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MIDDLE EAST
سي ام ال الشرق الأوسط

DPOLE® – Technical Presentation

(a case of study - JABAL AKDHAR PROJECT)

INTRODUCTION ON DPOLE® PRODUCT

HOT DIP GALVANIZED STEEL POLES

In the modern society the electric power has a crucial role, not only it defines the development of a Nation, but has become an essential element of our daily life or of our activities on the territory. A primary role for turning on the lights and the computer, but also and above all for every handicraft or industrial activity, is played by the distribution of the electric power, that needs a strong and reliable, as well as durable network. This primary role for the development and for the daily activity has to be played even with whims of the winds, agricultural fires, ice, floods and of the weather.

The galvanised steel distribution poles sustain the electric cables in a reliable and safe way maintaining the users safe, connected and productive granting the economic development.

The galvanised steel distribution poles take part at the construction of a network that is reliable, durable and economic, when and where necessary.

The galvanised steel distribution poles have a minor environmental impact (compared to wooden and concrete poles) and grant a 100% recycling.

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14 KEY POINTS OF THE GALVANISED STEEL POINTS COMPARED TO WOODEN OR CONCRETE POLES

1) Estimated life of 60 years (6 times the one of a wooden pole and twice of the concrete poles)
2) 3 times lighter than a wooden pole and 7 times lighter than a concrete pole (cost reduction for transport and erection)
3) Diminution of the “domino” effect risk if a pole falls
4) They do not burn (no risk with agricultural fires)
5) No maintenance requested (it is not necessary to tighten the assembly hardware, nor to retreat them)
6) Resistant to attacks of insects, woodpeckers, rodents
7) No toxic treatment based on arsenic (today forbidden in many countries) for obvious public health reasons
8) They are not porous, no infiltration is possible, they do neither break under the effects of ice (or deflect for high humidity level)
9) Very economic alternative for head or corner poles. They also allow to increase the span reducing the number of poles on the line
10) They have a flexibility that allows to regain the imbalances within the span rates (breaking of the cable due to freezing). This cannot be allowed by rigid supports such as concrete
11) High resistance for the embedded part against corrosion (the steel pole solution have the best behaviour since wood and concrete are acting like a sponge against the water in the ground and humidity and their structural characteristic will decrease into a short time (for the concrete there is a high of corrosion for the raw steel bar inside)
12) No need for earthing (in case of direct embedment in ground and good value for soil resistivity
13) Valid solution for wadi crossing and high span compared to what will be necessary for the same application with wood and concrete
14) Limited environmental impact with a 100% recycling possibility (impossible for wooden poles because of the treatments, and for concrete poles – both solutions have an extreme impact on the environment)

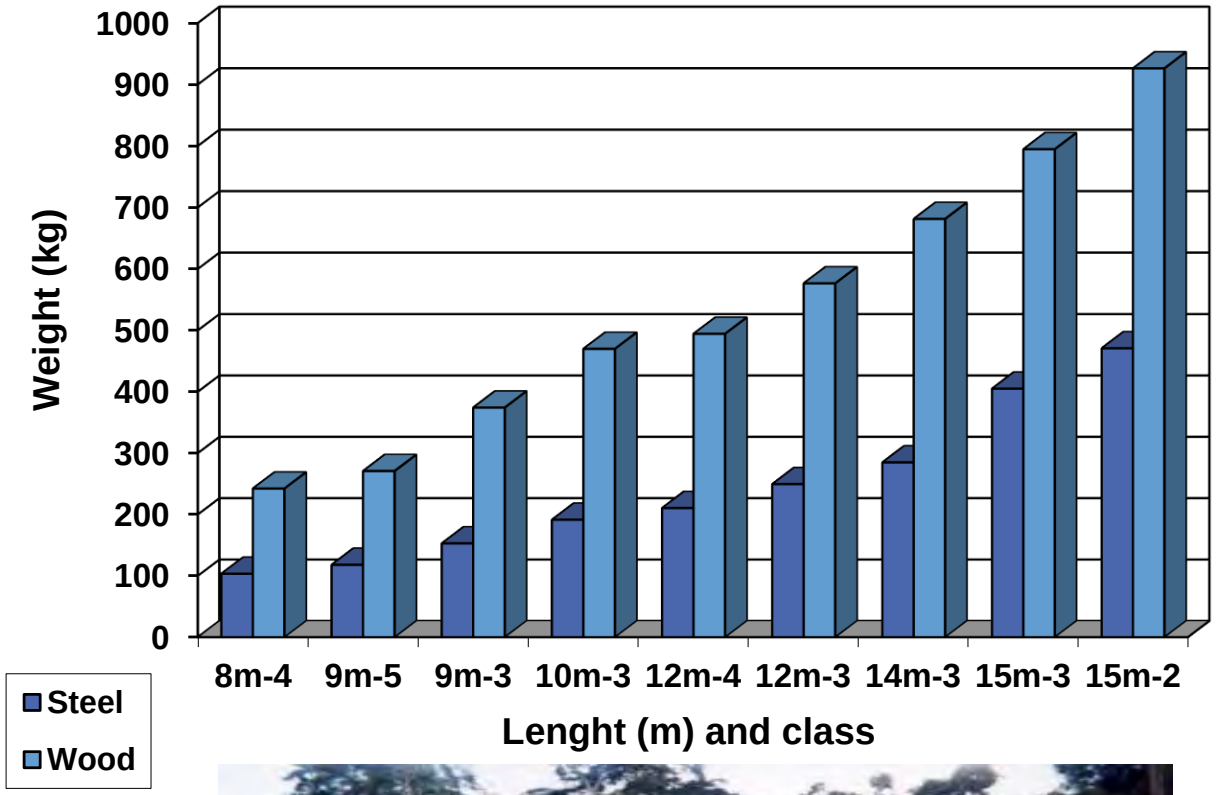
Woodpecker

Termites

Fire

Corrosion

UTILITY POLES SOLUTIONS - COMPARISON



	STEEL	BETON	WOOD
Life forecast	60 years	30 years	10 years
Wight	254 kg	1350 kg	790 kg
Installation costs	low	Very high	high
Transport costs	low	Very high	high
Maintenance costs	low	low	Important
Remaining value (recycling)	Positive	Negative	Negative
Influence on the environment	low	high	Average

TECHNICAL SPECIFICATIONS

MECHANICAL BEHAVIOUR

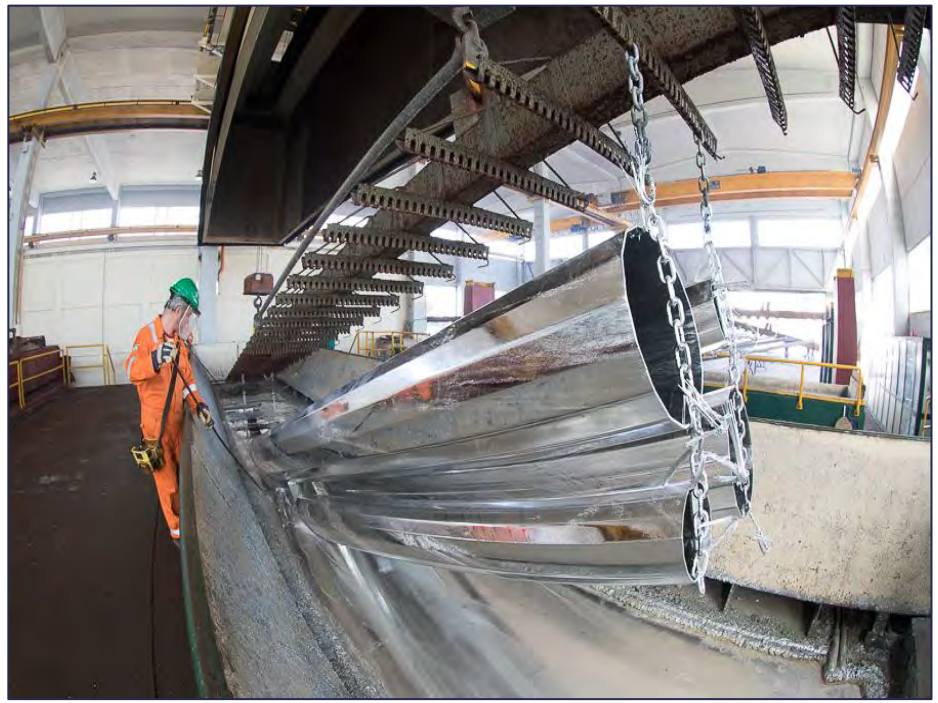
The metallic supports are dimensioned in order to resist to the nominal load F and on the wind pressure V applied at 0,25 m from the top. Under theses loads, the assured safety coefficient is significantly elevated and the pole resists to an elevated torque. The tests showed that the destruction of the support occurred over a coefficient of 2.1 . Moreover, the collapse of the support does not occur with a sudden break (as it is for the wooden or concrete poles) but through a plastic deformation or a local curvature of the connection section together with important deformations that allow to the pole to still sustain part of the initial loads.

STEELS

The used steels are in accordance with the EN 10149 class 1 type S500MC and have the following features:

- Elastic limit Re = 500N/mm²
- Granted resistance at -20 C
- Suitable to be galvanised according to NFA 35503 class I.
- Protection against corrosion

A product certificate of conformity can be supplied to the customer on request.



GALVANIZATION

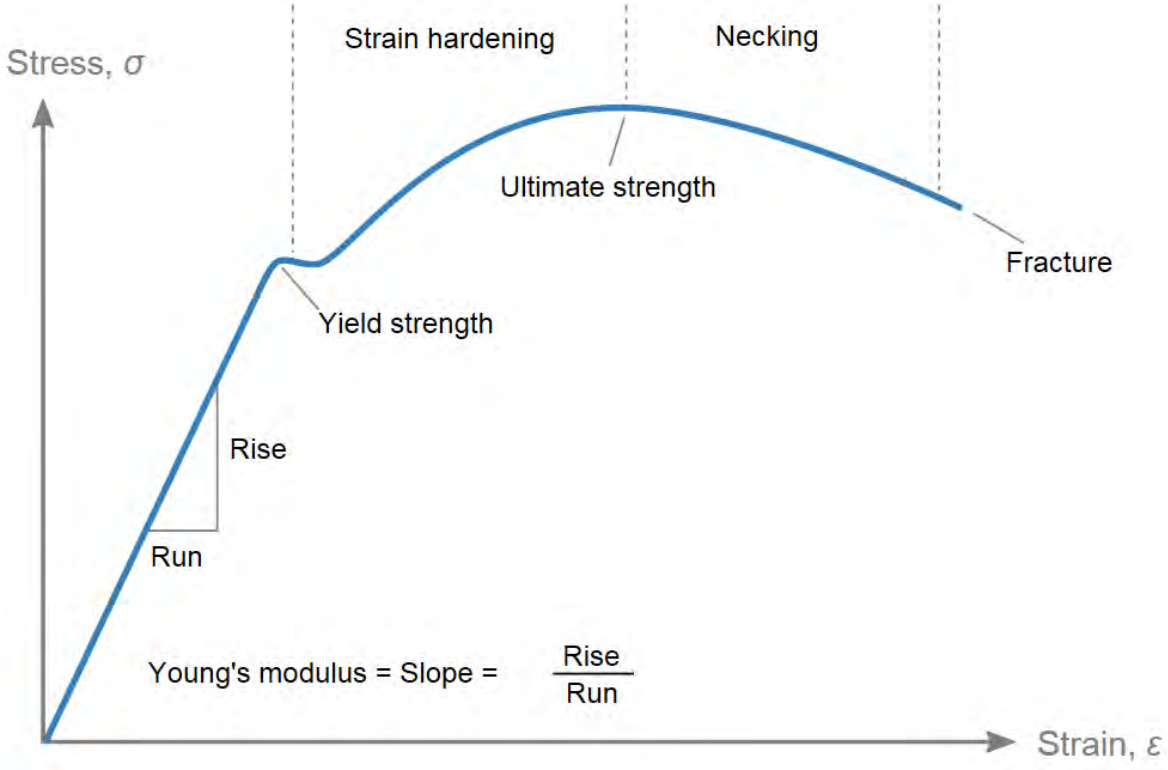
- **Hot – dip galvanisation**

The distribution pole is hot – dip galvanised according to EN 1461 in order to obtain an even zinc coating both in the interior and exterior of the pole.

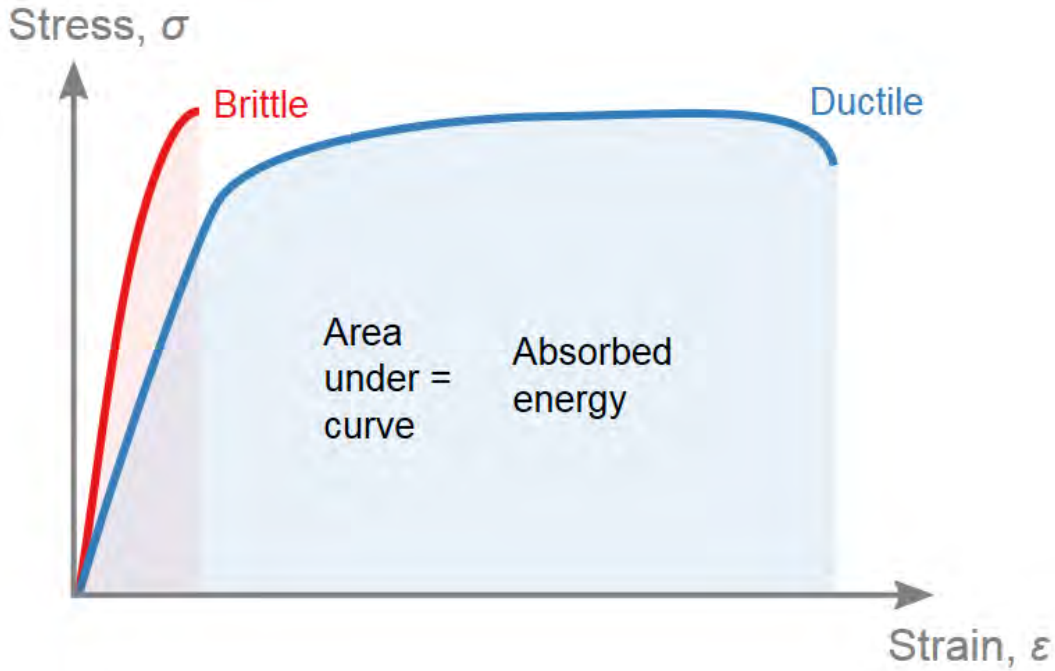
- **Protection of the buried part**

On request of the customer, the pole can be supplied with an additional bituminous protection (realised according to the customer's specifications)

TECHNICAL SPECIFICATIONS



Brittle material	Ductile material
Concrete	Steel
Glass	Wood
Composite	Plastic
Carbon fiber	Copper
Cast Iron	Alluminum
Ceramic	Zinc



DUCTILE material will have more availability to absorb a huge energy before breaking. Normally also the elastic part of the stress&strain curve is really big (this means that after load will return to the original status without any deformation). Generally speaking ductile material are more interesting and used for structural application .

TECHNICAL SPECIFICATIONS

Manufacturing tolerance

- Length of the elements: from 25 mm to + 75 mm
- Linearity: 2 mm per meter
- Torque: 1 grade for a length of 3 m
- Ovalisation: Max 3%
- Average diameter: +/- 0,5%
- Joint: +/– 150mm

Standard accessories:

- head cap
- standard holes
- data plate
- earthing
- bituminous protection

Sl	Items	Requirement
01	Standard	OES1 / BS EN 1991 / ASCE/SEI 48-2016 (as for OES-11 art. 0.05)
02	Material	S500MC (according EN 10149) and S355J2 according EN 10025-2 (suitable for galvanization)
03	Yield Strength	S500: > 500 MPa (according EN 10149) S355: >355 MPa (according EN 10025)
04	Tensile strenght	S500: 550-700 MPa (according EN 10149) S355: 510-680 MPa (according EN 10025)
05	Temperature and Impact energy	S500: -20°C / > 40J (according EN 10149) S355: -20°C / 27J (according EN 10025)
06	Total elongation (A%)	S500: > 15 (according EN 10149) S355: > 20 (according EN 10025)
07	Surface protection	Hot Dip Galvanization – min 127 µm According BS 729 or ASTM A123
08	Manufacture tollerances	- Element length: 25mm to + 75 mm - Linearity: 2 mm per meter - Torque: 1 grade for a length of 3 m - Ovalisation: Max 3% - Average diameter: +/- 0,5% - joint: +/– 150mm
09	Type/Model	I12, AS14 and AS22
10	Heights	15.05, 15.05 and 19.50 meters
11	Weights	900 kg, 900 kg and 2 tons
12	Diameters Base	700 mm, 700 mm and 1040 mm
13	Diameters Top	280 mm, 280 mm and 320 mm
14	Thickness	6mm, 5 mm and 4 mm
15	Marking	Plate and Danger plate as for OES-1
16	Ultimate Load	21 kN, 21 kN and 45 kN
17	Testing Lab	GeoConsultLab srl
18	Test Certificate	Attached

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HIGH RESISTANCE AGAINST CORROSION FOR THE EMBEDDED PART (direct ground embedment)

In case of steel pole we can underline the high resistance for the embedded part against corrosion (the steel pole solution have the best behaviour since wood and concrete are acting like a sponge against the water in the ground and humidity and their structural characteristic will decrease into a short time (for the concrete there is a high of corrosion for the raw steel bar inside).

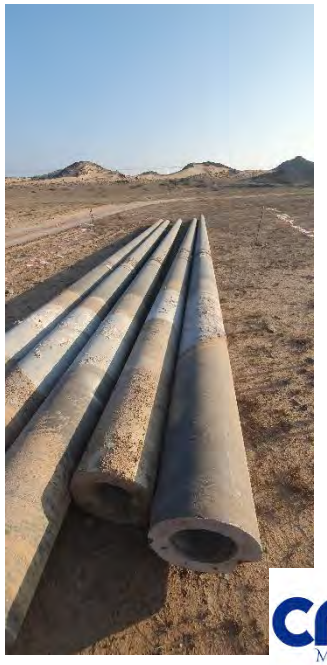
Wood behaviour is showing a fast decrease of the structural characteristics in the embedded part due to the action of the humidity (in some cases the water when the installation is close to rivers, lake or sea).

Concrete behaviour may be underlined from the picture at side. The steel inside is not galvanized at all and concrete is like a sponge in front of water and humidity. The effect is that the raw steel inside will be rusted increasing the volume and the concrete will break with huge decrease of performances.

Galvanized steel behaviour is the only offering (specially in combination with the high quality of galva and the requested galva thickness, 127 micron) a valid an durable protection. This resistance (already attested at the high values) can be even increased applying on the surface extra protection such as painting (combo with galva) or bituminous protection (in this case we may propose different solutions)





TECHNICAL SPECIFICATIONS

<- Bitumen painting (with different possibilities of bitumen thickness). It could be:

- ***The entire underground section + 400mm***
- ***800mm (400+400m) across the ground line***
- ***Entire internal bitumen painting***

Bituminous sheath applied on the → section at the ground level.

