

TITAN DUO

3-RAIL DESIGN

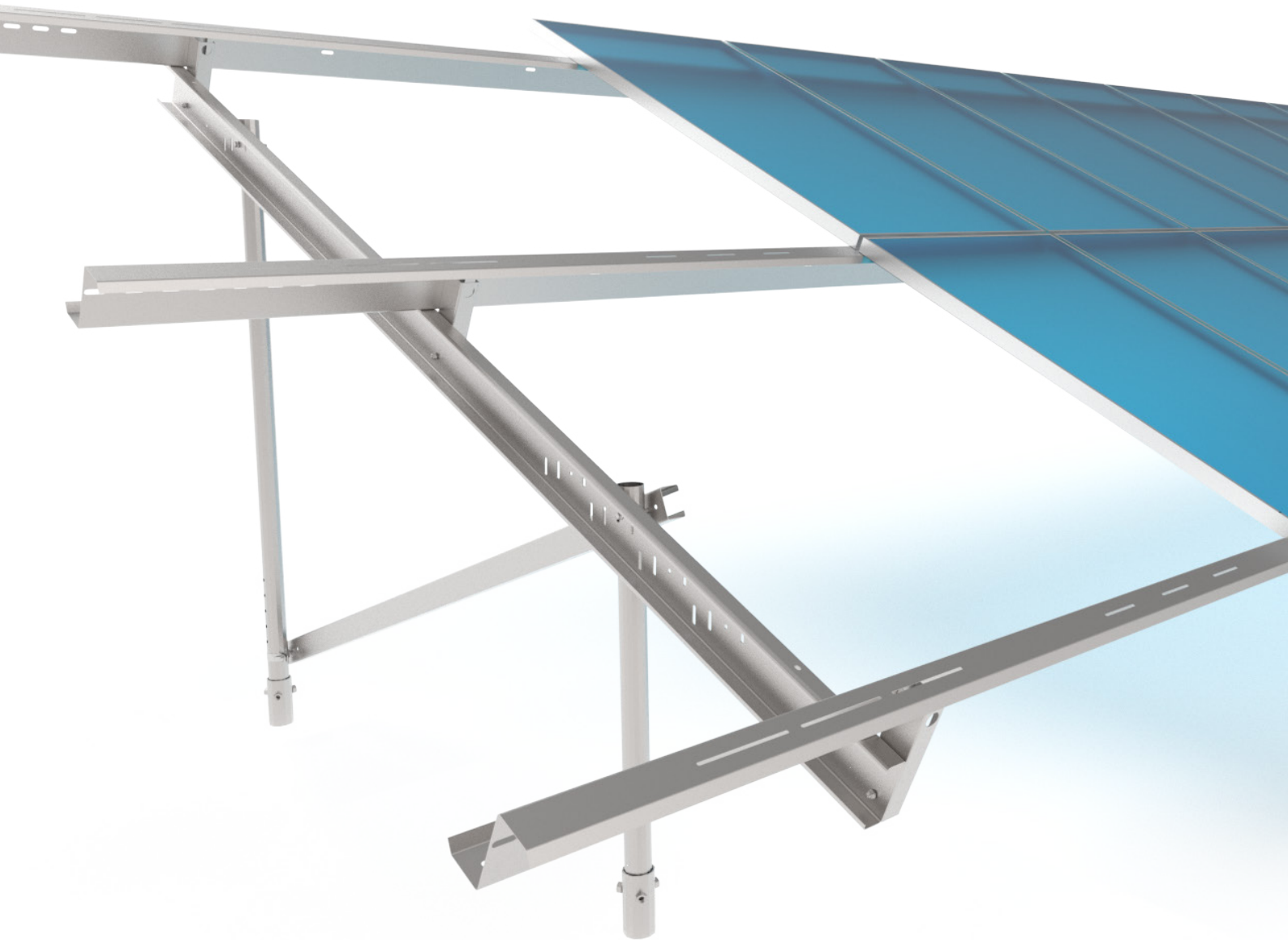


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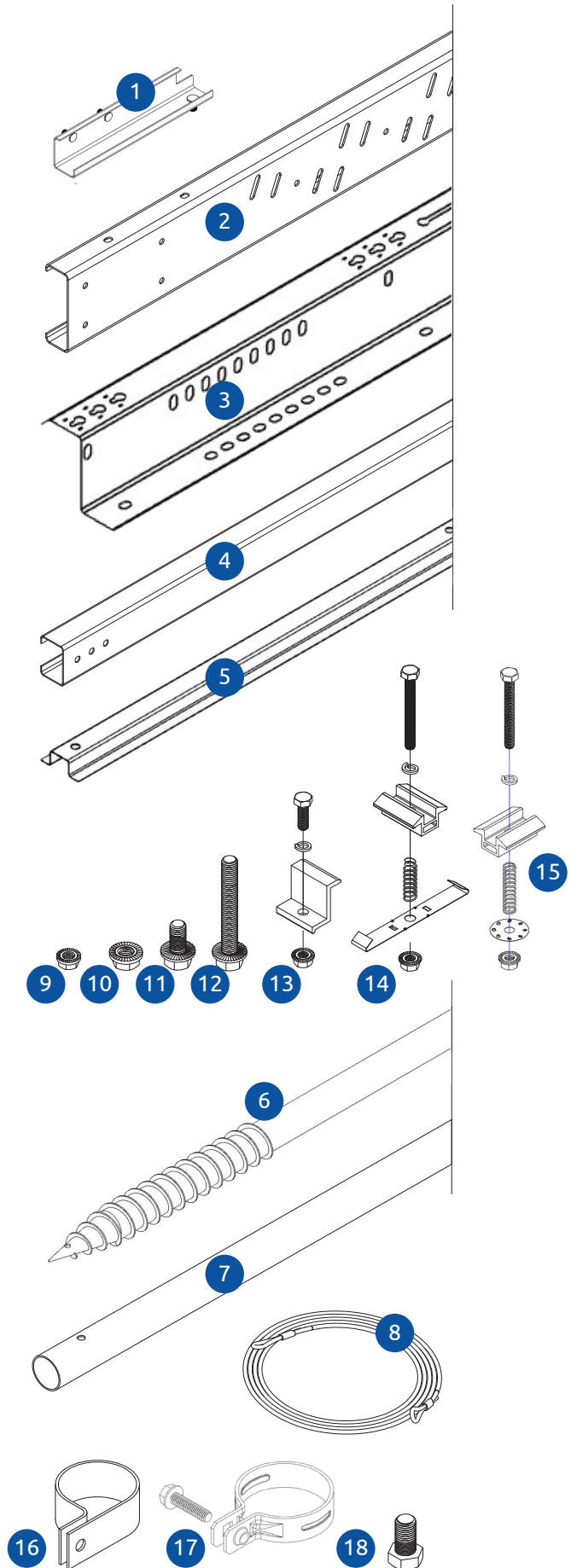
PARTS LIST

STRUCTURAL MEMBERS

- [1] ROLL BRACKET ASSEMBLY
2X 3/8-16X1.0" PUSH-IN STUD
1X 1/2-13X1.0" PUSH-IN STUD
- [2] N/S CHORD
- [3] E/W ZEE PURLIN
- [4] KNEE BRACE
- [5] TRANSVERSE BRACE
- [6] FOUNDATION (SCREW)
- [7] POST
- [8] CABLE BRACE

