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STRUCTURAL DESIGN CERTIFICATE – No: CSM-SC099-2016 Job No: 15S-483

Plant Description:
Vooyage International Co. Ltd solar panel mounting structures for tin and tile roofs.

Client/Owner:
Vooyage International Co. Ltd / Universal Solar Mounting

Site Address:
Locations throughout mainland Australia (Wind Regions A, B, C and D as Per AS/NZS 1170.2:2011).

Drawings and Documentation Included in this Certificate:

- The following drawings supplied by Vooyage International Co. Ltd and nominated in the table below are included in this structural certification for the solar assembly.

Table 1: Certified Drawings

Vooyage International Co. Ltd Flush Mount System – Tile Roof		
PC No.	Part Name	Model / Drawing No.
1	VG100TL Assembly	VG100TL Rev A
2	Rail	100101
3	Inter clamp	100102
4	End clamp	100103
5	Rail Splice Cover	100104
6	Rail Splice Clamp	100105
7	Lock	100106
8	Hook	100107
9	Hook	100201
10	Clamp Unit	100202

Table 2: Certified Drawings

Vooyage International Co. Ltd Flush Mount System – Tin Roof		
PC No.	Part Name	Model / Drawing No.
1	VG100T Assembly	VG100T Rev A
2	Rail	100101
3	Mid clamp	100102
4	End clamp	100103
5	Rail Splice Cover	100104
6	Rail Splice Clamp	100105
7	Lock	100106
8	L-Feet	100108
9	Hexagon Socket Cap Screw	M8x25

NOTE – The Client shall hold all Material Test Certificates for future reference and subsequent design changes.

The Design was carried out based on the following Standards:

AS/NZS 1170.0:2011 – Structural Design Actions Part 0: General Principles
AS/NZS 1170.1:2002 A2-2009 – Structural Design Actions Part 1: Permanent, imposed and other actions
AS/NZS 1170.2:2011A2-2012 – Structural Design Actions Part 2: Wind actions

Exclusions

- Solar Panel/Frame certified by others.
- Earthquake Code (AS/NZS 1170.4) not considered - Solar panel is not a major building structure.
- Set-up, instruction and installation manual.
- 304 Stainless Steel should not be used in a Marine environment or in an environment above 50 – 60 ^{0}C with chlorides present. The use of 316 Stainless Steel is recommended in these conditions.
- This certification does not include loadings for snow or earthquake loads and represent wind loads only.

Specification of this Structural Certificate

- Maximum Solar Panel Size = 2.0m x 1.0m.
- Maximum flush Module support Spacing as per Tables 5.1 through 6.4.
- Minimum four support clamps to rail per Solar Panel.
- Solar Panels to be installed on the building roof only.
- External wind uplift and internal positive wind pressures are considered.
- Wind Region A, B, C & D has been considered (Refer Tables 5.1 through 6.4).
- Regional wind speed for 500 year ARI.
- Building Height (h) conditions based on Terrain Categories 2.5,3 and 4
- Exlcudes terrain categories TC1, TC1.5 and TC2 special certifications required for these areas
- Maximum Building Height (h) is 20 m.
- Maximum roof pitch shall be 10° - 30°.
- Minimum Steel Purlin thickness to be 1.5mm for Commercial applications.
- Minimum Steel Purlin/batten thickness to be 0.75mm for Residential applications.

Details of the Design

Maximum Solar Panel Size	:	2.0m x 1.0m
Building Roof Pitch	:	10° - 30°
Australian Terrain Categories	:	Terrain Categories 2.5, 3 and 4
Wind Regions	:	A, B, C & D
Mounting Conditions onto Rails	:	Rail fastened to Flush Mount Leg then onto the roof purlins at maximum spacing as per Tables 5.1-5.4 & Tables 6.1-6.4
Maximum rail support spacing	:	As per Tables 5.1-5.4 (Commercial) & Tables 6.1-6.4 (Residential) (Based on a maximum pullout force per support leg)
Mounting Conditions onto Solar Panels	:	Four clamping positions per solar panel back to rails and Two rails per panel
Minimum purlin thickness for Commercial applications	:	1.50mm
Minimum purlin/batten thickness for Residential applications	:	0.75mm
Design life of structure	:	20 years

- CSM group has not carried out any inspection of any installed plant being completed, thus this Certificate **Does Not** cover Inspection of the plant for each site location.

- However, specific **building heights over 20m** are **outside the design parameters within this document** and should be specially analysed and be verified by the Certifying Engineer.

- It is strongly recommended that all the connections and fasteners should be checked against failure or corrosion immediately after **a 5 year ARI** wind event or annually, whichever comes first.

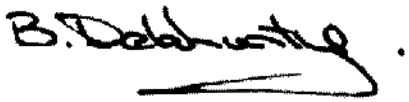
- The roof on which the solar assembly is to be installed must have the capacity to resist the combined dead and live loads per support clamp.

If manufactured, constructed and installed in accordance with the abovementioned drawings, specifications, details of the design and OEM Installation Manual, the support structure will be capable of sustaining the load conditions as specified in the Australian standards AS1170.2-2012 and AS1664.

