CARACAL

ENGINEERING

SPECIFICATION SHEET

Fixed-Tilt Ground Mount Systems

Stable. Easy to install. Cost-effective.

PV Solutions, Done Right.
DESIGNED. MANUFACTURED. BUILT.

Caracal Engineering is known to solve and deliver complex structural and mechanical engineering, construction, and product design services for commercial, industrial and utility scale photovoltaic (PV) projects across African, Asia-Pacific and Middle Eastern markets. We expertly design, manufacture, and build structures and systems for 200 kWp - 50 MWp solar projects.

Given the increasingly important cost item of mounting structures and the associated construction as well as the perpetual importance of getting the foundations right, it seems only right that most appropriate systems are advocated. Such a system must be able to handle the rigours of the environment in which it is placed. This is exactly what we strive to do, on repeat–now and into the future.

We've earned a reputation for working out complex PV engineering challenges. Maybe that's because we enjoy the process. For us, ingenuity happens when we collaborate.

Contents

Scope cover 2

Project and design inputs 3

Products

CR1 – Aluminium + Steel 6
CR1 – Steel 7
CR1 – 3CR12 8

Installation process 9

Warranty information 11

While we design, engineer and manufacture all of the components necessary for the delivery of the fixed-tilt ground mount system, we also spend a great deal of time on the construction once the material gets to site.

Our scope cover includes:

- Pull tests
  - Vertical uplift testing
  - Horizontal pressure testing
  - Corrosivity testing
  - Resistivity testing (optional)
- Drone mapping
- Renders
- Surveying
- Foundation preparation and implementation
- Table construction
- Module mounting
- Transport of material to site

We strive to be the turnkey structural contractor with our fixed-tilt systems to make the life of the EPC easier.

Important notes:
Caracal Engineering and its affiliates take no responsibility for the shading calculations or inter-row spacing between modules. This calculation needs to be undertaken by the client or EPC and the measurements given to Caracal Engineering.

Caracal Engineering does pressure calculations on the modules and will recommend alternative angles of inclination if the module pressure is exceeded. It is the client or end-user's responsibility to double check these calculations in conjunction with the supplier of the modules to ensure that the modules can withstand the environment in which they are placed.

It is critically important to acknowledge that the Pull Tests we need to undertake must be done once the ground has been prepared for construction. Working on a site that is not prepared will almost certainly give different results to a prepared site and as a result, the testing would need to be redone.

In terms of site preparation, drop us an email on info@caracalengineering.com for the specifications and we will gladly share this information with you.

With our fixed tilts, we design, engineer and manufacture the system to the specifications of the site and client's requirements.

The following are fundamental considerations for Caracal Engineering when developing commercial proposals and the eventual end product:

MODULE SPECIFICATION SHEET

Completion of this is critical to ensure the system can accommodate the selected module. Accurate dimensions of the module are of utmost importance.

ANGLE OF INCLINATION

We have a range of options from 5 degrees to 30 degrees. While we encourage lower angles of inclination to reduce gauges and frequency of frames, we can design to accommodate the requirements of a client.

LOCATION

This information is vital for determining the load on the system.

TYPE OF FOUNDING

These cover either hydraulically rammed, cast-in-situ bases, percussion drilled holes, augured holes or various other types of foundation solutions. The type of solution will be determined by a series of pull tests.

PROJECT SIZE

This informs how many modules will be installed.

STRING LENGTH

We need this information not so much for our application but to make it logical from an electrical reticulation perspective.

SERVICE LAYOUTS

The services below the site generally have less bearing with fixed tilts, however, they can have some implications.

A layout provided upfront is useful, however, we work with clients to develop the optimal system layout.

Note:
If any pull tests have been undertaken, it is useful for a client to share such reports with us but we will always undertake our own set of testing. Legacy testing has proved to be unreliable for our applications.

Key design considerations

No two project scenarios are quite the same, and there's no such thing as one-size-fits-all solar. This means that each system is site-specific. We carefully evaluate the context, conditions and purpose before starting a project or implementing any solution.