HARDWARE

- [9] 3/8-16 SERRATED FLANGE NUT
- [10] 1/2-13 SERRATED FLANGE NUT
- [11] 1/2-13X1.0" SERRATED FLANGE BOLT
- [12] 1/2-13X3.5" SERRATED FLANGE BOLT
- [13] END CLAMP ASSEMBLY
M8X1.25 25MM HEX BOLT
M8 LOCK WASHER
END CLAMP (SIZED FOR PANEL)
M8X1.25 SERRATED FLANGE NUT
- [14] GRAVITY CLIP ASSEMBLY
M8X1.25 70MM HEX BOLT
M8 LOCK WASHER
MID CLAMP
SPRING
GROUNDING SPACER
M8X1.25 SERRATED FLANGE NUT
- [15] MIDCLAMP ASSEMBLY
M8X1.25 70MM HEX BOLT
M8 LOCK WASHER
MID CLAMP
SPRING
GROUNDING SPACER
M8X1.25 SERRATED FLANGE NUT
- [16] KNEE BRACE CLAMP
- [17] CABLE CLAMP ASSEMBLY
- [18] M16X2.0 30MM HEX BOLT (GROUND SCREW SET BOLT)



CONSTRUCTION 101

All structures, regardless of how complex, are built one step at a time. Each new step builds on the previous. In order for the final structure to be complete, it is best to ensure that each step is done correctly. It is far easier, faster, and cheaper to take your time to ensure each step is done correctly before moving on. There is no remedy for an error other than a correction. Time and effort will be put forth eventually to redo steps, reconstruct, and make adjustments, but far less effort is required to correct mistakes as they appear. If errors are fixed immediately, each subsequent step will begin correct and projects will run more efficiently.

It is recommended to completely install a test row from beginning-to-end of the row, and from beginning-to-end of all steps (from layout, to panel installation, and adjustments). This will help you understand not only how to install the product, but understand how tolerances stack up, how mistakes in one step cause errors in other steps, and how to make the adjustments required to keep everything in tolerance and looking good.

SITE PREPARATION

Site preparation should be conducted prior to construction. This will typically involve grubbing, rock and debris removal, and any other preparation that will facilitate swift and unhindered installation.

UTILITIES

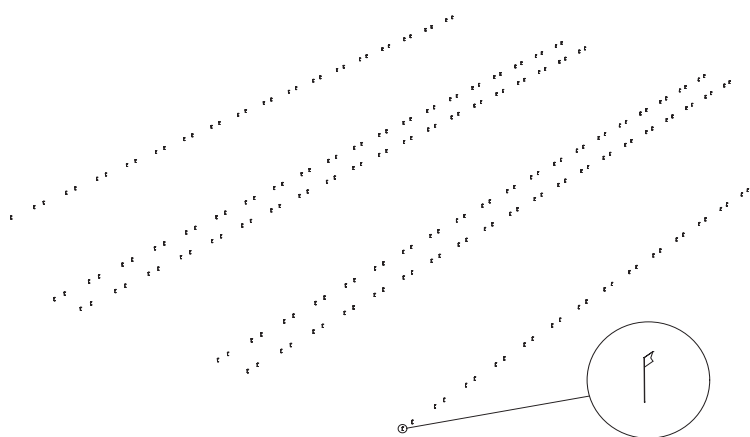
All utilities should be marked before any construction begins.

SURVEYING

To ensure that the solar array is installed according to customer plans, the site should be surveyed according to the scope of work. This includes the North and South foundation locations for the TITAN Duo system. For projects with significant topography, survey points should be checked with a tape measure. Typically, the TITAN Duo system requires a 100% survey.

TOOLS

The M16 ground screw set bolts require a minimum 400 ft/lb impact gun. 1/2" hardware requires a minimum 300 ft/lb impact gun to have enough torque to tighten fully. 3/8" hardware requires a standard Dewalt impact driver or similar. Use a 15" spud handled tool for alignment of E/W rail. For module installation, use a standard impact gun with a maximum of 154 ft/lb torque.



NOTE

Foundation locations should be surveyed by a professional surveyor, who can stake out row locations to the highest precision.

REVIEW & INSTALLATION PREPARATION

After site preparation has been completed and the site surveying is done, the foundations are ready to be installed. It is the responsibility of the site lead to review and understand the site foundation layout, surroundings, installation procedures, and to manage the installation to completion. Each project has different requirements (embedment depths, spans, etc.) that need to be met according to site testing and data gathered prior to the start of the project. The site lead must verify that the foundations on site match the order and project requirements.

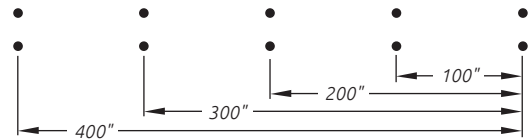
Dimensions in the East-West direction will change depending on row length, row location, and location within the row. Closely follow the construction plans and if there are any questions or discrepancies, report them to the site lead or project manager before installing any foundations.

UNEVEN GROUND

For sites with ungraded or rolling topography, it is important to ensure that the foundations are set to the correct depths. In cases where post locations can not be marked on the ground (uneven terrain), it is advised to check the survey points with a steel tape measure.

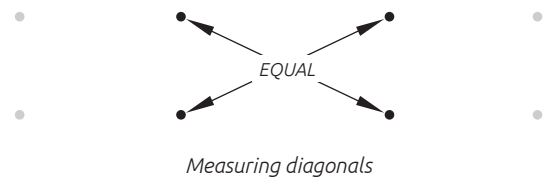
MEASURING

All measurements in the East-West direction must be made with a steel tape measure, and made from the start of the row, not foundation-to-foundation. For example, if the plans were to call for the first 4 spans to be 100" each, the tape should be staked to the ground, and the ground should be marked at 0", 100", 200", 300", 400".



Measuring from foundation-to-foundation allows tolerances to stack up. In this case, a 2" tolerance would have stacked up to be 8" off by only the fifth foundation, and will cause major installation issues further down the road. If necessary, tape measures should be marked prior to use or prints should be marked up to indicate additive measurements (ie. 0", 8'4", 16'8", 25'0", 33'4").

For TITAN Duo systems, the North and South points must remain in line with each other (one should not "chase" the other). Ensure the points are square every few sets by measuring diagonals. If marks are found to be out of square, make adjustments to correct.



FOUNDATION INSTALLATION

1. Preinstall the set bolts to ensure the integrity of the welded nut.
2. Drive the foundation with a single point, starting at one end of the site. The string line method is best for ensuring a straight line and a perfect plane of the array. Foundations are typically installed 6" above grade.
3. Ensure the foundation is held plumb and in the proper location using a level.
4. Drive the foundation to the correct depth as indicated by the construction documents.
5. Install all remaining foundations, using a string line as a guide for placement and height if necessary. Use a tape measure as described in the preparation process.

ALTERNATE FOUNDATION INSTALLATION

For sites with medium-to-heavy rock or bedrock, holes may need to be piloted and backfilled prior to foundation install. When required, perform the following steps prior to the steps above.

