KINGDOM OF CAMBODIA

Nation, Religion, King

ELECTRICITE DU CAMBODGE

TECHNICAL POLICY

EDC-TP-008

Concrete Poles and Guys (stay) Installation

May 2023

ELECTRICITE DU CAMBODGE

Version	Date	Technical Specification Name	Authorized by : (name and signature)
1.0	May, 2023	Concrete Pole and Guys (stay) Installation	
			AUN HEMRITH

Version	Drafted/reviewed by	Verified by	Approved by	Date
Draft1	AD			Dec 2021
Final 1	AD/EDC			Oct 2022
Final 2	AD/EDC			Feb 2023

Content

[Blank]

Concrete Poles and Guys Installation

1 General Provisions

1.1 Scope of application

The concretes pole and guys installation for LV and MV overhead Distribution construction works is subjected to this policy that remind the requirements of EDC technical design standard.

This document gives the main rules to be mandatorily respected as well as recommendations for easy installation.

It gives also recommendation for steel tower installation (case of very long span as example).

The prescriptions in this technical policy amend and invalid similar pages of EDC TECHNICAL DESIGN STANDARD

1.2 Safety and accident prevention

All work shall be undertaken with close attention to high standards of safety to works, the public, and to the Employer's and other owner's plant equipment.

1.2.1 Safety and risk of third party accidents

EDC or the Contractor shall manage on its own cost and responsibility all the necessary measures to avoid traffic or third parties accident.

Indeed, a significant part of the work is to be performed in villages or near roads. This work may lead to risks of third parties accident. Also, the phasing of implementation and the method of work will be absolutely established right from the start of work in consultation with the Employer, the authorities managing the public space and the roads and representatives of neighbourhoods so that all precautions are taken (public information, signage, barriers, lighting, temporary detour traffic, if necessary, etc...) to reduce traffic disturbances and accidents of the population.

1.2.2 Safety of Employees

All of the EDC or contractor's personnel shall be effectively trained and competent in safe working practices that must be adhered to at all times. All personnel shall be issued with and use at all time's relevant personal and work gang related safety equipment that shall be maintained in good order and condition by the Contractor.

EDC and the contractor shall mandatorily provide all personal protective equipment (helmet, gloves, safety shoes, safety belts or harnesses, specific protections, etc. ...) to its field staff, but also to temporary staff that it may need to be employed.

Similarly, as responsible for the security of its staff, the Employer will provide all the collective protection equipment such as absence of voltage indicators, earthing and short circuit, warning danger banners, etc.

It will also ensure that individual and collective protective equipment is utilized and checked periodically.

2 Pole Foundations

2.1 General Information

The foundations consist require the making of concrete blocks of various shapes as rectangular or cylindrical.

These foundations are executed, taking into account the nature of the soil, at the location mentioned on the line profile and according to the drawings given to the EDC or contractor team.

EDC or Contractor shall take all necessary measures to ensure that each pole location and type as well as pole orientation are those defined on the plans and drawings: **The right pole length and effort shall be at the right location.**

Foundations include excavations, eventual woodwork and water pumping, if necessary, adjustment of the metal supports (if any), concreting of foundations, execution of earthing, if applicable and restoration of the land cleaning and removing excess soil, stones, etc…

2.2 Preliminary Measures

Where the proposed work may pose risks to Pipes, cables and other underground or above ground installations, the contractor is required to take preliminary steps to ensure the safeguard in accordance with the regulations in force.

In particular, the EDC or the Contractor must address in writing a declaration of "intent to start work" to the concerned Services or Organizations at least ten days before the starting of works in order to inform them of the execution of such work and in order to obtain from them all useful information (by sending maps, presence of an on-site service representative at the time of the works, etc.) on their works and on the technical requirements to be respected during the work.

This will be the case for electric cables, including public lighting, telephone lines, gas or oil pipelines, water pipes, etc.

As regards to the crossing of structures such as railways, waterways, ... EDC or the contractor also informs the interested services sufficiently in advance in order to allow them delegate a representative on the site if they deem it useful. The same applies to work carried out close to the railways when the supports to be implanted engage the gauge.

As far as crossings of motorways are concerned, the work shall be carried out in accordance with the agreement between road official organisations and the contractor or EDC.

2.3 Execution of Excavations

EDC team or the Contractor shall be solely responsible for the proper execution of foundations. He shall make foundations with dimensions at least equal to those indicated hereinafter in the documents.