Under normal conditions, wind loads are designed for 1 in 25 year, 3 second gusts. However, wind speeds and geotechnical conditions are unique to each location. So, before we take on a project, we carefully consider the founding methodology, uplift forces, deadloads, moment capacity of the members, deflection and others to develop a solution best suited to the environment.

All designs are subjected to local standards and norms depending on the country. In the case of South Africa, the following codes are used during the design process:

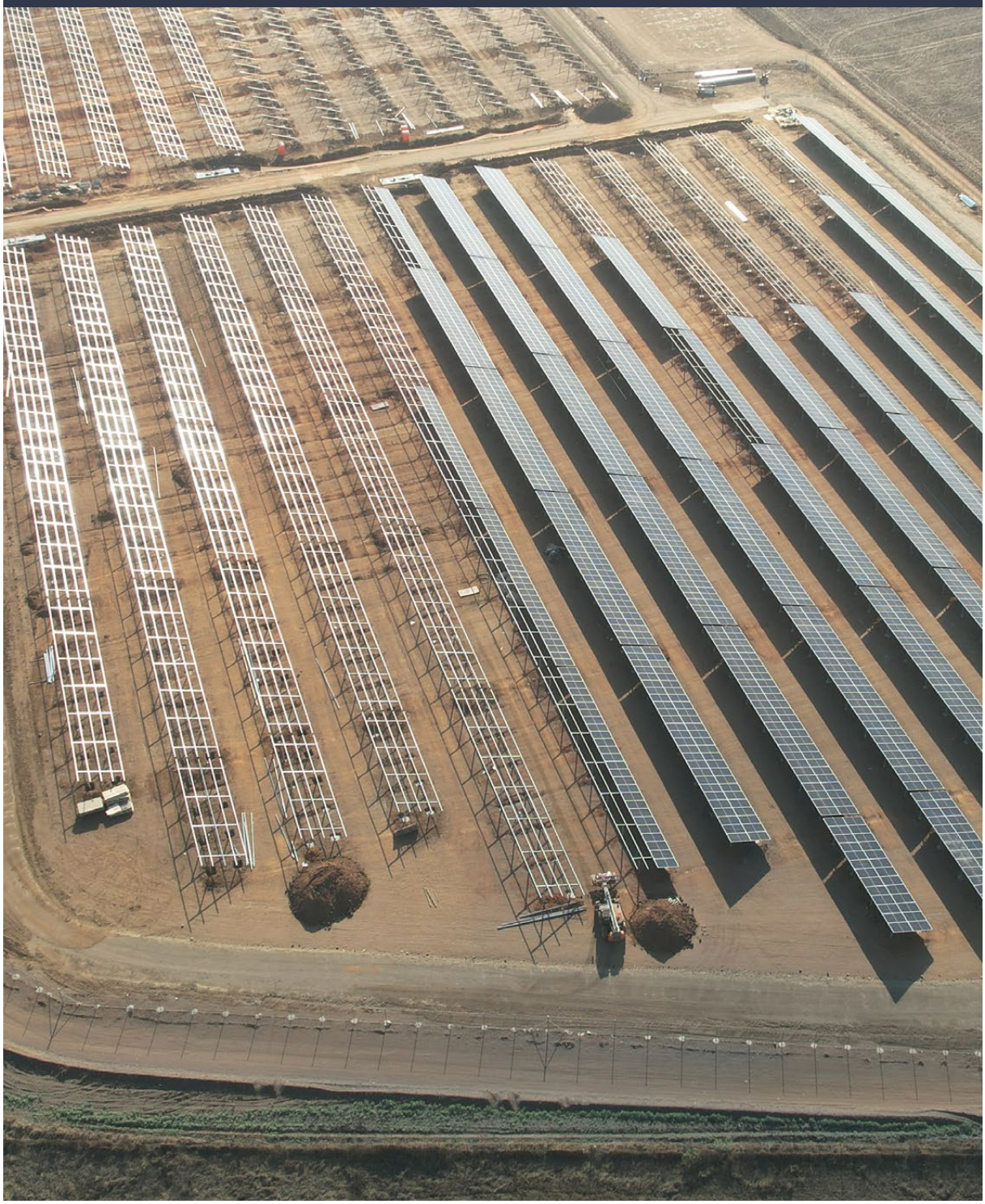
- SANS Code 10160 Part 3
- SANS Code 10162 Part 1
- SANS Code 10162 Part 2
- To calculate to other codes is not a problem, should it be required.