Normally we apply a sheath of 800 mm (or 600mm) half over the ground level and the other half underground

Bituminous sheath + quartz painting → on the section at the ground level.

This is exact as per the bitumious sheat including the quartz paiting over to protect the exposed section against the UV ray (during the pole life after instalaltion and during warehousing)

LONG SPAN (wadi crossing for example) APPLICATION:

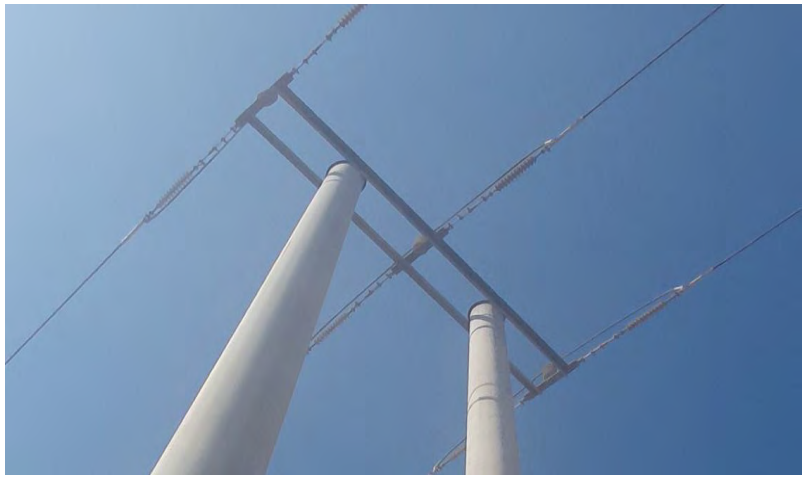
In case the OHL require a long span solution actually the possibilities are:

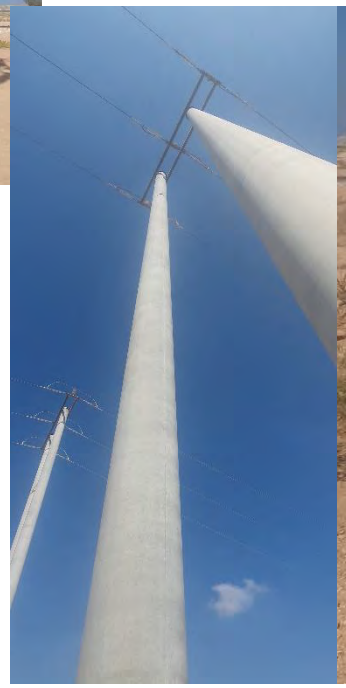
- Triple pole in wooden
- Double at even triple pole in concrete
- Lattice towers

All of them requires a huge work for foundation (normally concrete block) since direct embedment in ground is not possible.
Additionally the cost is obviously much more respect the simple solution of two monopoles embedded directly in ground.
Following pictures will give a clear idea:

Wooden solution for a span of 150m (triple pole with stay wires + galvanized steel connection crossbars + diagonals + concrete block)
A single double circuit steel pole (directly embedded in ground) can take the place of the 6 poles + stay wires in the picture

TECHNICAL SPECIFICATIONS





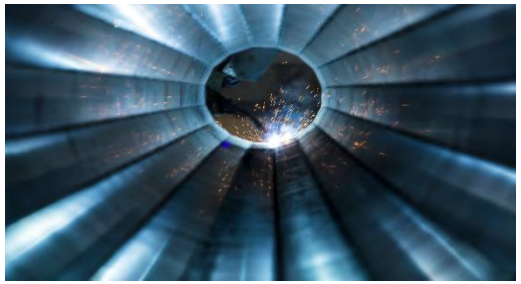
Concrete solution for a span of 150m (double pole with stop galvanized steel crossbars + concrete block).
Concrete poles used n. 2 AS21 (6500kg each).
A single double circuit steel pole (directly embedded in ground) can take the place of the 4 poles mentioned.
Globally the way proposed in concrete (21m pole of 6,5 ton each = 26 tons) is against 2 monopoles in steel of 2 ton each (4 tons globally) manufactured in 2 shafts (easy to be shipped on site – no need of special transportation and crane)

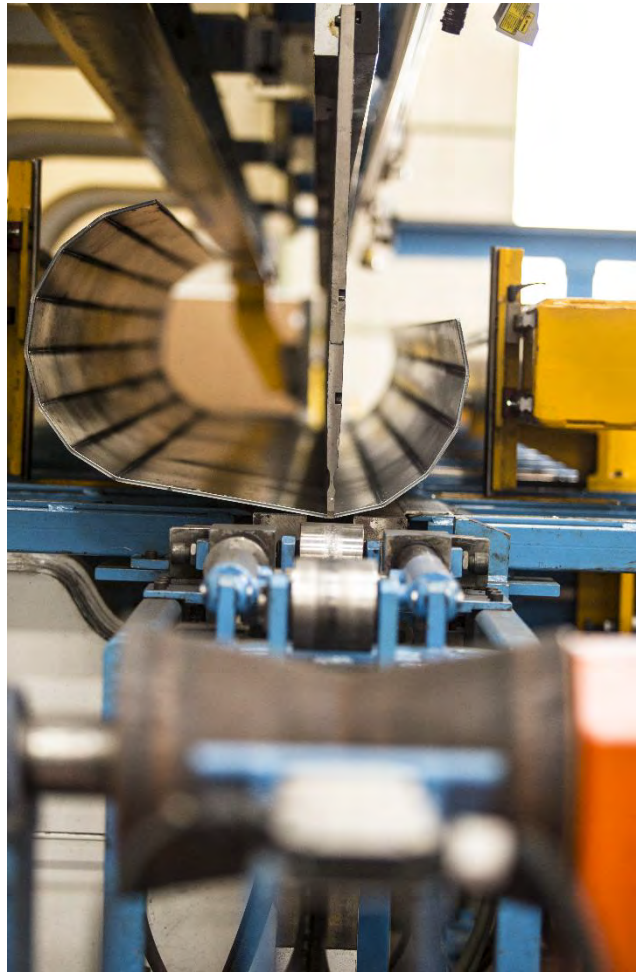
STANDARD FABRICATION DETAILS

The distribution poles are realised in a standard version with the following equipment or details:

- 5 pass through holes with a diameter of 18 mm and positioned in a regularly from the top.
- A M10 earthing nut positioned at 250 mm from the theoretical level of the ground.
- A top cap
- An identification plate that showing: total height of the pole, the maximum eligible load with a coefficient 1; year of production; brand of the manufacturer (the plate can be customised according to the specifications /indications of the customer)

The assembly of the poles on the ground is through burial installation.
Over 12m the poles are realised in two sections.





As an option and on the customer's request, the distribution poles can be supplied with:

- Specific identification place
- Additional holes for the change of lighting fittings or additional accessories on the head.
- An additional earthing nut of the electrical fittings fixed on the head of the pole.
- An anti – embedment plate on the base of the pole.
- A bituminous protection of 800 mm (400 mm under the ground and 400 mm above) – that can be modified according to the specifications/indications of the customer.
- Elements for the anchorage of the ladder or use of the climbing ladder.
- A series of removable rungs for the access to the top.

STANDARD FABRICATION DETAILS

Geometry and manufacturing

The distribution pole as a regular octagonal section (8 sides) that offers a resistance in all directions.
The poles of up to 11,9 m are made by just one section, above 12 m they are built into two sections assembled on the construction site through coupling. The nominal retrieval height must be equal to 1,5 times the average diameter among the edges of the top section. The acceptable effective joint height realised on the site must be higher than 1,35 times the diameter among the edges of the top section.

Manufacturing

Longitudinal welding

The longitudinal welding of the section is realised through the submerged welding following a qualified operational procedure and in accordance with standard NF ISO 15614-1.

Quality

The poles are manufactured on a site that is certified ISO 9001. The manufacturing and control procedures are clearly defined in the quality manual.

Other

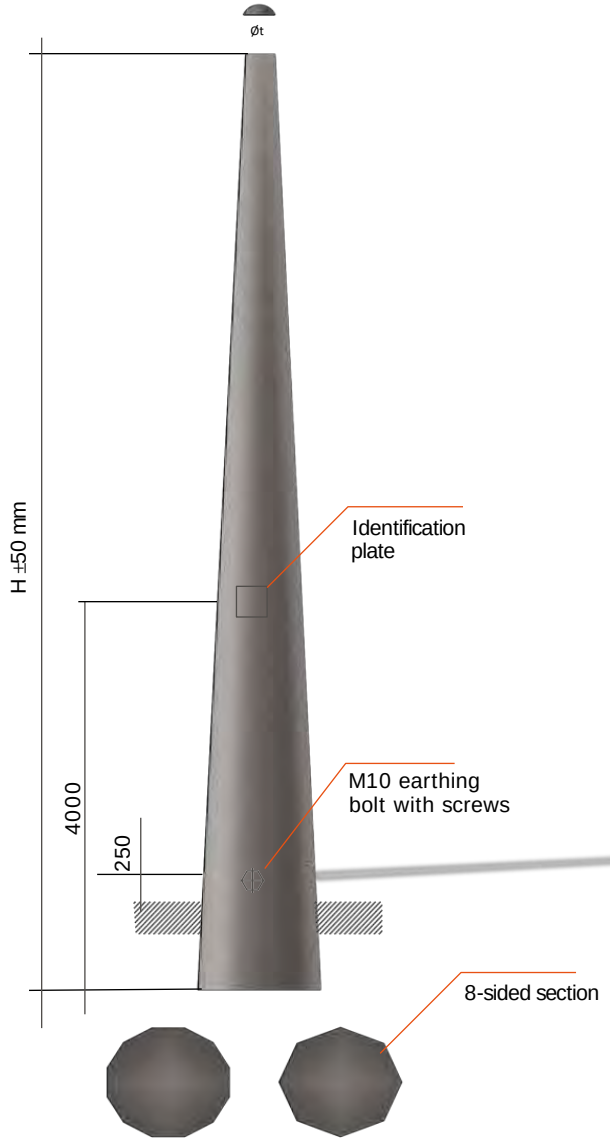
The holes, the welding and other operations are realised before the galvanisation in order to grant that the whole surface of the pole is protected from corrosion.

Dimensions and eligible loads

The eligible load is the one that leads the pole to the steel's minimum granted elastic limit with the wind, vertical load and variable safety coefficient. The application of a load due to the wind or to the addition of accessories on the pole (vertical load), as well as taking into consideration a safety coefficient, complicate the selection procedure of a pole and needs a specific calculation.
For this reason C.M.M.L as to contact us through:

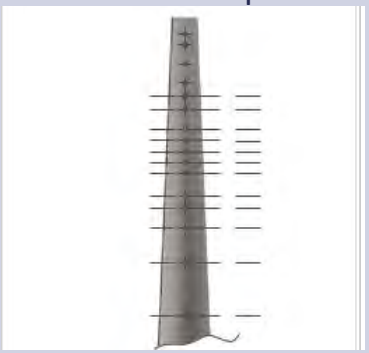
www.cml-me.com

DISTRIBUTION DPOLE RANGE

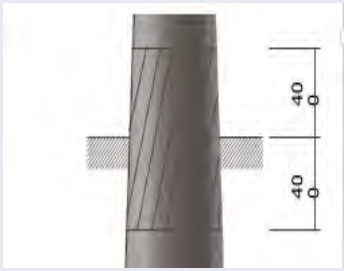


OPTIONS

Additional holes according to the client's request



Bituminous protection



Anti embedment plate

IKZI - JABAL AKDHAR

(double circuit on steel poles MV line)

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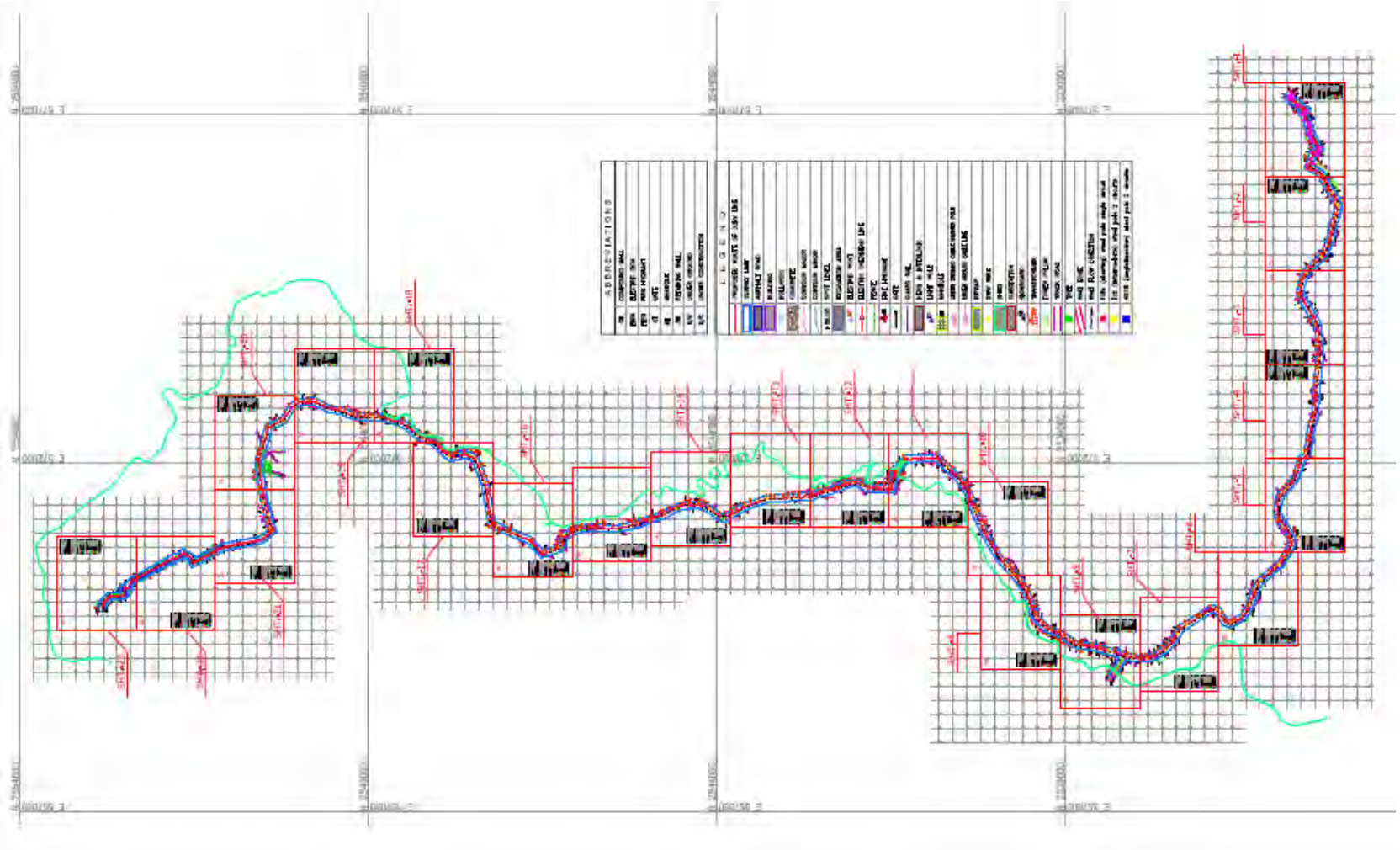


Approved route (with steel poles)

Site survey on June 18-19, 2022

JABAL AKDHAR PROJECT

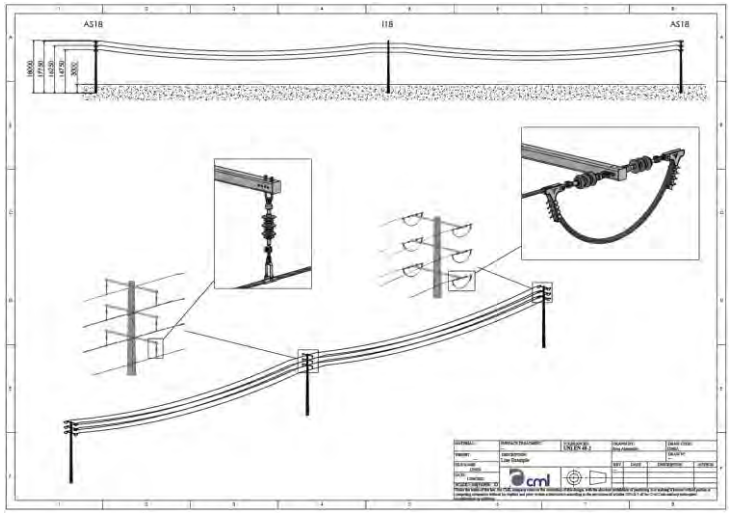
LINE DESCRIPTION:

Final customer: MAZOON ELECTRICITY COMPANY SAOC
Contractor: SCAN ELECTROMECHANICAL COMPANY

- *Around 28,6 km of 33 kV double circuit line;*
- *ACSR 200 sqmm Panther Conductor;*
- *Around 2 km underground;*
- *Around 2,6 km on steel lattice towers;*
- *Around 24 km on HDG steel poles directly embedded in ground with n. 3 crossarms each suitable for a double circuit MV (33 kV) line;*
- *Line elevation: min (545m) - max (2121m);*
- *Max steel pole span 159m;*
- *Nominal steel poles span 120m;*
- *Total number of steel poles needed -> 262;*
- *N. 163 poles AS18 (Angle&Section with 3 crossarms)*
- *N. 95 poles I18 (Intermediate with 3 crossarms)*
- *N. 4 poles I18s (Terminal poles with one crossarm)*

PROJECT MILESTONES:

- *Official PO received for steel poles → April 28th, 2022;*
- *From April to June 2022 steel poles engineering;*
- *Site survey 18-19 June 2022;*
- *Final design calculation and prototypes July 2022;*
- *FAT (with customer and contractor) 3-4 August 2022;*
- *Sag&tension file + elevation plan on September 2022;*
- *First shipment on site September 29th, 2022;*
- *First pole installed on November 7th;*
- *From November 7th up to today 150 poles installed;*
- *First stringing section February 6th, 2023*
- *From February 6th up to today 40 sites stringing done.*



COMPARISON WITH OLD DESIGNED LINE IN WOOD (single circuit):

ORIGINAL PROJECT (WOOD - single circuit)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOTAL	wodeen poles	steel wires
2H pole + 4 stay wires (intermediate)	3	21	17	19	20	27	23	13	9	18	9	4	16	14	12	11	5	8	8	15	2	**274**	548	1096
2H pole + 5 stay wires (angle)	1	9	3	7	6	3	4	4	5	3	3	15	4	6	7	1	8	8	4	3	0	**104**	208	520
2H pole + 2 stay wires (terminal)	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**3**	6	6
3H pole + 6 stay wires (medium span)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	**3**	9	18
3H pole + 12 stay wires (long span)	0	0	0	0	4	0	0	3	4	3	0	0	0	3	1	0	4	0	3	0	2	**27**	81	324
3H pole + 13 stay wires (long span + angle)	0	0	0	0	0	0	0	0	2	1	0	2	0	0	1	0	0	1	2	0	0	**9**	27	117
3T pole + 8 stay wires (right angle)	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	3	0	1	0	0	**8**	24	64
																			n° of sites -->			**428**	**903**	**2145**
NEW PROJECT (STEEL - double circuit)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**TOTAL**	**steel poles**	**wires**
AS18 monopole + n. 3 crossarms TRA4000-T	3	7	4	7	13	12	9	6	8	8	6	8	6	9	10	6	12	8	10	8	3	**163**	163	0
I18 monopole + n.3 crossarms TRA4000-I	0	9	6	8	5	8	7	7	4	7	2	4	7	3	2	2	4	2	3	2	3	**95**	95	0
I18s monopole + n. 1 crossarm TRA4000-T	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**4**	4	
																			n° of sites -->			**262**	**262**	**0**

Due to the resistance of these poles the lines has been revised removing a lot of intermediate wood poles (original project has been performed with a wooden pole solution on a single circuit line).