If EDC team or the contractor encounters difficulties in the execution of these excavations and the nature or consistency of which does not permit the adoption of foundations under consideration, it shall notify EDC management staff and agrees with him all the provisions that may be necessary.

EDC team or the contractor then remitted to EDC the drawings and calculations justifying the new foundations for approval before proceeding with the work. The EDC management staff agreement does not release the contractor from its responsibility for the soundness of foundations.

ELECTRICITE DU CAMBODGE

The excavations whose edges risk to run off are wooded. The woodworking is, as much as possible removed when the placing of the concrete.

The construction team makes arrangements to leave the shortest possible time the excavations open. It shall take all appropriate measures to avoid accidents resulting from open excavations left unattended and especially at night.

2.4 Pole location

The pole location is selected as follows. Here, not only the following instructions but also the prevention of the complementary construction should be considered.

2.4.1 Recommended pole location

- In case of road; if the road has a sidewalk, the pole location should be at the edge of the sidewalk opposite the vehicle way. If the road has no sidewalk, the pole location should be at the edge of centre of the road with the following distances:

The distance between the axle of the road and the poles will be as follow:

Road type	Distance
1-digit National Road	28 m
2-digit National Road	23 m
Other Roads	13 m

In case of impossibility (river, etc..) or special case, the Employer shall be informed and a special agreement for shorter distances shall be asked to the Ministry of Public Work and Transport for avoiding line displacement latter.

However, in any case the road administrator validates the above-mentioned distances and indicates the installing place.

- The pole shall be located not to disturb the existing buried objects such as gas line, water and sewage line, communication line.
- If the pole is located in angle point, curved point, branched point, anchored point, and if the guy is needed, the pole location should be considered in order to let guy installed easily.
- Instead of guyed pole, double twin pole can be installed instead of guyed pole. In this case, two poles will be placed next to each other and secured at the base by the foundation and at the top by bolts. As example double pole of 6kN withstand 12 kN.

2.4.2 Not recommended location

Following place should be avoided for the pole location.

- At a location where the pole disturbs traffic such as the entrance of building structure, in front of the garage, the entrance of alley, etc.
- At a location where the pole will be damaged by the car traffic.
- At the place where the pole will be obstacle for the visibility of the road traffic signs.
- In the slope which is extremely steep
- The customer's compound or the place that is difficult to enter the compound for maintenance.

- At a location where is water spring and where the ground is soft soil.
- Crumbly ground such as the groundwater path in the mountainous area.

2.4.3 Law

If the related law indicates about the location of the pole, the installing pole location complies with the law such as road law, river low.

2.5 Maximum number of spans for one installation section

The number of spans between two conductors anchorage is called installation section.

For MV and LV ABC overhead lines, this installation section shall not exceed 10 spans. That is to say that between two anchorage poles the number of poles fitted with suspension or pin or line post insulators shall not exceed 9 poles. (Refer to EDC-TP-003 and EDC-TP-005).

2.6 Dimension of excavations and foundations

2.6.1 Pole embedment (depth of excavation)

As per the General Requirements of Electric Power Technical Standard of the Kingdom of Cambodia the depth of pole embedment is equal to H/6 with H= pole length so:

Pole length	Pole embedment depth
9 m	1.50 m
12 m	2.00 m
14 m	2.35 m

2.6.2 Classification of soil

According table ES40H (article 39) of the General Requirements of Electric Power Technical Standard of the Kingdom of Cambodia, the classification of soil is shown in following table:

Classification of soil (SREPTS Article 40 Table ES40H)			
Classification of soil		**Class**	**Soil Coefficient (N/m^4)**
Normal soil	Aggregated soil or sand, and soil with plenty of gravel or stone belonging under hard soil	[A]	3.9×10^7
	Aggregated soil or sand, and soil with plenty of gravel or stone belonging under soft soil	[B]	2.9×10^7
Soft soil	Quicksand (with no soil mixed)	[C]	2.0×10^7
	Moist clay, humus, fill and other soft soils (excluding deep rice fields)	[D]	0.8×107

2.7 Reinforcement by foundation concrete block

The foundation concrete block shall be installed **in any case** but verified by calculations as requested by Article 39 of the General Requirements of Electric Power Technical Standard of the Kingdom of Cambodia.

The material of foundation block shall be concrete as defined herein after.

If the soil is extremely soft, concrete piles shall be installed under the concrete base at the bottom of the pole.

