

STR-02 ALTERNATIVE FOOTINGS

FOUR FOOTINGS WITH THE SAME STRENGTH AND WIND RESISTANCE AS THE CONTRACT PAD FOOTING

Supplement to TN-20261019-STR-FTG01 (elaboration of Attachment E), for use under Clause 2 (Footings)

Project	45 × LONGi 650 W off-grid PV array, low ground mount STR-02, 36 posts	Document	TN-20261019-STR-FTG02 Rev01
Site / Employer	Chiang Rai, Thailand · Private client	Date	19 October 2026

Purpose. Clause 2 lets Solar ESS change a footing on site where conditions call for it, provided the new footing is properly designed for wind load and uplift. This note gives four ready-designed alternatives that each match the contract pad footing on every design check. Any one of them can replace the pad at some or all of the 36 posts without changing the structure above the footing, the anchor bolts, the purlin levels or the Contract Price.

1. Equivalence criteria (taken from the contract footing)

Check	Requirement every alternative must meet
Wind uplift (DPT 1311-50, Chiang Rai, $V = 25$ m/s)	446 kgf at an interior post (223 kgf at a row end); safety factor ≥ 1.5 , with dead load counted at 90% only. The contract pad gives 1.58 .
Weight needed	$0.9 \times (\text{footing weight} + 70 \text{ kg structure share}) \geq 1.5 \times 446 \rightarrow$ footing weight (concrete + soil held on it) $\geq$ 673 kg , unless the soil is proven by a pull test
Lateral wind load	62 kgf at the post base; safety factor ≥ 1.5 against sliding
Soil bearing	$\leq 5 \text{ t/m}^2$ for firm natural soil (presumed; same as the contract design)
Connection	Same 2 × M12 J-bolts at 110 mm and the same 160 × 160 × 6 mm base plate (bolt pull-out capacity $\geq 4 \times$ demand)
Structure above	Purlin underside at +0.40 m (front) and +0.59 m (rear) above finished ground, so the panels sit exactly as designed



2. The four alternatives at a glance

Footing	Size (per post)	Concrete per post	Concrete 36 posts	Digging	Uplift SF	Main advantage	Needs
Contract: reinforced pad + stem	Pad $0.80 \times 0.80 \times 0.15$ m at 0.60 m deep, stem 0.25×0.25 m	0.124 m ³	4.5 m ³	$1.0 \times 1.0 \times 0.65$ m hole	1.58	Least concrete	Formwork, rebar mesh, layered compaction
A: plain block cast in the hole	0.60×0.60 m, 0.80 m deep, top flush with ground	0.288 m ³	10.4 m ³	$0.6 \times 0.6 \times 0.8$ m hole (the hole is the form)	1.54	One pour, no formwork, no backfill compaction; easiest for local labour	Hole sides that stand up
B: shallow ballast block	$1.00 \times 1.00 \times 0.30$ m, set 0.15 m into ground	0.300 m ³	10.8 m ³	0.15 m scrape only	1.59	Almost no digging; can be precast and moved later	720 kg block: cast in place or lift with a crane truck
C: augered concrete pier	Ø 0.40 m, 1.20 m deep	0.151 m ³	5.4 m ³	Auger hole, no backfill	≥ 1.5 with test	Fastest if an auger is available; small surface footprint	Auger; one pull test on site
D: steel ground screw	Ø 76 mm galvanized screw, 1.6 m long, top flange	none	none	None (screwed in)	≥ 1.5 with test	No concrete or curing; posts can go up the same day	Screw-driving machine; pull tests on site

SF = safety factor against wind uplift at an interior post (the worst case), dead load at 90%. Options A and B are proven by weight alone, exactly like the contract footing. Options C and D also rely on soil friction or screw grip, so they are accepted only after the site pull test in Section 4.

