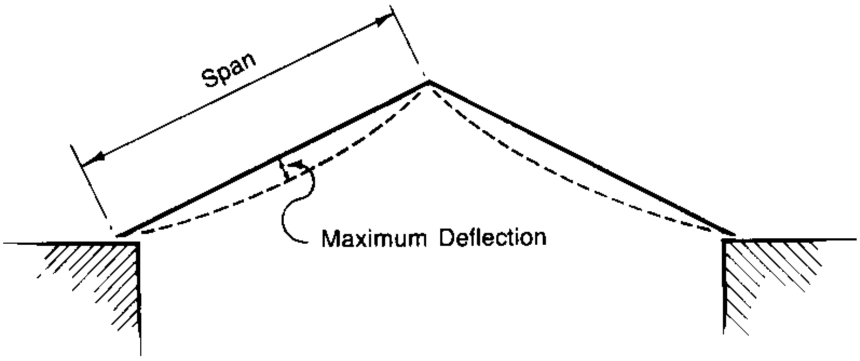

Figure 8.2: Ridge Skylight Deformation under Gravity Loads

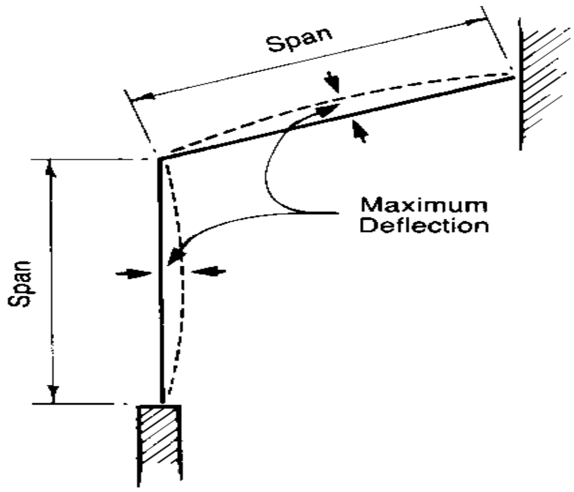

Figure 8.3: Lean-to Skylight Deformation under Wind Load

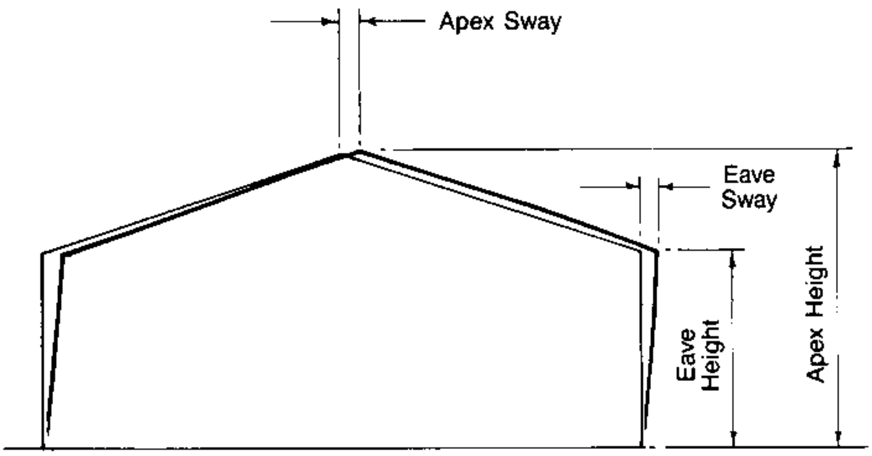

Figure 8.4a: Gable Frame Deformation under Wind Load

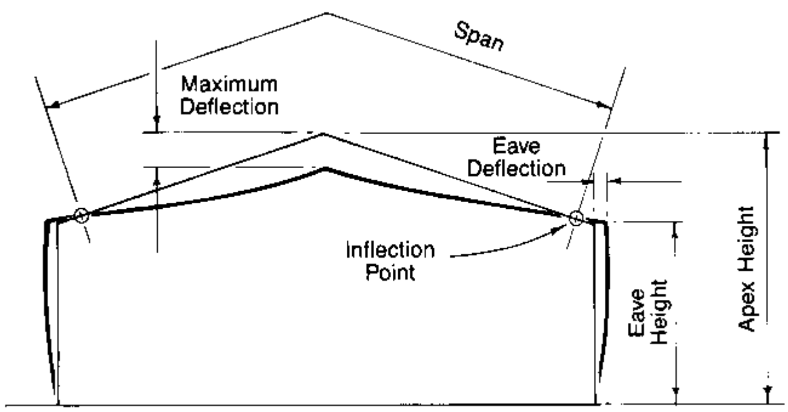

Figure 8.4b: Gable Frame Deformation under Gravity Loads

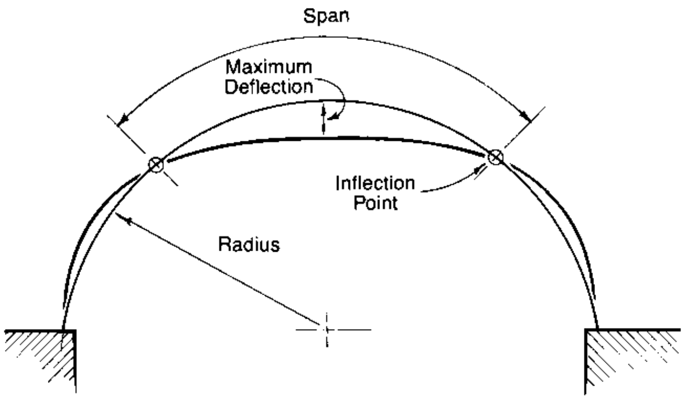

Figure 8.5a: Arched Frame Deformation under Gravity Loads

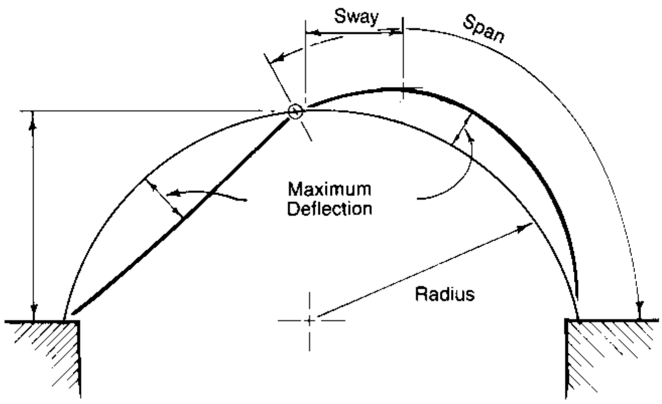

Figure 8.5b: Arched Frame Deformation under Wind Loads

d) SUPPORTS

Support conditions and other interfaces between aluminium and adjacent construction can also be complex. Not only should thermal movement, deflection, water infiltration and electrolytic corrosion effects be considered, but the transfer of loads from one structural element to another must be accomplished. Care must be exercised in coordinating the structural requirements and assumptions of the supporting structure with those of the skylight.

All skylights exert some degree of both vertical and horizontal forces on the supporting structure. Considerable horizontal forces on the supporting structure. Gravity loads alone can generate considerable horizontal thrust. Improperly designed supports can lead to excessive skylight deflection and other associated complications. As a general guideline horizontal deflection of skylight supporting curbs should be limited to 1/750 of the curb length or 12mm unless curb flexibility is considered in the analysis of the skylight frame.

The skylight manufacturer is responsible for the structure integrity of the skylight system and should fully describe all forces exerted on the supporting structure. Responsibility for the design of the structure supporting the skylight is that of the building's structural engineer. Improved communication between engineers, designers and manufacturers is the key to eliminating problems associate with supporting structure. Typically, the supporting structure is constructed of steel, concrete or wood. All three of these materials can be engineered to properly support a skylight; however, several practical concerns warrant review.

i) Steel

Erection tolerances for steel are commonly unacceptable for pre-fabricated skylights. Dimensions must be either guaranteed or adequate provisions made for adjustment within the skylight system. Pre-drilled holes and shop-welded support brackets must be detailed with caution as their in-place location is often suspect. Access to supporting steel can also be complicated by prior coordination between trades. Careful planning with input from the skylight manufacturer is recommended.