1. With an auger or rock drill, drill a pilot hole to correct depth and diameter.
2. Fill the hole with stone as indicated by APA. The amount of stone varies based on the site's soil type.

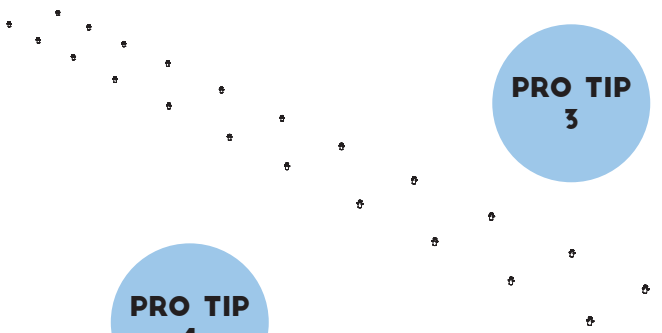
POST INSTALLATION

1. Insert the short post at the first point on the south set of foundations.
2. Measuring from the ground to the top of the post, ensure the post is at the correct height according to the construction plans. Also ensure the upper bolt holes are rotated to align in the East-West direction. Temporarily secure the post in place with a quick clamp or similar tool.
3. Repeat further down the south side of the row with another foundation to create the next attachment point for the string line, once again measuring and ensuring plumbness. When topography is present, additional transition posts must be installed at transition points so that the string line can flow through hills and valleys at a moderate rate. Although the racking will follow terrain, it has limitations. Therefore, ensuring smooth flow will greatly aid the installation process.

PRO TIP 2

PRO TIP 3

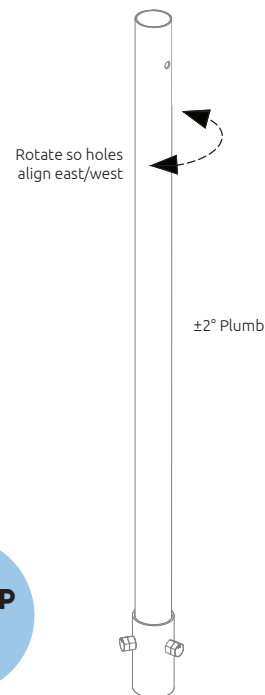
PRO TIP 4



NOTE

Check all survey points before pilot drilling.

PRO TIP 5



PRO TIP 6

POST INSTALLATION (CONTINUED)

4. Continue to the end of the row as required to set a string line.

5. Run a string line between all foundations at the same height. For consistency, string line should run along the same side of the foundation for the entirety of the site (for example, always wrap counterclockwise, then install new foundations on the South side of the string). This will help prevent zigzagging.

6. Ensure the heights of all posts are correct and flow with the terrain in the method indicated in the construction plans.

7. Secure the transition posts at the foundations with three (3) bolts and remove the temporary clamps.

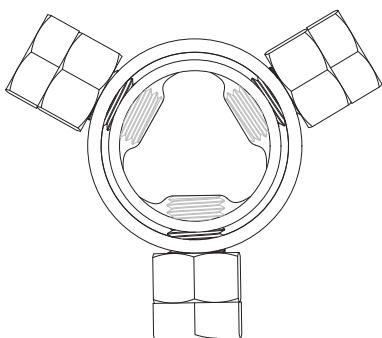
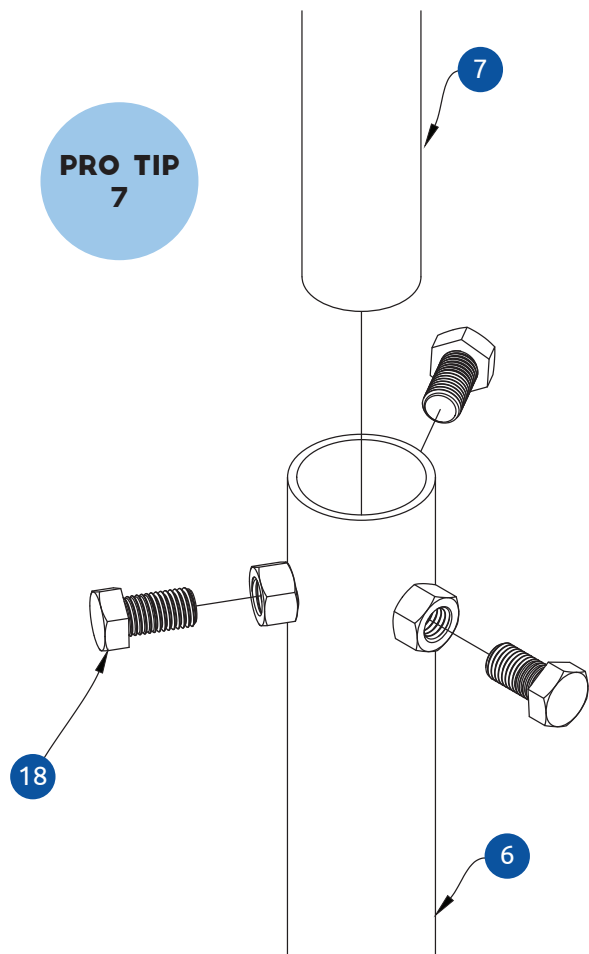
[6] SCREW FOUNDATION

[7] POST

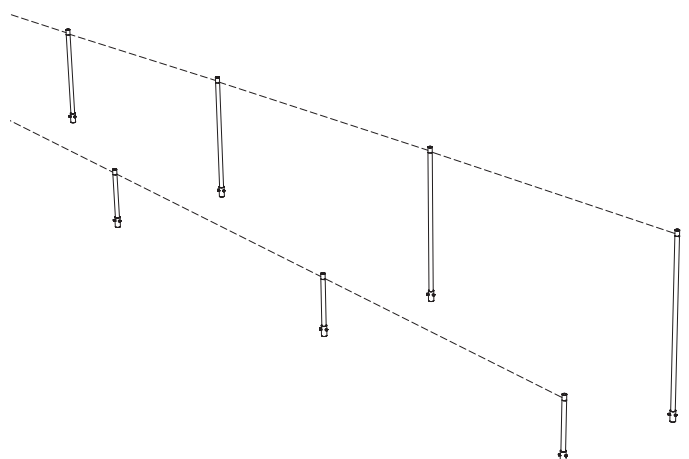
[18] M16X2.0 30MM HEX BOLT (GROUND SCREW SET BOLT)

8. Once heights are verified correct and rotation is correct, bolts can be tightened. Every post should be checked to ensure the bolts are fully seated.

9. Once the south side posts are installed, set the north side posts by adjusting the height to the designed tilt angle per foundation set (check the build plans for the correct tilt angle). Use a steel guide and angle finder to determine the tilt. Repeat the string method for the north side posts.