Certifying Engineer

Signature

Date: 29/01/2016



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1. Determine the wind region for your site location

Using the table below, determine the region your site location is in paying particular attention to differing regions within 50 and 100km of the coastal perimeter of the nation (if in doubt consult your engineer).

Wind regions are pre-defined for all of Australia by Australian Standard 1170.

- Most of Australia is designated in Regions A1-7 which indicates a Regional Ultimate Basic Wind Velocity of 45m/sec.
- Several coastal areas including Brisbane are within Region B (57m/sec).
- Region C areas (69m/sec) are generally referred to as Cyclonic and are generally limited to northern coastal areas. Most Region C zones end 100km inland.
- Region D (88m/sec) Australia's worst Cyclonic Region between Carnarvon and Pardoo in Western Australia.

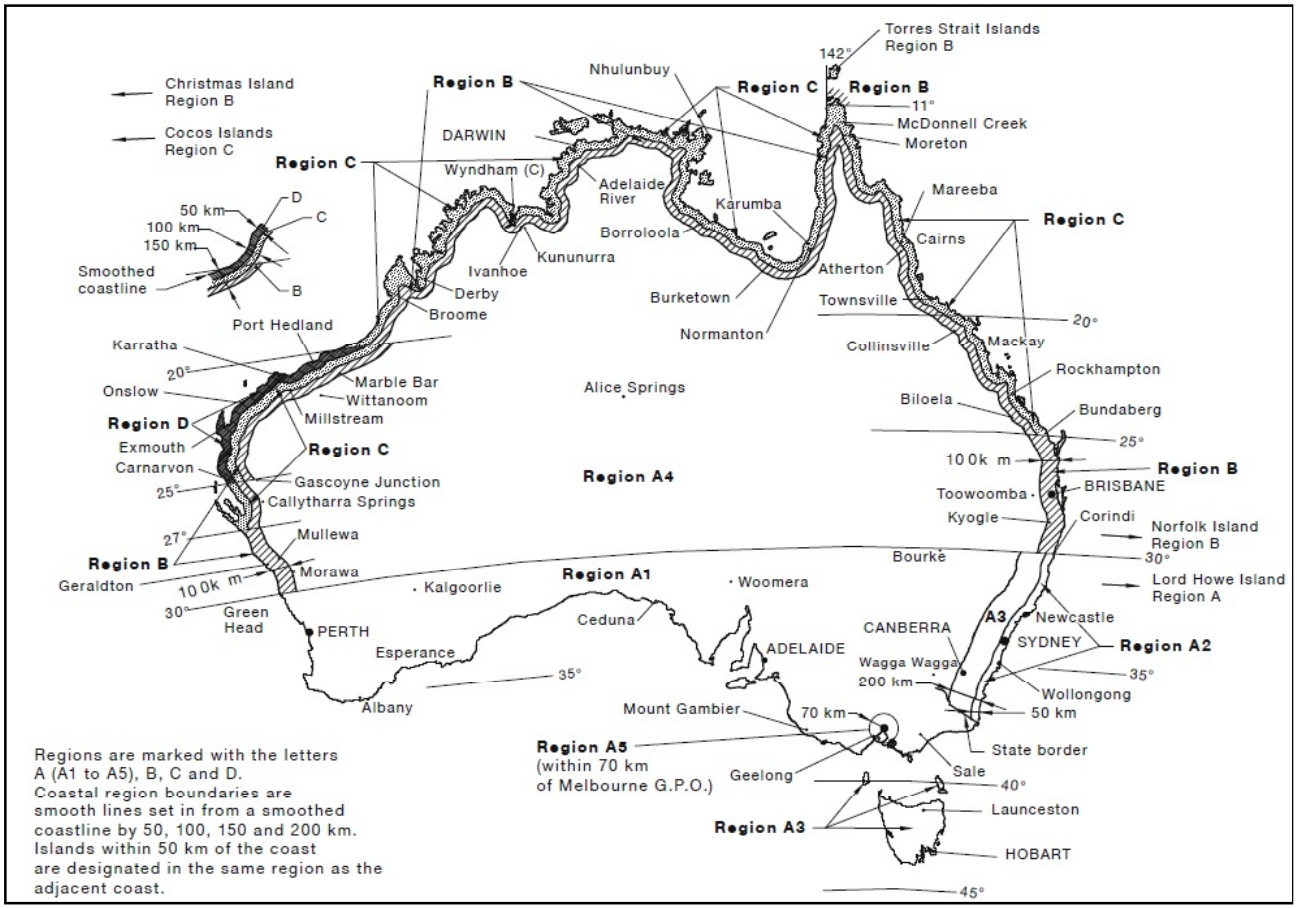


Figure 1 – Australian Wind Zones

2. Determine the building height at your site location

The height 'h' is equal to the distance from ground to the mid height of your roof ie, between the eaves and the roof ridge. Whilst this certification covers building heights to 20m it is important to get special engineering advice for buildings over this maximum height.