The average span has increased to approx. 120m, and no location has been changed, only removed. The result is that now we have almost half of the site (262 locations instead of 428 for wood), with a consequent huge saving in material, work, accessories, preparation works, access roads, time in every phase of the activity on site.

- ***Line in wood → single circuit: 428 sites – 903 poles***
- ***Line in steel → double circuit: 262 sites – 262 poles***

Less number of sites it means:

- ***Less holes***
- ***Less trasportation cost***
- ***Less installation cost***
- ***Less cost for insulator and chain link***
- ***Less time for the project exection***
- ***Less cost***

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POLES and CROSSARMS:

Line has been designed with software internally developed for Sag&Tension + pole + crossarm calcualtion according the OES1-33kV and in particular:

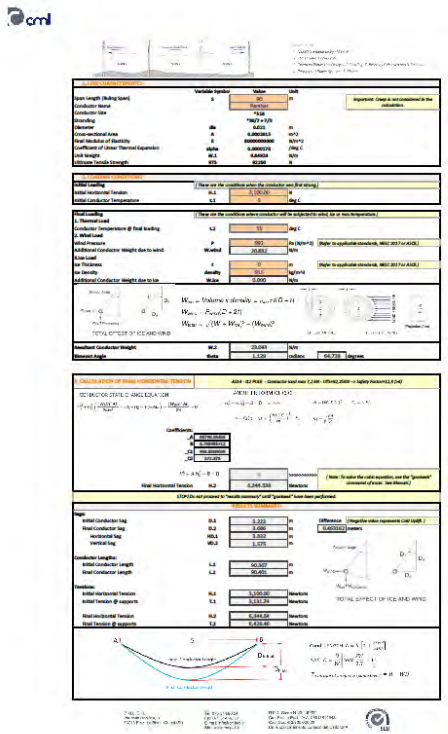
a. *Wind load → 992 Pa*
b. *Min/Max temperature → 5/85 C*
c. *Ground clearance → 7m*
d. *Design calculation according OES*

SULTANATE OF OMAN

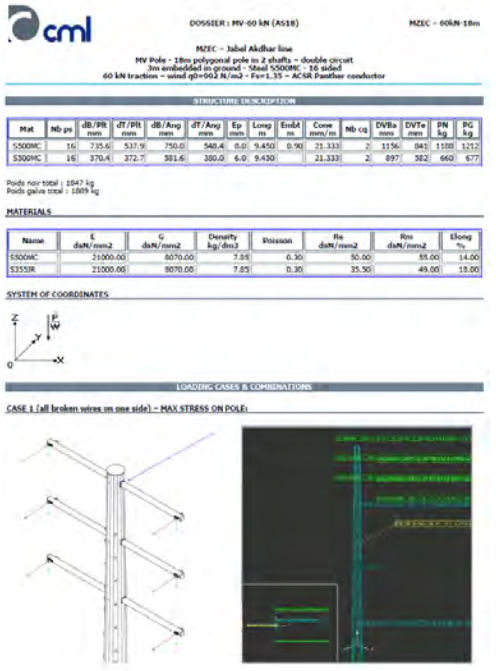
MINISTRY OF ELECTRICITY & WATER

STANDARD - OES 1
33KV AND 11KV OVERHEAD LINES

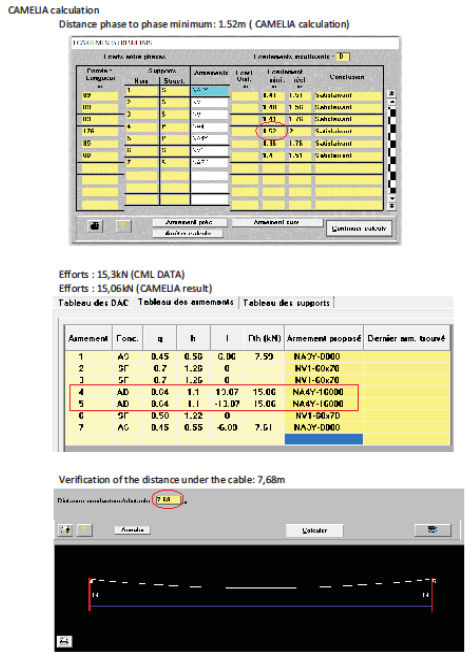
Second Edition : January 1995



Sag & Tension



Pole
(design calculation)



Crossarm

Complete quality book (CML quality certificates, with mill certificates, dimension check, zinc check, calculation, drawing, pictures,.....are delivered with each shipment)

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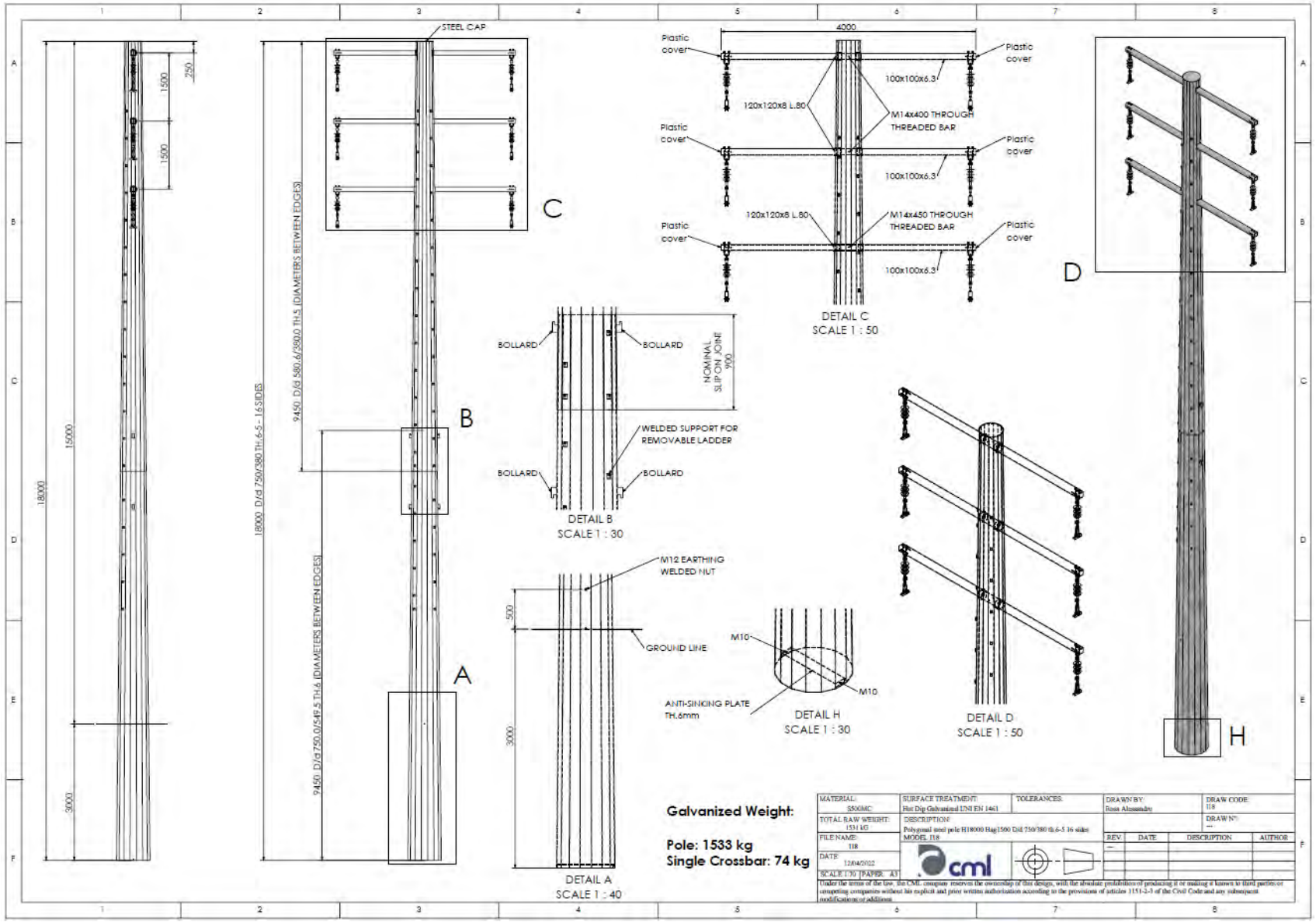


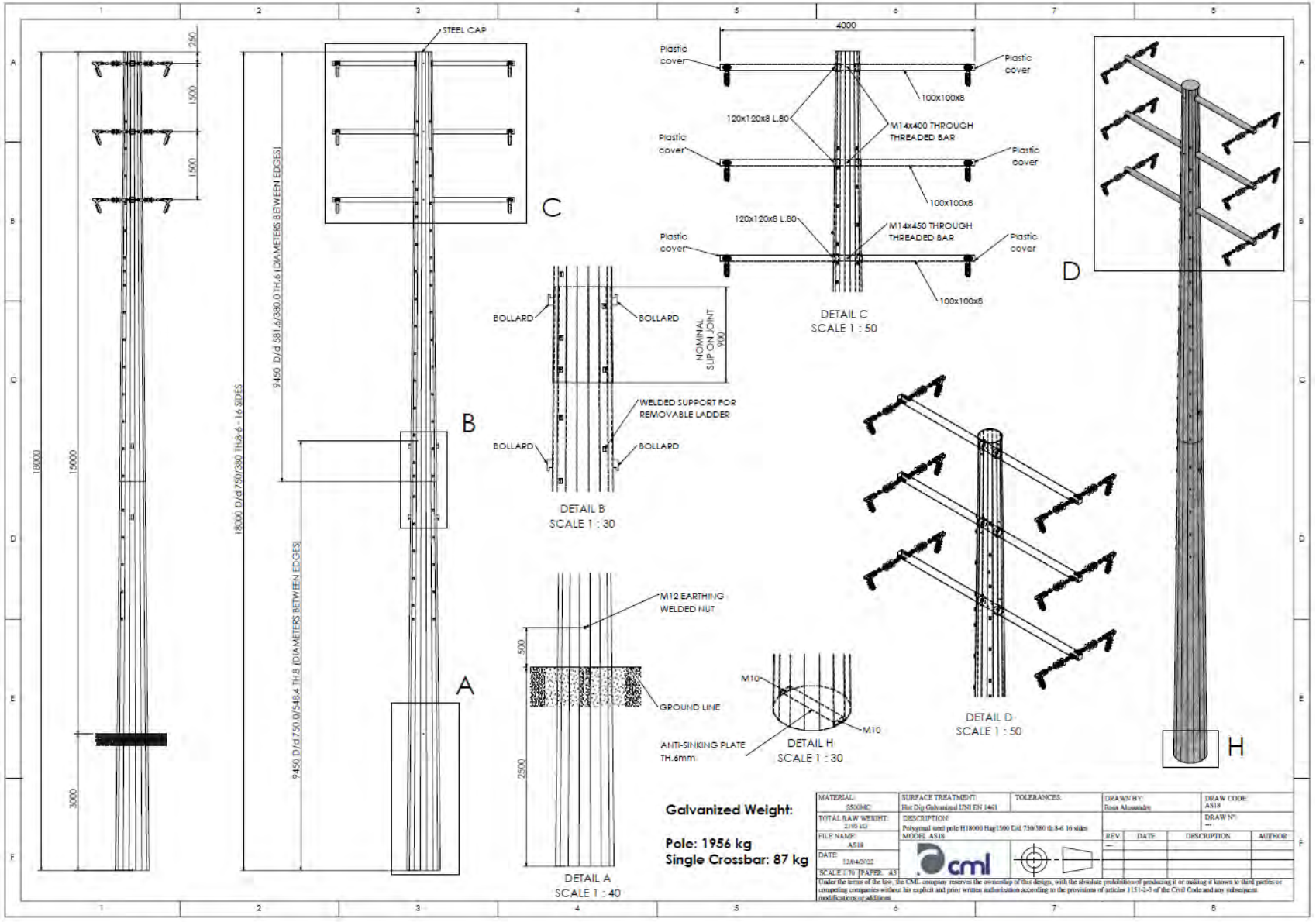
I18 steel pole

Working load=45kN - Weight=1533kg

INTERMEDIATE POLE 15m a.g.

Embedment 3m – pole diameter 0,75m - hole diameter needed 1m

JABAL AKDHAR PROJECT



AS18 steel pole

Working load=60kN - Weight=1956kg

ANGLE & SECTION POLE 15m a.g.

Embedment 3m – pole diameter 0,75m - hole diameter needed 1m

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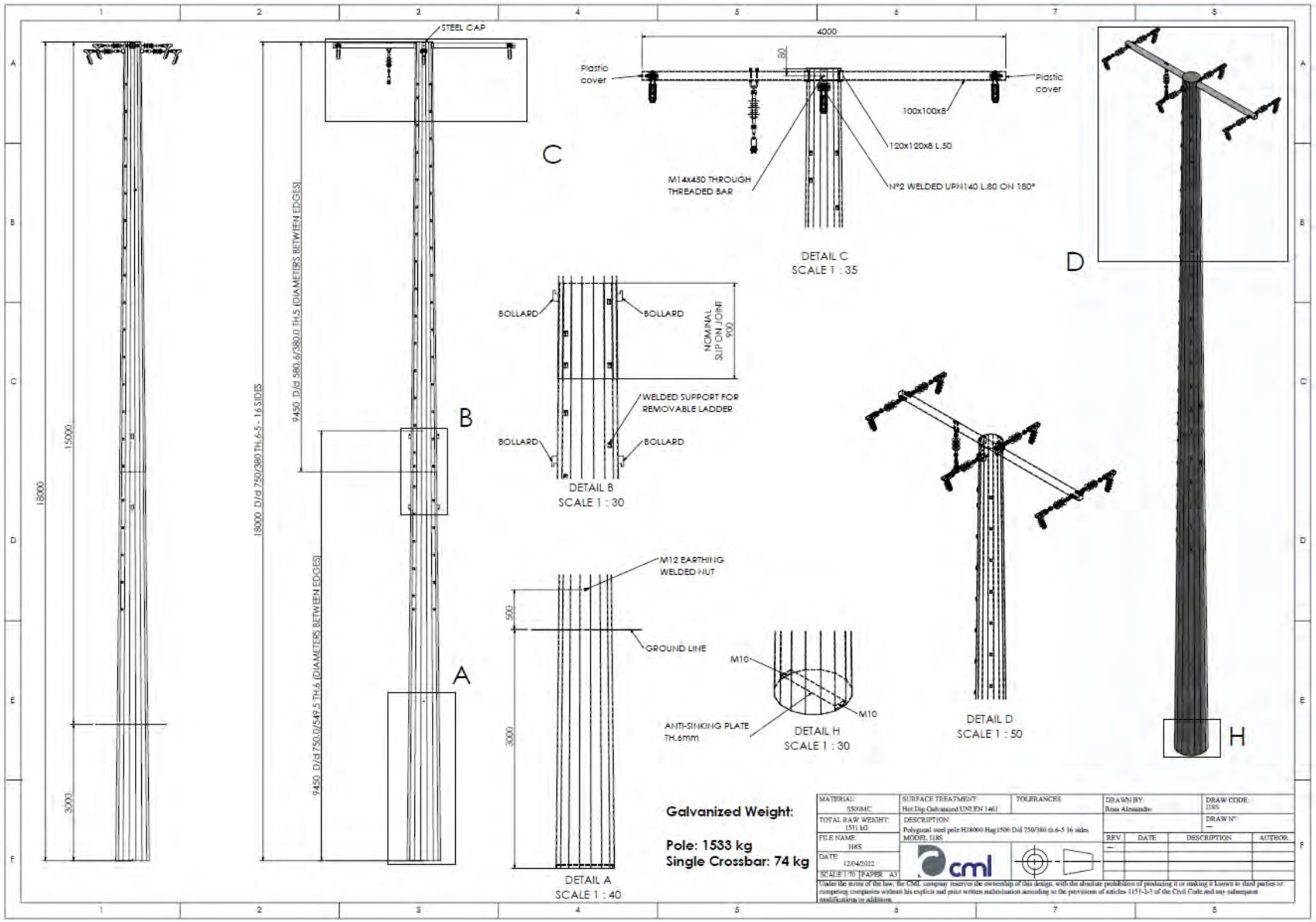

I18s steel pole

Working load=45kN - Weight=1533kg

TERMINAL POLE 15m a.g.