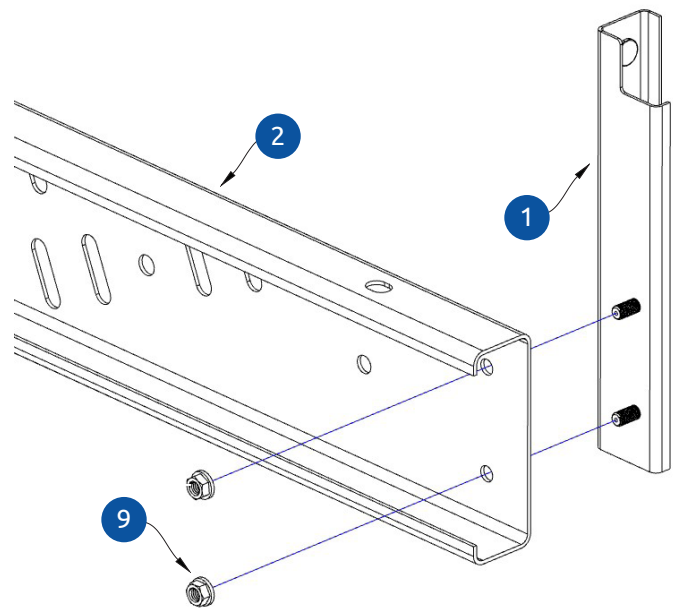
Top view of post and fully tightened bolts



ROLL BRACKET-TO-N/S CHORD

1. Along the flat side of the N/S chord, with the slots on the N/S chord pointing up, attach a roll bracket assembly.
2. Match the two (2) studs in the roll bracket assembly in the correct hole set at the front of the part. Refer to site build plans to determine which set to use. Correct usage is based on specifications provided by the module manufacturer, and will remain consistent on each project (assuming only one module model is used).
3. Secure both studs, each with a nut.
4. Repeat steps for all remaining roll brackets. There are three (3) roll brackets per N/S chord.

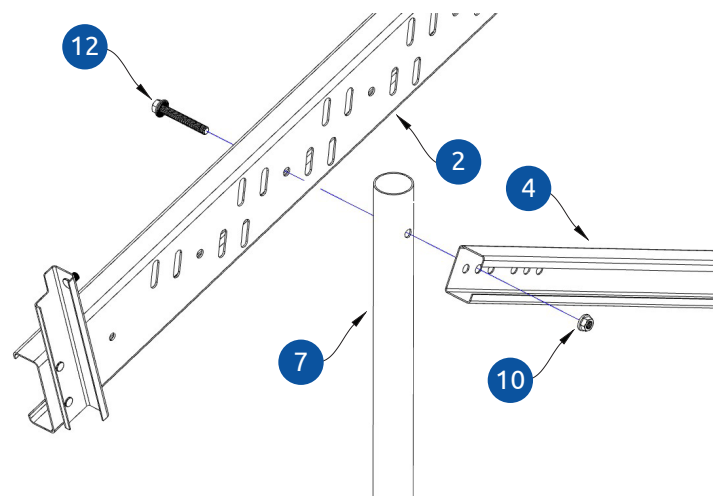
- [2] N/S CHORD
- [1] ROLL BRACKET ASSEMBLY
- [9] 3/8-16 SERRATED FLANGE NUT



KNEE BRACE & N/S CHORD-TO-FRONT POST

1. Refer to the construction drawings for the correct nominal attachment holes/slots in both the knee brace and the N/S chord. Additional holes/slots can be used for adjustments.
2. Ensure the flat side of the N/S chord and knee brace are against the post. The N/S chord should have the flange with the slots pointing upwards, and be placed on the West of the post. The knee brace should be on the East side of the post.
3. Attach the N/S chord and the knee brace to the front post (south) at the same time.
4. Secure with a bolt and nut through the single hole in the post. Fasten loosely.

- [2] N/S CHORD
- [4] KNEE BRACE
- [7] POST
- [10] 1/2-13 SERRATED FLANGE NUT
- [12] 1/2-13X3.5" SERRATED FLANGE BOLT



PRO TIP
8

NOTE

Images are for reference only. Ideal hole/slot connection points may vary.

N/S CHORD-TO-REAR POST (CONTINUED)

2. Ensure the long, flat side of the clamp is facing the East so it can mate flush with the knee brace, as shown.
3. Confirm that the N/S chord is on the West side of the post, with the flat side against the post, and that the smaller flange with the slots pointing upwards, as shown.
4. Secure with a bolt and a nut through the single hole. Fasten loosely.

KNEE BRACE-TO-BRACE CLAMP

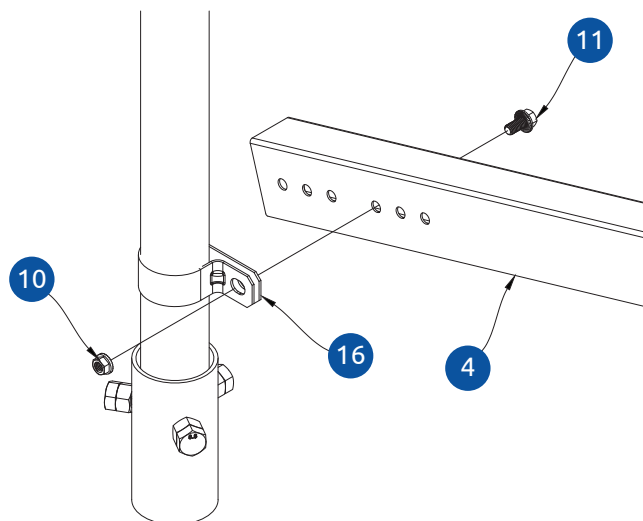
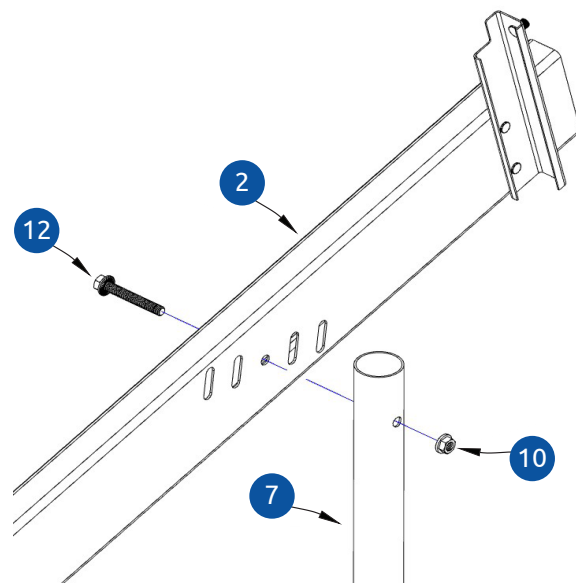
1. Secure through the nominal hole as indicated in the construction documentation with a bolt and a nut. Fasten loosely.

[11] 1/2-13X1.0" SERRATED FLANGE BOLT

[16] KNEE BRACE CLAMP

ADJUSTMENTS

1. Adjust the N/S chord to align, ensuring that the front of the row is straight and follows the terrain. Fully tighten all fasteners once adjustments have been made.



ZEE PURLIN STAGING

Stage the zee purlins by setting them on the N/S chord and resting above the roll brackets.

1. Refer to the build plans to ensure the correct zee purlins are in the correct position. There are differences in either length or hole pattern in the zee purlins, so ensure the correct part number is used. There typically are multiple zee purlins of the same length, with only slightly different hole patterns.

2. Ensure the zee purlins are in the correct orientation with the slotted side facing up and towards the front of the rack.

TRANSVERSE BRACE-TO-ZEE PURLINS

1. Install the transverse braces to the zee purlins at the locations required per the construction plans. Braces are always installed in sets of two (2); one pointing East, and one pointing West. Braces are required at the first and last purlin splice on each row, and at increments required per the construction documents.

