

3<sup>rd</sup> August 2023



**Project Name: Ground Mount Kit Certification – AS/NZS 1170.2:2021**

**Reference: 23E-0187**

**Revision: 1**

To whom it may concern,

RMA Engineers Pty Ltd have independently checked and certified the Ground Mount 'Kit' – Sigma S1 Alu system, as contained in this certificate and appendices. The kit has been designed for multiple frame types ranging from 15° to 30° in pitch in wind regions A and B and is suited to both clay soils (firm to stiff and very stiff to hard) and non-cohesive sands (medium dense and compact). Specific wind parameters and soil characteristics applicable to this certification are detailed in later sections.

### Code Compliance

The design and associated calculations are generally in accordance with the Structural Engineers requirements of the National Construction Code, Engineering Principles and the following Australian Standards:

- AS/NZS 1170.0:2002 – Structural Design Actions – Part 0: General Principles
- AS/NZS 1170.1:2002 – Structural Design Actions – Part 1: Permanent, imposed and other actions
- AS/NZS 1170.2:2021 – Structural Design Actions – Part 2: Wind Actions
- AS/NZS 1664.1:1997 – Aluminium structures
- AS/NZS 4600:2018 – Cold-formed steel structures

The design checks have been based on the information and parameters provided by S-Rack, analysed against the frame members specified below at the request of S-Rack.

### Module Specifications

There are two different module sizes/specifications that have been analysed and are covered by this certification. In general, can be referred to as below,

#### 1. 2200mm Panel

- Members
  - > Girder: 125x55x10x2mm (Steel)
  - > Pile: C-Post 150x70x14x3.5mm (Steel)
  - > Strut: 60x3mm (Steel)
  - > Purlin: 45/75CS (Aluminium)

## 2. 2400mm Panel

- Members
  - > Girder: C-Post 150x70x14x3.5mm (Steel)
  - > Pile: C-Post 150x70x14x3.5mm (Steel)
  - > Strut: 60x3mm (Steel)
  - > Purlin: 45/75CS (Aluminium)

Relevant frame drawings for each system type are included within the appendices.

### Analysis

The analysis for each module type was conducted for the following situations,

- Frame pitches of 15°, 20°, 25°, 30° (pitches taken from the horizontal)
- 2200mm and 2400mm panel types
- Wind regions A and B (AS1170.2:2021)
- Embedment philosophies:
  - > Driven steel piles
  - > Pre-drilling
    - 300mm diameter full depth of pile embedment and backfilled with 5% stabilised sand
- Embedment conditions (refer table 1 for specific parameters)
  - > Cohesive
    - Firm – Stiff Clays
    - Very stiff – Hard clays
  - > Non-cohesive
    - Medium-dense sand
    - Compact sand

An iterative design process was undertaken assessing the structure for each wind region, module size, and tilt angle, in a finite element analysis program (FEA) – SpaceGass. Member capacities were assessed to AS4600:2018 (steel) and AS1664.1 (aluminium) upon determining optimised spans. Pile embedment depths were designed in accordance with AS2159 in addition to verification of their lateral capacity to an industry standard method (Broms).

### Fixed parameters and design conditions

The following fixed design conditions have been adopted throughout the project to provide this certification:

- Importance Level = 2 (NCC)
- Design Life = 25 Years
- Annual Probability of Exceedance (APE) = 1:500 (NCC)
- Terrain Category = 2 (AS1170.2:2021)

- Mt & Ms = 1.0 (AS1170.2:2021)
- Wind Direction multiplier for Regions A and B taken as 0.95 from the North and South. System is assumed to be pitched towards and facing north.
- Wind region B has adopted the climate change factor, Mc = 1.05 to account for worst case region B zones (i.e., region B2)
- Pressure coefficients to AS1170.2:2021, appendix B.6.2
  - > The critical shape factors from this appendix for each relevant pitch have been adopted in design, to simulate a 'worst case' situation
  - > Appendix B.6.2 clause notes restrictions and limitations for which the solar array must comply with in order to be applicable. We have assumed the given 'Kit' system will meet these requirements, and it is the responsibility of the installer/contractor/project manager of each specific kit project to verify their projects array meets the limitations of use.
- Panel weight = 15kg/m<sup>2</sup>
  - > No additional weights from ancillary attachments e.g. inverter boxes have been included in this assessment. Ancillary attachments required to be fixed to the frames require specific assessment.
- Panel width taken as 1.1m for both 2200mm and 2400mm panel systems (typical S-rack dimension). Max panel gap assumed to be 25mm.
- Maximum purlin cantilever
  - > The maximum allowable purlin cantilever is specified for each respective wind region as,
    - Wind region A = 1000mm
    - Wind region B = 600mm
- Maximum table length = 30.0m
- Pile Testing requirements are not applicable
- Services near proposed ground mount kit location
  - > RMA has not considered the presence of any services (electrical, water, sewer, telecoms etc.) to be present within the plan area of future proposed kit systems or running adjacent (parallel or perpendicular) to end frame piles
  - > The installer/contractor/project manager of each specific kit project is responsible for verifying services, conducting appropriate clash detection and liaising with service providers (if required)
  - > Required services trenches in close proximity (within 1500mm and deeper than 200mm to piles) will require a project specific design
- Corrosivity conditions
  - > Atmospheric or ground corrosivity conditions have not been considered
  - > The installer/contractor/project manager of each specific kit project is responsible for verifying their projects site conditions are suitable for the standard kit protection

methods (refer to S-Rack drawings for standard corrosion protection systems)

- Ground slope (topography conditions)
  - > Project sites height has been assumed no greater than 500m above sea level
  - >  $H/(2.L_u)$  has been considered to be 1.0, where
    - $H$ =height of the hill, ridge or escarpment (in the North or South wind direction)
    - $L_u$ =horizontal distance upwind from the crest of the hill, ridge or escarpment to a level of half the height below the crest of said hill
  - > For all other sites a project specific design is required.

### Foundation considerations

Two separate soil conditions and lithologies were considered for the design of the kit system, being,

- Cohesive materials (i.e. stiff – very stiff clays)
- Non-cohesive materials (i.e. dense – medium dense sands)

Table 1 below denotes the critical design parameters used for each situation which are to be verified by the relevant installer/contractor/project manager of each specific Kit project.

Parameter	Adopted value
<u>General</u>	
Strength reduction factor ( $\phi_g$ )	0.5
Depth of soil ignored	200mm
<u>Cohesive materials (clays)</u>	
Undrained shear strength ( $C_u$ ) of firm – stiff clays	50kPa
Undrained shear strength ( $C_u$ ) of very stiff – hard clays	100kPa
<u>Non-cohesive materials (sands)</u>	
Medium dense sands – Modulus of horizontal subgrade	7,000 kN/m <sup>3</sup>
Dense sands – Modulus of horizontal subgrade	16,500 kN/m <sup>3</sup>
Medium dense sands – Internal friction angle $\phi$	35°
Dense sands – Internal friction angle $\phi$	40°
Medium dense sands – Bulk unit weight	18kN/m <sup>3</sup>
Dense sands – Bulk unit weight	19kN/m <sup>3</sup>

Table 1 - Geotechnical design properties

## Findings

The two panel types were analysed to the situations and conditions described above to produce a results table, that maximises the span / frame spacings of each array. This philosophy provides optimal efficiency to the structural 'Kit' members and the allowable embedment depths for each tilt angle.

The tabulated 'Kit' certification data is shown in the first Appendix.

Yours sincerely,

**Aaron Neubauer**  
**Senior Engineer (Structural)**  
**RMA ENGINEERS PTY LTD**

B.E. (Civil), RPEQ 15029, MIEAust, CPEng/NPER 2621812, NER

*Appendices:*

1. *Ground Mount Kit Results Analysis*
2. *2200mm Panels Frame drawings – Wind regions A and B*
3. *2400mm Panels Frame drawings – Wind regions A and Bs*