Embedment 3m – pole diameter 0,75m - hole diameter needed 1m

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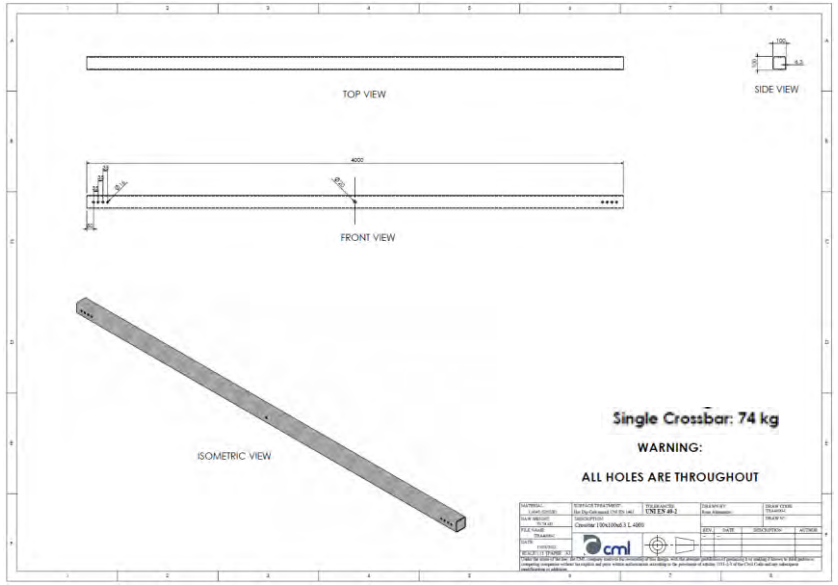
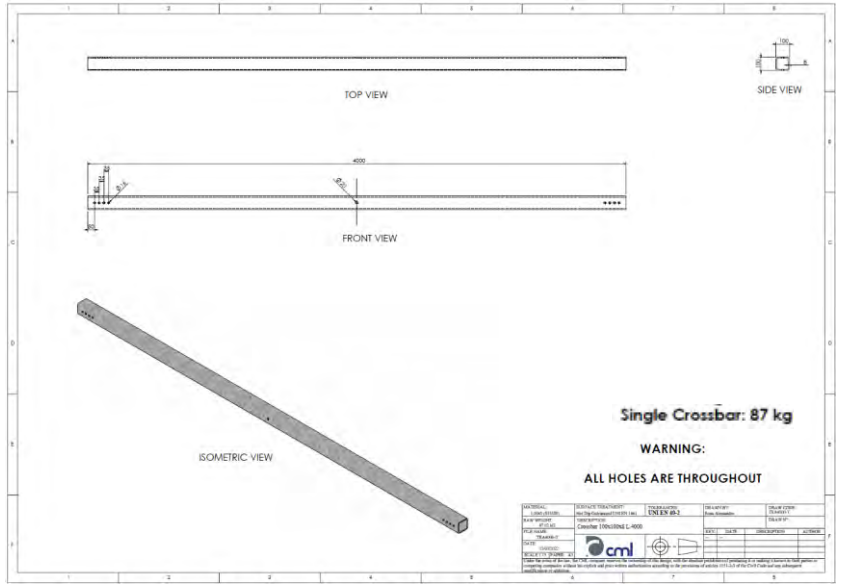
I18 crossbar:



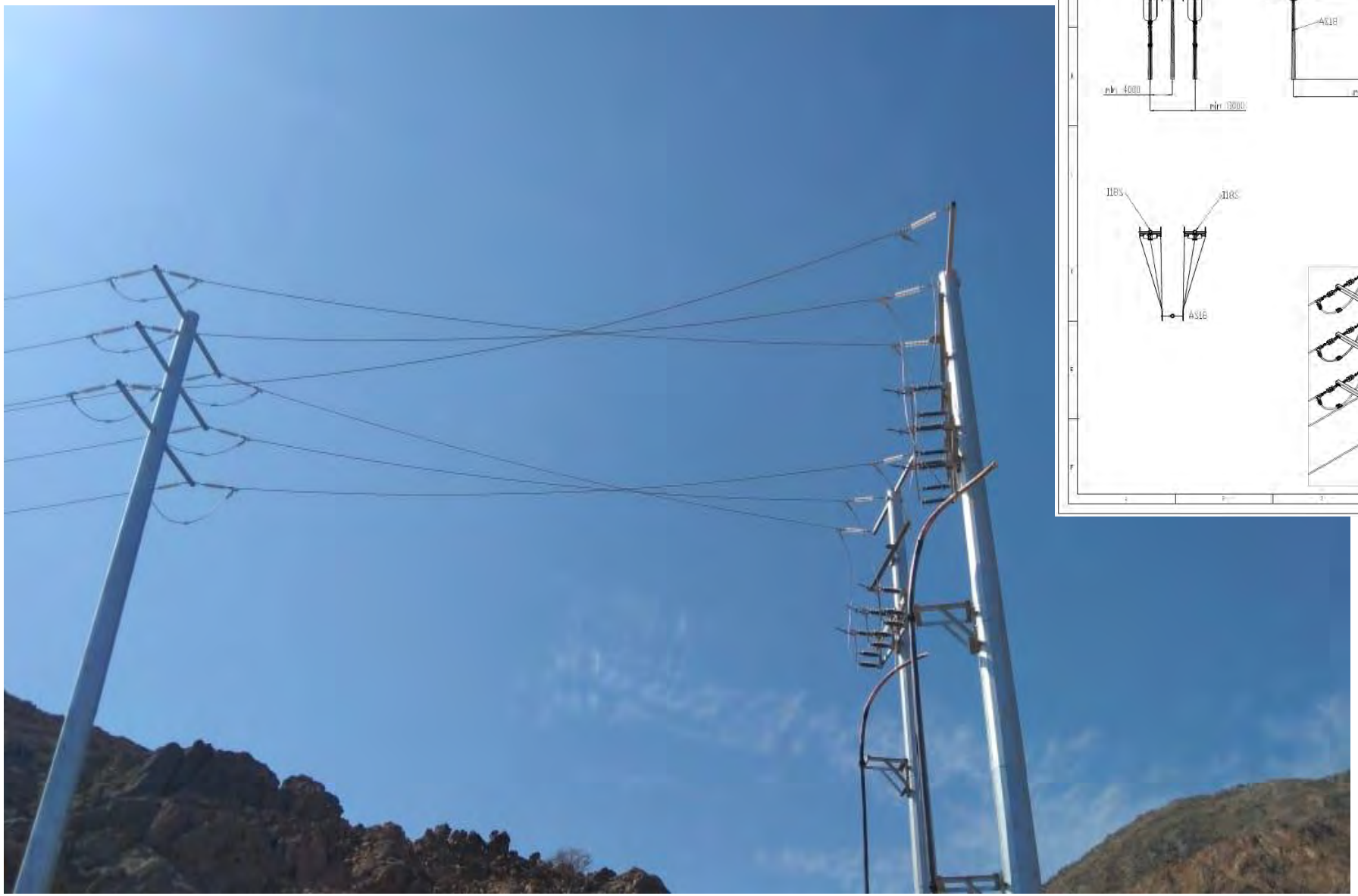
I18s+AS18 crossbar:

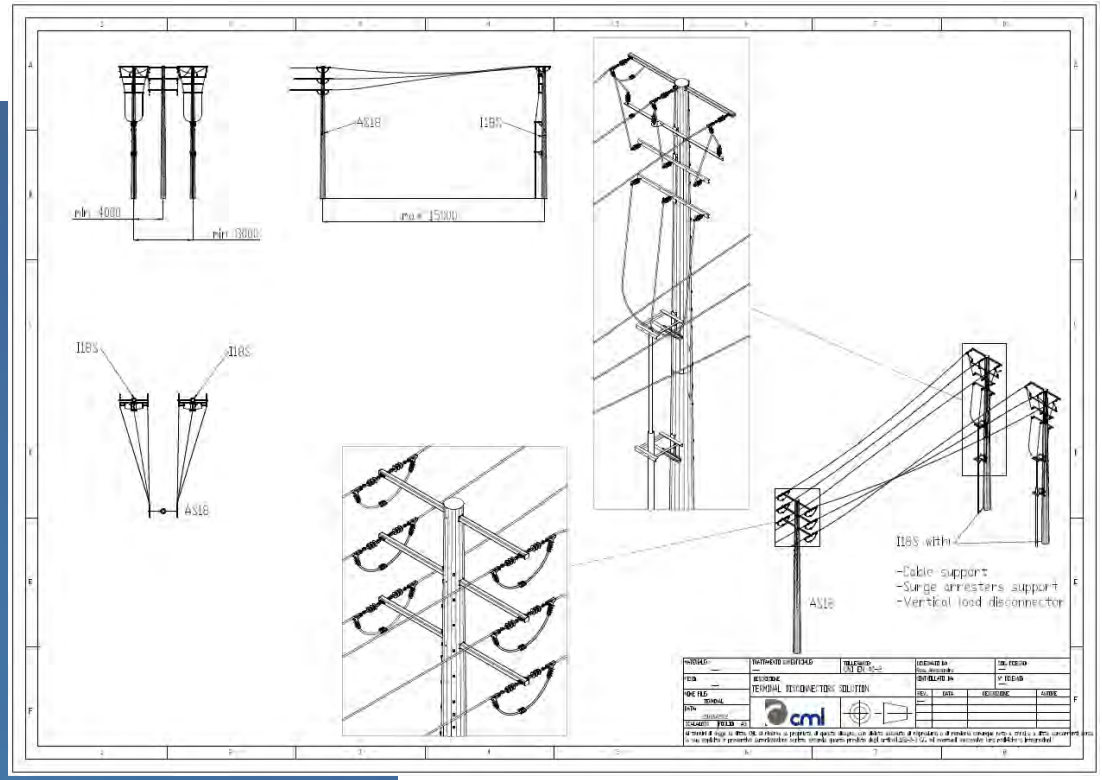


Crossarms easy to be fixed.
Just insert the crossarm on the reinforced pole opening and fix it by using a treaded bar M14x500mm with double nut.

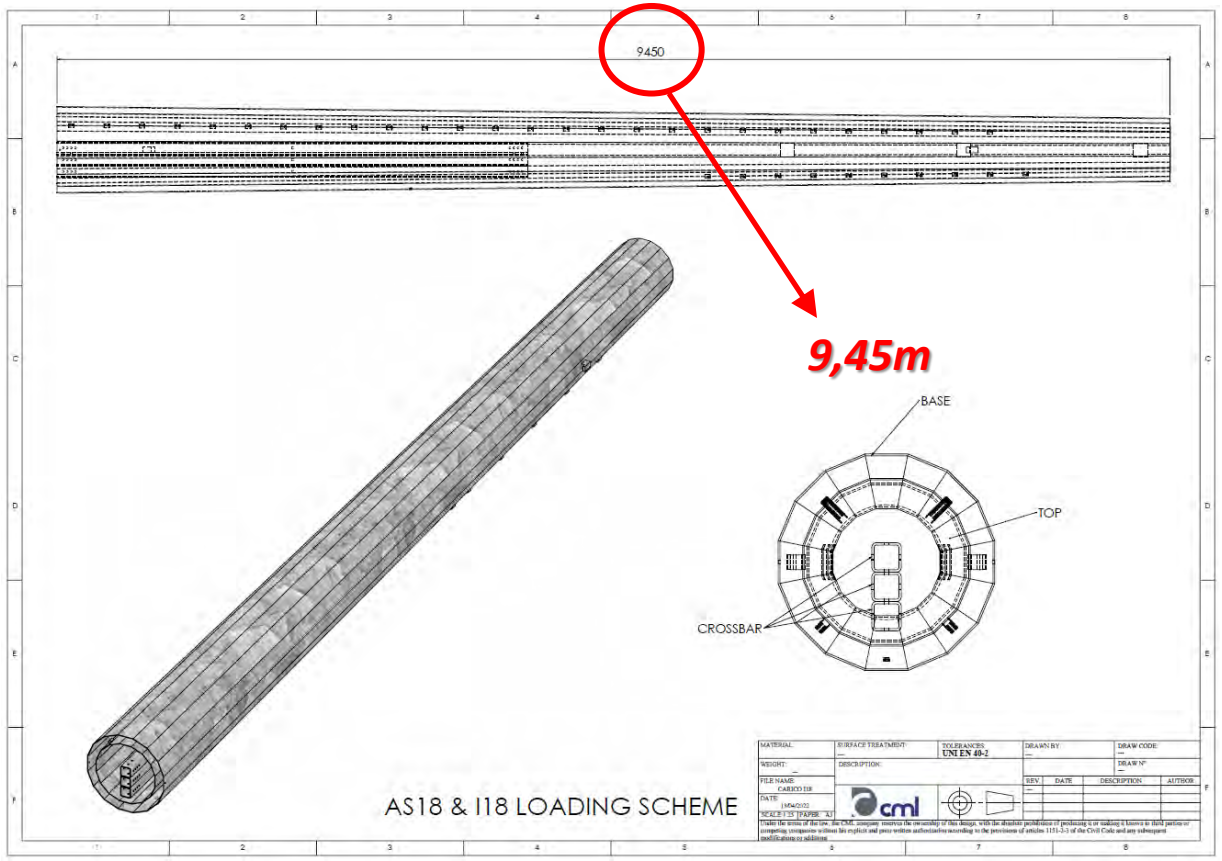
cml MIDDLE EAST

Terminal I18s (and splicing):





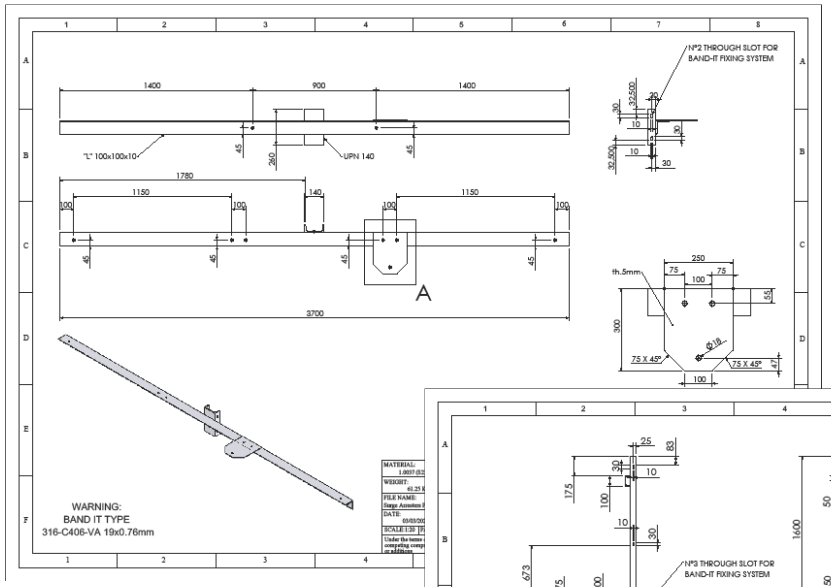
Pole and crossarm packaging (for site shipment):



Smart packaging for storage and site delivery.
The poles and the crossarm are designed to take into account the shipment and the storage. As per drawings and pictures the complete pole is an item of 9,45x0,75m with the top shaft and the crossarm and all other material insert inside.
So the storage is really easy and simple to find the material and the transportation on site it can be done with a smal truck. A small crane for down loading is enough for the operation (the max weight of the package is 2 ton).