3. Drawings

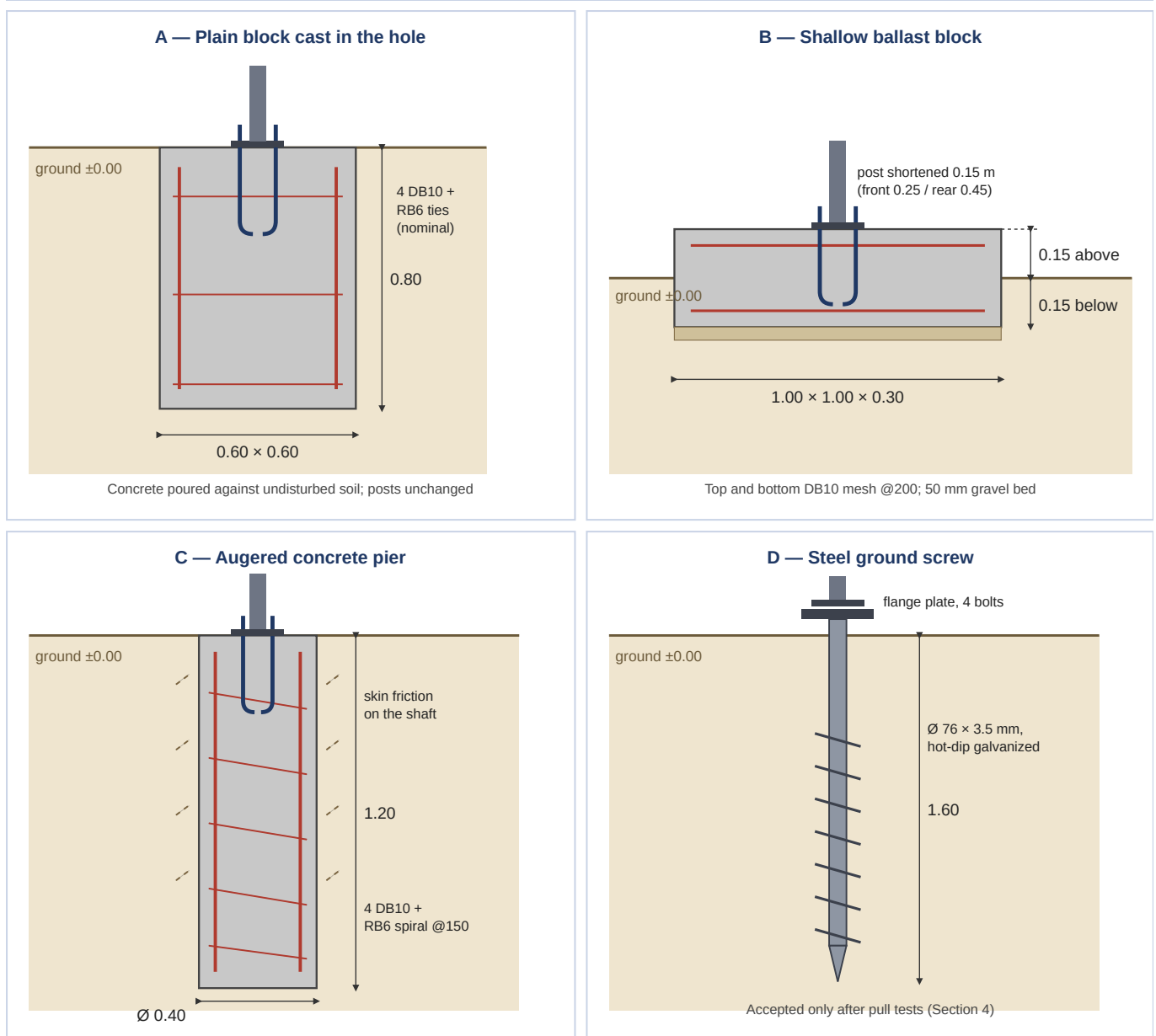


Figure 1 — Typical sections of the four alternatives (not to scale with each other; dimensions in metres). All use the same post, base plate and 2 × M12 anchors as the contract footing, except D, which bolts the post base plate to the screw's flange.

4. Design of each alternative

Option A — Plain concrete block cast in the hole (0.60 × 0.60 × 0.80 m)

Check	Calculation	Result
Concrete weight: $0.60 \times 0.60 \times 0.80 = 0.288 \text{ m}^3 \times 2,400 \text{ kg/m}^3$	691 kg; with structure share 70 kg → 761 kg	
Uplift (side friction ignored)	$0.9 \times 761 = 685 \text{ kg} \div 446 \text{ kgf}$	SF 1.54
Row-end post	$0.9 \times (691 + 37) = 655 \text{ kg} \div 223 \text{ kgf}$	SF 2.9
Bearing	$(446 + 761) \text{ kg} \div 0.36 \text{ m}^2 = 3.4 \text{ t/m}^2$ against 5 t/m^2	OK
Lateral	Passive soil on a 0.60 m face, 0.80 m deep $\approx \frac{1}{2} \times 3 \times 1,600 \times 0.8^2 \times 0.6 = 922 \text{ kg}$ against 62 kgf	SF > 10
Anchors	2 × M12 J-bolt, 250 mm in concrete (same as contract)	OK

- **Build:** dig a neat 0.60 × 0.60 m hole to 0.80 m with straight sides, put in a small cage of 4 DB10 (0.75 m) with three RB6 ties to hold the bolts and control cracking, and pour in one go up to ground level. Set the bolts with the template and trowel the top level. No formwork, gravel seat or layered compaction is needed.
- **Where to use:** anywhere the hole sides stand up without collapsing (most firm clay or silty soil). In loose sand or fill, use Option B.
- **Real safety factor is higher:** concrete poured against undisturbed soil also grips the sides, which is not counted.