3. Determine Roof Installation Area

The breadth 'b', depth 'd' and height 'h' of a building is illustrated in Figure 2 and Figure 3.

The installation area for solar panels attached to enclosed buildings with aspect ratios of $h/d \leq 0.5$ and $h/b \leq 0.5$ is shown in Figure 2. The installation area for solar panels attached to enclosed buildings with aspect ratios of $h/d > 0.5$ and $h/b > 0.b$ is shown in Figure 3.

The solar roof panel system in Figure 2 has an exclusion zone of '2S', where 'S' is the gap between the underside of the panel and the roof (No pitch frames). 'S' has to be a minimum of 50mm and a maximum of 300mm. Please refer to Figure 2 for the installation area in the End and Central Zone.

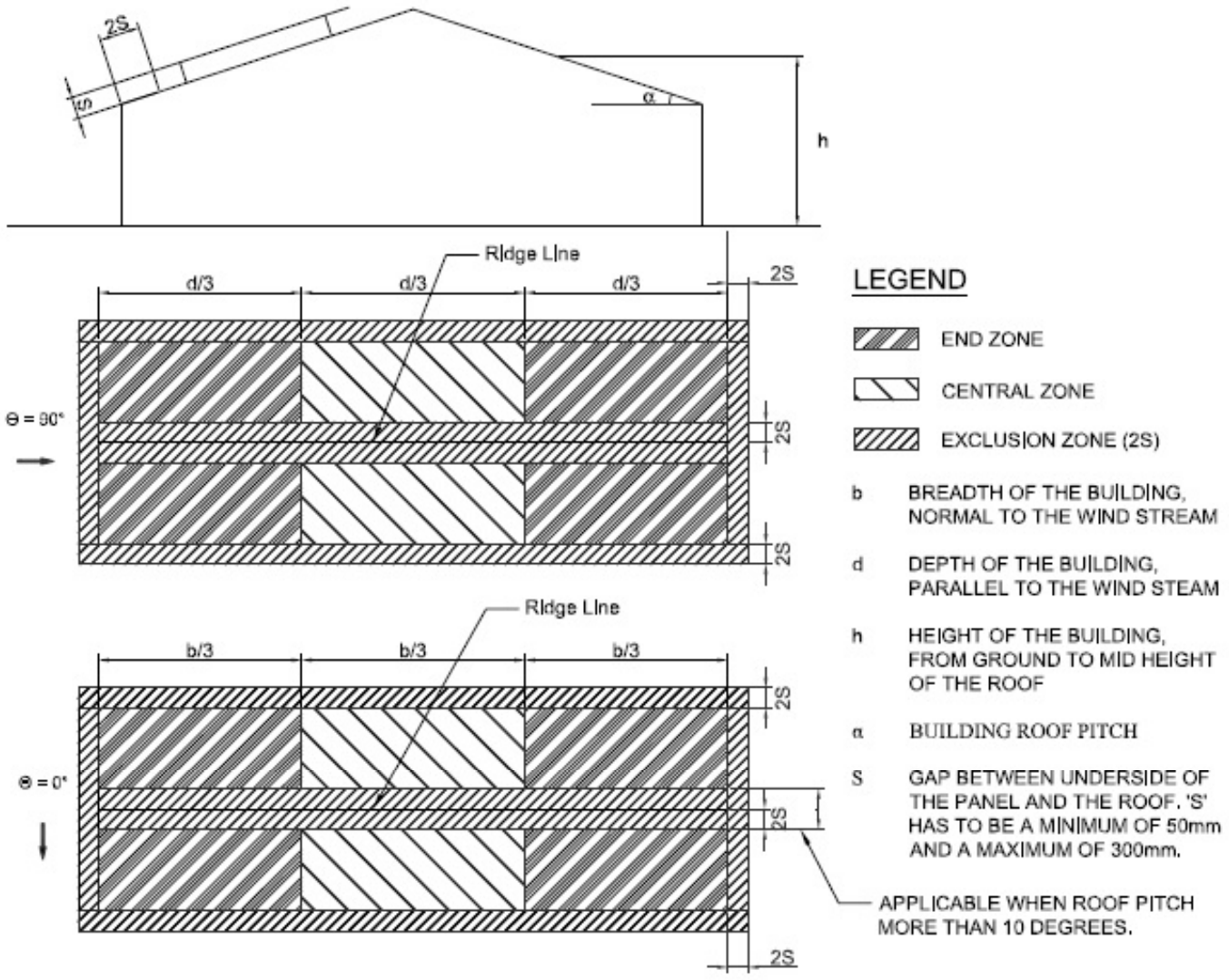


Figure 2 – Roof Installation Area (h/d≤ 0.5 and h/b≤ 0.5)

The solar roof panel system in Figure 3 has an Edge Zone around the complete roof of a minimum distance of 0.1b or 0.1d. The solar roof panel system should generally not be installed within the Edge Zone unless absolutely required by the installers. The Edge Zone can be used for installation using Tables 5.3, 5.4, 6.3 & 6.4. In some cases you may use the edge zones as per the tables, but do not install in the corner zones of 0.1b or 0.1d from the corners.