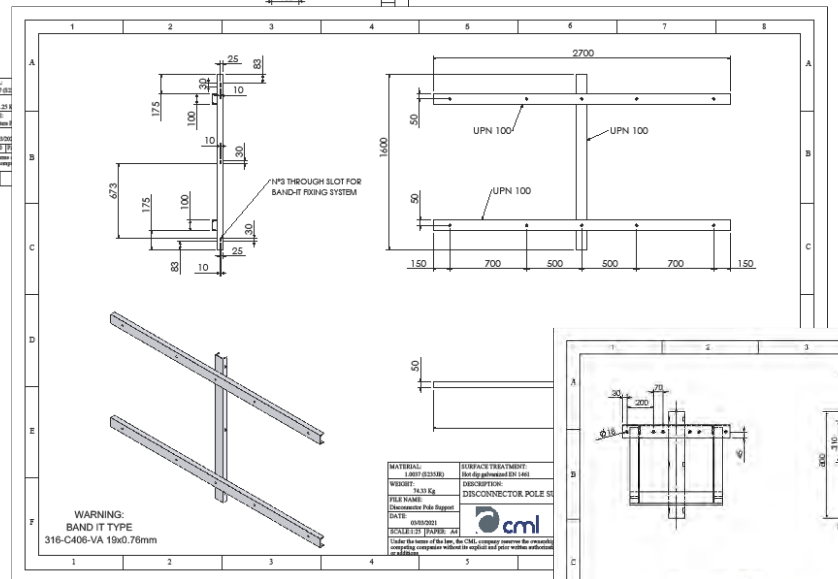
JABAL AKDHAR PROJECT

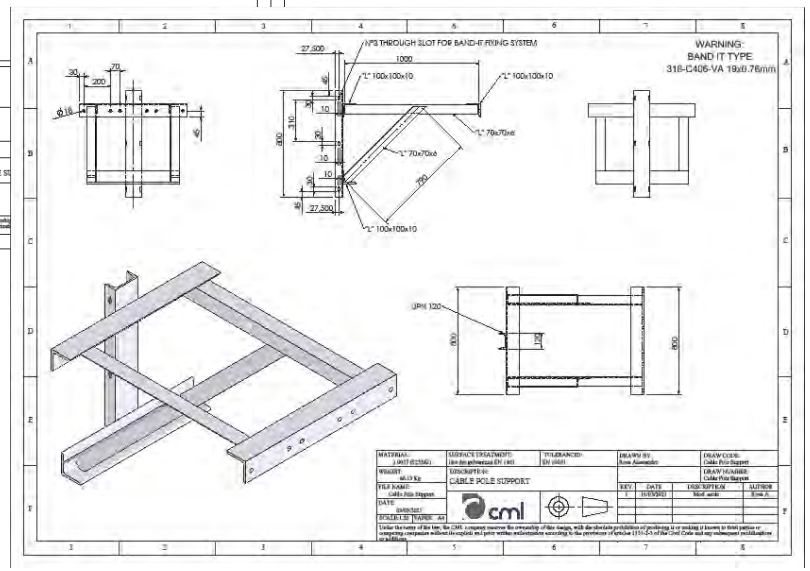
Supports on pole



Surge arresters support

Disconnector support





Cable support

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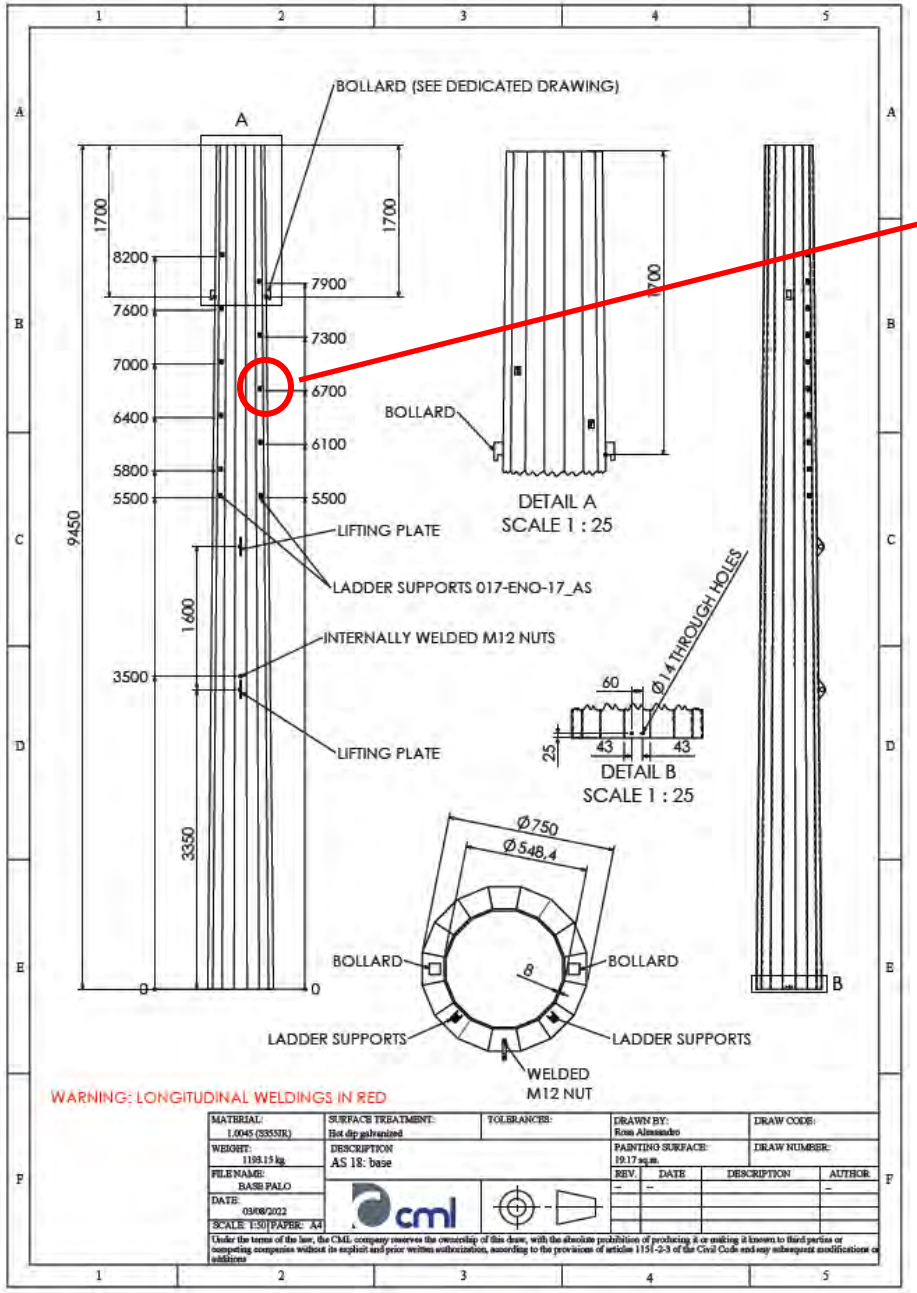
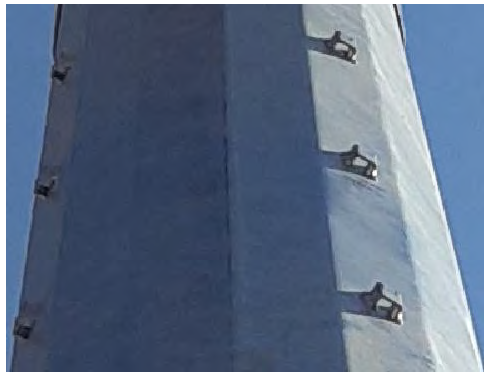
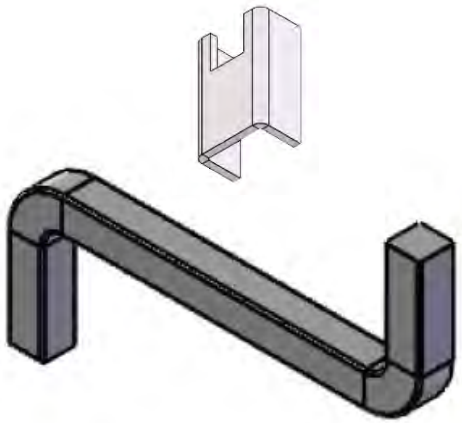




Sockets for Removeable steep ladder



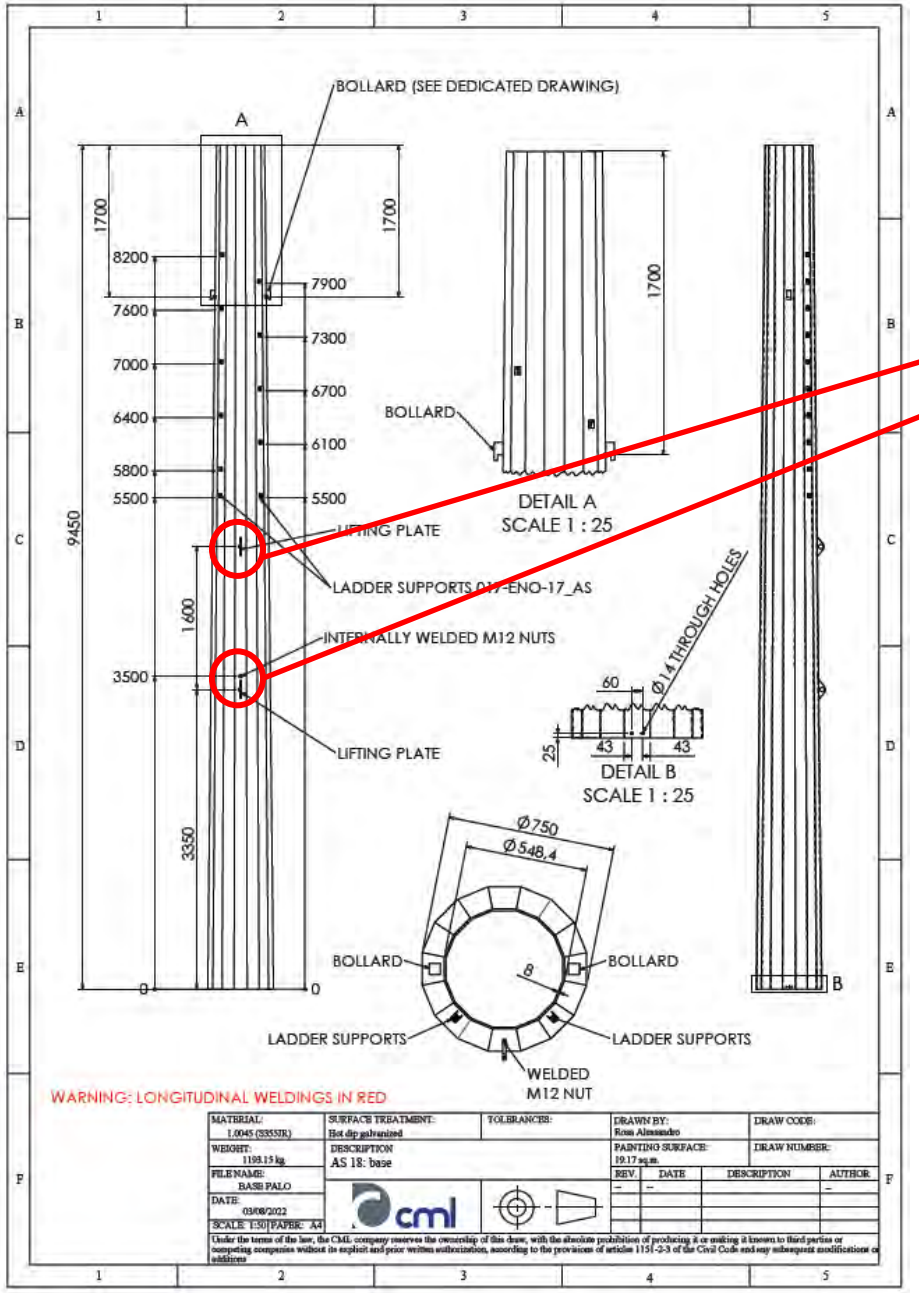
Additional topics on steel poles

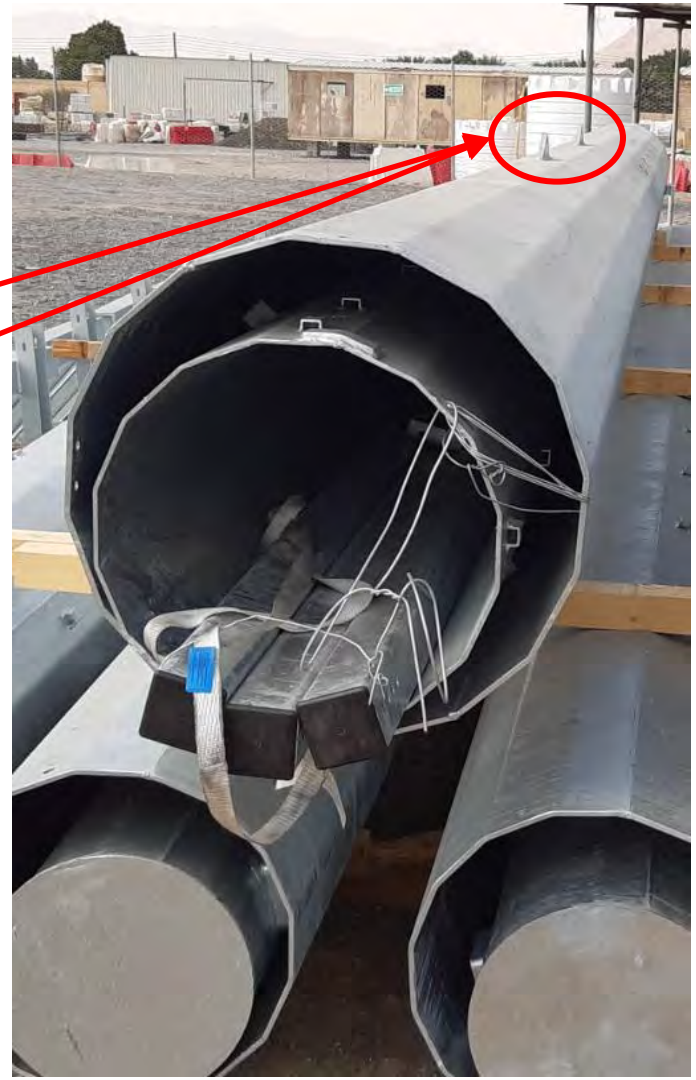
Very helpful during:

- ***Erection***
- ***Stringing***
- ***Maintenance***

cml MIDDLE EAST

Additional topics on steel poles





Lifting + pulley hook

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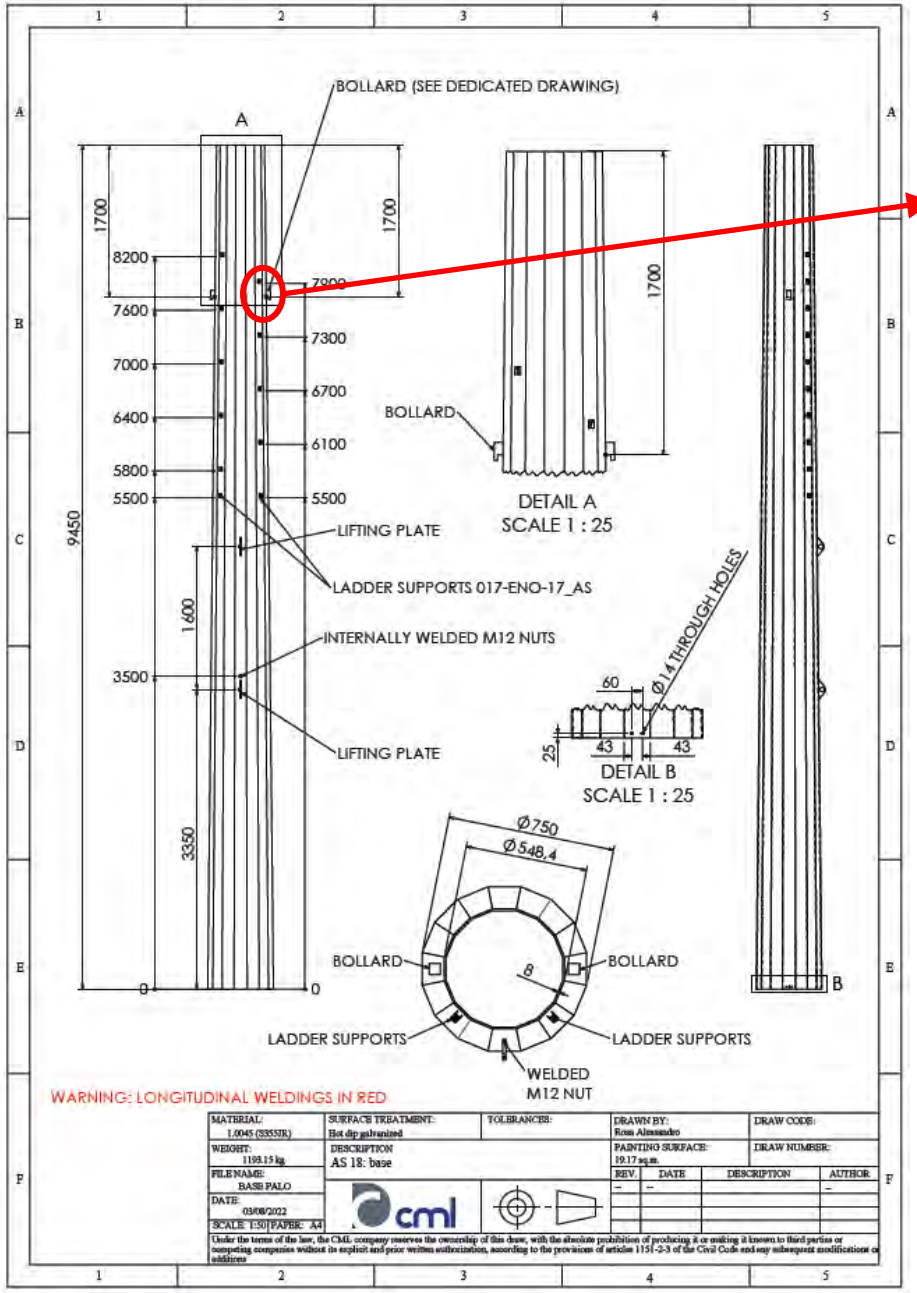
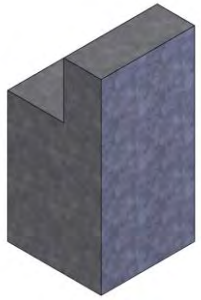


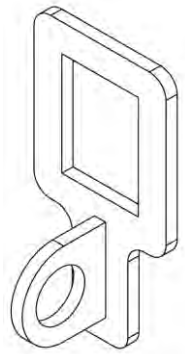
Additional topics on steel poles



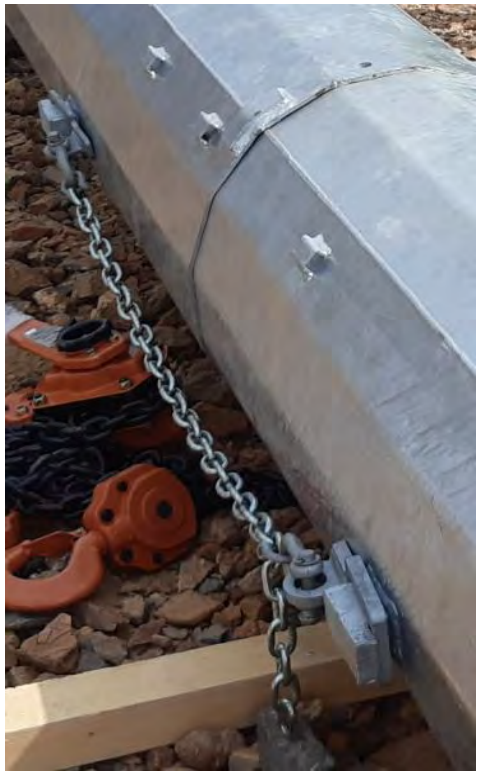
Bollard

Device used for:

- *slip on joint phase for assembly*
- *to install the removable double safety chain during erection*