Option B — Shallow ballast block (1.00 × 1.00 × 0.30 m, 0.15 m in the ground)

Check	Calculation	Result
Concrete weight: $1.00 \times 1.00 \times 0.30 = 0.30 \text{ m}^3 \times 2,400 \text{ kg/m}^3$	720 kg; with structure share 70 kg → 790 kg	
Uplift	$0.9 \times 790 = 711 \text{ kg} \div 446 \text{ kgf}$	SF 1.59
Row-end post	$0.9 \times (720 + 37) = 681 \text{ kg} \div 223 \text{ kgf}$	SF 3.1
Bearing	$(446 + 790) \text{ kg} \div 1.0 \text{ m}^2 = 1.2 \text{ t/m}^2$ against 5 t/m^2	OK
Sliding at full uplift	Net weight $711 - 446 = 265 \text{ kg} \times \text{friction } 0.45 = 119 \text{ kg}$, plus soil on the 0.15 m embedded face, against 62 kgf	SF 1.9
Post length	Block top at +0.15 m, so posts are 0.15 m shorter: front 0.25 m, rear 0.45 m ; purlin levels unchanged	OK

- **Build:** scrape 0.15 m, compact, lay 50 mm gravel, set a 1.0 × 1.0 m board form, place top and bottom DB10 mesh at 200 mm, set the bolts with the template and pour. Or precast it off site (720 kg, needs a crane truck and two cast-in lifting loops).
- **Where to use:** rock or a high water table close to the surface, buried pipes, or where the footing may need to be moved or the array extended later.
- **Note:** the 0.15 m embedment is what stops sliding. Do not set the block on top of the ground.

Option C — Augered concrete pier (Ø 0.40 m × 1.20 m)

Check	Calculation	Result
Concrete weight: $\pi \times 0.20^2 \times 1.20 = 0.151 \text{ m}^3 \times 2,400 \text{ kg/m}^3$	362 kg; with structure share → 432 kg; $0.9 \times 432 = 389 \text{ kg}$	
Skin friction needed for SF 1.5	$1.5 \times 446 - 389 = 280 \text{ kg}$ over the shaft below 0.2 m ($\pi \times 0.40 \times 1.0 = 1.26 \text{ m}^2$) → 0.22 t/m² (2.2 kPa)	
Typical skin friction, firm clay or silt	10–30 kPa, which is 5 to 14 times the 2.2 kPa needed	Confirm by test
Bearing and lateral	Downward load carried by end bearing plus shaft friction; lateral 62 kgf resisted by 1.2 m of embedment	OK

- **Build:** auger Ø 0.40 m to 1.20 m, clean the bottom, lower a cage of 4 DB10 (1.15 m) with RB6 spiral at 150 mm, pour to ground level and set the bolts. No backfill.
- **Acceptance:** before doing all 36, build one test pier, let it cure 7 days and pull it to **670 kgf** (1.5×446) with a jack against a reaction beam; movement under the load must stay under 5 mm. If the soil changes across the site, test one pier per row.

Option D — Galvanized steel ground screw (Ø 76 mm × 1.6 m)

Item	Requirement
Screw	Ø 76 × 3.5 mm steel tube with continuous helix, 1.6 m long, hot-dip galvanized at least 80 µm, flange top plate with 4 bolts to the post base plate
Pull-out test (uplift)	At least 3 test screws spread over the site, each held at 670 kgf for 5 minutes, with movement under 5 mm
Lateral test	95 kgf (1.5×62) applied at 0.6 m above ground; deflection at the top under 10 mm
Installation torque	Record the final torque of each test screw. Every production screw must reach at least the same torque, otherwise lengthen it or use Option A at that post

- **Advantage:** no concrete, no curing and no surplus soil; posts can go up the same day and the screws can be removed later.
- **Limits:** needs a screw-driving machine; screws may stop on rock or large stones; capacity depends entirely on the site tests.

5. Which one to use

Site condition or priority	Recommended footing
Normal firm soil, local hand labour	Option A: one pour, no formwork or compaction; the simplest to build correctly
Rock, water or pipes near the surface; loose sand or fill; may relocate later	Option B: shallow block, little digging
Auger available, firm cohesive soil, need speed	Option C, after a passing pull test
Fastest erection, no concrete, machine available	Option D, after passing pull and lateral tests
Least concrete, ground suits compaction	The contract pad footing

Footing types can be mixed on site, post by post, because they all give the same uplift and lateral resistance and the same purlin levels. Any change is recorded with its footing ID (A1 ... F6), a photo and the reason, and reported in the progress update as required by Clause 2.

6. Notes

- Design basis, loads and soil assumptions are the same as TN-20261019-STR-FTG01: DPT 1311-50 wind load for Chiang Rai; dead load at 90%; concrete 240 ksc; DB10 SD40; firm natural soil with presumed allowable bearing 5 t/m².
- Options A and B rely on weight only and need no soil test. Options C and D rely on soil friction or screw grip and are accepted only after the site tests stated above.
- Concrete quantities are net; allow about 10% for waste. Option B needs posts 0.15 m shorter; all other options use the posts in Attachment A unchanged.