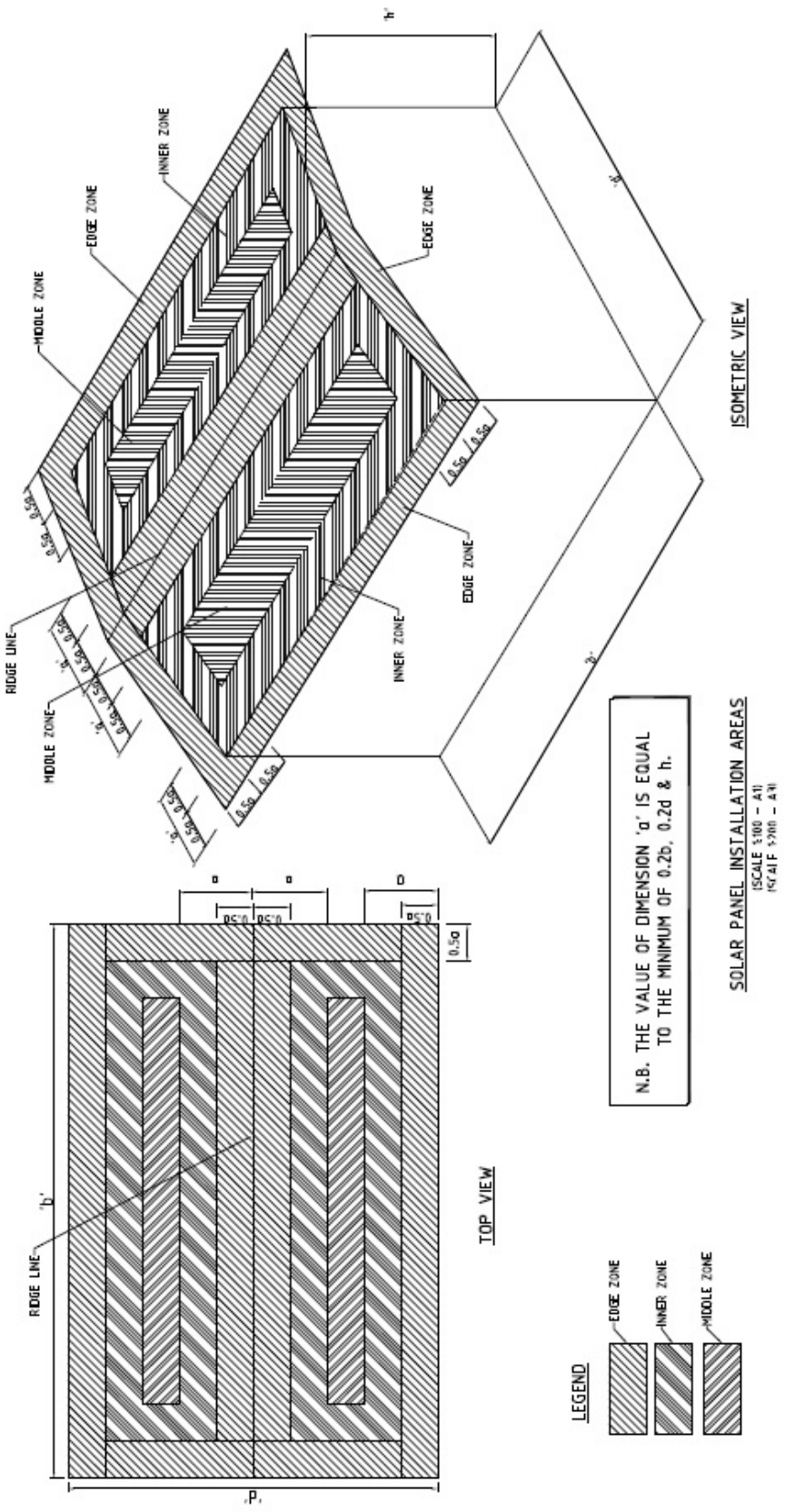


Figure 3 – Roof Installation Area (h/d> 0.5 and h/b> 0.5)

4. Determine whether your solar layout is in Portrait or Landscape Orientation

Portrait orientation denotes the short side of the solar panel (1.001m) is installed parallel the supporting rail and for landscape orientation the long side of the solar panel (1.675m) is installed parallel the supporting rail.