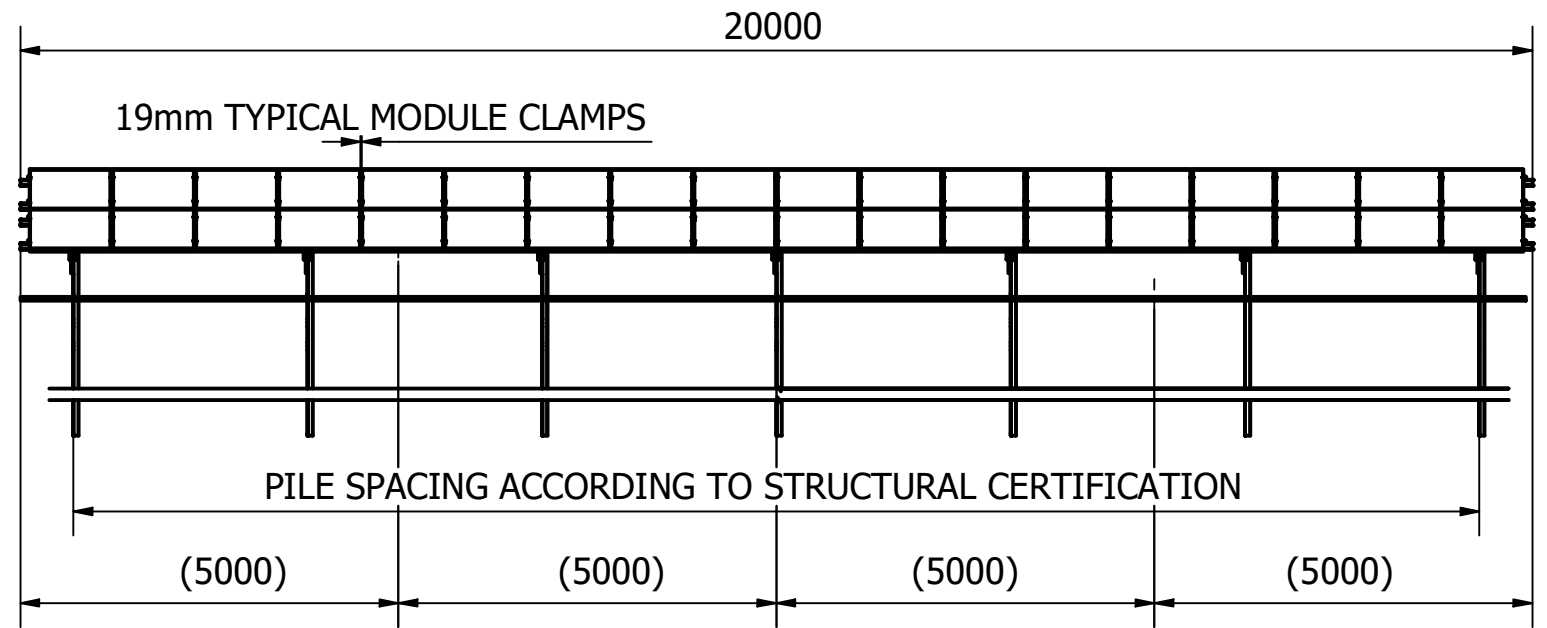
**GROUND MOUNT KIT - RESULTS ANALYSIS**

<b>WIND REGION</b>	<b>Region A</b>								<b>Region B</b>							
<b>PANEL TILT (DEGREES)</b>	<b>15</b>		<b>20</b>		<b>25</b>		<b>30</b>		<b>15</b>		<b>20</b>		<b>25</b>		<b>30</b>	
<b>PANEL LENGTH</b>	<b>2200</b>	<b>2400</b>	<b>2200</b>	<b>2400</b>	<b>2200</b>	<b>2400</b>	<b>2200</b>	<b>2400</b>	<b>2200</b>	<b>2400</b>	<b>2200</b>	<b>2400</b>	<b>2200</b>	<b>2400</b>	<b>2200</b>	<b>2400</b>
<b>FRAME PARAMETERS</b>																
<b>H1 (clearance Height) (m)</b>	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
<b>H2 (m)</b>	1.689	1.689	2.026	2.026	2.351	2.351	2.664	2.664	1.689	1.689	2.026	2.026	2.351	2.351	2.664	2.664
<b>Rafter Inclined Length (m)</b>	3.396	3.396	3.396	3.396	3.396	3.396	3.396	3.396	3.396	3.396	3.396	3.396	3.396	3.396	3.396	3.396
<b>Maximum purlin cantilever (m)</b>	1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
<b>Frame Spacing (m)</b>	<b>3.3</b>	<b>2.85</b>	<b>3.1</b>	<b>2.8</b>	<b>3</b>	<b>2.6</b>	<b>2.9</b>	<b>2.9</b>	<b>2</b>	<b>1.75</b>	<b>1.9</b>	<b>1.7</b>	<b>1.8</b>	<b>1.8</b>	<b>2.5</b>	<b>1.8</b>
<b>EMBEDMENT DEPTH CALCULATIONS - CRITICAL ACTIONS</b>																
<b>Critical base moment (kNm)</b>	14.2	14.85	12.7	12.2	10.3	9.6	7	8.2	14.5	14.9	12.4	11.72	10.1	10.4	10.6	8.7
<b>Maximum compression load (kN)</b>	13.1	15.1	12.8	15.1	13	14.95	12.1	16.4	14.4	14.9	14.1	14.9	14.2	16	18.1	16.7
<b>Maximum pullout force (kN)</b>	11.6	11.3	11	11	10.4	10	9.8	10.9	13.8	13.3	12.9	12.8	12.1	13.3	16.4	13.3
<b>EMBEDMENT DEPTH (+/-0.1m) - COHESIVE SOILS</b>																
<b>MAX PILE DEPTH ALLOWABLE (m)</b>	<b>2.439 +/- 0.1</b>		<b>2.186 +/- 0.1</b>		<b>1.939 +/- 0.1</b>		<b>1.7 +/- 0.1</b>		<b>2.439 +/- 0.1</b>		<b>2.186 +/- 0.1</b>		<b>1.939 +/- 0.1</b>		<b>1.7 +/-0.1</b>	
<b>Firm - Stiff Clays (Pile driven)</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>Firm - Stiff Clays - w/ Predrilling</b>	1.6	1.6	1.6	1.6	1.5	1.6	1.5	1.4	1.6	1.7	1.5	1.7	1.5	1.8	1.4	1.7
<b>Very Stiff - Hard Clays (Pile driven)</b>	2.439	2.439	2.186	2.186	1.939	1.939	1.7	N/A	2.439	2.439	2.186	2.186	1.939	N/A	N/A	N/A
<b>Very Stiff - Hard Clays - w/ Predrilling</b>	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3	1.2	1.4	1.2	1.4
<b>EMBEDMENT DEPTH (m) - NON COHESIVE SOILS</b>																
<b>Medium-Dense Sands (Pile driven)</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>Medium-Dense Sand - w/ Predrilling</b>	N/A	N/A	N/A	N/A	1.9	N/A	1.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>Dense Sands (Pile driven)</b>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>Dense Sands - w/ Predrilling</b>	2.1	2.4	2.1	2	1.8	1.8	1.6	1.6	2.3	2.4	2.1	2.1	1.8	1.9	1.6	1.7

# Sigma S1 Alu

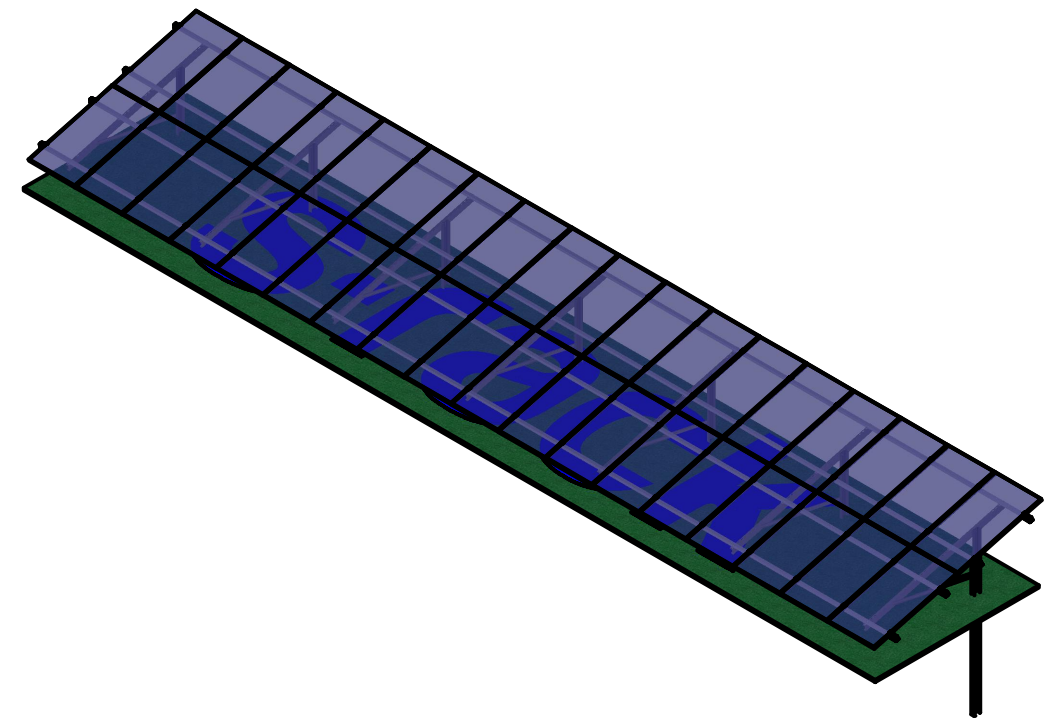
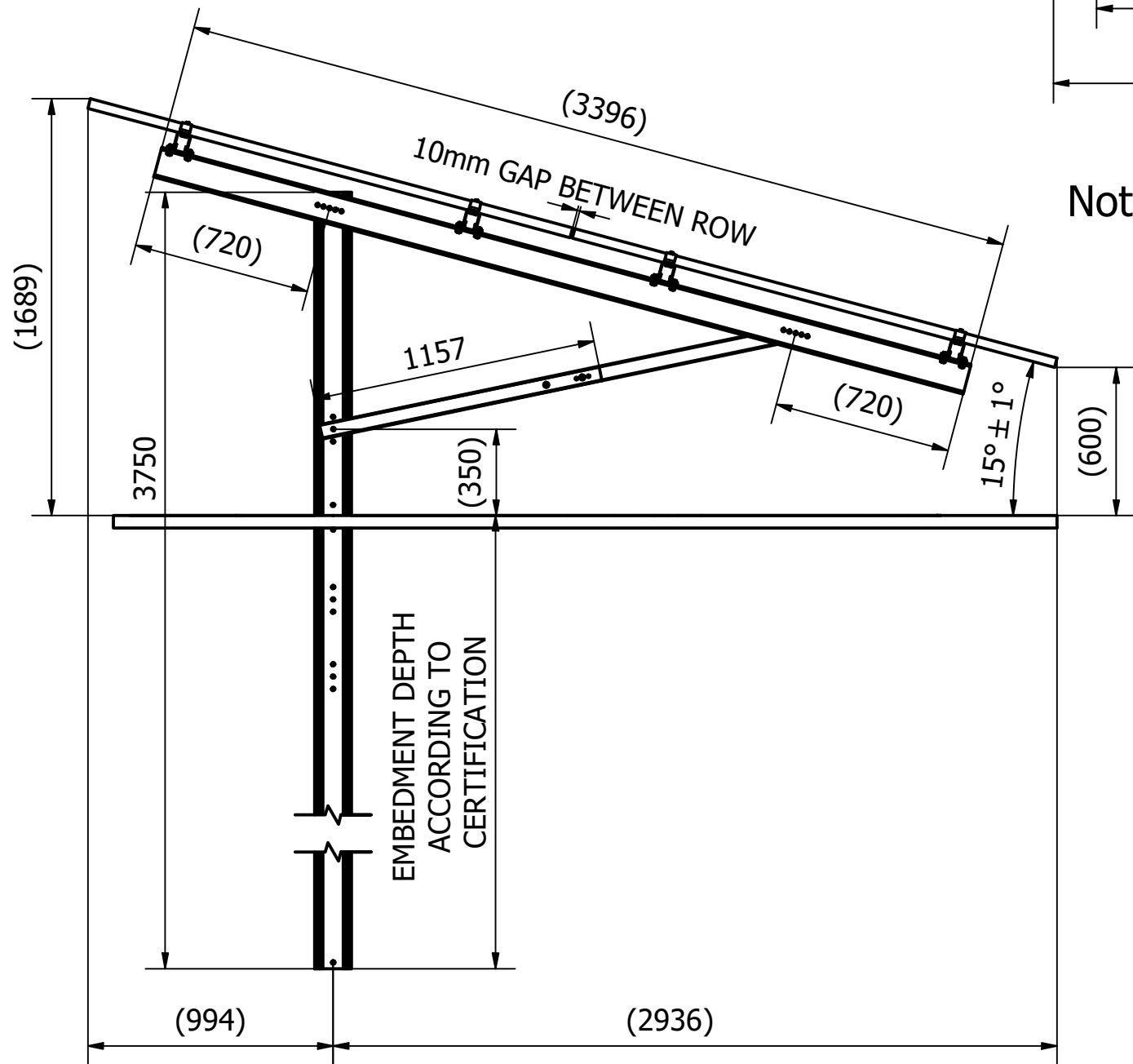
Max module length: 2150mm  
 Refer to module's installation manual  
 for approved clamping location

Module Inclination: 15° / 20° / 25° / 30°



VIEW A

Note: Each purlin section need to be supported by at least 1 frame.