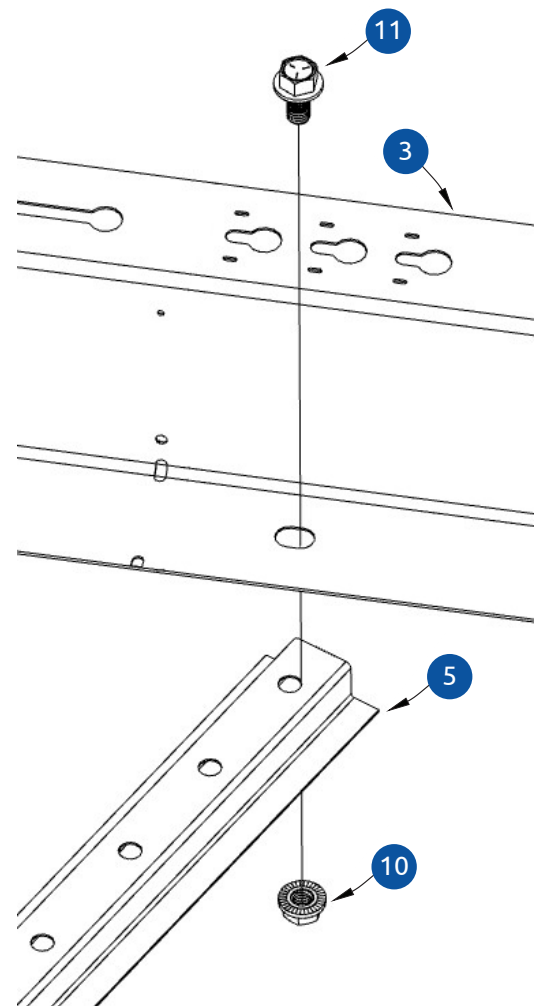
2. Starting at the South most zee purlin splice, fasten the transverse brace to the zee purlin through the outer-most lower slot of the zee purlin. The holes in the transverse brace must face up, but the orientation (which direction the flanges point) is unimportant. The correct hole in the transverse brace must also be used. This is dependent on the location of the roll bracket (inner or outer) and will be indicated on the construction documents. If the roll brackets are installed in the outer location, the outer-most holes at each end of the transverse brace are used. If the roll brackets were installed at the inner location, the middle holes in the transverse brace should be used.

3. Secure with a bolt and nut (ensuring the bolt is facing down). Fasten loosely.

- [3] E/W ZEE PURLIN
- [5] TRANSVERSE BRACE
- [10] 1/2-13 SERRATED FLANGE NUT
- [11] 1/2X1.0" SERRATED FLANGE BOLT



Example zee purlin layout



TRANSVERSE BRACE-TO-ZEE PURLINS (CONTINUED)

4. Repeat at the opposite end of the transverse brace, directing the brace away from the zee purlin splice. There is a solo slot approximately 5' from the outer zee purlin splice hole. Fasten through this hole using the outer or middle hole in the transverse brace (same as step 2).
5. Finally, fasten the transverse brace to the middle zee purlin using the middle hole of the middle set of holes in the transverse brace.
6. Repeat steps 2-5 and install the matching transverse brace on the opposite side of the zee purlin splice, and angle it in the opposite direction.
7. Repeat steps 2-6 for all remaining braces as indicated on the construction documents.

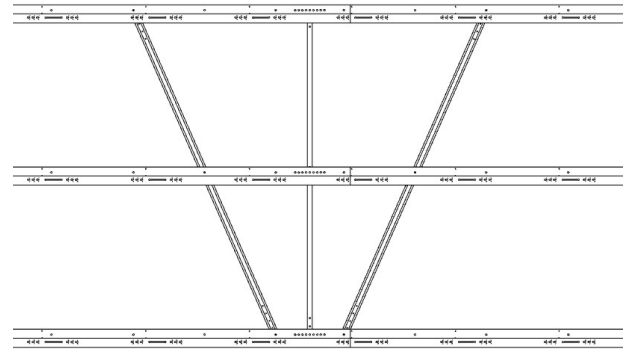
NOTE

Transverse braces are not for squaring the structure but to minimize transverse movement (racking) and keep the rack square. If the rack is not square to begin with, the transverse braces will not fit or function correctly. If different holes than outlined here must be used, the rack is not square and further installation of the panels will not be correct. Ensure transverse braces are installed prior to panels installation.

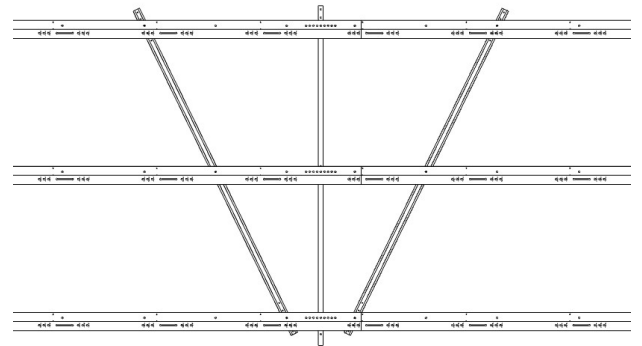
ZEE PURLINS-TO-ROLL BRACKET

1. Ensure the stud goes through both zee purlins.
2. The stud should typically go through the center slot (4th slot) on both purlins. Occasionally, the other slots may need to be used to resolve foundation installation errors.
3. Secure with a nut. Fasten loosely.
4. Repeat at all locations for each N/S chord. There are three (3) roll brackets and connections required per N/S chord.

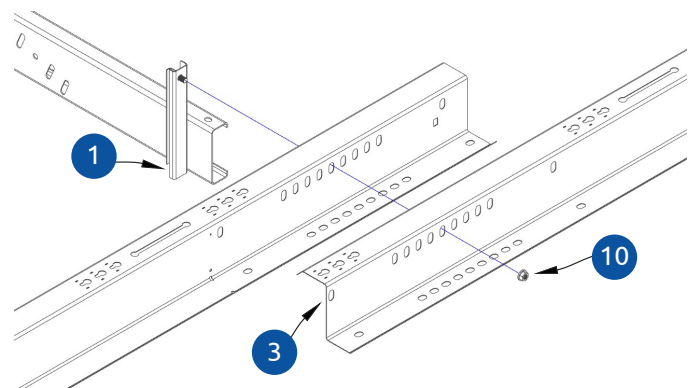
- [1] ROLL BRACKET ASSEMBLY
- [3] E/W ZEE PURLIN
- [10] 1/2-13 SERRATED FLANGE NUT



Roll Brackets (and Zee Purlins) set to outer holes, use brace outer holes



Roll Brackets (and Zee Purlins) set to inner holes, use brace inner holes

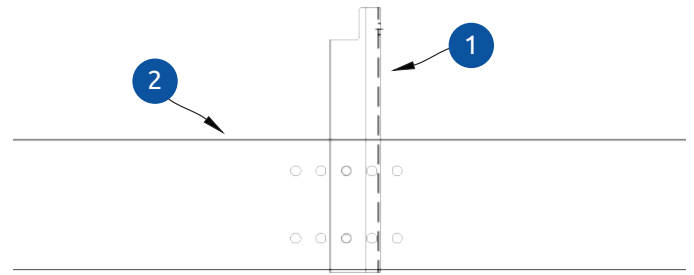


ADJUSTMENTS

1. The middle zee purlin should visually align when sighted East to West. Use the roll bracket adjustment holes on the N/S chord to move the zee purlin if necessary.