It is recalled that foundation concrete blocks must be calculated/verified according article 40 of the Electric Power Technical Standard of the Kingdom of Cambodia given in annex. Indications given here in after are indicative only and foundation dimensions are minimum only.

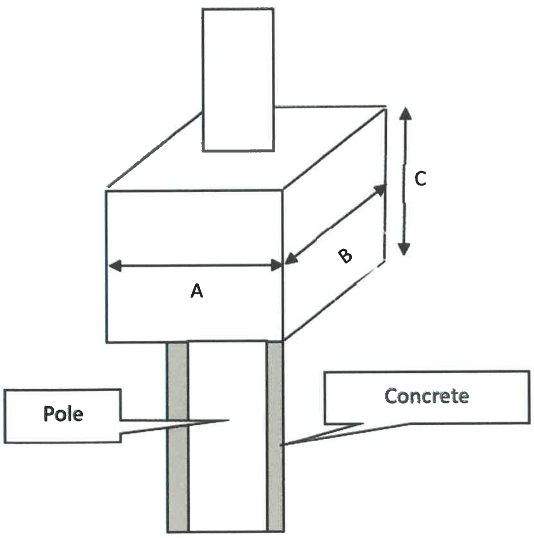
According soil class and poles class that are:

Pole class	Pole application
S	Pole installed for straight line
A	Pole installed for angle
T	End pole

the concrete foundations will be as follow:

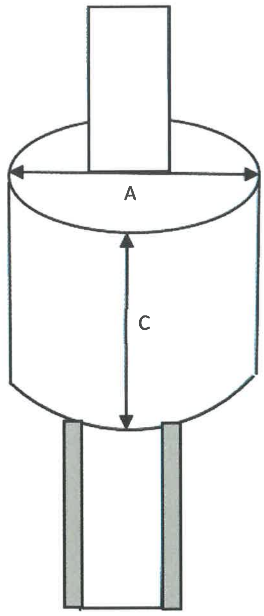
2.7.1 Single pole in soil class [A], [B] and [C]

*2.7.1.1 **Class S** pole with cubic concrete foundation*



	9 m pole	12 m pole	14 m pole
A	0.5 m	0.5 m	0.6 m
B	0.5 m	0.5 m	0.6 m
C	0.5 m	0.5 m	0.8 m
In all case, the minimum distance between the pole and the edge of foundation shall be more than 12 cm so foundations must be enlarged if necessary.			

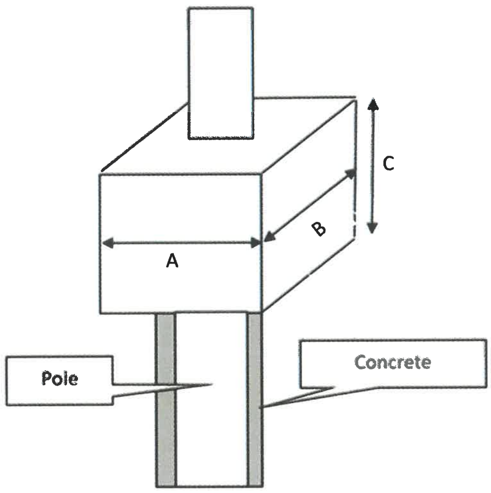
2.7.1.2 *Class S, poles with cylindrical concrete foundation*



	9 m pole	12 m pole	14 m pole
A	0.6 m	0.6 m	0.8 m
C	0.5 m	0.6 m	0.8 m

In all case, the minimum distance between the pole and the edge of foundation shall be more than 12 cm so foundations must be enlarged if necessary.

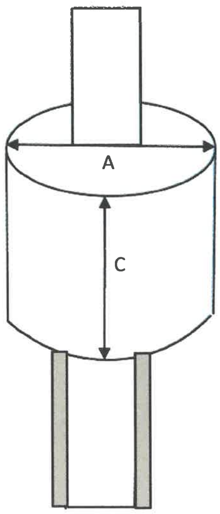
2.7.1.3 ***Class A*** *pole with cubic concrete foundation*



	9 m pole	12 m pole	14 m pole
A	0.7 m	0.9 m	0.9 m
B	0.7 m	0.9 m	0.9 m
C	0.9 m	0.9 m	1.2 m

In all case, the minimum distance between the pole and the edge of foundation shall be more than 12 cm so foundations must be enlarged if necessary.