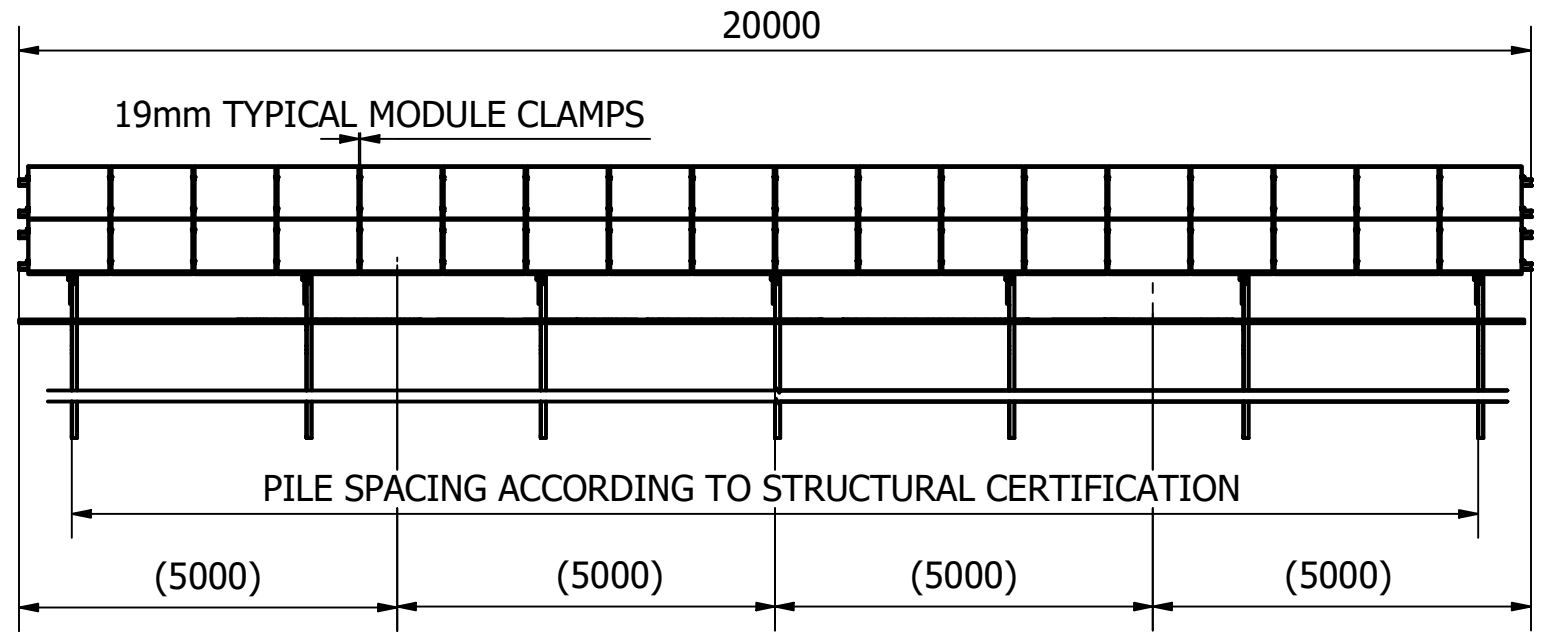
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			Revision 00	Sheet 1 / 1

Foundation	C-Post 150x70x14x3.5mm	HDG Steel
Girder	125x55x10x2mm	HDG Steel
Purlin	45/75 CS	Mill Aluminium

# Sigma S1 Alu

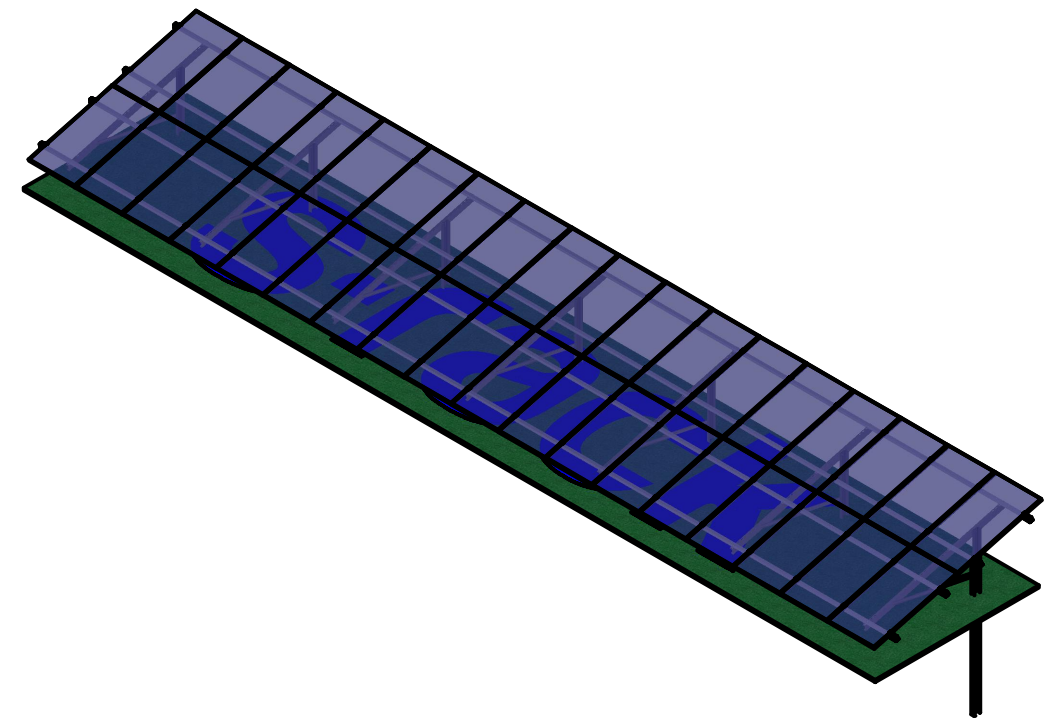
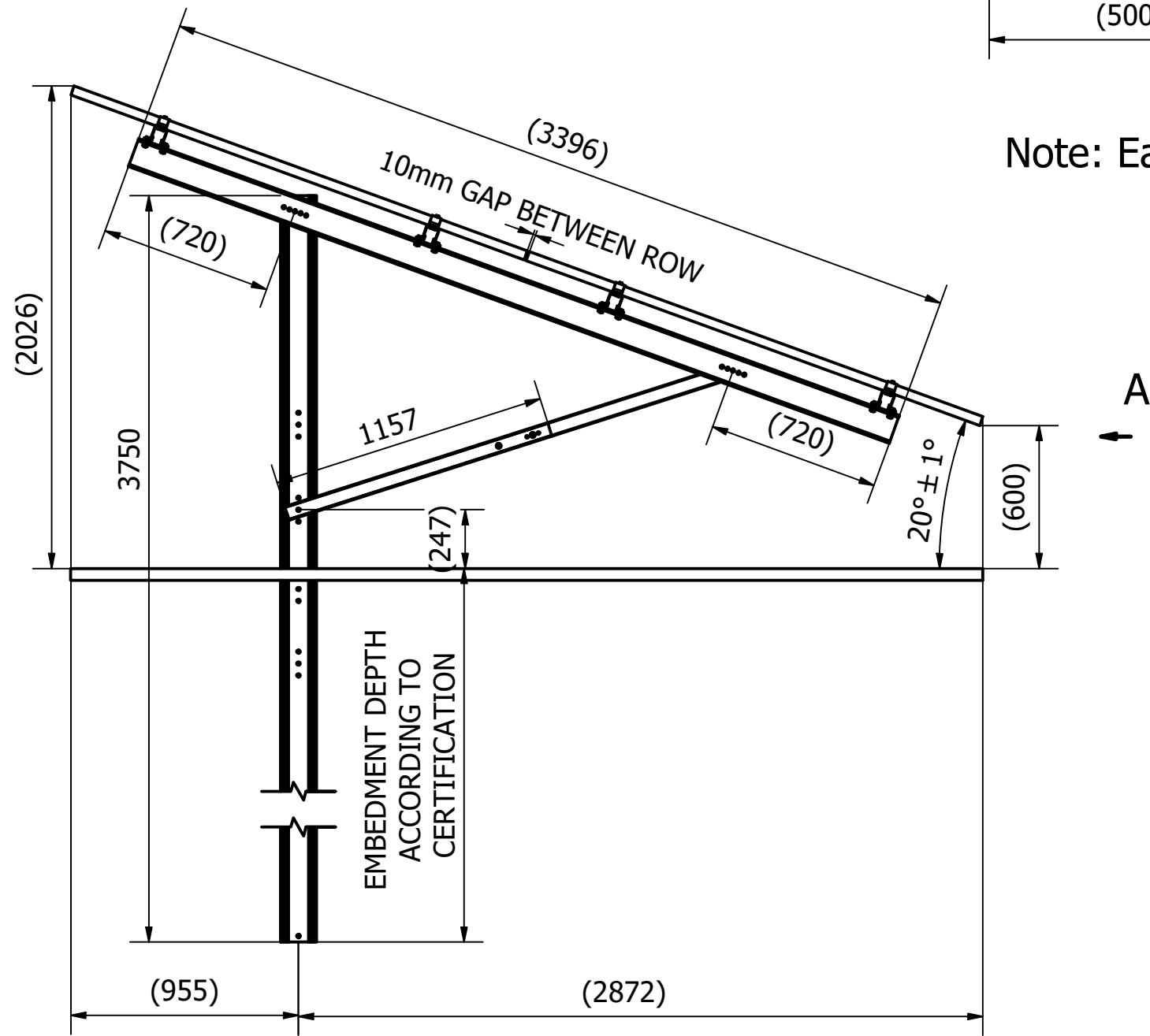
Max module length: 2150mm  
 Refer to module's installation manual  
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Module Inclination: 15° / 20° / 25° / 30°



VIEW A

Note: Each purlin section need to be supported by at least 1 frame.



Foundation	C-Post 150x70x14x3.5mm	HDG Steel
Girder	125x55x10x2mm	HDG Steel
Purlin	45/75 CS	Mill Aluminium

Designed by FC	Checked by	Approved by JK	Date 2/06/2023	Date 2/06/2023
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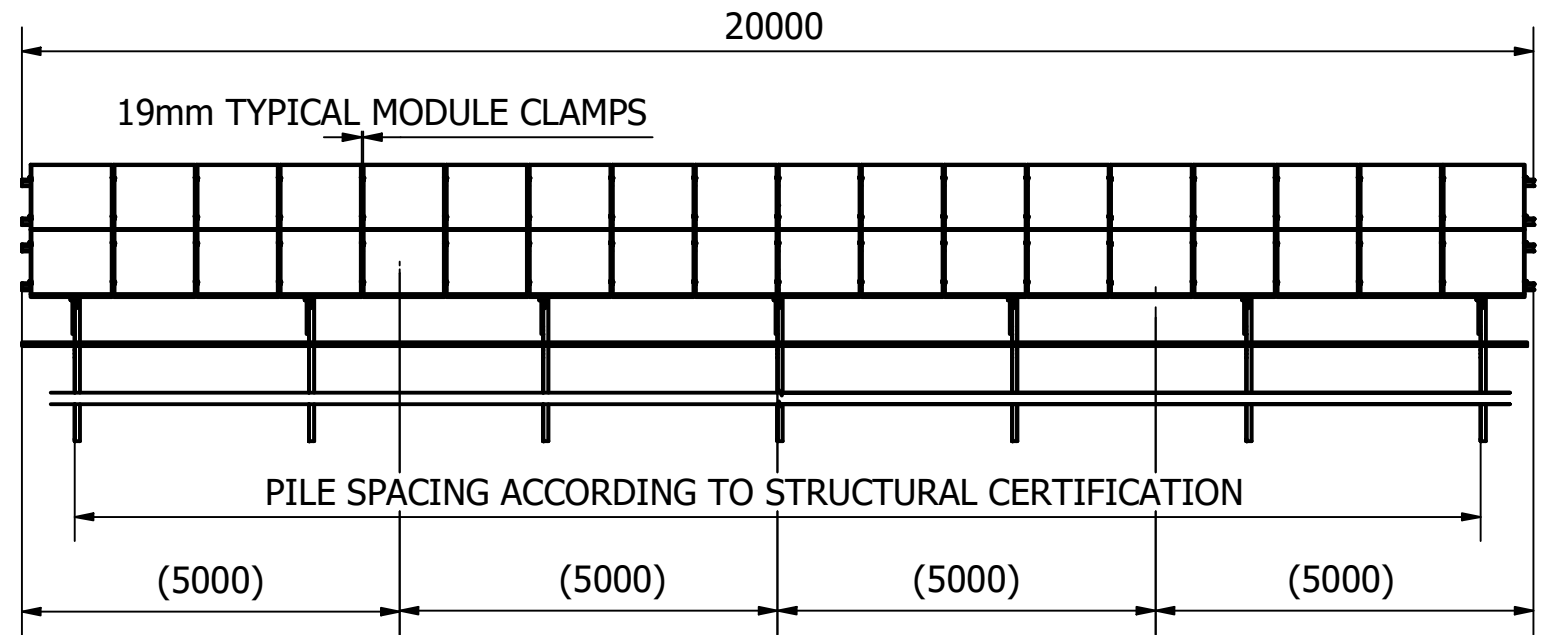