[1] ROLL BRACKET ASSEMBLY

[2] N/S CHORD



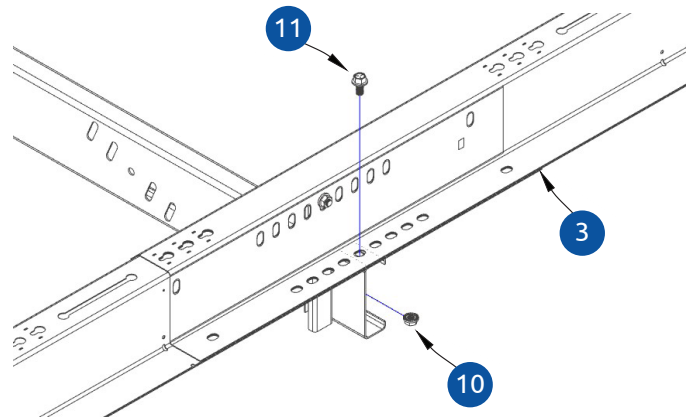
ZEE PURLINS-TO-N/S CHORD

1. The zee purlins should already be in the correct location and loosely fastened by now.

2. Fasten the zee purlins to the N/S chord with a bolt and nut. Ensure the bolt is facing down (to keep wire tray clear). Fasten loosely.

Note: the lower slots are matched to the middle slots, so there is no choice in slots at this point. See note about nominal slots in the ZEE PURLIN STAGING step on page 10.

3. Repeat at all locations for each N/S chord. There are three (3) connections required per N/S chord.



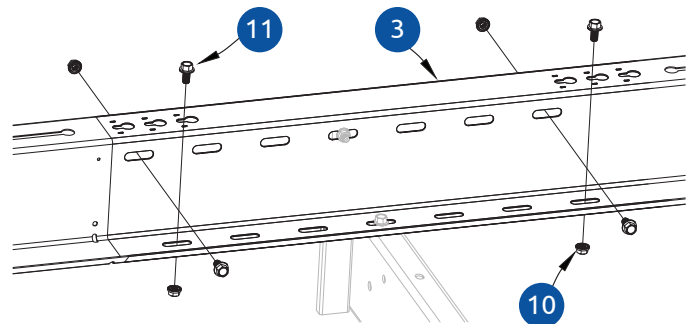
ZEE PURLIN-TO-ZEE PURLIN (SPLICE)

1. Splice the zee purlins together once the transverse braces are installed and the purlins are attached to the N/S chords.

2. Each zee purlin splice should have four (4) additional bolts at each location. Ideally, these should be at the outer-most slots at the center web and on the lower flange of the zee purlins.

3. If the zee purlin splice is already connected at the lower flange with a transverse brace, only the two (2) connections in the center web are needed. If the N/S chord is located at either outer-most hole, those zee purlin splice bolts should be moved inward one (1) set. All zee purlin splices should have six (6) connections total.

4. Secure each with a bolt and nut. Fasten loosely.



[3] E/W ZEE PURLIN

[10] 1/2-13 SERRATED FLANGE NUT

[11] 1/2X1.0" SERRATED FLANGE BOLT

PRO TIP
9

GRAVITY CLIP PREINSTALLATION

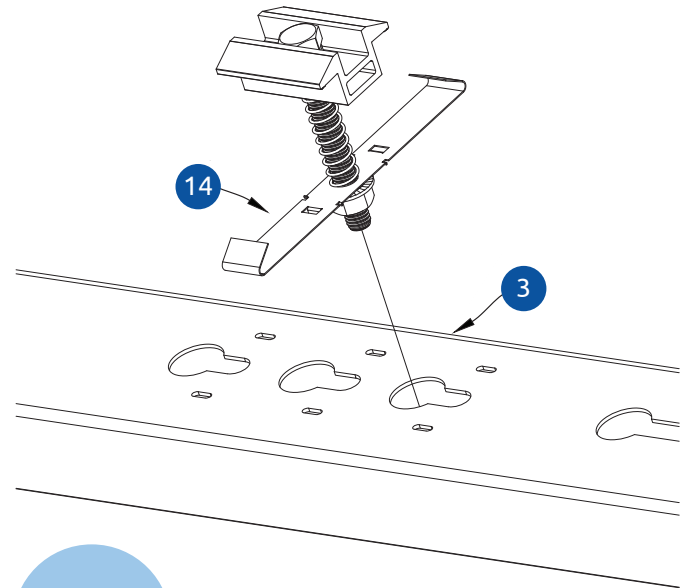
1. On the center zee purlin, install the gravity clip assembly.
2. Refer to the construction documents for the precise locations of where the gravity clip assemblies are required. Two gravity clip assemblies are required per panel which are shared with the panel above or below it.
3. Gravity clip assemblies should typically only be installed in the short keyslots. There are three short keyslots for each set. Refer to construction documents for correct slot usage.
4. Install by holding the assembly with the nut down towards the zee purlin.
5. Push the nut through the large hole in the keyslot, and slide the assembly over until the two tabs on the gravity clip engage with the two slots above and below the keyslot. This keeps the gravity clip in place and prevents rotation and movement in further steps.
6. If needed, rotate the midclamp so that the long side aligns with the zee purlin. Do not tighten.
7. Install all remaining gravity clip assemblies for the row.

[3] E/W ZEE PURLIN

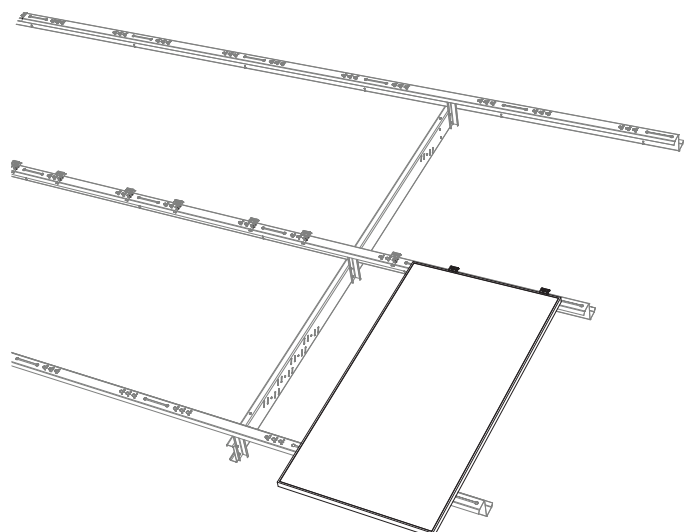
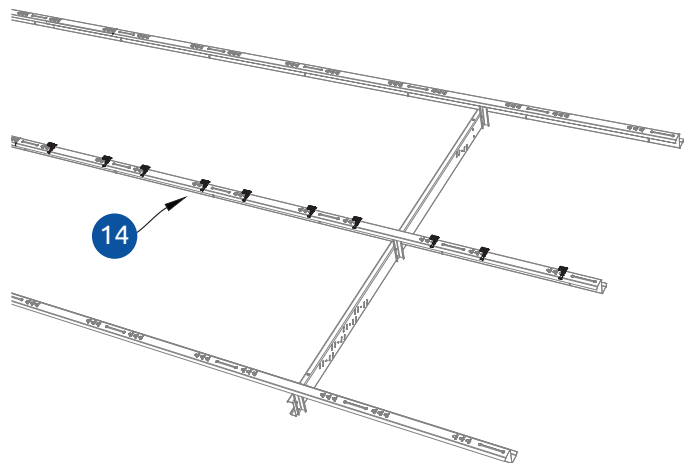
[14] GRAVITY CLIP ASSEMBLY