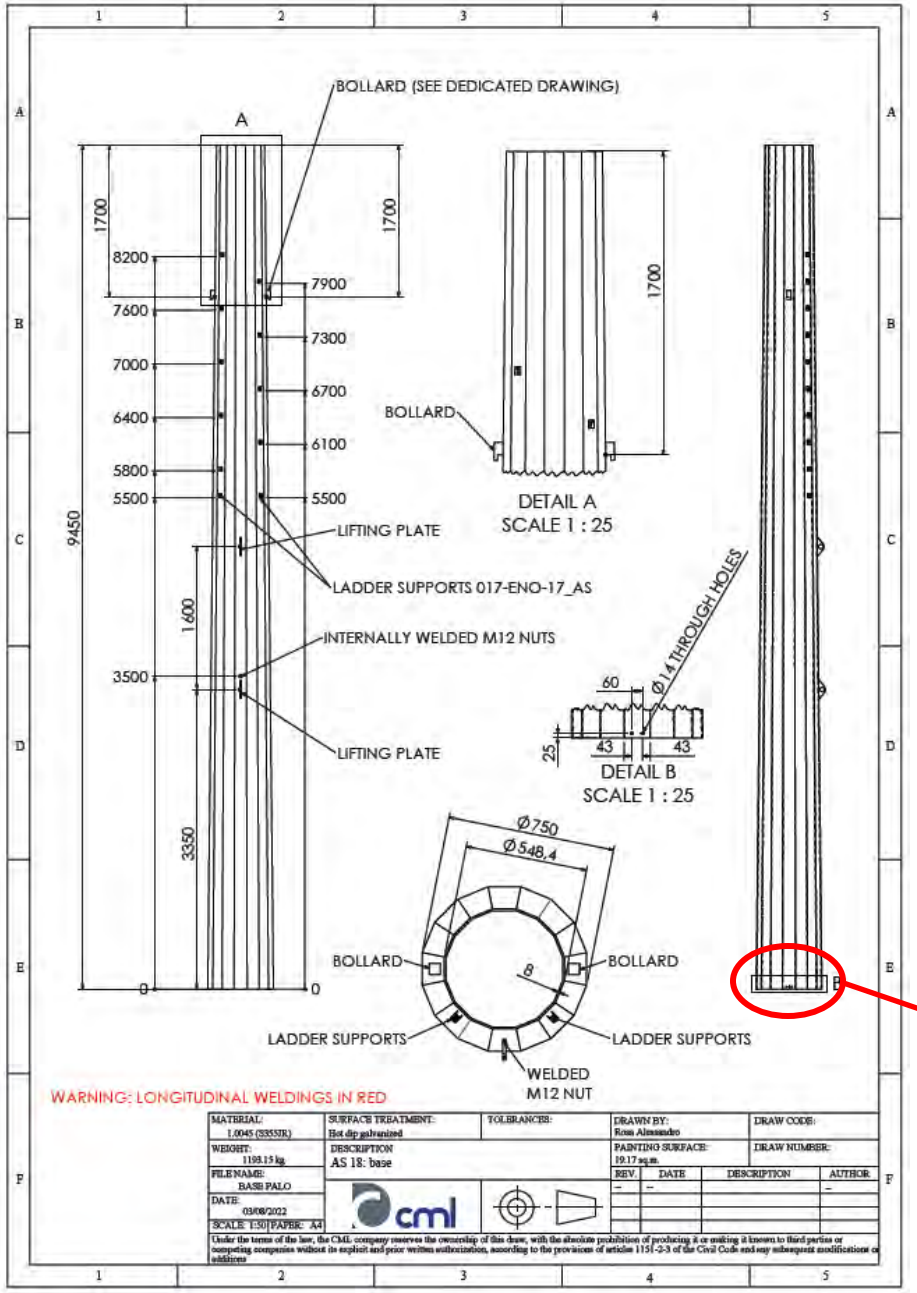
Safety block



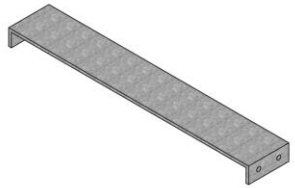
cml MIDDLE EAST

JABAL AKDHAR PROJECT

Additional topics on steel poles



Method for danger plate installation on steel poles



Anti-embedment plate

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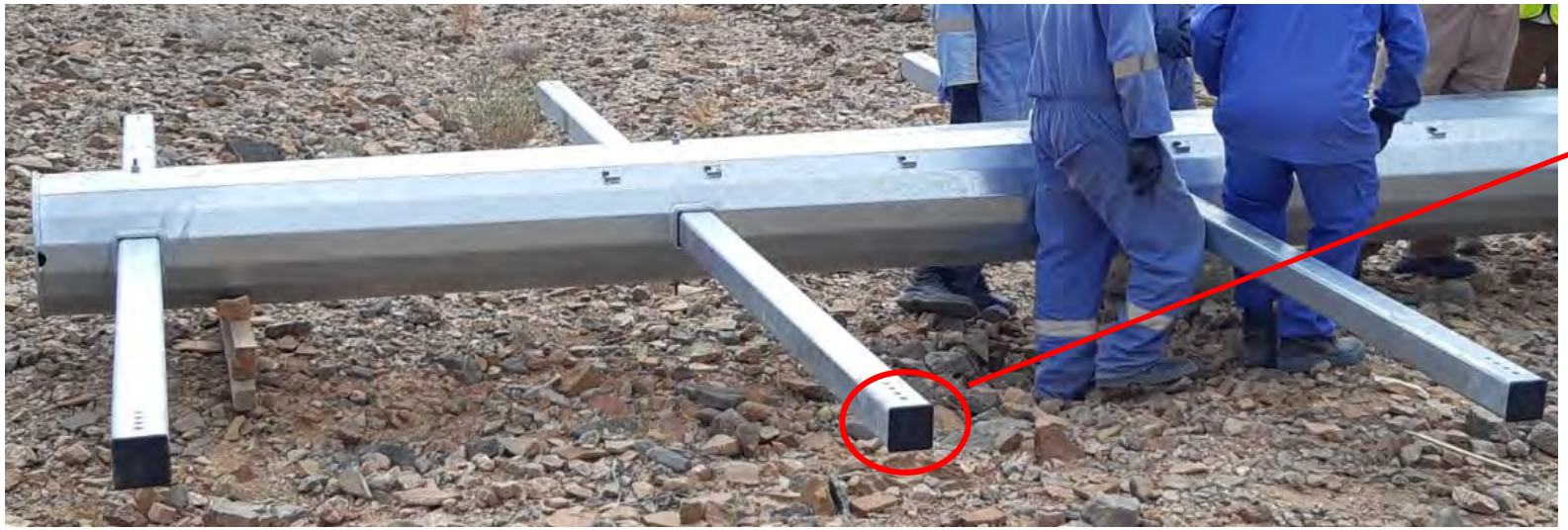
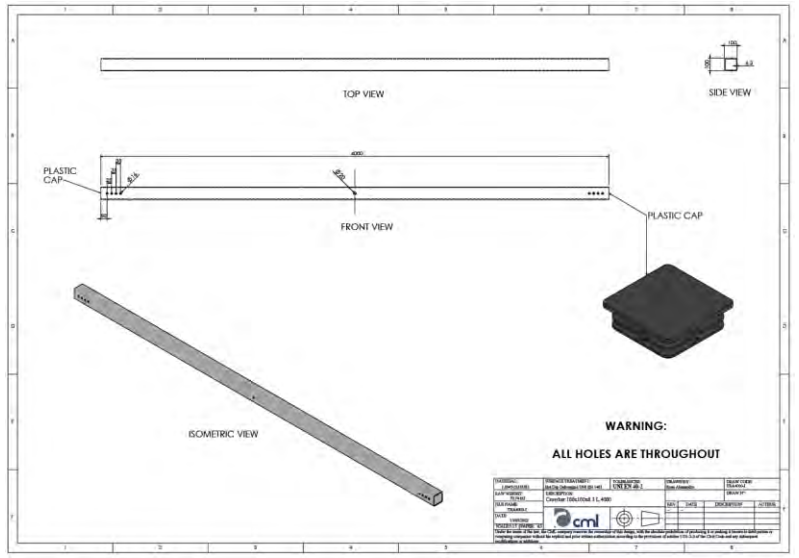
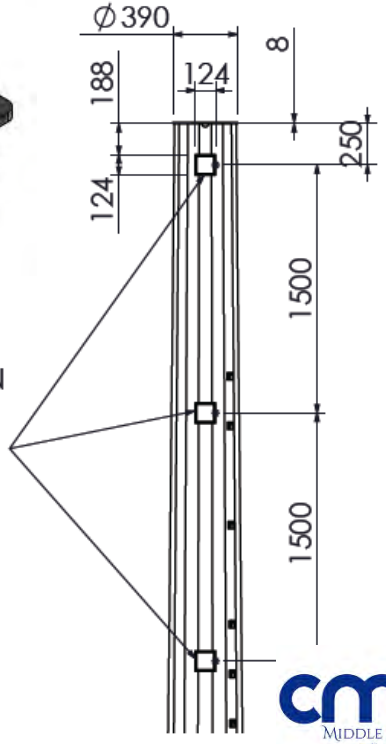
Additional topics on steel poles





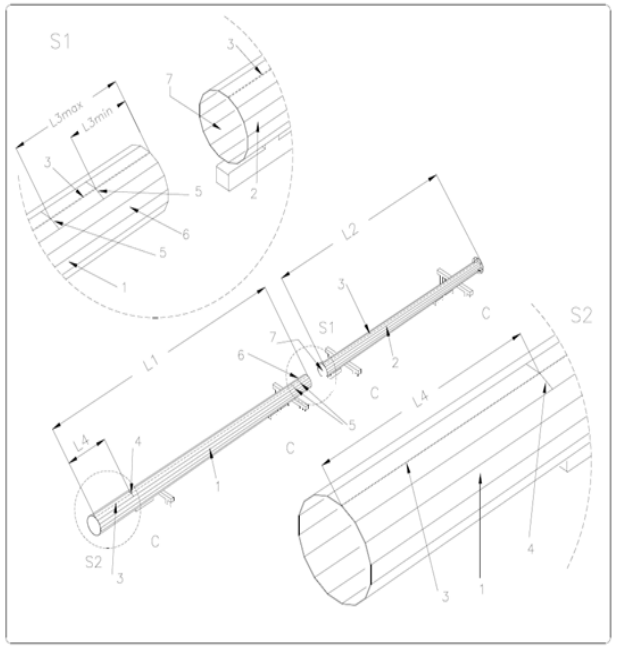
120x120x8 L.50
PROFILE
(SEE DETAILS ON
DEDICATED
DRAWING)

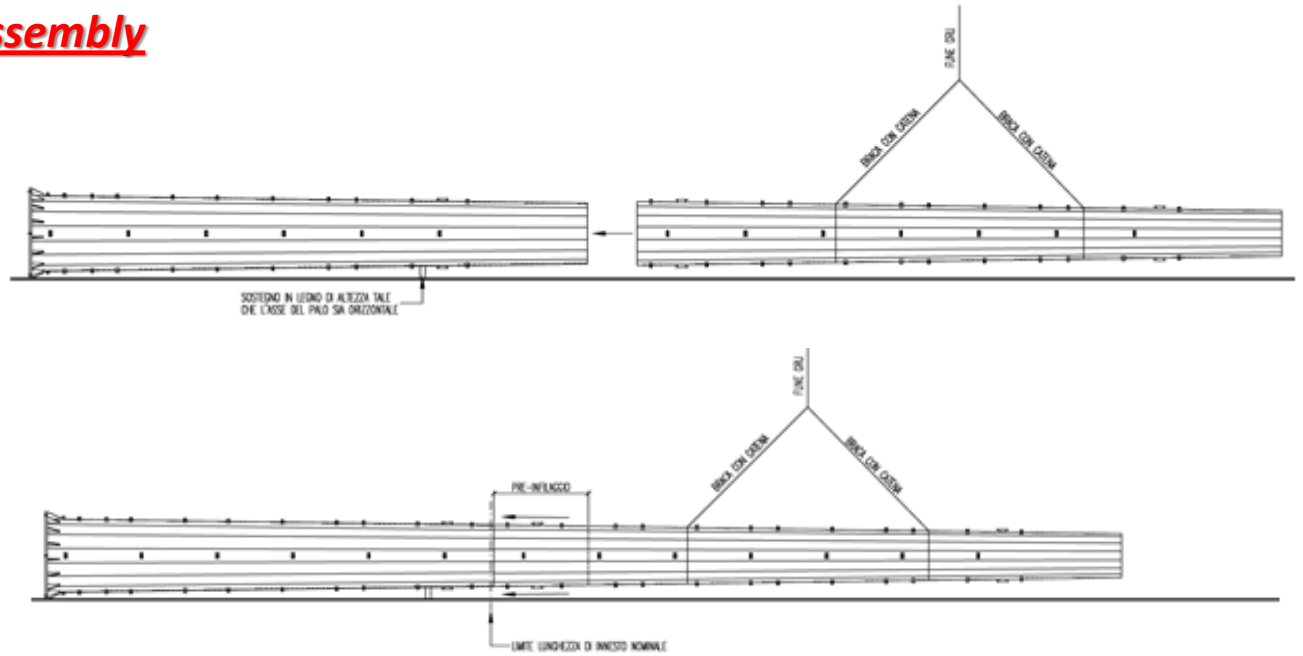


Easy installation for crossarms: *The crossarm is just insert inside reinforced openings on the pole and fixed with a simple M14x500mm treaded bar. Each crossarm is equipped with 2 PVC covers on the external side.*

JABAL AKDHAR PROJECT

Poles assembly





A detailed assembly procedure with related drawing and slip on joint forces and leght is provided for each pole model. The «slip on joint» is a technology of conical poles (with a poligonal or circula section) assembly.

A shaft is connected with the other by overlapping by the application of a force in order to guarantee the nominal lenght for the slip and absure the appropriate friction.

The connection will be stable and the gravity after installation will improve friction between the two sections.

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JABAL AKDHAR PROJECT

Poles assembly

SEMI-BOLLARD WELDED ON POLE TO PERFORM THE SLIP ON JOINT

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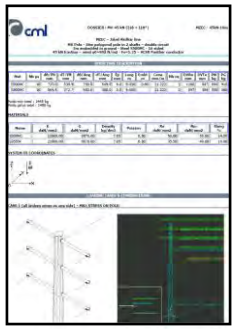
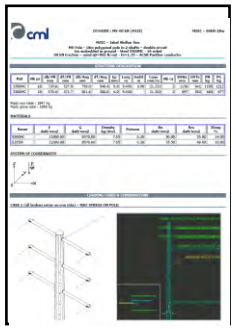
Poles assembly





IT CAN BE PERFORMED:

By heavy tirforts + chain

By hydraulic jacking system

AS18 poles:

Slip on Joint design (max force)			Slip on Joint design (lenght)		
N° sides of polygonal section:	16		N° sides of polygonal section:	16	
Taper:	0.02133		Coefficient η:	3.040	
Female shft tickness (S_f):	6	mm	Friction coefficient μ (galvanized steel):	0.3	
Steel quality female section (S...):	500	5000	Coefficient ξ* and safety coefficient K:	10.332	mm
Slip on joint lenght:	900	mm	FIF diameter of male shaft (Ds):	537.9	mm
Safety coefficient:	1.5		Tapero (c):	0.02133	
Admissible load (σ_{amm}):	3333	kgf/cm²	Key of femal shaft (ds):	527.5	mm
Slip on joint max force (F_i):	10188	kgf	Base material slip on joint lenghte (i_{min}):	704.3	mm
			2ª class weiled material slip on joint lenght (i_{min}):	830.7	mm

Slip on joint max force = 10188 kgf

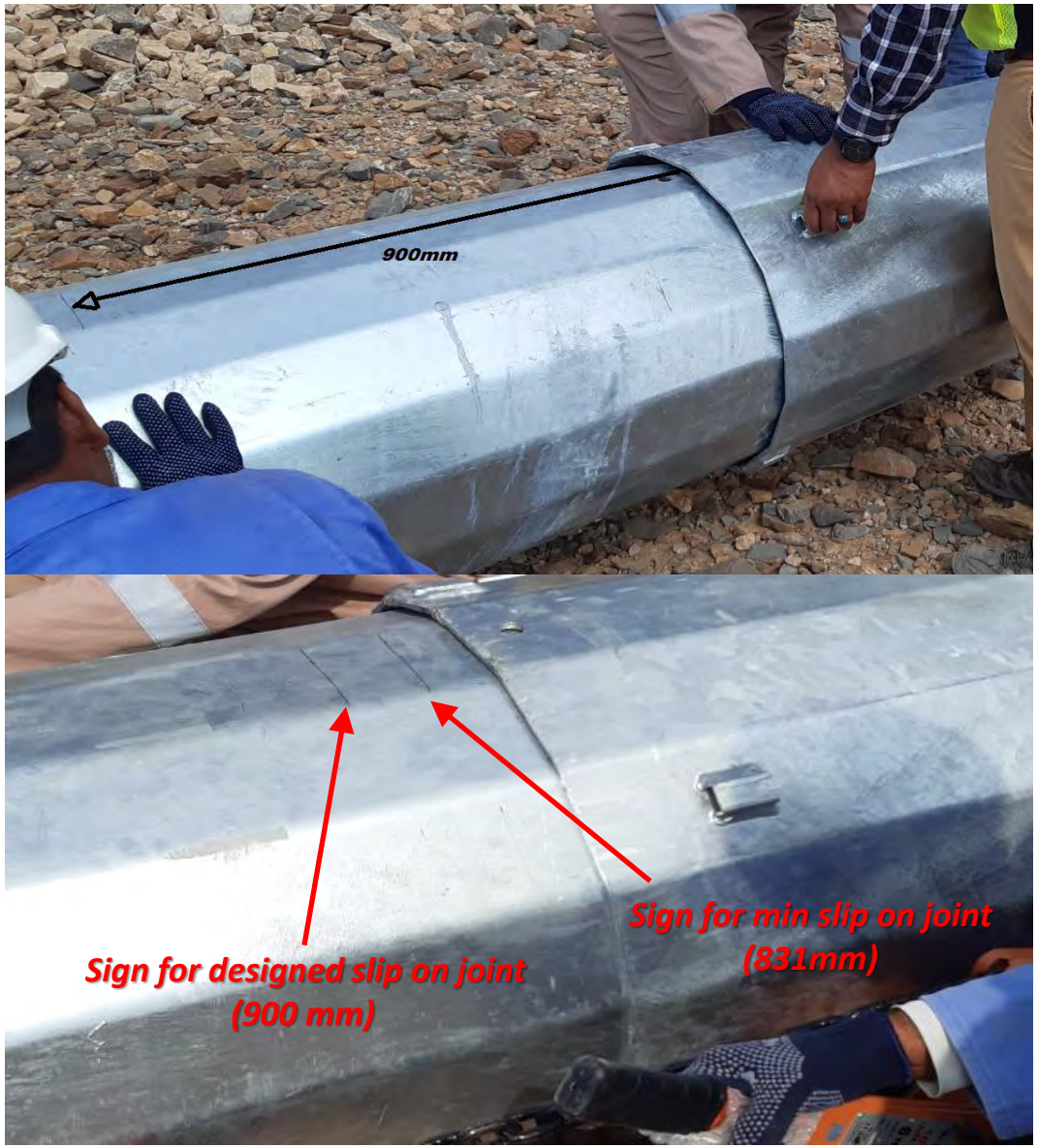
Minimum slip on joint = 831mm

I18 + I18s poles:

Slip on Joint design (max force)			Slip on Joint design (lenght)		
N° sides of polygonal section:	16		N° sides of polygonal section:	16	
Taper:	0.02123		Coefficient η:	3.040	
Female shft tickness (S_f):	5	mm	Friction coefficient μ (galvanized steel):	0.3	
Steel quality female section (S...):	500	5000	Coefficient ξ* and safety coefficient K:	10.332	mm
Slip on joint lenght:	900	mm	FIF diameter of male shaft (Ds):	538.9	mm
Safety coefficient:	1.5		Tapero (c):	0.02122	
Admissible load (σ_{amm}):	3333	kgf/cm²	Key of femal shaft (ds):	528.6	mm
Slip on joint max force (F_i):	8448	kgf	Base material slip on joint lenghte (i_{min}):	705.7	mm
			2ª class weiled material slip on joint lenght (i_{min}):	832.3	mm

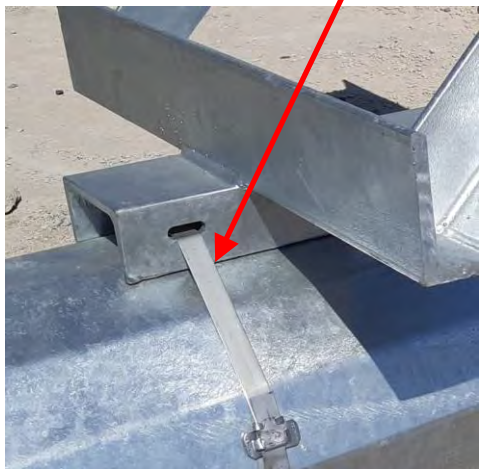
Slip on joint max force = 8448 kgf

Minimum slip on joint = 832mm

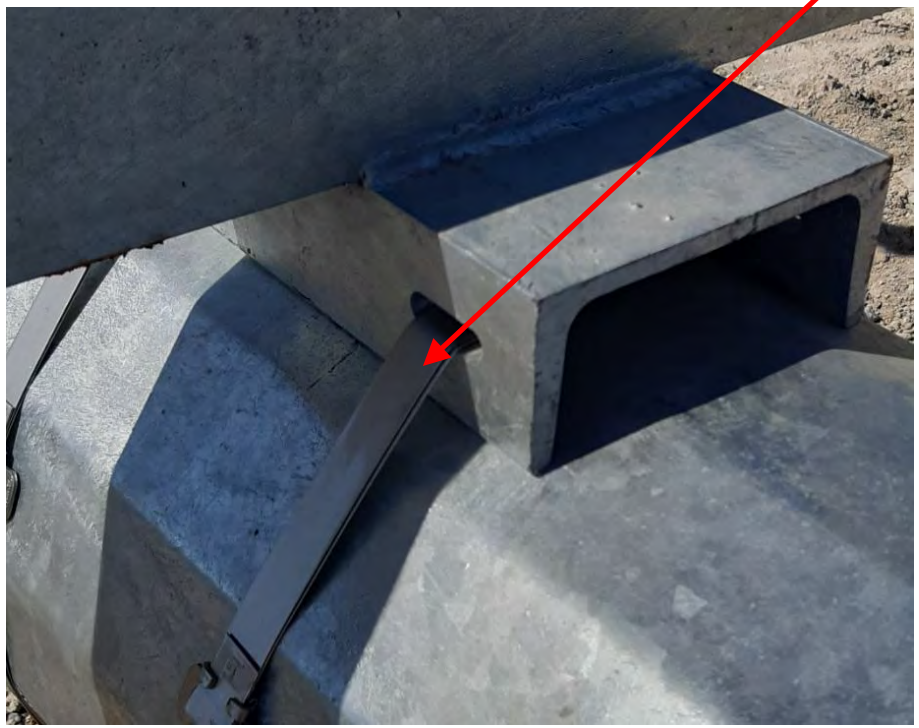


JABAL AKDHAR PROJECT

Supports assembly



Cable support (single band-it to be used)



Surge arrester (double band-it to be used)

Following detailed drawing for each support (cable, disconnector or surge arrester) it will be installed on related pole. The conncetion of all supports will be done by band-it in stinaless steel model 316-C406-VA 19x0,76mm will be used. The use of such type of connection will provide a high level of flexibility on positioning of the supports.