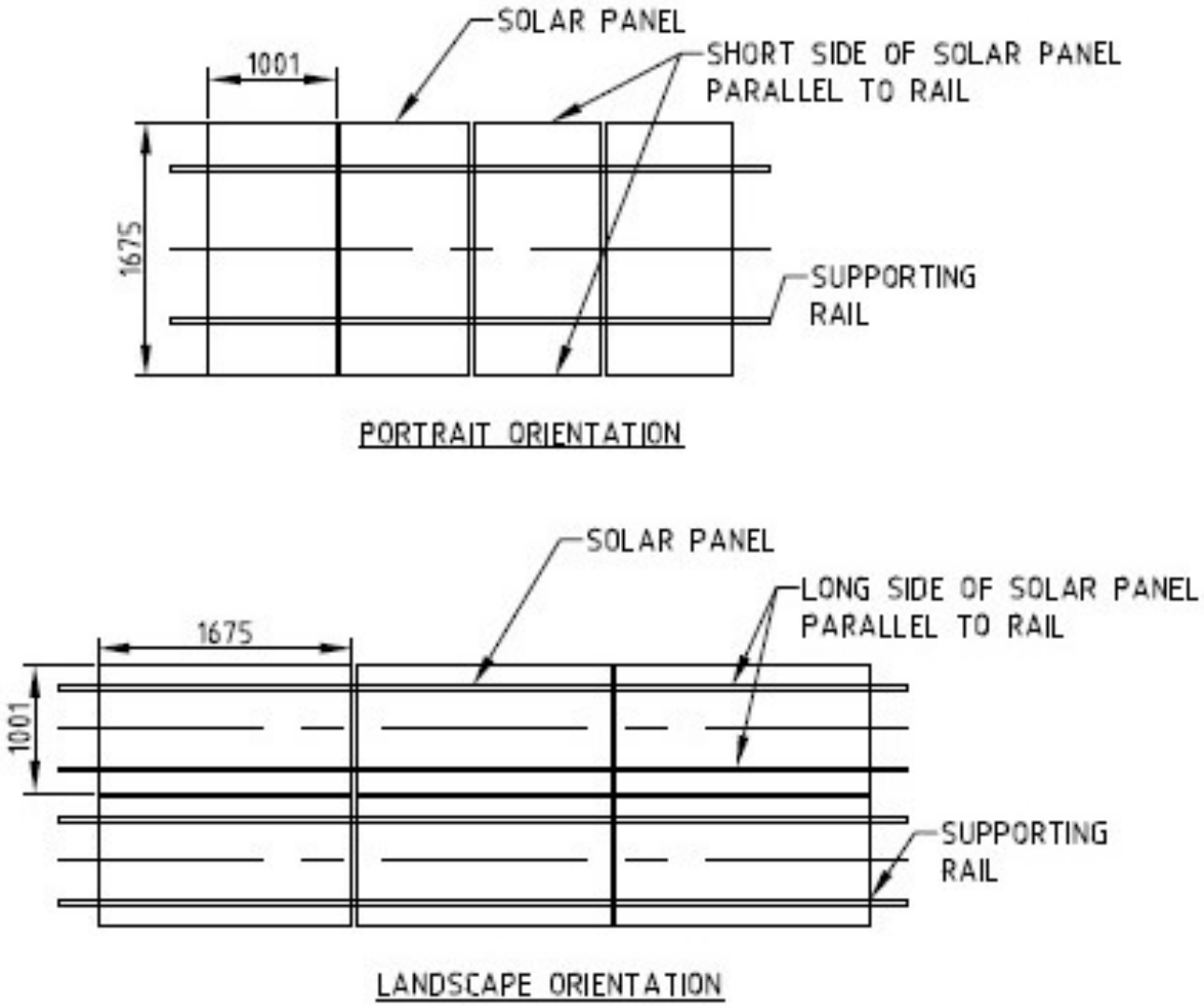


Figure 4 – Example Portrait or Landscape Orientation

5. Determine the Maximum Support Spacing for the Rail 100101- Premium for a commercial application

The following tables 5.1 & 5.2 are used to determine the maximum rail support spacing of Flush Mount system **(within the central and end zones of the roof as per Figure 2 above)** and tables 5.3 and 5.4 are used to determine the maximum rail support spacing of Flush Mount system **(within the middle, inner and edge zones of the roof as per Figure 3 above)** for a roof for a solar panel of maximum dimensions 2.0m length x 1.0m width with a hold down fastener on each leg with a **minimum pull-out strengths** of **4.68kN** per fastener for 1.5mm thick steel purlin. Should this differ please advise the consultant.

Refer Appendix 'A' for a table of pull-out strengths for roof fasteners to confirm the fastener to be used

Table 5.1 – Maximum Rail Support spacing of Flush Mount Panels - Portrait Orientation for Commercial applications where h/d ≤ 0.5 & h/b ≤ 0.5

Maximum Rail Support Spacing for Roofs (mm)								
Building height (h)	Wind Region A		Wind Region B		Wind Region C		Wind Region D	
	Central	End	Central	End	Central	End	Central	End
<5m	1700	1400	1300	900	900	600	500	300
5 to 10m	1600	1300	1100	800	800	500	500	300
10 to 15m	1500	1200	1000	700	700	500	400	300
15 to 20m	1500	1100	900	600	600	400	400	200

Table 5.1 is used for portrait orientation as per Figure 2 above.