PANEL INSTALLATION

1. Starting at one end, begin hooking the pv modules on the gravity clip. Refer to the construction documents to determine the correct orientation of the module to correctly align the junction boxes at the rear of the module.
2. Stage the first lower module by hanging the module on the lower hooks of the first two preinstalled gravity clip assemblies. Start in the middle of the keyslot.
3. Stage the upper module directly above the lower module, ensuring the module aluminum frame is against the gravity clip. Failure to ensure a good fit may result in the grounding teeth not engaging properly.



**PRO TIP
10**



**PRO TIP
11**

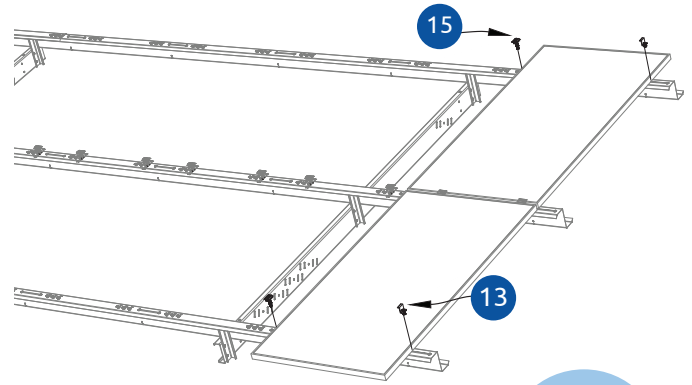
PANEL INSTALLATION (CONTINUED)

4. Align the long edges of the modules so they are flush.
5. Install an end clamp at the beginning, on both the top and bottom modules, in the long keyslot. Keep loose.
6. Install midclamp assemblies on the inner edges of the top and bottom modules, typically in the long keyslots. Keep loose.

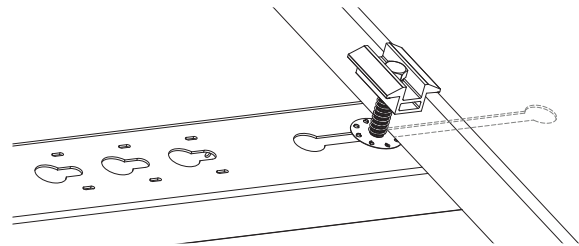
[13] END CLAMP ASSEMBLY

[15] MIDCLAMP ASSEMBLY

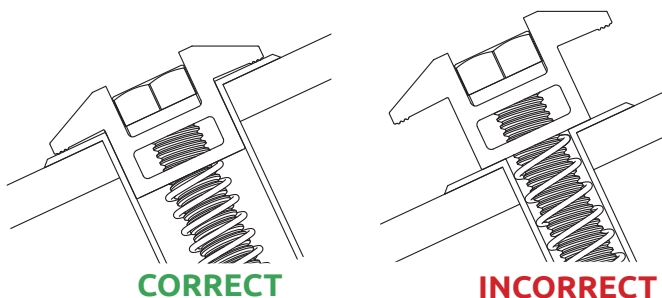
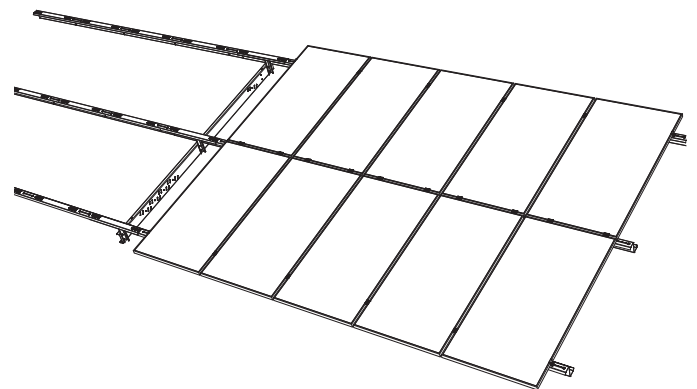
7. Continue staging modules and placing midclamp assemblies up to the reset point, which requires more end-clamps. Each time, stage the lower module, then upper module, then both midclamp assemblies.
8. Adjust the modules East to West until they are all in the correct place, and the long edges are flush and square.
9. Tighten the gravity clamp assemblies. One person should push the lower and upper modules up slightly so the module frame is against the side of the aluminum clamp on both the front and rear side. If the clamp is above the module frame, tighten assembly slightly to ensure frame does not touch the bolt/spring. Another person must tighten the nut from below the rack.
10. Tighten the endclamp assemblies.
11. Adjust and tighten remaining gravity clip assemblies and midclamp assemblies, each time ensuring that all modules are tight against the aluminum clamps both above/below and to the clamps to the sides.
12. Tighten endclamps. Ensure all grounding barbs are engaged in the aluminum module frames.
13. Repeat steps 1-12 to the end of the row, in sections. Reference your construction documents to determine the correct location of module clamps and end clamps.



PRO TIP
12



Midclamps may be preinstalled from either side of the long keyslot



WARNING

DO NOT stage an entire row of modules. Only stage enough modules required to properly adjust them left to right (East to West). **DO NOT** leave modules unattended with untightened clamps, as wind may blow them off and cause damage.