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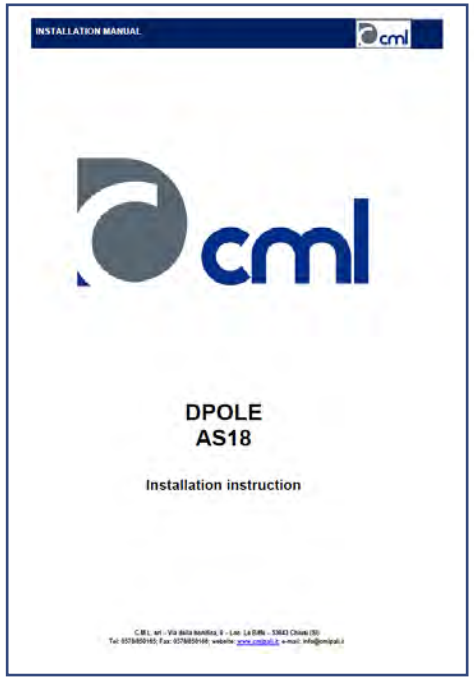
JABAL AKDHAR PROJECT

Pole installation



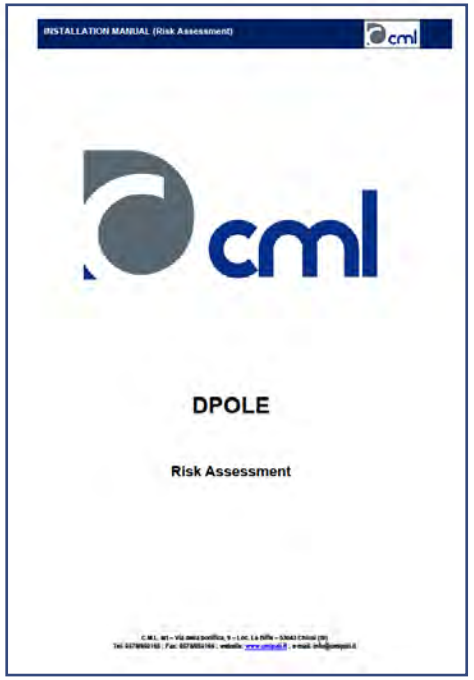


Figure legend:

Position	Description	Position	Description
(0.00)	Conventional indication of the ground level	A	Height of the earthing 300 mm
H	Total height of the hole* 3500 mm	C	Height heat-shrink sleeve 400 mm
B	Embedment heat-shrink sleeve 400 mm	D_b	Hole diameter for the placement of the shaft= 1040 mm

* the depth shall be checked before of pole installation and in any case approved by the project manager.

Figure: Reference quotes for the embedment

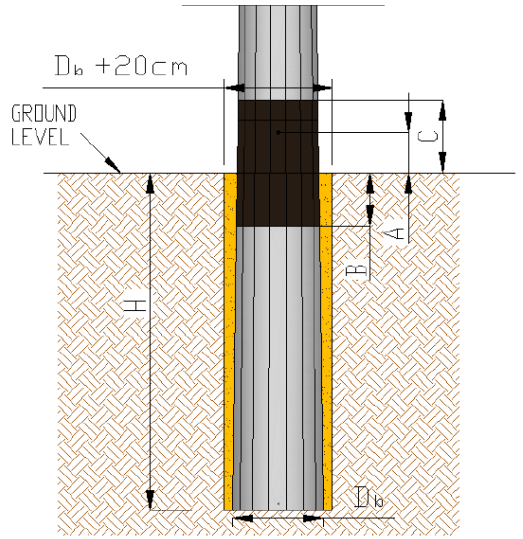
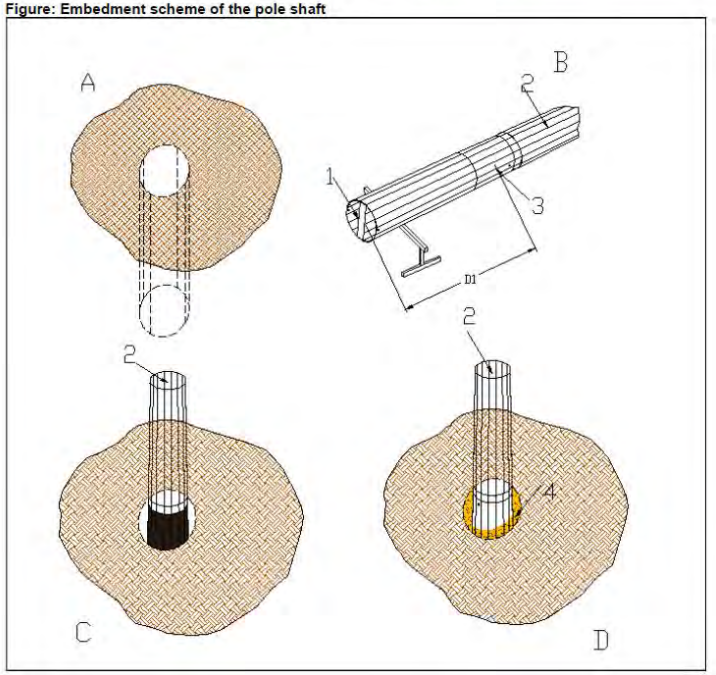


Figure legend:

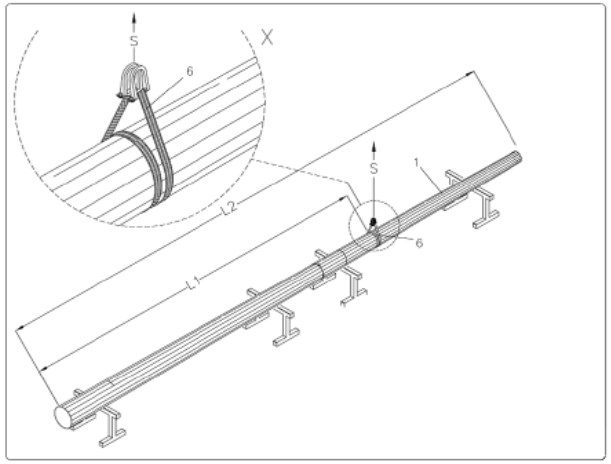
Position	Description	Position	Description
1	Anti - embedment plate	A	Foundation Hole
2	Base shaft of the pole	B	Ready shaft for the embedment
3	heat-shrink sleeve	C	Embedded and vertically placed shaft
4	sand with vibrating systems	D	Finishing with vibrated and compacted sand and Seal with a cement mortar collar

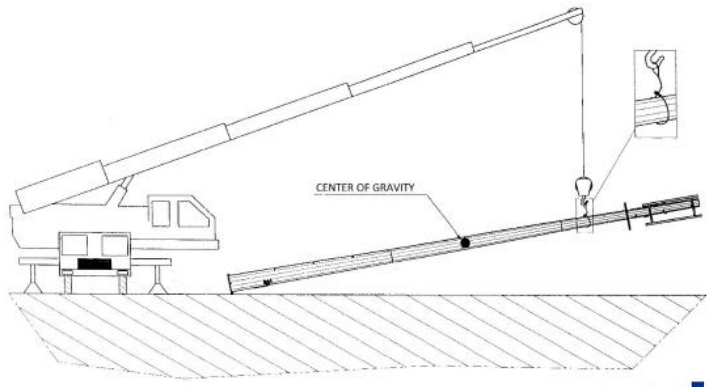
Figure: Embedment scheme of the pole shaft



A detailed installation procedure with related drawing and risk assestement manual is provided for each pole model.

Procedure for lifting, load, gravity centre, embedment lenght and back filling procedure is deeply explained in the manual. Embedment could be directly in ground or in concrete block (even solution with base plate and anchor cage are possibile)





cml MIDDLE EAST

JABAL AKDHAR PROJECT

Pole installation (drilling)

A common drilling rig has been used to perform the activity. The drilling depth depend from soil characteristics and is calculated for each model of poles.

In our case we have (for all poles) that:

- *base diameter = 750 mm*
- *Embedment lenght = 3 m*
- *Auger dimension = 1 m*

JABAL AKDHAR PROJECT

Steel vs Concrete comparison

Pole Type	Work Load (KN)	Length (m)	Ø Top (mm)	Ø Bottom (mm)	Weight (t)
IL-12	4.18	12	175	355	1.210
I-12	6	12	220	400	1.547
I-12+	7.3	12	220	400	1.625
I-13	6	13	220	415	1.757
I-14	6	14	220	445	1.96
I-15	6	15	220	445	2.172
I-16	6	16	220	460	2.396
I-17	6	17	220	475	2.631
A/S-12	15	12	340	520	2.315
A/S-14	15	14	340	550	2.848
A/S-16	15	16	370	610	3.881
A/S-18	15	18	370	640	4.577
A/S-18-18	18	18	370	640	4.865
A/S-18-22	22	18	415	685	5.93
A/S-20	15	20	370	670	5.657
A/S-20-18	18	20	370	670	6.134
A/S-21	15	21	370	685	6.074
A/S-22	15	22	370	700	6.506
A/S-24	15	24	370	730	7.23
T-12	30	12	460	640	3.462
T-13	30	13	460	655	3.831
T-14	30	14	460	670	4.213
T-16	30	16	460	700	5.316
T-18	40	18	516	840	7.750
G/P-18	10.5	18	310	580	3.960
DC-1610	10	16	250	490	2.900
DC-1618	18	16	370	610	4.100

Pic 1: **Overview of concrete poles type**

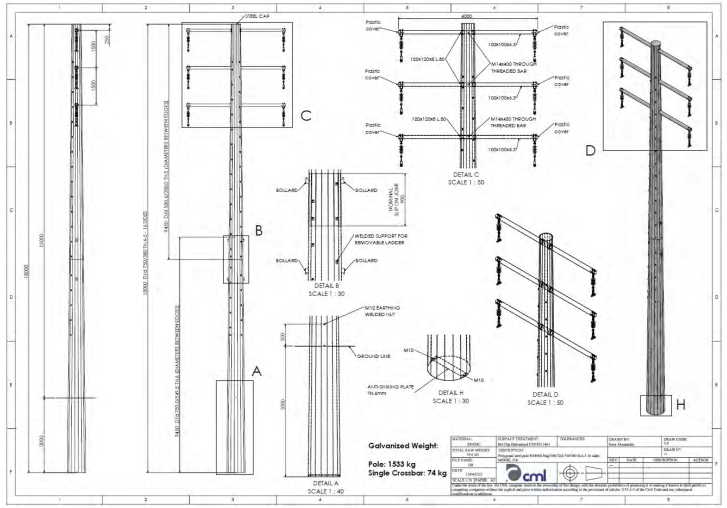
Making a comparison between steel and concrete poles (in the same comparable range):

- I18 comparable with n. 2 poles AS18-22 (globally we have 1,53 ton against 11,86 ton);

- AS18 comparable with n. 3 poles kind AS18-18 (globally we have 1,95 ton against 14,6 ton)

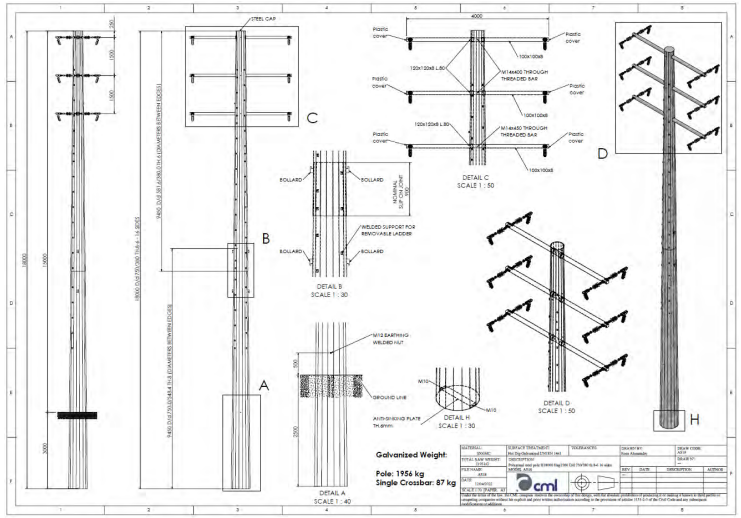
The concrete solution is 7,5 times more heavy

The number of poles needed is 683 against 262



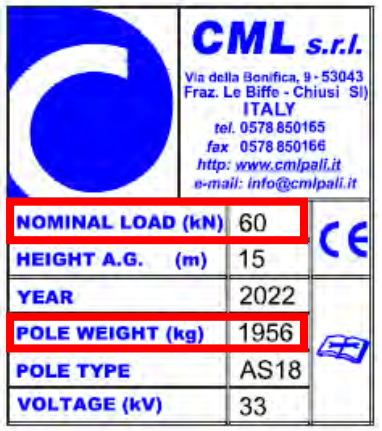
I18 steel pole

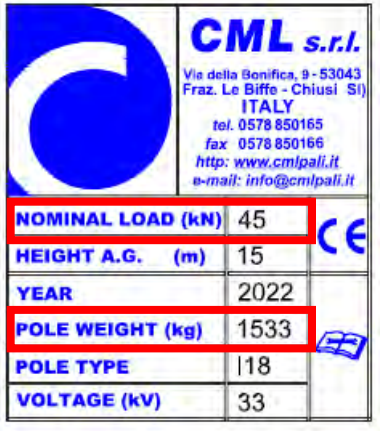
Working load=45kN - Weight=1,53 ton



AS18 steel pole

Working load=60kN - Weight=1,95 ton





Steel poles danger plates

cml MIDDLE EAST

JABAL AKDHAR PROJECT

Pole installation (erection)

1. Hole drilling

2. Hole checking

3. Slinging and erection

4. Pole lifting

5. Hole approach

PLEASE NOTE THE USE OF A LIGHT CRANE FOR ALL ERECTION OPERATIONS

JABAL AKDHAR PROJECT

Pole installation (erection)

6. Hole centering *7. Ground embedment* *8. Embedment checking* *9. Back filling* *10. Finishing*

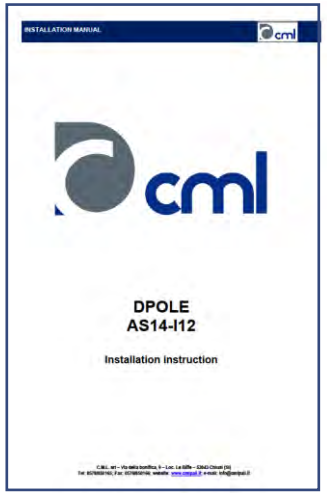
PLEASE NOTE THE USE OF A LIGHT CRANE FOR ALL ERECTION OPERATIONS

cml MIDDLE EAST

JABAL AKDHAR PROJECT

Pole installation (back filling)

Sand + water back filling
(for poles emebdded directly in ground)



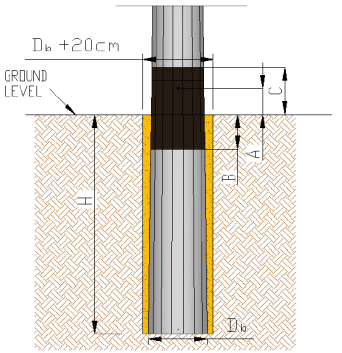
Back filling indications are reported in the installation procedure

Figure legend:

Position	Description	Position	Description
(0,00)	Conventional indication of the ground level	A	Height of the earthing 300 mm
H	Total height of the hole* 3500 mm	C	Height heat-shrink sleeve 400 mm
B	Embedment heat-shrink sleeve 400 mm	D_b	Hole diameter for the placement of the shaft= 1040 mm

* the depth shall be checked before of pole installation and in any case approved by the project manager.

Figure: Reference quotes for the embedment



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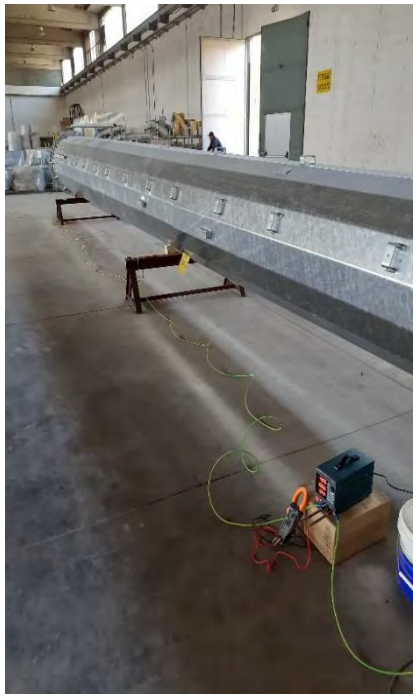
Hot Dip Galvanized poles are a good conductor?



	Test I	Test II	Test III	Test IV	Test V	Test VI	Test VII	Test VIII	Test IX
voltage (V)	12	12	12	24	24	24	4	4	4
Current intensity (A)	0,2	0,5	1	1	0,5	0,2	0,2	0,5	1
ΔV (mV)	11,5	29,1	58,4	58,5	29,2	11,6	11,7	29,2	58,3
Theoretical resistance (Ω)	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2
Resistence value found (Ω)	0,057	0,058	0,058	0,058	0,058	0,058	0,058	0,058	0,058

The test was carried connecting the two ends of the pole (preliminary jointed – slip on joint system) with copper cables of 6 sqmm, to the power supply; on the head, the cables were fixed to the equipotential bar, the other is connected to the gussets at the base of the tower where there is the predisposition for grounding. Same approach with the pole embedded.
Subsequently the electrical current clamp has been connected to the laboratory power supply in order to record the voltage difference (ΔV) between the two ends of the tower; on the save side, the resistance of cables and the resistance of the bolted joints has been neglected.
On the right you can read the data of the results obtained in the 9 tests carried out with voltage 4V 12V 24V and a current intensity of 0,2 A - 0,5 A - 1 A.