Table 5.2 – Maximum Rail Support spacing of Flush Mount Panels - Landscape Orientation for Commercial applications where h/d ≤ 0.5 & h/b ≤ 0.5

Maximum Rail Support Spacing for Roofs (mm)								
Building height (h)	Wind Region A		Wind Region B		Wind Region C		Wind Region D	
	Central	End	Central	End	Central	End	Central	End
<5m	2400	2000	1900	1600	1600	1200	1100	700
5 to 10m	2300	1900	1800	1500	1500	1100	1000	700
10 to 15m	2200	1800	1700	1400	1400	1000	800	600
15 to 20m	2100	1700	1600	1300	1300	900	800	500

Table 5.2 is used for landscape orientation as per Figure 2 above.

Table 5.3 – Maximum Rail Support spacing of Flush Mount Panels - Portrait Orientation for Commercial applications where h/d > 0.5 & h/b > 0.5

Maximum Rail Support Spacing for Roofs (mm)												
Building height (h)	Wind Region A			Wind Region B			Wind Region C			Wind Region D		
	Middle	Inner	Edge	Middle	Inner	Edge	Middle	Inner	Edge	Middle	Inner	Edge
<5m	1600	1300	900	1200	800	600	800	500	400	500	300	200
5 to 10m	1600	1100	800	1100	700	500	700	500	300	400	300	200
10 to 15m	1500	1000	700	900	600	400	600	400	300	400	200	200
15 to 20m	1400	900	700	900	600	400	600	400	300	300	200	100

Table 5.3 is used for portrait orientation as per Figure 3 above.

Table 5.4 – Maximum Rail Support spacing of Flush Mount Panels- Landscape Orientation for Commercial applications where h/d > 0.5 & h/b > 0.5

Maximum Rail Support Spacing for Roofs (mm)												
Building height (h)	Wind Region A			Wind Region B			Wind Region C			Wind Region D		
	Middle	Inner	Edge	Middle	Inner	Edge	Middle	Inner	Edge	Middle	Inner	Edge
<5m	2300	1900	1600	1800	1500	1200	1500	1100	800	1000	600	500
5 to 10m	2200	1800	1600	1700	1400	1100	1400	1000	700	900	600	400
10 to 15m	2100	1700	1500	1600	1300	900	1300	800	600	800	500	400
15 to 20m	2000	1600	1400	1600	1200	900	1200	800	600	700	500	300

Table 5.4 is used for landscape orientation as per Figure 3 above.

6. Determine the Maximum Support Spacing for the Rail 100101- Premium in a residential application

The following tables 6.1 & 6.2 are used to determine the maximum rail support spacing of Flush Mount system **(within the central and end zones of the roof as per Figure 2 above)** and tables 6.3 and 6.4 are used to determine the maximum rail support spacing of Flush Mount system **(within the middle, inner and edge zones of the roof as per Figure 3 above)** for a roof for a solar panel of maximum dimensions 2.0m length x 1.0m width with a hold down fastener on each leg with a **minimum pull-out strengths** of **2.86kN** per fastener from 0.75mm thick steel purlin/batten. Should this differ please advise the consultant.

Refer Appendix 'A' for a table of pull-out strengths for roof fasteners to confirm the fastener to be used

Table 6.1 – Maximum Rail Support spacing of Flush Mount Panels - Portrait Orientation for Residential applications where h/d ≤ 0.5 & h/b ≤ 0.5

Maximum Rail Support Spacing for Roofs (mm)								
Building height (h)	Wind Region A		Wind Region B		Wind Region C		Wind Region D	
	Central	End	Central	End	Central	End	Central	End
<5m	1200	900	800	500	500	300	300	200
5 to 10m	1100	800	700	500	400	300	300	200
10 to 15m	1000	700	600	400	400	300	200	100
15 to 20m	900	600	500	400	400	200	200	100

Table 6.1 is used for portrait orientation as per Figure 2 above.

Table 6.2 – Maximum Rail Support, spacing of Flush Mount Panels - Landscape Orientation Orientation for Residential applications where h/d ≤ 0.5 & h/b ≤ 0.5

Maximum Rail Support Spacing for Roofs (mm)								
Building height (h)	Wind Region A		Wind Region B		Wind Region C		Wind Region D	
	Central	End	Central	End	Central	End	Central	End
<5m	2400	1800	1600	1100	1100	700	600	400
5 to 10m	2300	1600	1400	1000	900	700	600	400
10 to 15m	2000	1400	1200	900	800	600	500	300
15 to 20m	1900	1300	1100	800	800	500	500	300

Table 6.2 is used for landscape orientation as per Figure 2 above.

Table 6.3 – Maximum Rail Support spacing of Flush Mount Panels – Portrait Orientation for Residential applications where h/d > 0.5 & h/b > 0.5

Maximum Rail Support Spacing for Roofs (mm)												
Building height (h)	Wind Region A			Wind Region B			Wind Region C			Wind Region D		
	Middle	Inner	Edge	Middle	Inner	Edge	Middle	Inner	Edge	Middle	Inner	Edge
<5m	1100	700	500	700	400	300	500	300	200	300	200	100
5 to 10m	1000	700	500	600	400	300	400	300	200	200	100	100
10 to 15m	900	600	400	500	300	200	400	200	200	200	100	100
15 to 20m	800	500	400	500	300	200	300	200	100	200	100	100

Table 6.3 is used for portrait orientation as per Figure 3 above.