20 Degrees		Revision 00	Sheet 1 / 1
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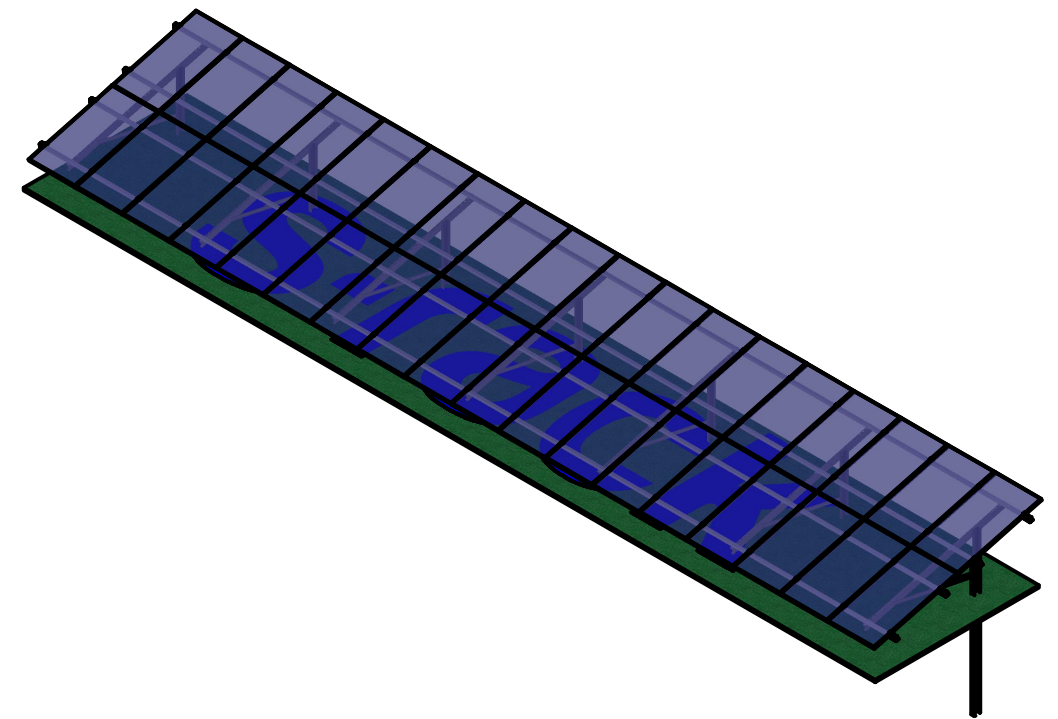
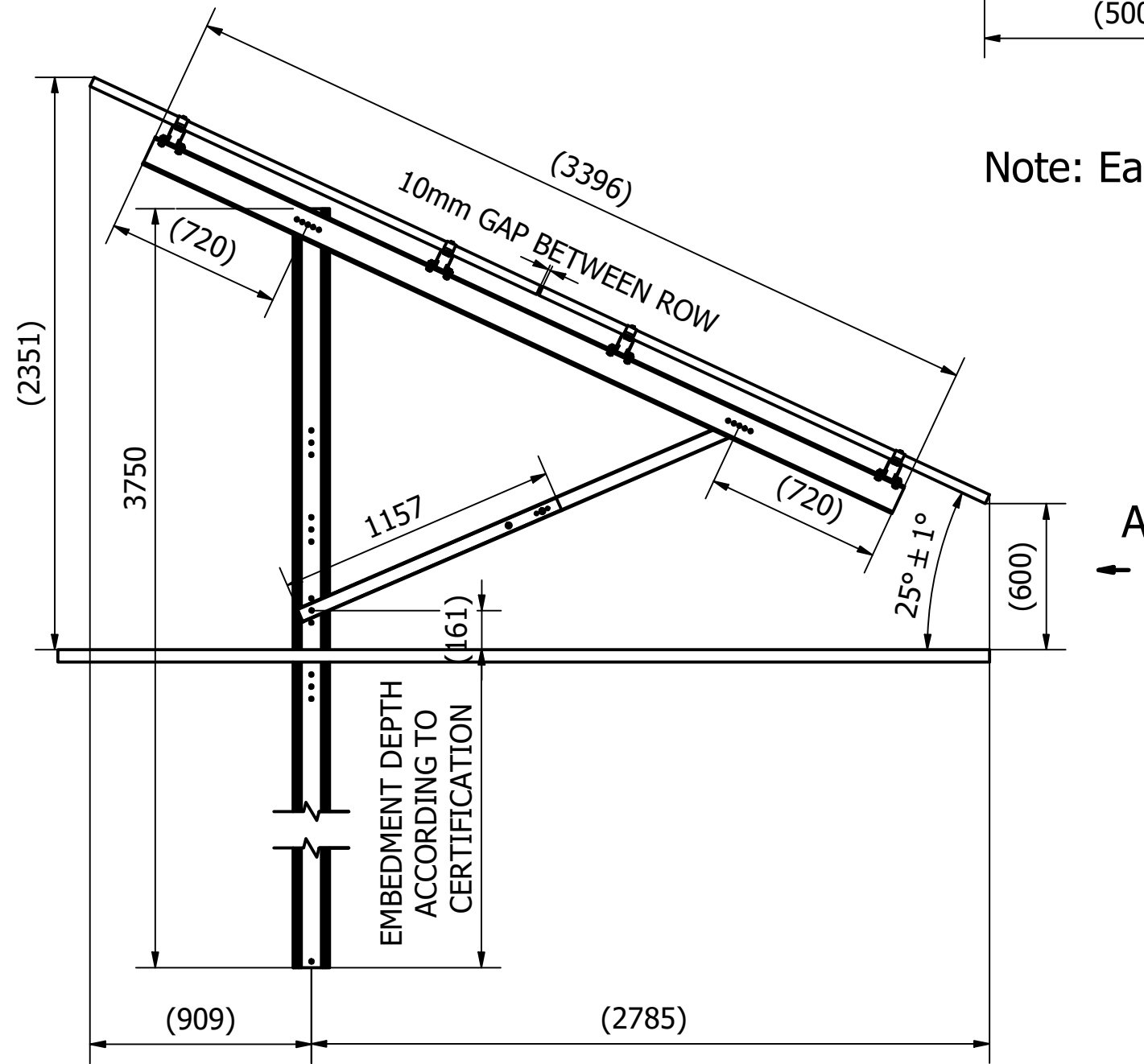
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 for approved clamping location

Module Inclination: 15° / 20° / 25° / 30°



VIEW A

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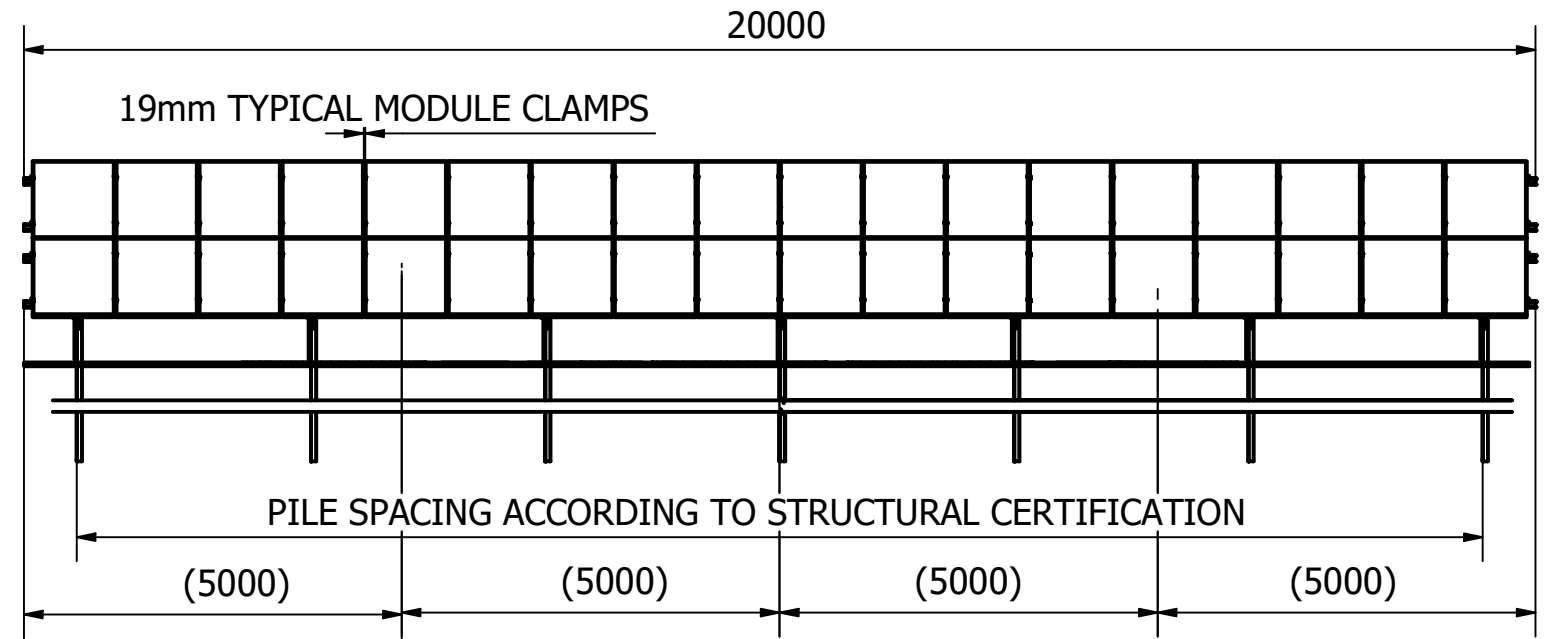
Foundation	C-Post 150x70x14x3.5mm	HDG Steel
Girder	125x55x10x2mm	HDG Steel
Purlin	45/75 CS	Mill Aluminium