As shown in the table the resistance using the steel hot dip galvanized pole as a conductor for the earthing much less than to maximum resistance coming form specs (0,2 Ω). Is it also interesting to consider that the resistance of ground conductor used (6 sqmm) and the bolted connection (at the top and at the bottom side) is not considered and this is the greatest part of the 0,057 Ω measured ….. so the resistance of the pole is really minimal lower than the value (already low) measured.

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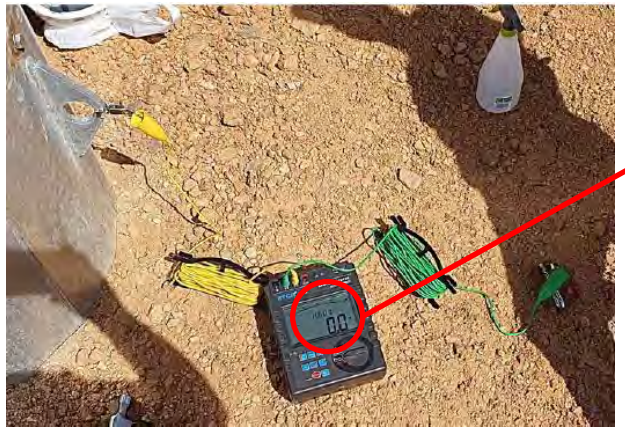
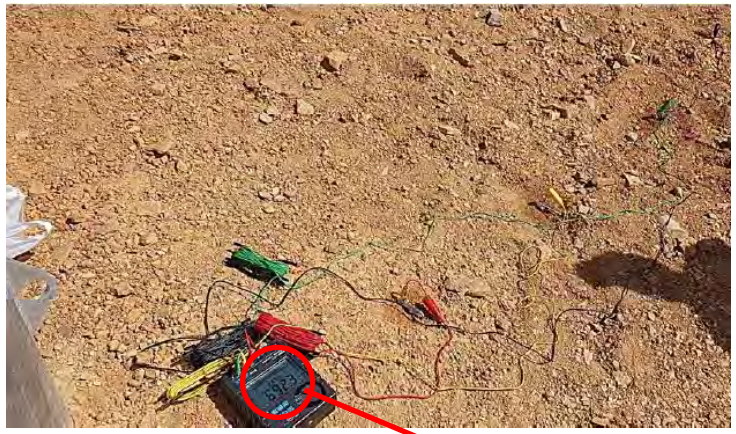
Embedded HDG steel poles are good for ground earthing?



2 wires earth voltage test:
0 Volt



4 wires soil resistivity test:
692 Ωm

2 wires resistance test:
9,54 Ω

The following results has been obtained:
Earth voltage → 0 Volt
Soil resistivity → 692 Ωm
Earth resistance → 9,54 Ω
As reported, the performance of a hot dip galvanized steel pole directly embedded in ground without and insulation (concrete or layers on poles) is more than what it is possible to obtain (and this is physically correct if we consider that a HDG steel surface is a perfect conductor and that there are 7 sqm of external contact surface (the I18 pole is embedded in ground for 3m and the base diameter is 750mm) respect the 0,2 sqm of standard copper bar used for local earthing (and this is just considering the external surface of the pole). The value of earth resistance are much lower than the 20 Ω internationally recognized as a reference for human body safety.

Following test is about the earth resistance/resistivity measurements for embedded hot dip galvanized steel poles; these results confirm the possibility to NOT provide earthing on the poles, ONLY in case of direct installation into the ground (DIRECT EMBEDMENT) and not on concrete foundation or insulated installation.
The test was carried out in accordance with the international specifications using a earth resistance/soil resistivity tester (2/3/4 wires precision tester) and in particular the following methodology has been applied:
for the earth voltage measurement → 2 wires testing methodology
for the soil resistivity measurement → 4 wires testing methodology (Wenner methodology)
for the earth resistance measurement → 2 wires testing methodology (Volt-Amperometric)
A hot dip galvanized pole (as per below pictures) has been used as a conductor for grounding.
Note that the pole is a multi-bended (16 sides) steel plate longitudinally welded and made in two section jointed using slip on joint (friction) technique.

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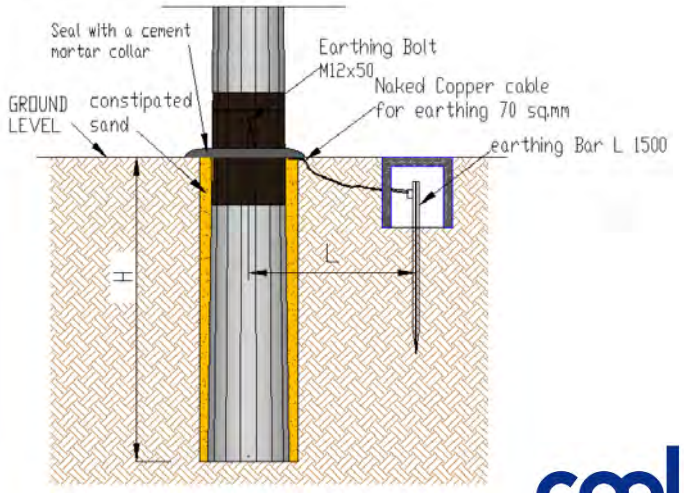
Additional local earthing is it possible?

All our steel poles are equipped with a welded nut for a local earthing as per below description. Local earthing is mandatory in case the pole is not directly embedded in ground (for example concrete embedment) and it is suggestd in any case every 2 km.

Earthing indications are reported in the installation procedure

Technical pole installation specifications:

Position	Description
H	Total height of the hole* 2550 mm
L	Distance of Earthing Bar 1500 mm



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Conductor stringing

Span between the 2 sites

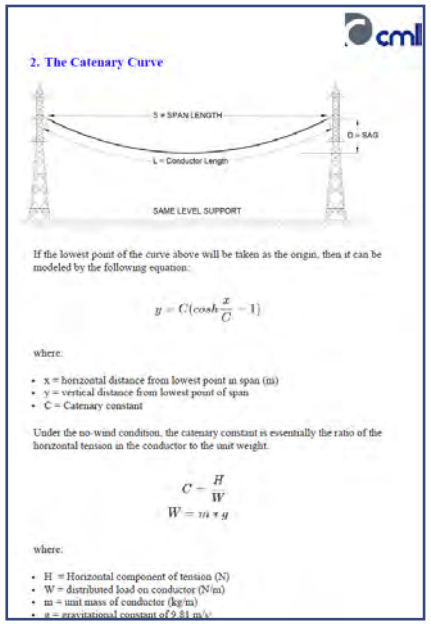
Start	End	Type St	Type End	Quota Palo	Quota Palo E	Distance	Max Loa	Max Sag	Preload	Final Load	Final Sag	Clearance	Note	OK Tir	OK Sag
1	2	I18S	I18S	585.7	585.7		7500			0.000	0.000	0.000		OK	OK
2	3	I18S	AS18	585.7	587.4	20.711	10000	3.7488	500.00	1,167.105	1.062	9.686		OK	OK
3	4	AS18	AS18	587.4	606	112.271	10000	10.0017	1,600.00	3,733.758	9.821	7.180		OK	OK
4		AS18	AS18	606	601	76.717	10000	2.3448	1,200.00	5,000.000	2.263	7.000		OK	OK
5	6	AS18	AS18	601	571.5	109.021	10000	11.5471	1,300.00	3,037.010	11.434	7.113		OK	OK
6	7	AS18	AS18	571.5	572.5	99.622	10000	12.0929	1,100.00	2,570.804	11.306	7.787		OK	OK
7	8	AS18	I18	572.5	574.5	94.53	10000	3.4875	3,300.00	7,497.150	3.439	7.048		OK	OK
8	9	I18	AS18	574.5	577	95.846	10000	9.9844	1,200.00	2,803.322	9.562	7.423		OK	OK
9	10	AS18	I18	577	616	83.254	10000	6.0931	1,500.00	3,495.988	5.747	7.346		OK	OK
10	11	I18	I18	616	619.5	23.97	7500	5.2769	500.00	1,167.781	1.424	10.853		OK	OK
11	12	I18	I18	619.5	590	103.09	7500	5.9966	2,300.00	5,333.602	5.763	7.234		OK	OK
12	13	I18	I18	590	578	77	7500	5.1597	1,500.00	3,493.761	4.914	7.245		OK	OK
13	14	I18	I18	578	564	100.445	7500	8.7997	1,500.00	3,500.137	8.370	7.421		OK	OK

Site IDs

Poles type

PRELOAD to be applied during stringing

CLEARANCE as per calculation



C.M.L. SAG & TENSION CALCULATOR

Release 2.0.1

POLES CALCULATION SETTINGS		
CONDUCTOR TYPE:	Panther	
INITIAL TEMPERATURE:	30	°C
FINAL TEMPERATURE:	30	°C
WIND PRESSURE:	992	N/m^2
ICE THICKNESS:	0	m
ICE DENSITY:	915	kg/m^3

CUSTOM CONDUCTOR SETTINGS:		
ULTIMATE STRENGHT:	6000	kg
WEIGHT PER METER:	1.2	kg/m
CROSS SECTIONAL AREA:	0.0004	m^2
CONDUCTOR DIAMETER:	0.025	m
ELASTICITY MODULUS:	7900000000	N/m^2
LINEAR EXPANSION PER °C:	0.0000192	

POLES TO BE CALCULATED

FROM ROW: 3

TO ROW: 4

REFERENCES

CALCULATE

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FOR STRINGING:

All information will be provided and on site preload needs to be checked and the final clearance verified

CML software for Sag & Tension

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Dinamometer for preload checking

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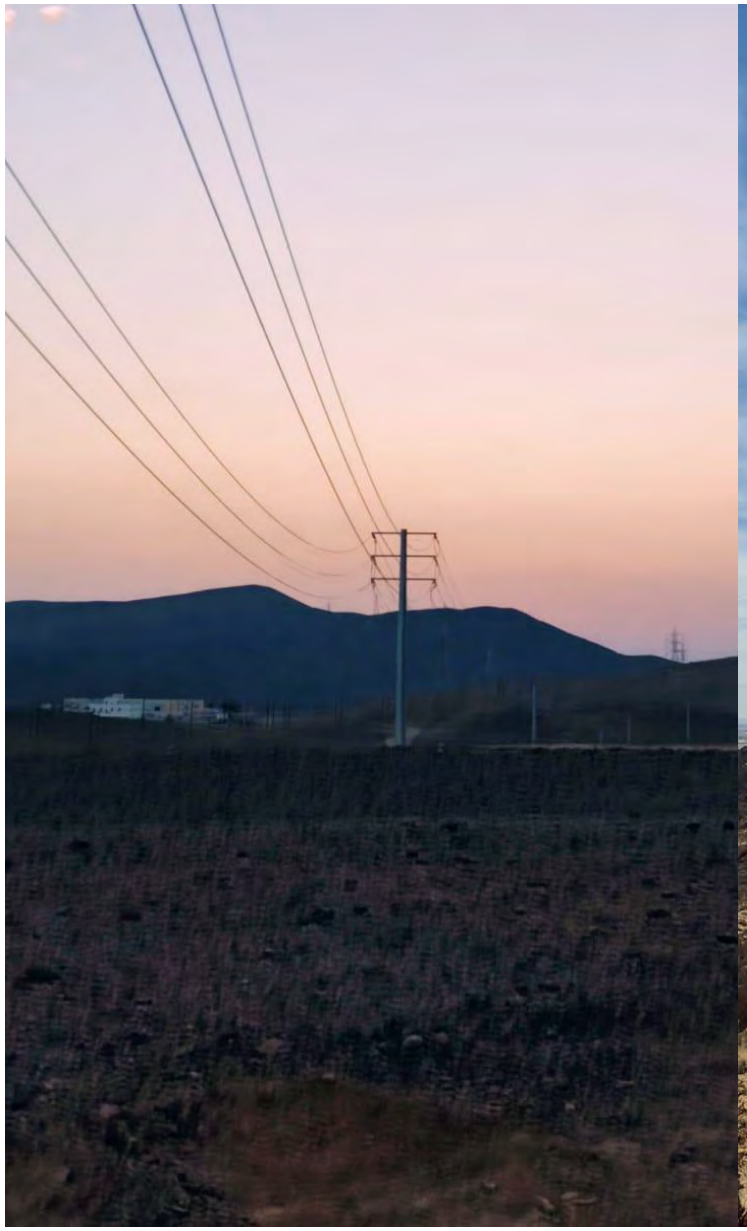

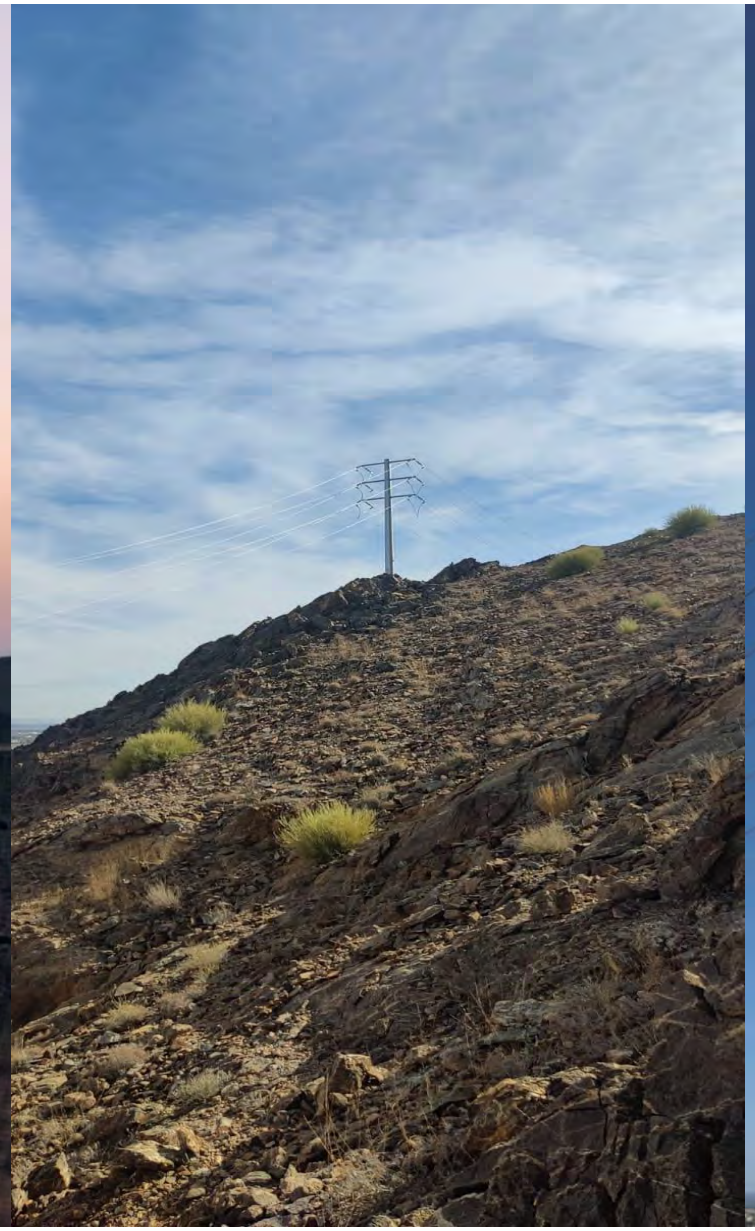

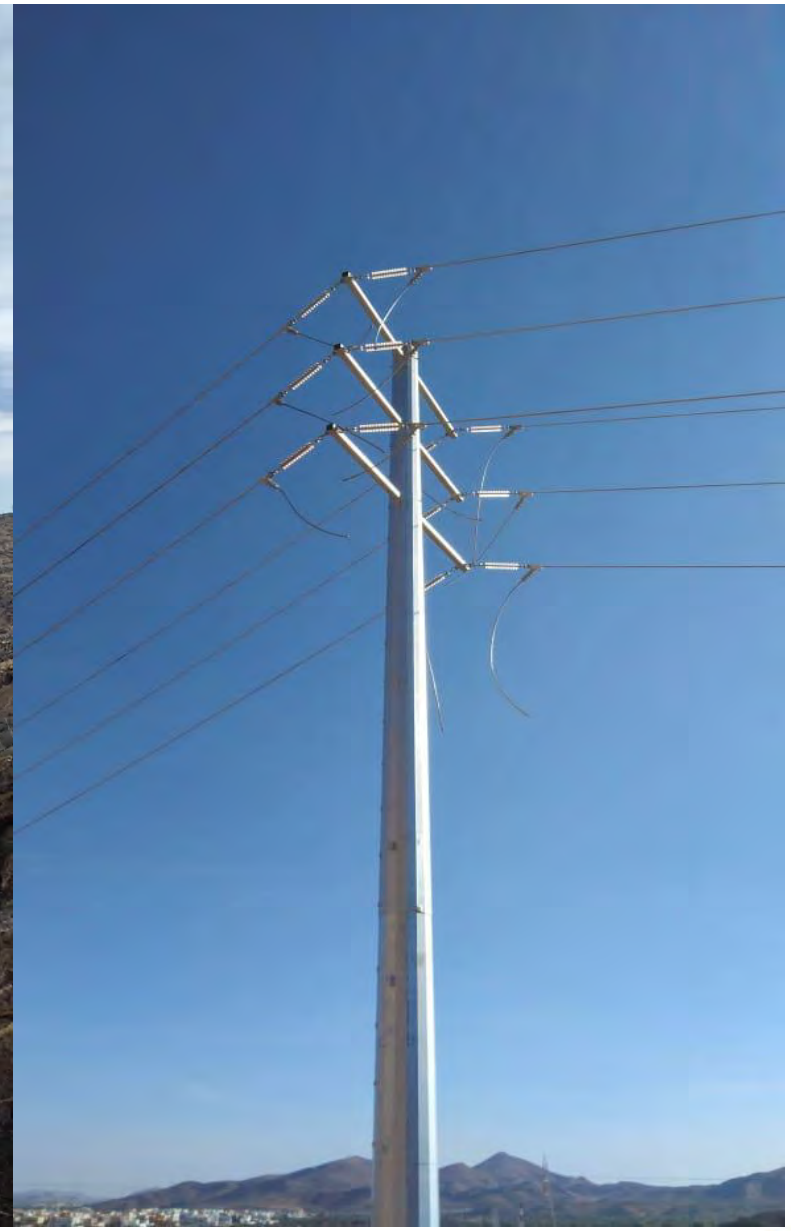

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