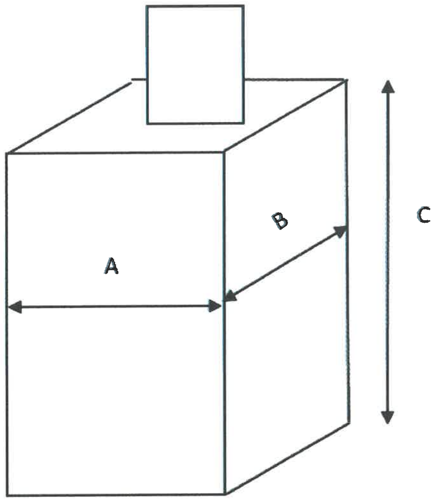
2.7.1.4 ***Cass A*** *pole with cylindrical concrete foundation*



	9 m pole	12 m pole	14 m pole
A	0.9 m	0.1 m	0.1 m
C	0.9 m	0.9 m	1.2 m

In all case, the minimum distance between the pole and the edge of foundation shall be more than 12 cm so foundations must be enlarged if necessary.

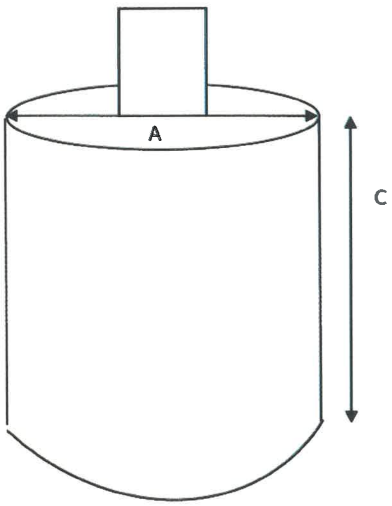
2.7.1.5 ***Class T**, 9 and 12 m pole with cubic concrete foundation*



	9 m pole	12 m pole	14 m pole
A	0.9 m	1.1 m	1.1 m
B	0.9 m	1.1 m	1.1 m
C	1.5 m	2 m	2.35 m

In all case, the minimum distance between the pole and the edge of foundation shall be more than 12 cm so foundations must be enlarged if necessary.

2.7.1.6 *Class T pole with cylindrical concrete foundation*

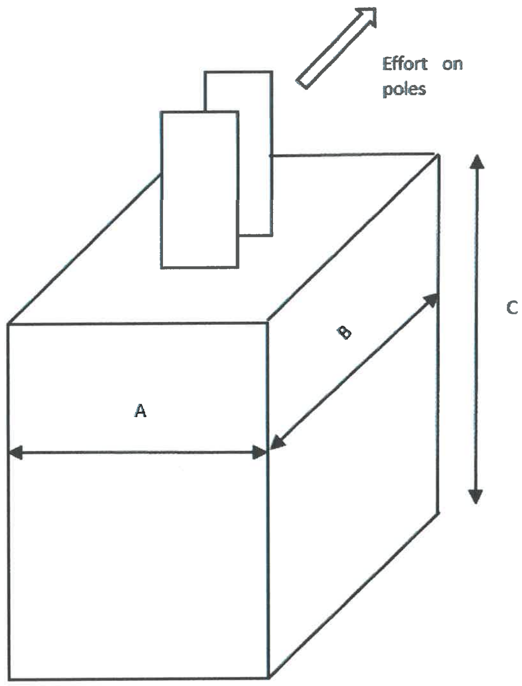


	9 m pole	12 m pole	14 m pole
A	1.2 m	1.2 m	1.2 m
C	1.5 m	2 m	2.35 m

In all case, the minimum distance between the pole and the edge of foundation shall be more than 12 cm so foundations must be enlarged if necessary.

2.7.2 *Twin poles*

In case there is no enough place for installing a guy in angle or end pole; twin poles of class A and T could be used. In those cases, the foundations will be as follow:

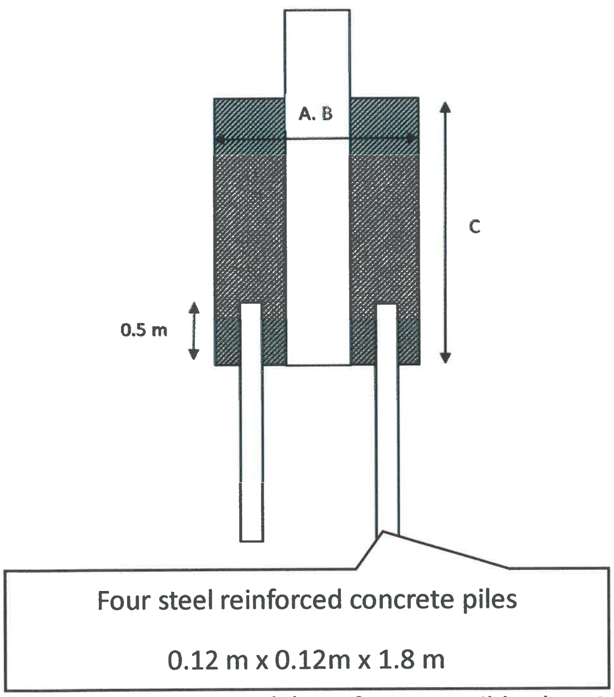


	9 m pole	12 m pole	14 m pole
A	0.9 m	1.1 m	1.1 m
B	1.1 m	1.2 m	1.3 m
C	1.5 m	2 m	2.35 m
In all case, the minimum distance between the pole and the edge of foundation shall be more than 12 cm so foundations must be enlarged if necessary.			

Circular shapes foundations are not allowed for twin poles.

2.7.3 Single Pole foundations in soil of class [D]

Only one type of foundation shall be done for all pole classes as follow:



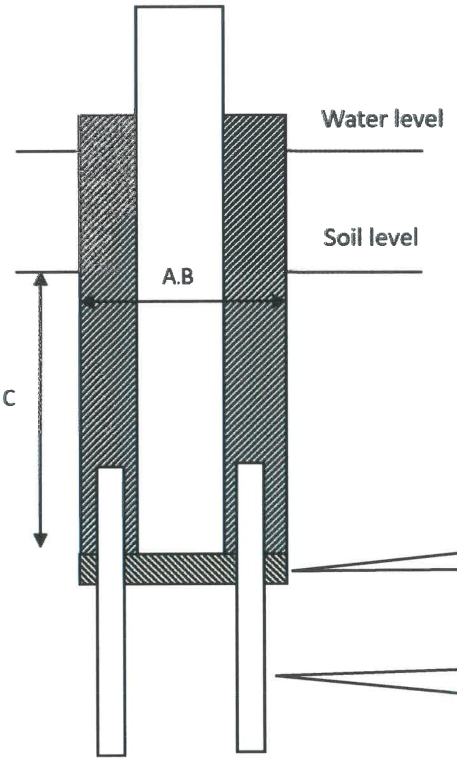
Rectangular foundations			
	9 m pole	**12 m pole**	**14 m pole**
	Class S poles		
A	0.5 m	0.5 m	0.6 m
B	0.5 m	0.5 m	0.6 m
C	1.5 m	2 m	2.35 m
	Class A poles (1)		
A	0.7 m	0.9 m	0.9 m
B	0.7 m	0.9 m	0.9 m
C	1.5 m	2 m	2.35 m
	Class T poles (1)		
A	0.9 m	1.1 m	1.1 m
B	0.9 m	1.1 m	1.1 m
C	1.5 m	2 m	2.35 m
In all case, the minimum distance between the pole and the edge of foundation shall be more than 12 cm so foundations must be enlarged if necessary.			

(1) As far as possible class A and Class T poles shall be avoided in class [D] soils.

In case of circular foundations, the dimensions mentioned above shall be applied.

2.7.4 Special case of foundation block

In case of the **extremely soft soil** such as lake, underwater, swamp or rice field, foundation block or pole stubbing shall be installed. Following figure shows the foundation block for class S and A poles only. However, if possible, it is better to install in another place because installing in the swampy place is not recommended. Installation of class T poles in such soils is forbidden.



Rectangular foundations			
	9 m pole	**12 m pole**	**14 m pole**
	Class S poles		
A	0.5 m	0.5 m	0.6 m
B	0.5 m	0.5 m	0.6 m
C	1.5 m	2 m	2.35 m
	Class A poles (1)		
A	0.7 m	0.9 m	0.9 m
B	0.7 m	0.9 m	0.9 m
C	1.5 m	2 m	2.35 m
In all case, the minimum distance between the pole and the edge of foundation shall be more than 12 cm so foundations must be enlarged if necessary.			

In case of circular foundations, the dimensions mentioned above shall be applied.