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# Sigma S1 Alu

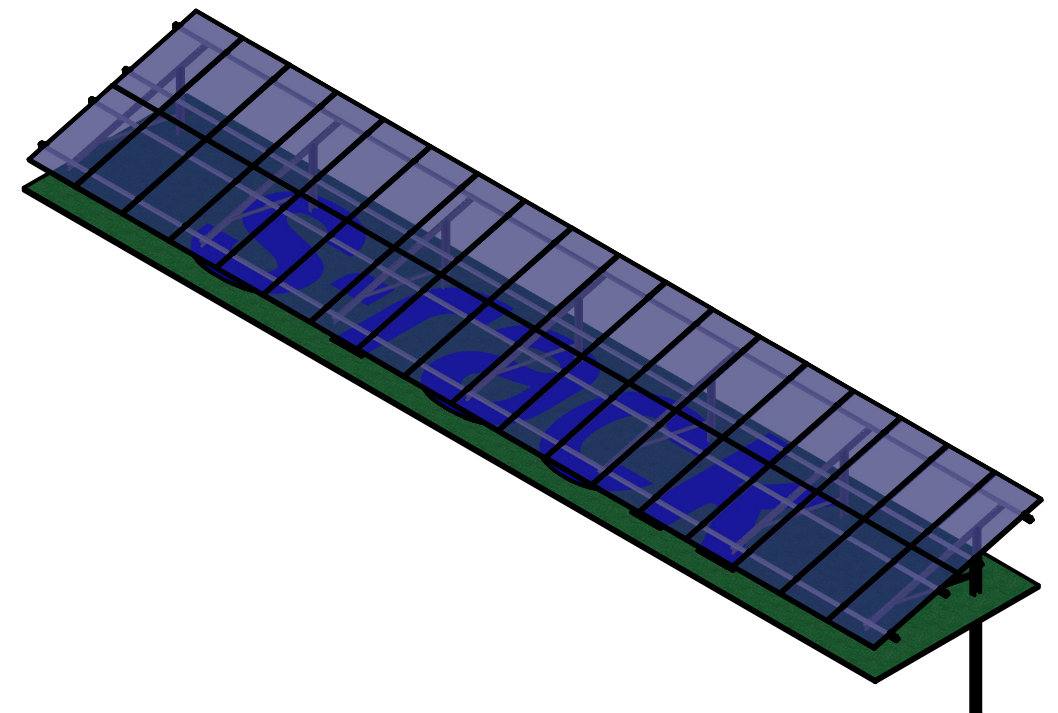
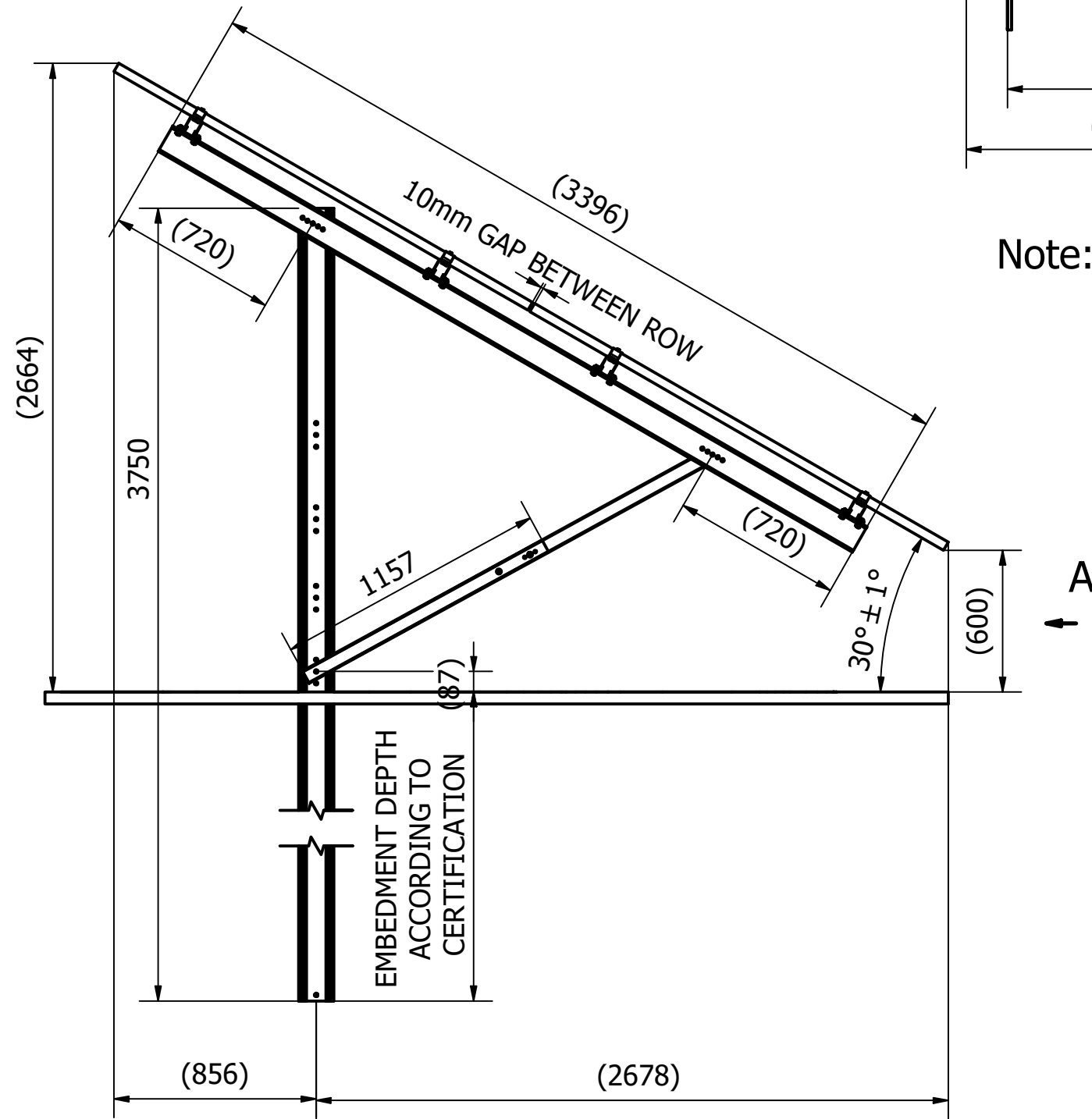
Max module length: 2150mm  
 Refer to module's installation manual  
 for approved clamping location

Module Inclination: 15° / 20° / 25° / 30°



VIEW A

Note: Each purlin section need to be supported by at least 1 frame.



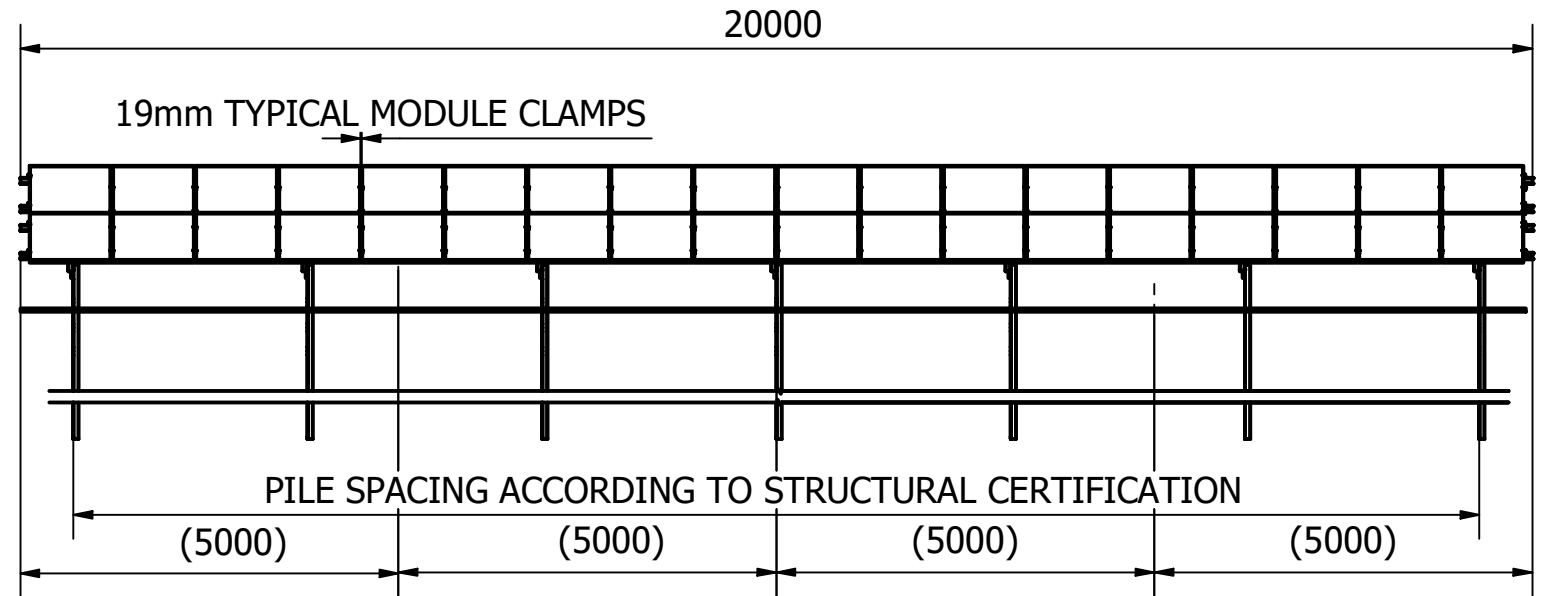
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Girder	125x55x10x2mm	HDG Steel
Purlin	45/75 CS	Mill Aluminium