ii) Concrete

As with steel, tolerance and accessibility are critical concerns. Cast-in-place anchor bolts are often located improperly. Zinc or cadmium plated steel expansion anchors are usually preferred. Minimum spacing and edge distances for expansion anchors in concrete often dictate a curb width of at least 200mm.

iii) Wood

Wood is a popular choice for skylights substructure, but must be engineered with caution. Wood is very flexible. Its stiffness is one-tenth that of aluminium. Curb deflection must be closely scrutinized. Lag bolts in wood have limited holding power compared to steel or concrete. Anchor design is typically governed by the strength of the wood, not the fastener, and in many instances leads to an excessive number of anchors.

i) LATERAL BRACING OF BEAMS

Lateral bucking is a failure mode commonly overlooked in the design of aluminium skylights.

j) SLENDERNESS AND STABILITY RATIO

Contact the Aluminium Federation of Southern Africa for information regarding Standards and Stability ratios. This failure mode can be prevented by adequate lateral bracing of the compression flange. Of course, cross bars or purlins, provide this critical function under typical live and load conditions. However, under negative wind load cases, the compression flange may be partially brace or un-braced. For adequate crossbar bracing of the compression flange in this mode, the crossbar depth must be at least 50% of the main rafter bar's depth.

8.9 PROPERTIES FOR SPECIALIZED PLASTIC GLAZING MATERIALS

Table 8.2: Shading Coefficients* for Specialised Plastic Glazing Materials

Cast Acrylic Sheet		
Clear	1,0	
Bronze	0,78	
Opal	0,47	
Polycarbonate Sheet		
Clear	0,97	
Bronze	0,75	
Opal	0,67	
Multiwalled Polycarbonate Sheet	**6mm**	**10mm**
Clear	0,99	0,98
Bronze	0,63	0,63
Grey	0,58	0,58
Blue	0,81	0,76
Green	0,59	0,59
Opal	0,87	0,82

** Due to the vast range of available product the specifier is advised to consult with manufacturers/suppliers to obtain/confirm relevant data.*

Table 8.3: Acoustical Insulation Solid Polycarbonate * Sheet DIN 52210

Thickness in mm	75 Rw (db)
4	27
5	28
6	29
8	31
9.5	32
12	34

Table 8.4Heat Loss Properties Solid Polycarbonate * Sheets

Thickness in mm	U-Value W/m^2K
4	5,33
5	5,21
6	5,09
8	4,84
9.5	4,69
12	4,35

** Due to the vast range of available product the specifier is advised to consult with manufacturers/suppliers to obtain/confirm relevant data.*