3 Guys

When the safety factor of foundation is less than 2.0, a guy should be installed under the condition of following table. For all installations, it has to be satisfied that the strength of pole itself shall be such that it endures a half or more of the wind load pressure.

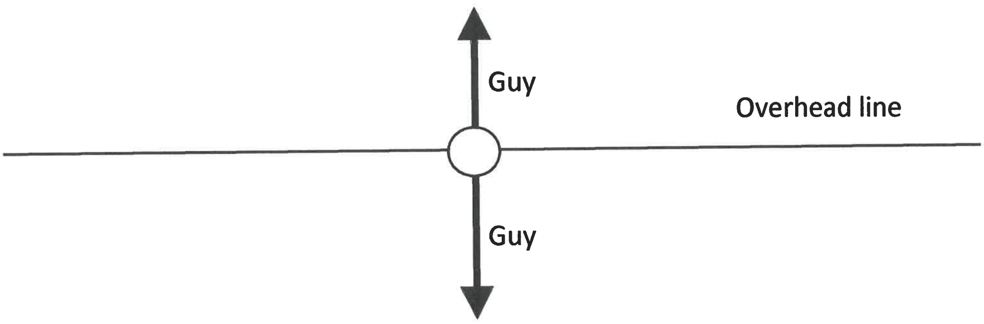
3.1 Condition of installation of guys

Conditions of installation of guys as per Article 40 of Electric Power Technical Standard of the Kingdom of Cambodia (SREPS)		
Condition	**Installation method**	**Guy safety factor**
a) Lacking strength against the wind pressure.	Guys that withstand the wind pressure shall be installed at right angle to the lines: swing prevention guys.	2.5 or more

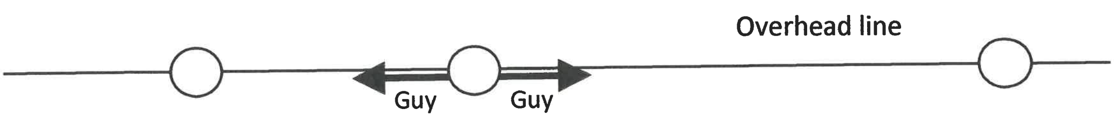
b) Supporting structures on which spans on both sides are too different.	Guys that withstand the force caused by unbalanced tension shall be installed on both sides in the direction of line: line direction guys. (Supporting structures are installed without strength calculation.)	
c) Supporting structure of which lines on both sides make an angle of more than 5 degrees.	Guys that withstand the force caused by the assumed maximum tension of each line shall be installed at the opposite side of the line: Angle guys. (Supporting structures are installed without strength calculation.)	1.5 or more
d) Supporting structure that supports the end of the line.	Guys that withstand the assumed maximum tension of the line shall be installed at the opposite side of the line: end guys. (Supporting structures are installed without strength calculation.)	