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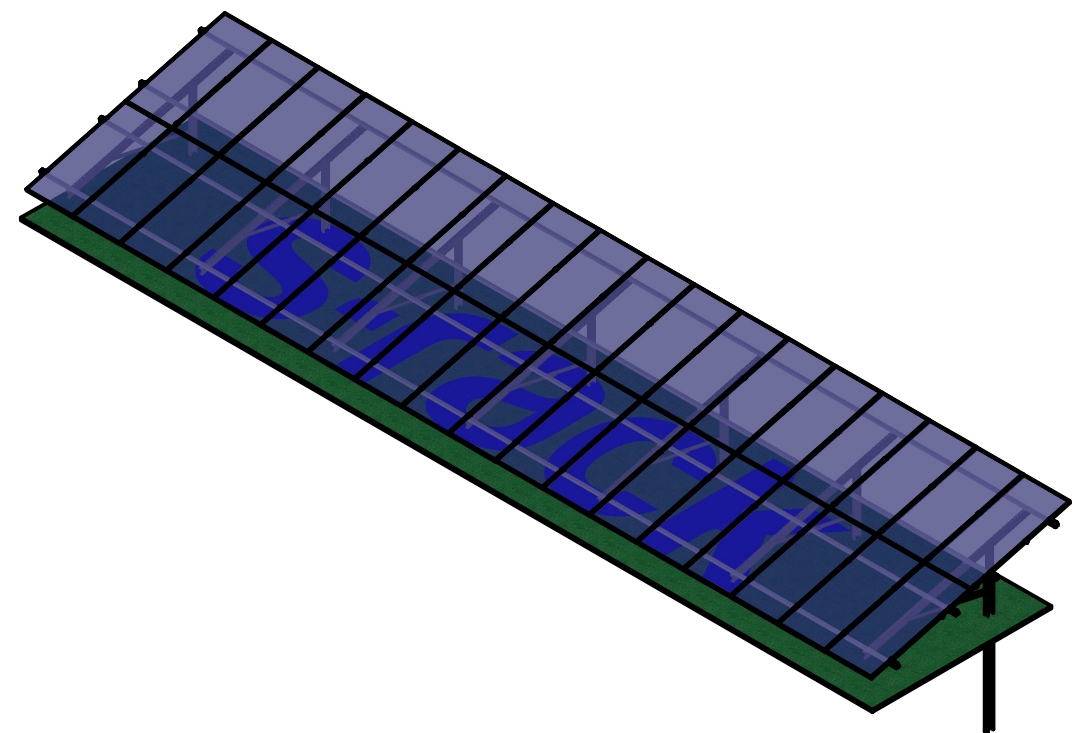
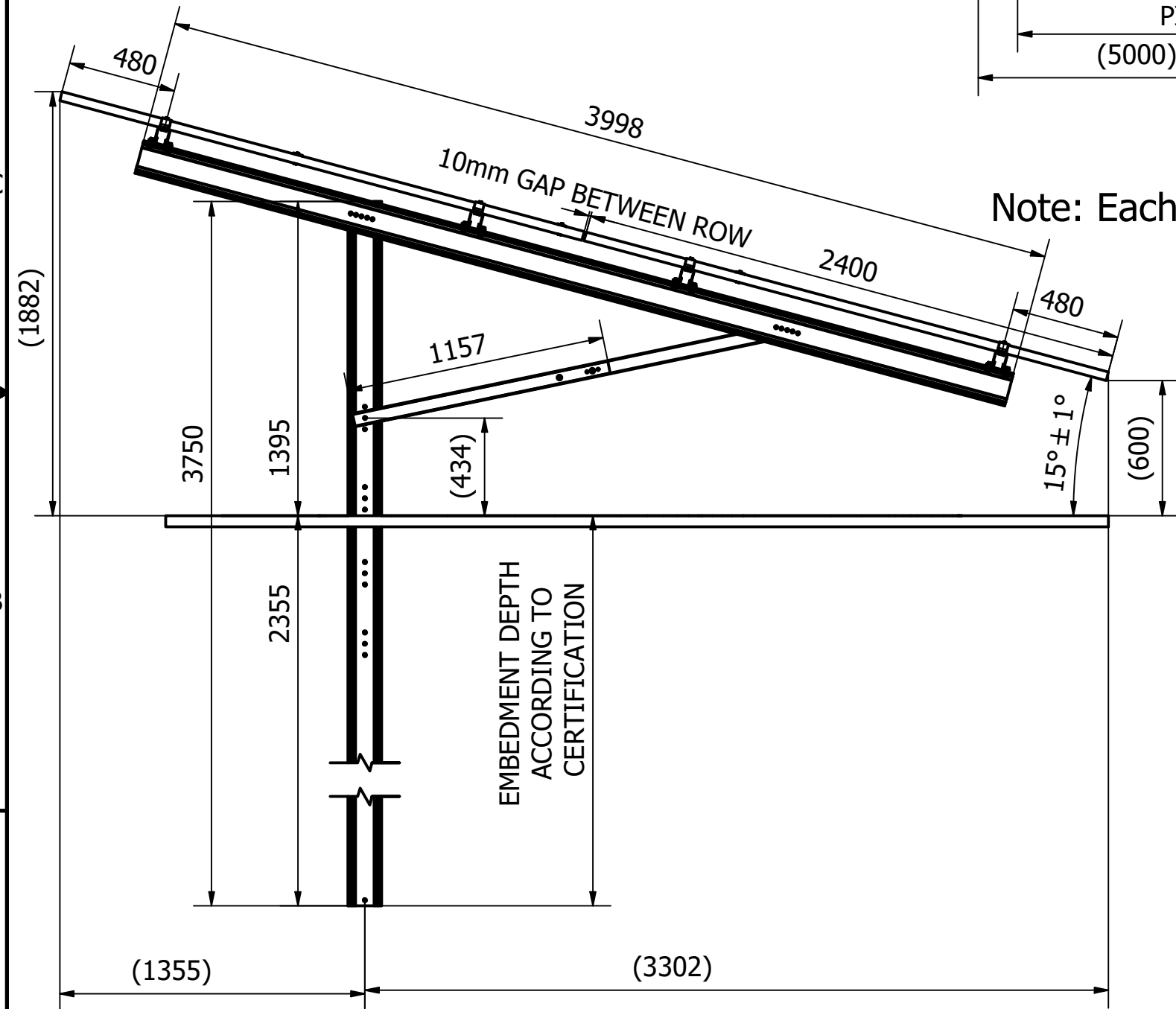
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 Refer to module's installation manual  
 for approved clamping location

Module Inclination: 15° / 20° / 25° / 30°



VIEW A

Note: Each purlin section need to be supported by at least 1 frame.



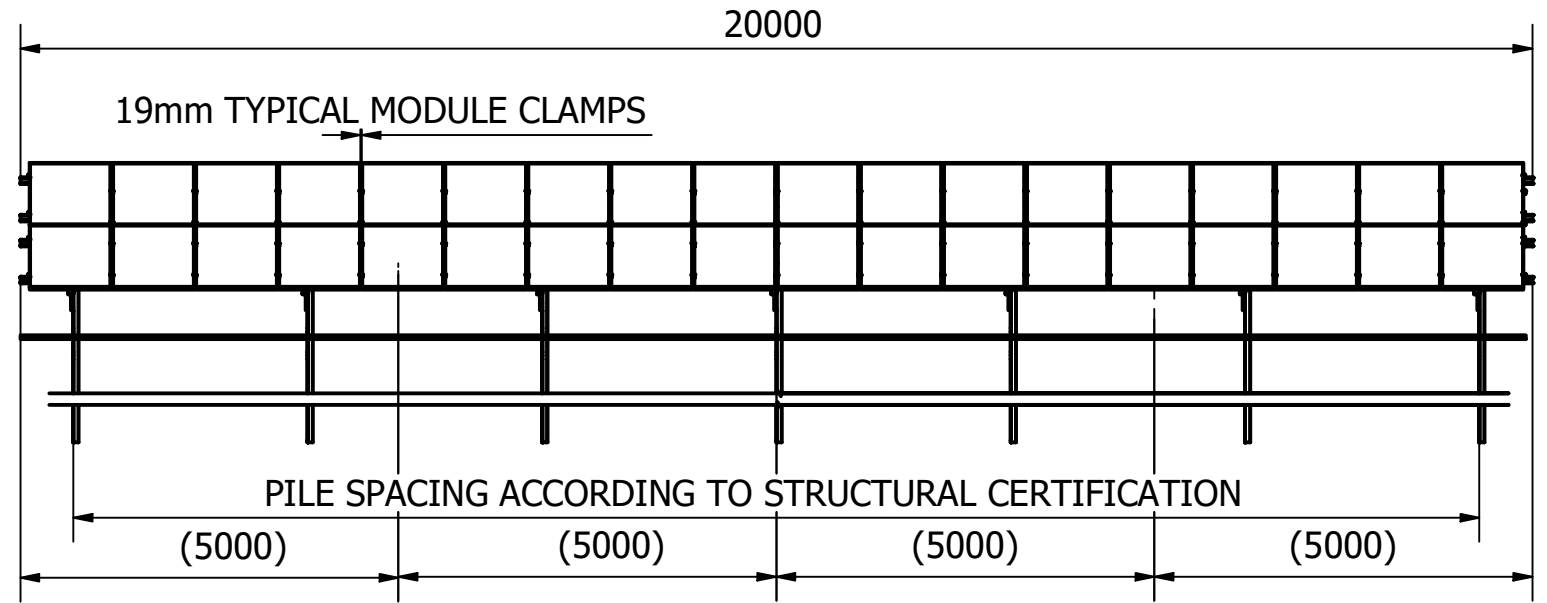
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# Sigma S1 Alu

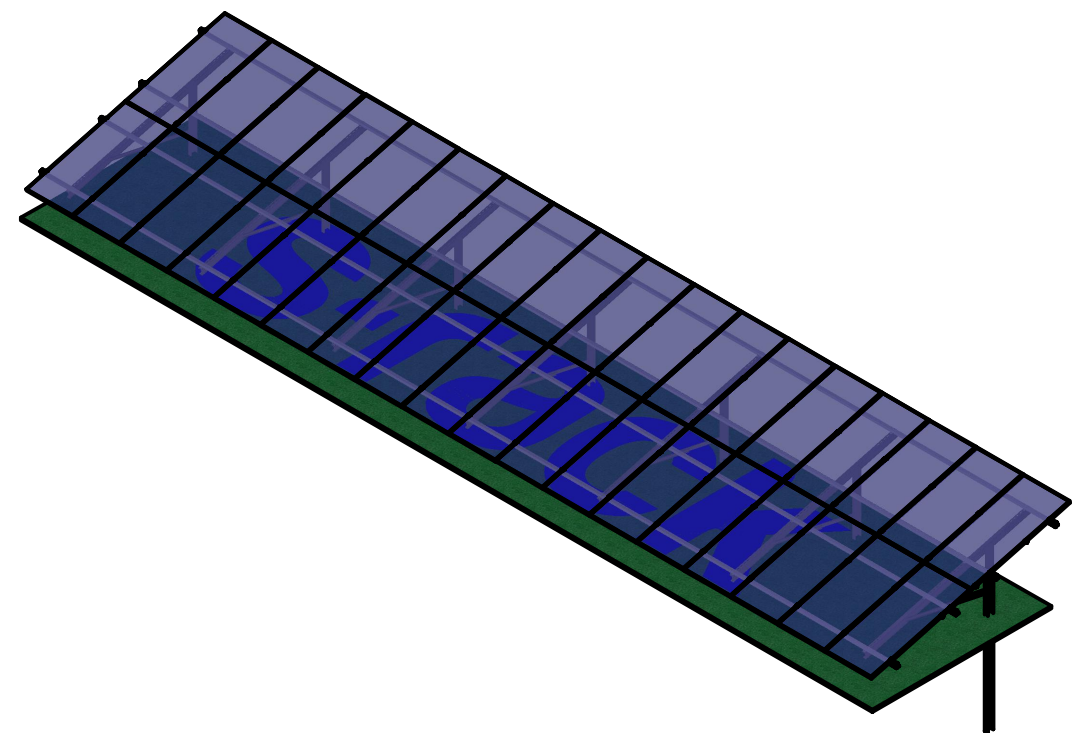
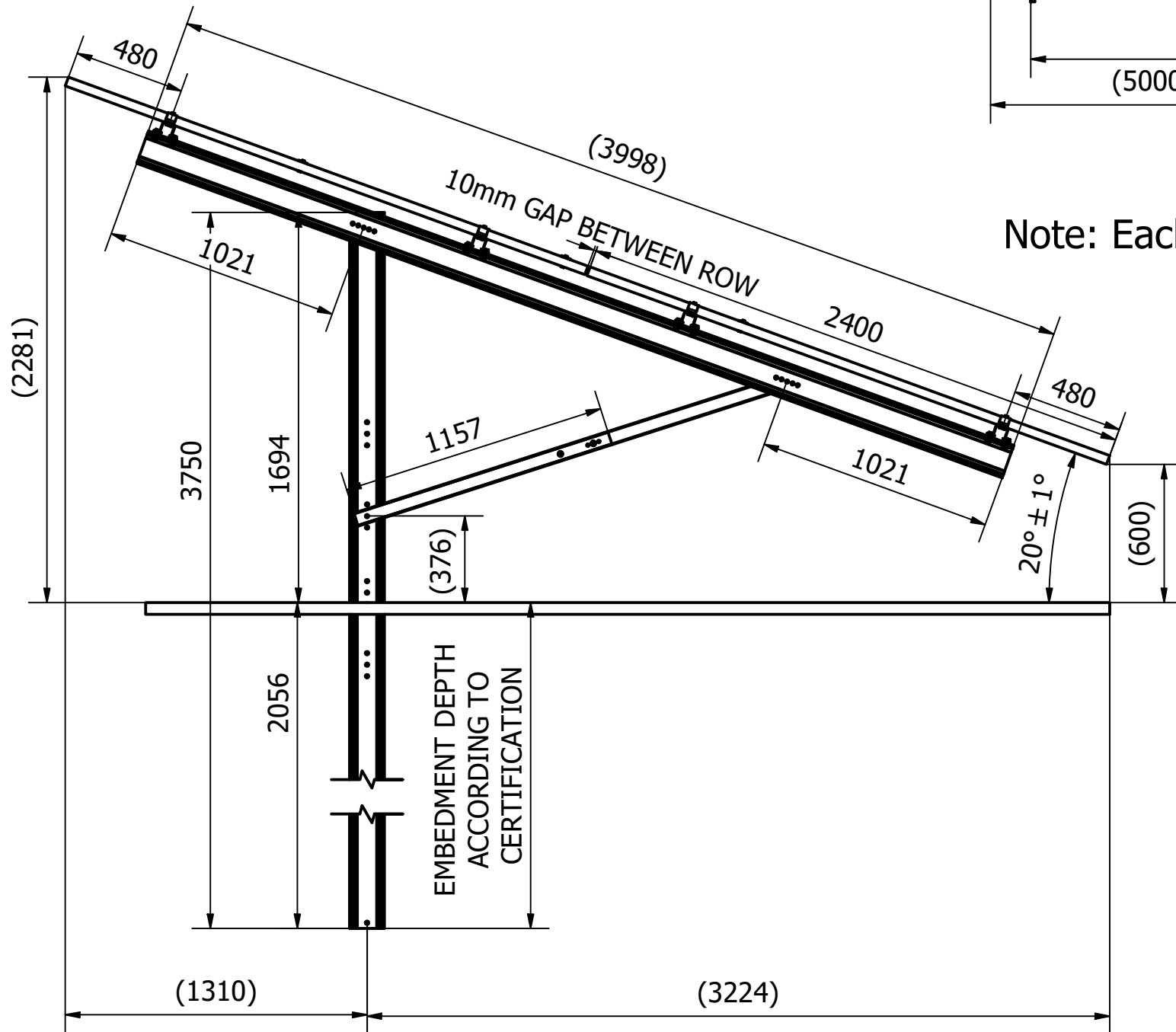
Max module length: 2400mm  
 Refer to module's installation manual  
 for approved clamping location