CABLE BRACE-TO-POST

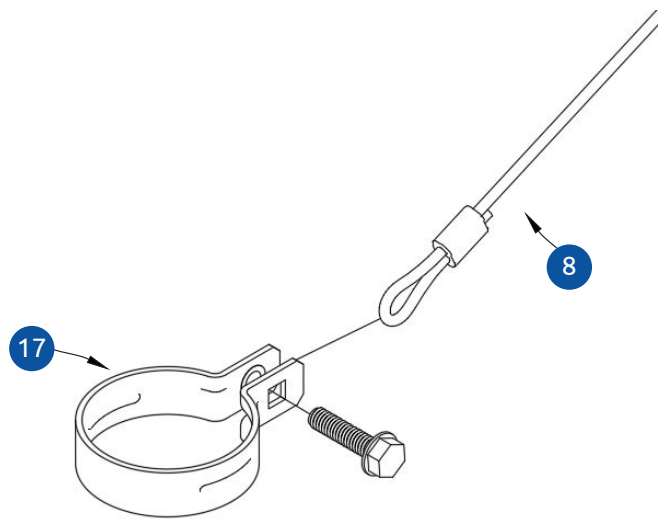
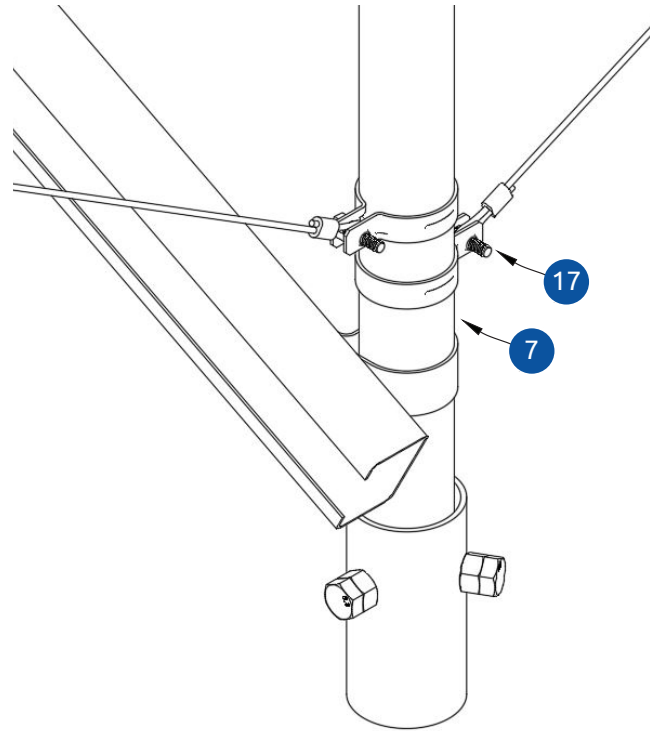
Depending on the array and project parameters, a set of posts may get multiple sets of cable braces to limit movement and reduce fatigue. Refer to the construction documentation for locations and frequency of cable bracing.

1. If clamps were not installed prior to installing the N/S chord (highly recommended), spread the clamp apart, slide around the post, and re-compress it. Install clamps as required.
2. Once clamps are installed, string a cable between the two clamps (note: there may be multiple lengths of cables on one job; refer to construction documentation to use the correct one).
3. Secure with bolts, loosely. Ensure that the bolts are pointing to the interior of the rack.
4. Position one clamp slightly above the knee brace clamp and fasten tightly.
5. Slide the opposite clamp as far as possible and fasten the bolt tightly. Cables should be taut and have no noticeable slack or sag.
6. Repeat for all remaining cables as indicated in the construction documentation.

- [7] POST
- [8] CABLE BRACE
- [17] CABLE CLAMP ASSEMBLY

NOTE

Cable braces are not used to induce static tension, like trusses of a bridge, but instead only to keep the posts from spreading or shifting.



PRO TIPS

PRO TIPS are pieces of advice from installation experts. They are intended to provide practical solutions to real-world problems that you may encounter. Before implementing any of the below tips, make sure to request approval from APA's Engineering team, as not all solutions are allowed on every site.

[1] Use a steel tape rather than a fiberglass tape to measure distances over the length of the row. Fiberglass can stretch over time and affect layout and installation lengths.

[2] With extreme topography, every foundation must be marked and the string line must be attached to every foundation in order to ensure that the racking will flow at every high and low point.

[3] Install the beginning, middle and end foundations about half of the way to depth (typically until threads are not showing). Then attach a string line to these installed foundations, creating a straight line for the installation process. This will give the installer a guide and ensure that the foundations are plumb.

[4] If holes are pre-drilled, they must be filled with aggregate immediately, ensuring debris or water doesn't fall into the holes. If this happens, a void can be created causing the foundations to possibly sink in the future.

[5] While it is very difficult to make every post perfectly plumb and at the correct height, care should be taken to keep them within the tolerances specified in the plans in order to ensure that the system fits and functions as intended.

[6] When dealing with extreme topography, additional transitions will have to be added to make the racking flow with the terrain.

[7] Use grip clamps when setting post transitions. This is the best technique to use so that no improper dimpling is done to the posts if adjustments are needed. Once desired flow is reached, then tighten the set bolts.

[8] Use a grip clamp to squeeze and close the clamp shut while installing the clamp bolt. Connect the knee brace to the knee brace clamp with a squeeze vise. This process takes less effort as the clamps are very rigid.

[9] Use a spud wrench to align keyhole slots while installing the overlapping zee purlins. Use a spud wrench/alignment punch to pry onto the stud. At times, due to topography, the opposite side of the zee purlin will have to be lifted in the air to properly seat onto the previously installed zee purlin.

[10] When staging panel clamps, tighten the bottom nut until the spring is slightly compressed. This will help the panel installer free up one hand. If the spring is not compressed prior to staging, the clamp will spin and another installer will have to hold the panel.

[11] When determining the position in the keyslot, start in the middle. Adjust left or right moving through the row. It will change based on topography or achieving certain aesthetics.

[12] To square the panel, measure the distance from the edge of the panel to the flat part of the zee purlin on both sides, ensuring equal distance.

OPERATION & MAINTENANCE

Regular inspections and proper maintenance are essential to maintain the design life and warranty of the TITAN solar racking system. Solar racking is exposed to many elements from initial construction to seasonal changes and can even be susceptible to severe weather conditions. The following Operation and Maintenance procedures should be followed and performed on an annual basis to ensure the warranty for the racking system remains active. The procedures below highlight the critical points to be examined and maintained for a properly functioning solar racking system.

BOLTED CONNECTIONS

Bolted connections need to be visually inspected annually to ensure the components are properly joined together. There are torque marked nuts/bolts at the beginning, middle, and end of each row per the APA QA/QC process. These marked locations should be visually inspected to confirm no movement of the bolted connections have occurred. If loose hardware is found, re-tighten to the specifications noted in the plan set for the racking system.

SOLAR PANEL CLAMPS

Clamps need to be visually inspected annually to ensure modules are properly secured. If loose clamps are found, re-tighten to the specifications noted in the plan set for the racking system.

GALVANIZE COATING

The galvanized coating ensures that the steel components are protected from corrosion and that the solar racking system will last for the entire project life. The solar racking system should be inspected annually for any areas of corrosion or rust. If areas are found, they should be repaired in a timely manner by cleaning the area, then generously applying cold galvanizing compound.

The cut, slit and sheared edges of the racking system are exposed steel that are expected to show corrosion or rust. This is normal and should be expected, but does not affect the structural integrity of the system.

Copper should be isolated and cannot touch the galvanized coating, as it will expedite corrosion.

CROSS BRACING CABLE WIRE

If applicable to your project, the bracing needs to be visually inspected on an annual basis to ensure that it has not become loose. Cables are required to be taut for limiting motion, but do not need to be tensioned.

SYSTEM DAMAGE

The solar racking system should be visually inspected for other types of damage. Examples include damage from mowing equipment, maintenance equipment, falling trees or branches, storm damage, system lean, soil erosion, etc. Any components that are damaged or deformed should be replaced as they may be weaker or corrode faster than intended. Some components may be able to be repaired onsite if replacement is not practical. Contact APA for assistance with replacement parts or instructions on repairing a component.

GENERAL OPERATION

It is important to maintain the solar racking system to ensure the design lifespan.

Keep all vegetation managed and off of the racking system and solar modules.

Check that module cleaner solution, weed killer, or other chemicals used on or around the solar racking system are not corrosive to galvanized or stainless steels.

Check electrical wiring to ensure it is managed properly and protected.

Take note and log when inspections were performed and if any corrective actions were taken or need to be taken in the future.