We use structural analysis software, our own, as well as Prokon Sumo to significantly reduce the time spent on design. This saves clients unnecessary costs.

As transparency and accuracy is of utmost importance to us, we utilise external structural engineers for an objective, final verification of our designs and we provide a detailed design report to substantiate all systems.

Additionally, we welcome input and dialogue with Owners Engineers (OE) or Lenders Technical Advisers (LTA). Depending on the size of the project, we would insist on the incorporation of these professionals to ensure we provide the best solution and the EPC/End User gets a product that meets expectations.

We offer the full mechanical wrap, supplying and building the structure as well as mounting the modules; making your life easier and the project more cost effective.



CR1 – Aluminium + Steel

CR1 is the premium product for this application. The use of aluminium purlins with a steel substructure is motivated by the look of the end product, as well as the reduction of execution time.

To ensure availability of material, the ground mount system uses standard steel sections for the girders and foundation. Caracal Engineering's own aluminium section is used for the purlins.

Please note

Caracal Engineering mitigates any possibility of bi-metallic corrosion between the material through the use of an EPDM gasket. Powder coating or anodising can be done to the sections if you favour the use of aluminium in corrosive environments.

We do not recommend angles of inclination of 0 degrees due to the impact of soiling. The modules have a self cleaning effect at 5 degrees. While possible to design and implement angles of inclination up to 35 degrees, the client must balance this consideration against the increase in cost of the structure to accommodate the additional loading.

CONFIGURATIONS	Generally 2 in portrait for large format modules
	Up to 3 in portrait using large format modules
	Up to 4 in portrait using small format modules
	Up to 8 in landscape for either large or small format modules
	Maximum length of the tables is 35m
ANGLE OF INCLINATION	From 5 to 30 degrees
MATERIALS AVAILABLE	• All aluminum 6063 T6: milled, anodised or powder coated for the purlins • All steel S355 structural grade steel: HDG or precoated for the struts and girders • Modules clamps: 6063 T6- milled, anodised or powder coated • Smalls: Stainless steel
SPANS DISTANCES	Depending on the loading the system can accommodate: • Up to 5m spans • Up to 1.6m cantilevers *Other configurations are possible*
FOUNDING METHOD	• Hydraulically rammed foundations • Cast in situ (generally not used given the cost of work but something we can do) • Micro-piling or auguring for piles • Percussion drilling and concreting • Chemical anchoring for bespoke applications

CR1 – Steel

Our CR1-Steel is a fixed-tilt ground mount solution for situations where price is more important than aesthetics. Yet the system remains simple to install, robust, and designed to withstand the rigours of the environment in which it is placed.

To embed the steel foundations of the structure, we hydraulically ram, ballast, augured or bored (percussion) holes and concreted them into place.

We deploy only structural grade steel for our applications with a minimum temper of S230 to S500 depending on the application and the loading on the system. We also use different corrosion protection measures to negotiate the different climates across Africa.

We would use the following:

Hot-dipped galvanised steel

The gauge of the HDG is according to the relevant specification and code.

Pre-galvanised

If the application is in low corrosion rate environments, such as C1, then there is a possibility of implementing pre-galvanised material.

Pre-coated

Our pre-coated material is Zinc- Alum-Magnesium. The benefits of this coating are numerous, however, of critical importance is a consistent finish, similar to a dark matt grey, as well as the performance in relation to HDG.