Module Inclination: 15° / 20° / 25° / 30°



VIEW A

Note: Each purlin section need to be supported by at least 1 frame.



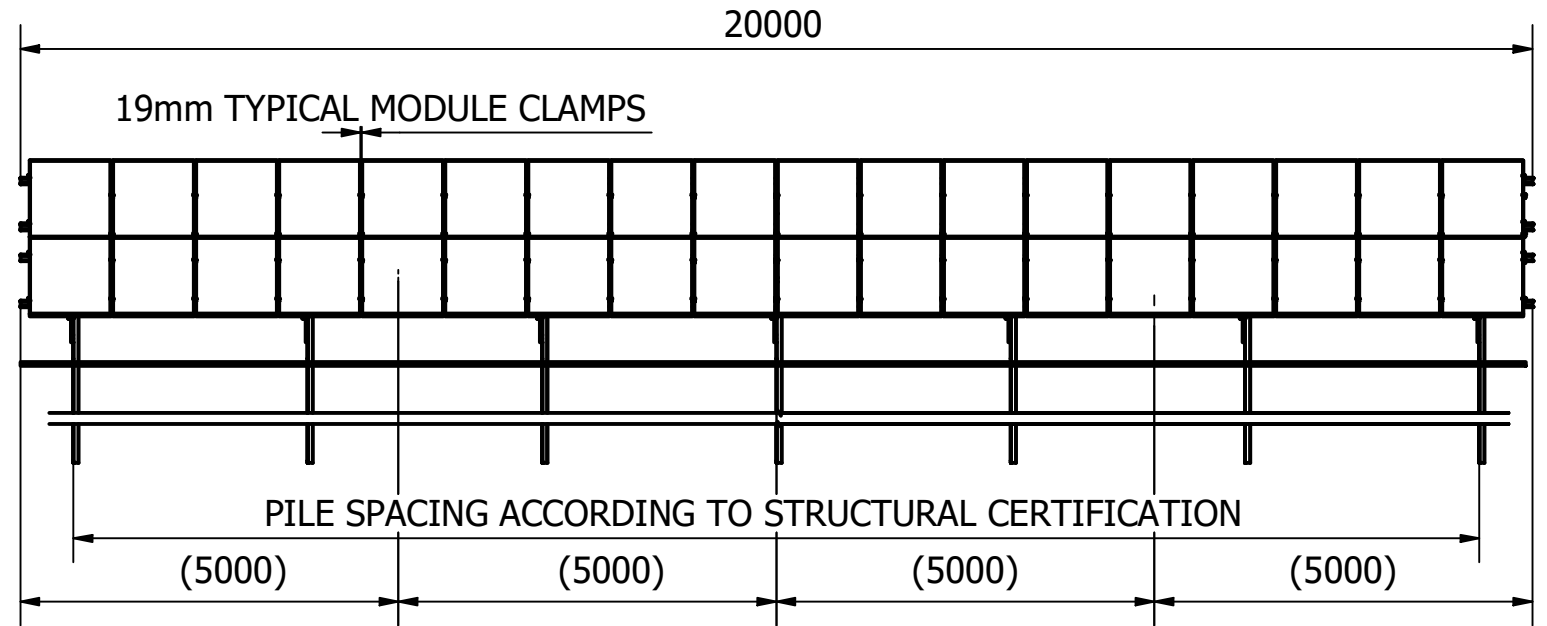
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			Revision 00	Sheet 1 / 1

Foundation	C-Post 150x70x14x3.5mm	HDG Steel
Girder	150x70x14x3.5mm	HDG Steel
Purlin	45/75 CS	Mill Aluminium

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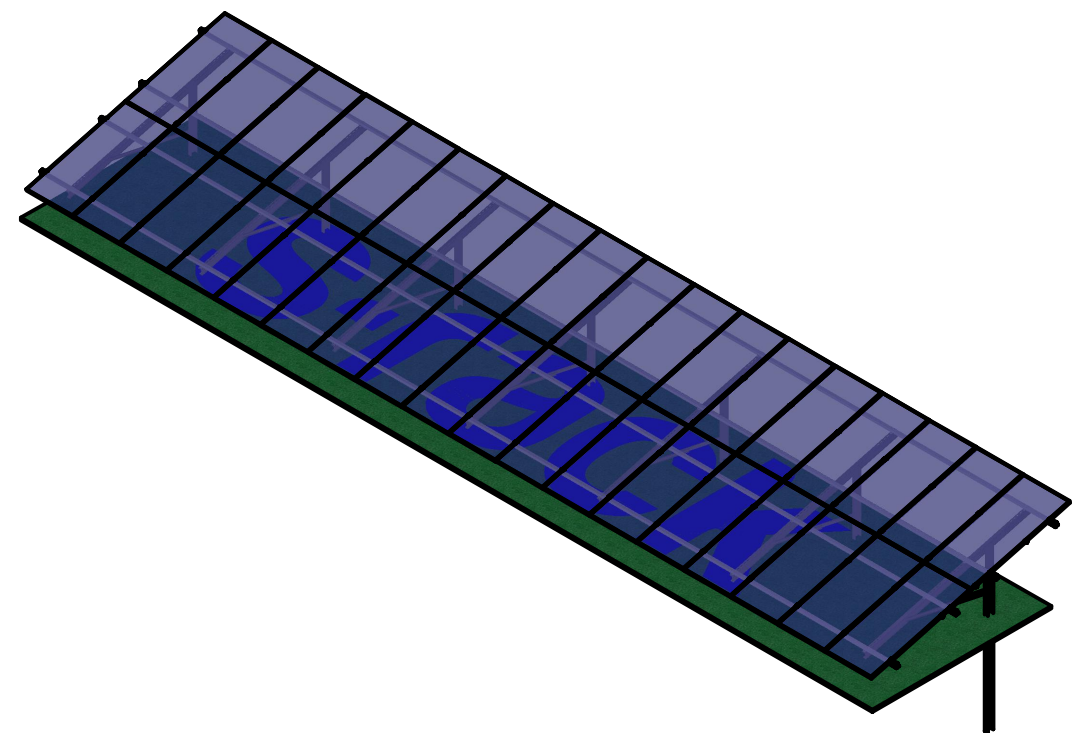
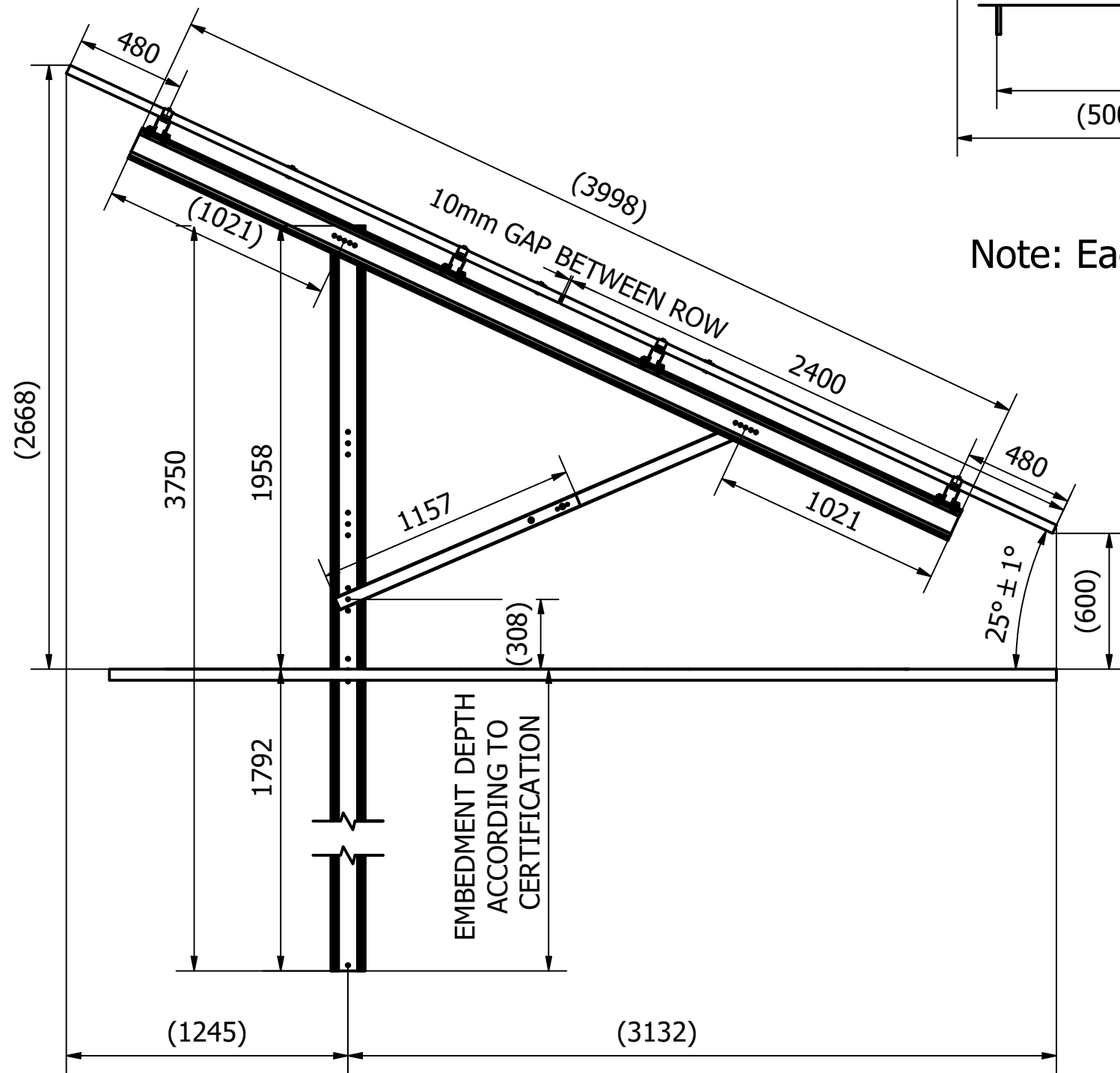
Max module length: 2400mm  
 Refer to module's installation manual  
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Module Inclination: 15° / 20° / 25° / 30°



VIEW A

Note: Each purlin section need to be supported by at least 1 frame.