Table 6.4 – Maximum Rail Support, spacing of Flush Mount Panels - Landscape Orientation for Residential applications where (h/d > 0.5 & h/b > 0.5)

Maximum Rail Support Spacing for Roofs (mm)												
Building height (h)	Wind Region A			Wind Region B			Wind Region C			Wind Region D		
	Middle	Inner	Edge	Middle	Inner	Edge	Middle	Inner	Edge	Middle	Inner	Edge
<5m	2300	1500	1100	1400	900	700	1000	600	500	600	400	300
5 to 10m	2100	1400	1000	1300	800	600	900	600	400	500	300	200
10 to 15m	1900	1200	900	1100	700	500	800	500	400	500	300	200
15 to 20m	1700	1100	800	1100	700	500	700	500	300	400	300	200

Table6.4 is used for landscape orientation as per Figure 3 above.

7. **Check Acceptable End of Rail Overhang**

   Rail end overhang must not be greater than 33 percent (one third of support spacing) of the Flush Mount System support spacing. Thus, if the Flush Mount System support spacing is 1200mm, the Rail end over hang can be up to 400mm ie, 1200/3 = 400mm.

8. **Confirm Solar Panel slope**

   The Solar panel Flush module system can be installed in a building roof where the roof pitch can vary from 10 degrees to 30 degrees.

9. **Determine the Type of Fastener and Minimum Number of Fasteners to be used**

   The following table 9.1 determines the correct fasteners to attach the Flush Mount panel brackets to the roof supports being a timber rafter or truss, or 0.75mm thick steel purlin/batten for residential applications and or a minimum 1.5mm thick steel purlin or truss for commercial applications. The length of the fastener will vary according to the roofing profile; however the 65mm length should be applicable for most installations.

Table 9.1 – Fasteners used to attach Flush Mount through Roof into either Timber or Steel Rafters/Trusses or Purlins

Storm-Tite Roofing Fasteners – (for use greater than 1000m from the coast)

– Dual Point for Timber and Steel Drilling (min.1.5mm thick steel purlin - max. 2.0mm thick steel purlin)

Code	Point	Gauge	TPI	Length	Finish
C14-1465-D4Z	Dual	14	10	65mm	Class 4
C14-14125-D4Z	Dual	14	14	125mm	Class 4
C14-14150-D4Z	Dual	14	14	150mm	Class 4

– Steel Drilling Point (above 2.0mm thick steel)

Code	Point	Gauge	TPI	Length	Finish
C14-1025-S4Z	SD	14	10	25mm	Class 4
C14-1050-S4Z	SD	14	10	50mm	Class 4
C14-1070-S4Z	SD	14	10	70mm	Class 4
C141080-S4Z	SD	14	10	80mm	Class 4
C14-10100-S4Z	SD	14	10	100mm	Class 4
C14-10125-S4Z	SD	14	20	125mm	Class 4
C14-20150-S4Z	SD	14	20	150mm	Class 4

Buildex- Stainless Steel Roofing Fasteners

– (for use within 1000m of the coast into steel purlins) (min.0.75mm thick steel purlin - max. 2.0mm thick steel purlin)

Hex. Head with Al/Neo (S Pt)

Gauge	T.P.I	Length	Pack	Part Number	Pack Type	Finish
14	**14**	**31**	500	6-397-0107-7	Bulk	Grade 305
14	**14**	**52**	500	6-397-0108-8	Bulk	Grade 305
14	**14**	**70**	500	6-397-0109-9	Bulk	Grade 305
14	**14**	**80**	500	6-397-0110-1	Bulk	Grade 305
14	**14**	**90**	500	6-397-0111-1	Bulk	Grade 305

– (for use within 1000m of the coast into timber rafters/trusses) (min.1.5mm thick steel purlin - max. 2.0mm thick steel purlin)

Hex. Head with 16mm aluminium bonded washer

Gauge	T.P.I	Length	Pack	Part Number	Pack Type	Finish
14	**10**	**25**	500	6-037-0022-4	Bulk	Grade 304
14	**10**	**50**	500	6-037-0023-2	Bulk	Grade 304
14	**10**	**65**	500	6-037-0024-1	Bulk	Grade 304
14	**10**	**75**	500	6-037-0025-9	Bulk	Grade 304
14	**10**	**90**	500	6-037-0026-7	Bulk	Grade 304

Fastener Notes:

1. Minimum embedment length into timber to be not less than 36mm;
2. Never set drill on impact when installing screws, otherwise fastener warranties are void;
3. Use Dual Point screws up to 2.0mm thick steel purlins or rafters;
4. Use Steel Point screws over to 2.0mm thick steel purlins or rafters;
5. Use Stainless Steel screws within 1000m of the coast;
6. Use a Minimum 1 off 14gx10 TPI (T17s) roofing fasteners per support leg to a minimum 0.75mm thick steel purlin/batten or pine/ hardwood timber for a residential application;
7. Use a Minimum 1 off 14gx10 TPI Teks roofing fasteners per support leg to a minimum 1.5mm thick steel purlin for commercial building;