We have standardised on this material for the majority of our material because of the cost benefit and its performance.

Duplex system coating

In rare instances, we can deploy epoxy-coated steel members to improve corrosion resistance. This duplex system entails a second additional coating on the steel members after they have been galvanised.

For more info please get in touch at *info@caracalengineering.com*

CONFIGURATIONS	Generally 2 in portrait for large formal modules
	Up to 3 in portrait using large format modules
	Up to 4 in portrait using small format modules
	Up to 8 in landscape for either large or small format modules
	Maximum length of the tables is 35m
ANGLE OF INCLINATION	From 5 to 30 degrees
MATERIALS AVAILABLE	• All steel S355 structural grade steel: HDG or precoated for the struts and girders • Modules clamps: 6063 T6- milled, anodised or powder coated • Smalls: Stainless steel
SPANS DISTANCES	Depending on the loading the system can accommodate: • Up to 5m spans • Up to 1.6m cantilevers *Other configurations are possible*
FOUNDING METHOD	• Hydraulically rammed foundations • Cast in situ (generally not used given the cost of work but something we can do) • Micro-piling or auguring for piles • Percussion drilling and concreting • Chemical anchoring for bespoke applications

We do not recommend angles of inclination of 0 degrees due to the impact of soiling. The modules have a self cleaning effect at 5 degrees.

CR1 – 3CR12

Our CR1-3CR12 is our most corrosion resistant fixed-tilt ground mount system in our range.

3CR12, an alternative to coated steel, was developed by Columbus Steel in the 1970's and is now the most specified 12% chromium utility stainless steel. The high tensile strength and corrosion resistance makes it an interesting alternative.

The system is simple to install, robust and designed according to the local loading requirements. Notably, it is designed for both an industrial or coastal environment in which corrosion makes the use of hot dipped galvanised steel difficult or impossible.

To embed the steel foundations of the structure, we hydraulically ram, ballast or bored concrete into place.

CONFIGURATIONS	Generally 2 in portrait for large formal modules
	Up to 3 in portrait using large format modules
	Up to 4 in portrait using small format modules
	Up to 8 in landscape for either large or small format modules
	Maximum length of the tables is 35m
ANGLE OF INCLINATION	From 5 to 30 degrees
MATERIALS AVAILABLE	• All steel S355 structural grade steel: 3CR12 • Modules clamps: 6063 T6- milled, anodised or powder coated • Smalls: Stainless steel
SPANS DISTANCES	Depending on the loading the system can accommodate: • Up to 5m spans • Up to 1.6m cantilevers *Other configurations are possible*
FOUNDING METHOD	• Hydraulically rammed foundations • Cast in situ (generally not used given the cost of work but something we can do) • Micro-piling or auguring for piles • Percussion drilling and concreting • Chemical anchoring for bespoke applications

We do not recommend angles of inclination of 0 degrees due to the impact of soiling. The modules have a self cleaning effect at 5 degrees.

Soil tests

Before the project commences, various geotechnical tests are conducted to assess the suitability of the soil, namely:

- Uplift tests
- Incline Traction tests (infrequently applied)
- Horizontal Traction tests
- Saturation tests (unique application)
- Corrosivity testing of the soil

Note

While we can undertake incline traction and saturation testing, we employ the relevant testing to our prescripts. Should additional testing be required by OEM's or LTA's we shall undertake them, however, it will attract additional costs and time allocation.

Drone mapping and surveying

Much of the design undertaken by EPCs in the initial conception of the project is based on Google Earth images, which although helpful, is unreliable when scale is considered. We, therefore, undertake a drone mapping campaign. This entails flying the drone over the site across a predetermined map and taking several hundred high resolution pictures.