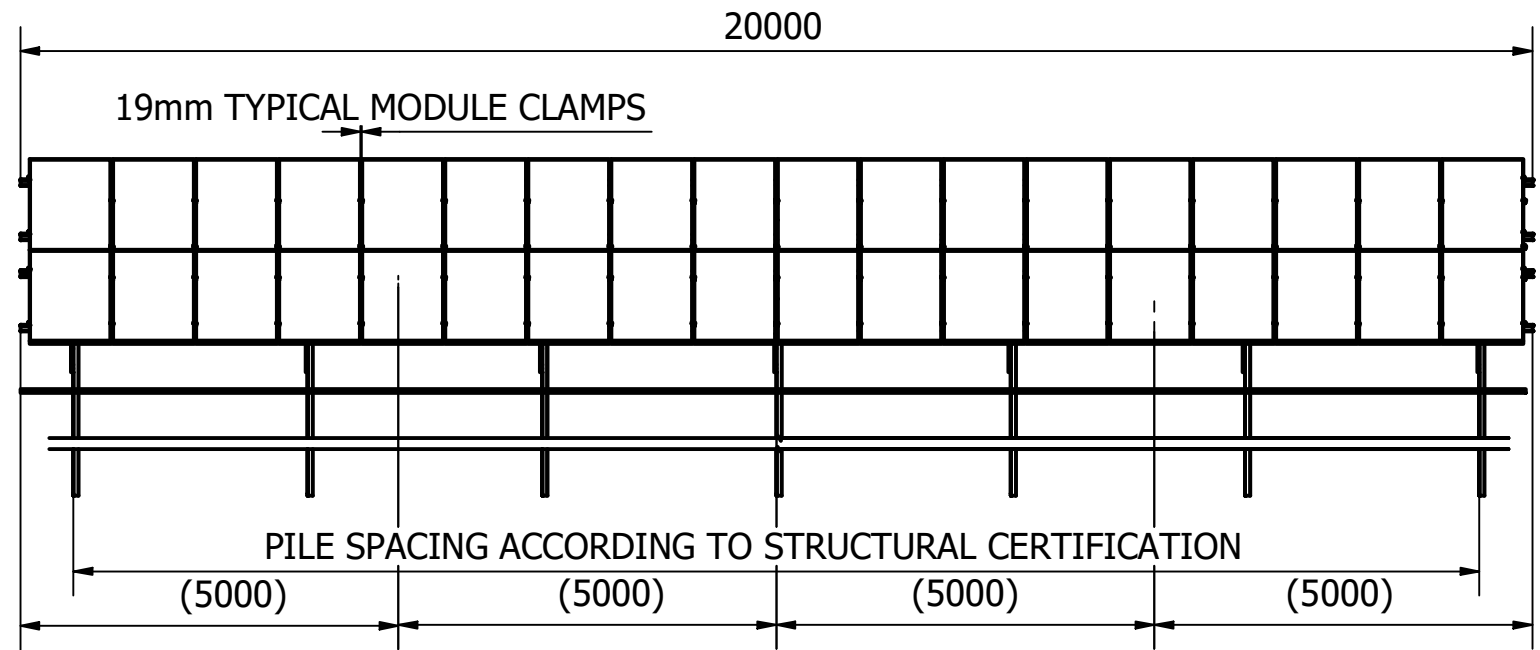
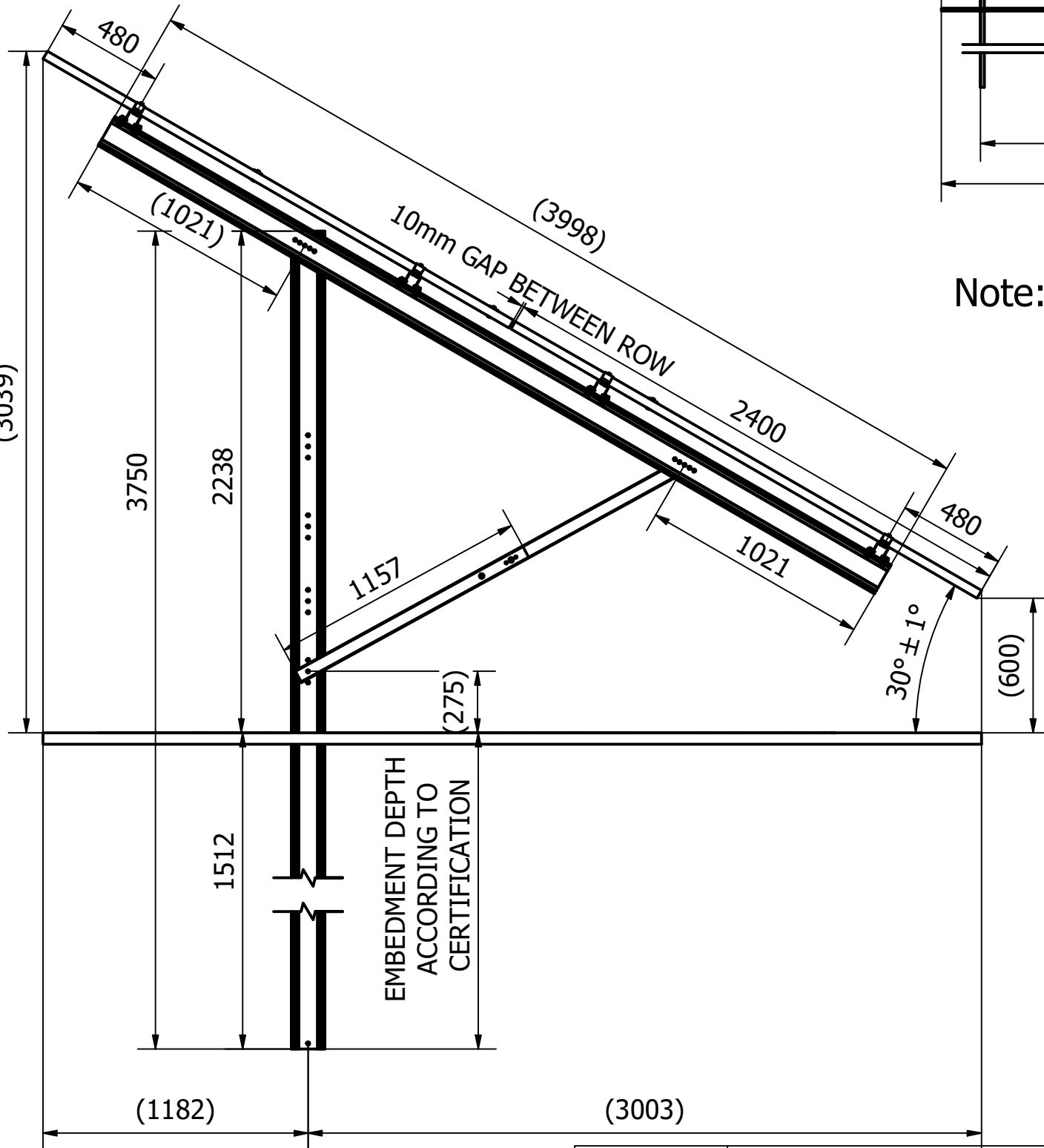
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Girder	150x70x14x3.5mm	HDG Steel
Purlin	45/75 CS	Mill Aluminium

# Sigma S1 Alu

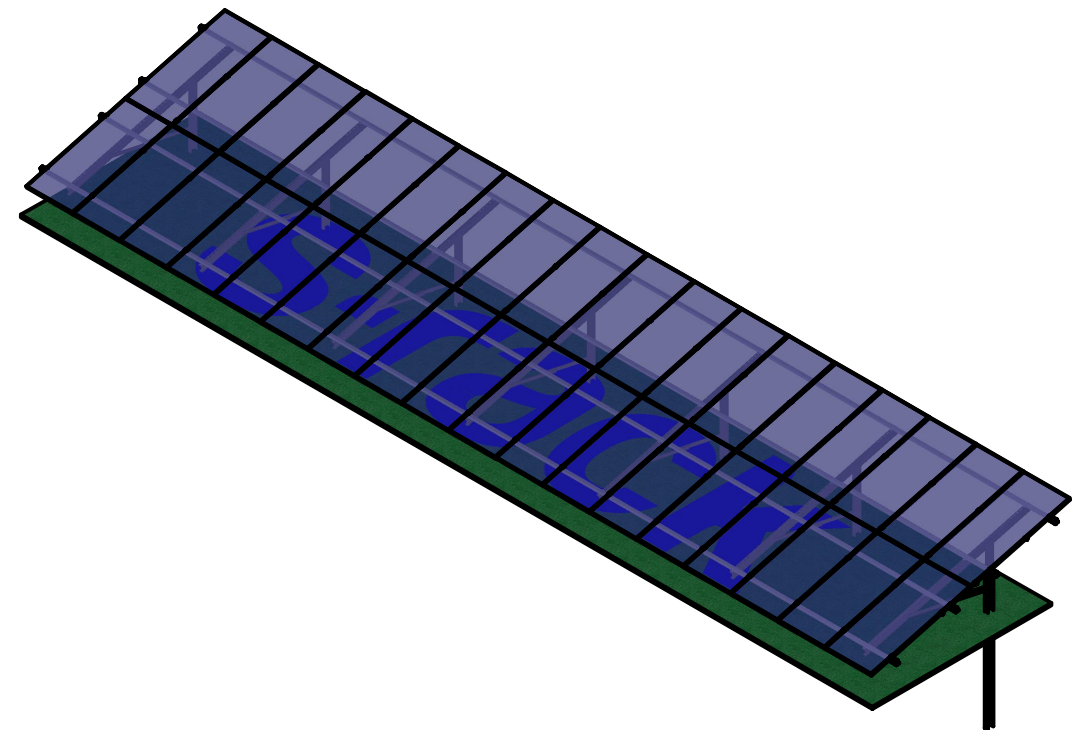
Max module length: 2400mm  
Refer to module's installation manual for approved clamping location

Module Inclination: 15° / 20° / 25° / 30°



VIEW A

Note: Each purlin section need to be supported by at least 1 frame.



Foundation	C-Post 150x70x14x3.5mm	HDG Steel
Girder	150x70x14x3.5mm	HDG Steel
Purlin	45/75 CS	Mill Aluminium

Designed by JK	Checked by	Approved by	Date	Date 18/05/2022
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			Revision 00	Sheet 1 / 1