Note: The installer is solely responsible for:

- Complying with all applicable local or national building codes;
- Ensuring that the Solar Tilt Module System, fasteners and clamps used and or other products are appropriate for the particular installation at the particular installation environment;
- Ensuring that the roof and its components ie, rafters, connections, and other structural support members can support the solar array assembly under building live load conditions;
- Using only Solar Tilt Module System parts and installer-supplied parts as specified by Solar World Asia Pacific Pte Ltd;
- Maintaining the waterproof integrity of the roof, including selection of appropriate flashing and fasteners;
- Ensuring safe installation of all electrical components of the PV solar assembly;
- Ensuring that **dissimilar metals** have a rubber pad between them such as aluminium and galvanised steel;

APPENDIX 'A'

FASTENER PULLOUT STRENGTHS

Buildex®

One of the world's leading manufacturers and suppliers of self-drilling screws and fasteners.

Technical Specifications

Pullout Values (Newtons) - Buildex Fasteners into Steel

Screw Gauge/TPI	Steel Thickness								
	0.55mm Batten	0.75mm Batten	1.2mm Stud	1.5mm Purlin	1.9mm Purlin	2.4mm Purlin	6.0mm Hot Roll Steel	8.0mm Hot Roll Steel	12mm Hot Rol Steel
10g - 16 TPI Teks®	-	1,860	2,320	4 200	5,500	7,820	-	-	-
10g - 24TPI Teks®	-	-	2,320	4 280	5,820	7,680	-	-	-
M6 RoofZips®	1,520	2,480	3,280	5 240	5,940	-	-	-	-
12g - 24 TPI Teks® *Hex + Wafer Series 500*	-	-	-	-	-	6,260	16,700*	16,700*	16,700*
12g - 14 TPI Teks® *Screw length longer than 20mm*	-	-	1,380	3 040	5,160	6,960	-	-	-
12g - 14 TPI Teks® *Screw length 20mm or shorter*	-	-	2,200	4 060	5,420	7,360	-	-	-
12g - 24 TPI Teks®	-	-	-	-	-	7,780	-	-	-
14g - 10 TPI Teks®	-	-	2,500	4 680	6,500	8,100	-	-	-
14g - 20 TPI Teks®	-	-	2,400	4 200	5,500	7,700	19,860	-	-

* Axial tensile value of screw

Note: Appropriate safety factors should be applied for design purposes.
All values are averages obtained under laboratory conditions.
These figures apply to Buildex® (BX Head marked) products only.

Pullout Loads (Kilo Newtons kN)
The load required to pull the fastener out of the material it is screwed into.

Pullout Values (Newtons) - Buildex Fasteners into Timber, Lightweight Battens & Steel

Screw Gauge/TPI	Thickness							
	0.55mm Batten	0.75mm Batten	1.2mm Stud	1.5mm Purlin	1.9mm Purlin	F7 Pine Timber	F17 Hard Wood	Ultra Hard Timber
10g - 12 TPI (T17s)	1,320	2,220	-	-	-	5,700	6,000	-
12g - 11 TPI (T17s)	1,510	2,400	-	-	-	3,900	6,460	-
14g - 10 TPI (T17s)	1,740	2,860	-	-	-	3,820	6,980	-
M5.5 - 11 Batten Zips®	1,540	2,420	2,680	-	-	5,710	6,460	6,960
M6 RoofZips®	1,520	2,480	3,280	5,240	5,940	4,300	6,570	-

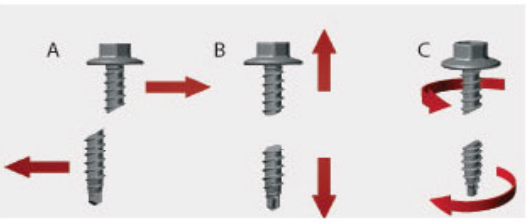
* Pullout values at 36mm embedment into timber

Note: Appropriate safety factors should be applied for design purposes.
All values are averages obtained under laboratory conditions.
These figures apply to Buildex® (BX Head marked) products only.

Mechanical Properties

Screw Gauge/TPI	Single Shear Strength (N)	Axial Tensile Strength (N)	Torsional Strength (Nm)
M6 RoofZips®	8,500	15,400	14.0
10g - 16 TPI	6,800	11,900	8.4
10g - 24 TPI	6,200	11,400	8.6
12g - 11 TPI	8,400	13,900	13.5
12g - 14 TPI	8,800	15,300	13.2
12g - 24 TPI	9,000	16,700	13.5
14g - 10 TPI	10,900	19,700	18.5
14g - 20 TPI	11,200	21,200	20,400

Note: Appropriate safety factors should be applied for design purposes.
All values are averages obtained under laboratory conditions.
These figures apply to Buildex® (BX Head marked) products only.



A. Single Shear Strength (N)
The shear load required to break the screw

B. Axial Tensile Strength (N)
The tensile load required to break the screw

C. Torsional Strength (Nm)
The torque required to break the screw