We then take these images and use the relevant software to stitch them together to form a scaled map of the site. Aside from being useful to the EPC and other contractors on site that have to work from the same coordinates, it helps us to:

- Plan out the positions of the piles
- Accommodate the shading distance provided by the client
- Identify topographical challenges which would inform the civil contractor's scope of work

The drone mapping dovetails with our internal surveying services. To make the process from conception to implementation move efficiently, Caracal Engineering has internalised the survey function. While we are happy to work with external surveyors, this service more directly meets our requirements.

It should be noted that we insist on sanity checks of the survey positions from the client to the extent that we have a hold point in place until we get sign-off from the client. We do not proceed with work until the client has signed off that they are satisfied that the design is in line with their requirements, particularly the azimuth of the site and the shading distance between tables.

Ballast + drilled + micro-piled + chemically anchored

Depending on the ground conditions and client requirements, we use a range of founding methods depending on what the context demands. These include:

- DTH boring
- Micro-piling
- Cast in situ
- Chemically anchoring
- A hybrid based on the conditions

Top structure

While the application of the foundation may differ where we use IPE risers or precast concrete ballast block for the PremierPort, or percussion drilled holes and concrete for the EconoPort, the principle of the balance of construction remains the same. The struts are connected to the girder and purlin clamps are placed along the girder ready to receive the purlins. The full assembly is then lifted into place on the foundation or the rammed strut, depending on foundation methodology.

Girder preparation

If required, EPDM gaskets are placed where the purlins will be to ensure mitigation of bimetallic corrosion between the different metals of the girder and purlin. Where we use steel purlins there is no need for EPDM gaskets.

Purlin placement

Purlins are placed, spanning between girders and fastened with the preplaced clamps.

Module installation

Finally, the modules are added and securely clamped to the purlins to ensure there is no movement.

Our warranty spans 10 years commencing on the date of completion of the structure or once it is delivered to site or alternatively, when the structure is handed over to a client for commissioning, whichever is sooner.

In highly corrosive environments and or conditions where there is a changing context such as industrial development of site subsidence, Caracal Engineering reserves the right to reduce or eliminate the warranty period. The warranty period cannot be extended beyond the initial period even if components are replaced during this period.

Please note:

- Caracal Engineering's warranty is conditional upon damage being caused to a component. Despite proper installation and handling under normal use, and provided the client has adhered to the maintenance requirements, the supplier would, at their cost, repair or replace the respective component within the warranty period.
- Our warranty is limited to the repair, supply and delivery of replacement parts for the defective components upon notification of damage within the warranty period, i.e. 10 years.
- Caracal Engineering would not be obligated to honour this warranty if the damage arises from causes beyond our control, i.e. exceptional circumstances such as fire, abnormal weather conditions, mechanical damage, physical damage, malicious damage, pollution, instability of the sub-surface, exposure to acidic, chemical, biological or other hazardous sources which are believed to be damaging to the components.
- With respect to installation and handling, the technical product descriptions and installation instructions provided by us would govern. If a shorter lifespan is explicitly indicated for specific construction components, either generally or within our custom designs for particular types of use, the warranty period would be limited to that lifespan or period.

No claims may be made for damages covered or capable of being covered by insurance.

NB: Our Limited Warranty applies exclusively to claims made by our direct clients and is non-transferrable in whole or in part. Any statutory warranty or liability claims remain unaffected.

Any changes made to the structure without the expressed permission and relevant calculation supporting the change with the addition of the sign-off from a Caracal Engineering representative will void the warranty entirely.

Failure to inspect and maintain the components at the specified intervals will invalidate the warranty.

In the event of a claim being made, the following records need to be made available to Caracal Engineering or our nominees:

- Inspection and details of cleaning/washing records.
- Maintenance records.
- Any other data relevant to the service history of the mounting structure.

For more information on our warranty as well as care and maintenance and the format of the required Inspection and Maintenance Logbook, please reach out to a Caracal Engineering representative.

This datasheet only provides information for Caracal Engineering Fixed-tilt Ground Mount systems. The contents of this document will vary depending on where the project is situated and the client requirements.

CONTACT US

Let's do Solar better. Get in touch!

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