3.2 Type of guys

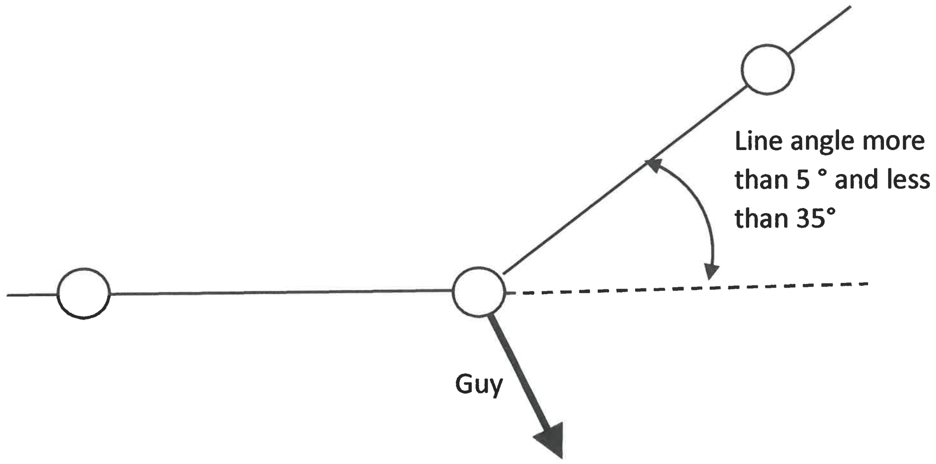
3.2.1 Swing prevention guys

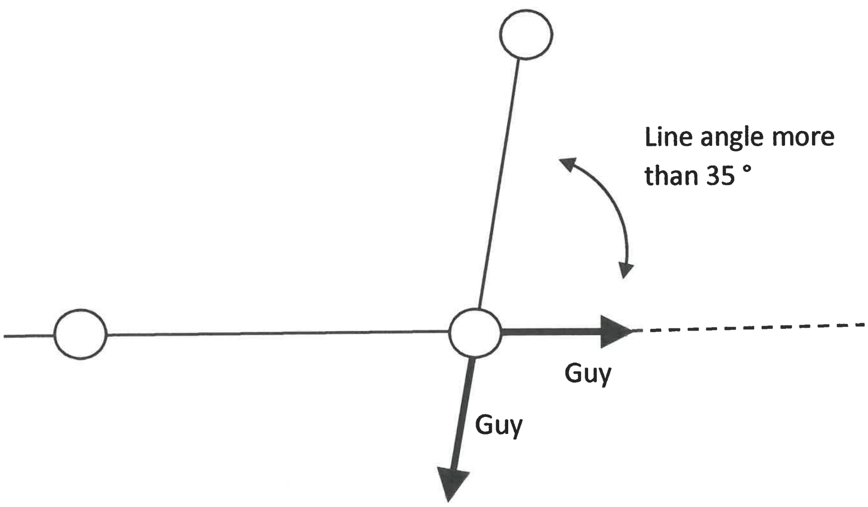


3.2.2 Line direction guys



3.2.3 Angle guys



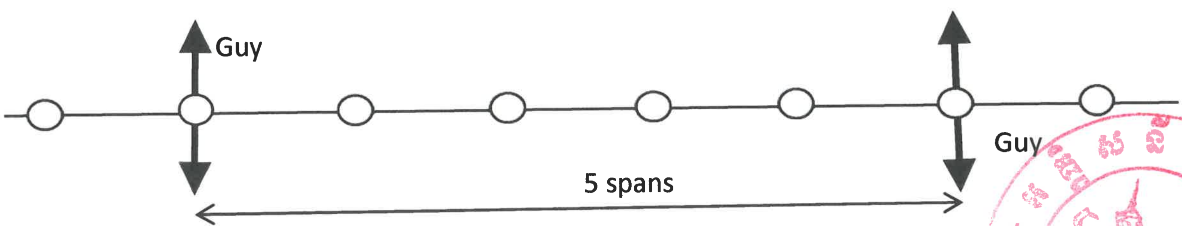


This disposition avoids angle pole breaking in case all conductors in one pole side fall on the ground.

3.2.4 End guys

3.3 Prevention of series bending

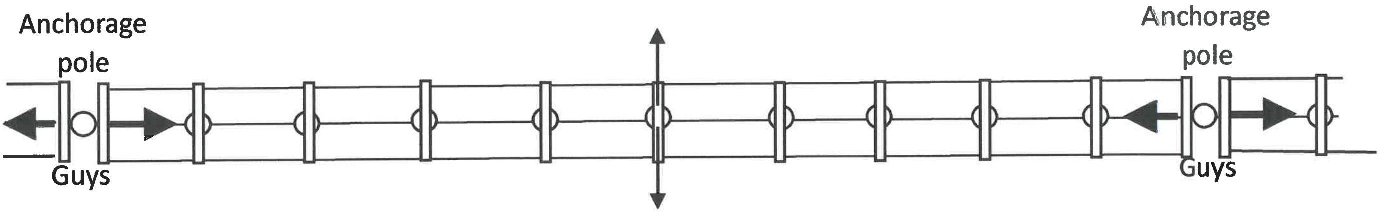
In order to prevent the series bending of the poles in case of strong wind (storms as example), in every 5 span the swing prevention guys should be installed.



This is to be adapted to the network configuration according anchorages pole but in any case, if the pole number exceed 8 spans between 2 double anchorage poles; series bending prevention guys shall be installed approximately in the middle of the section.

3.4 Line direction guy for every 10 spans

In order to prevent the pole, come tumbling down like dominos in case of storm and typhoon, every 10 spans anchor poles with direction guys shall be installed to limit any damage in case conductors fall down. The damages are then limited to only one small part of the line.



3.5 Guy position on pole and ground.

3.5.1 Pole side

- the position of the guy shall not disturb the workspace of the pole
- the position of the guy just under the resultant force point of conductor tensions
- the position not to disturb the construction of attaching and detaching the cross arm

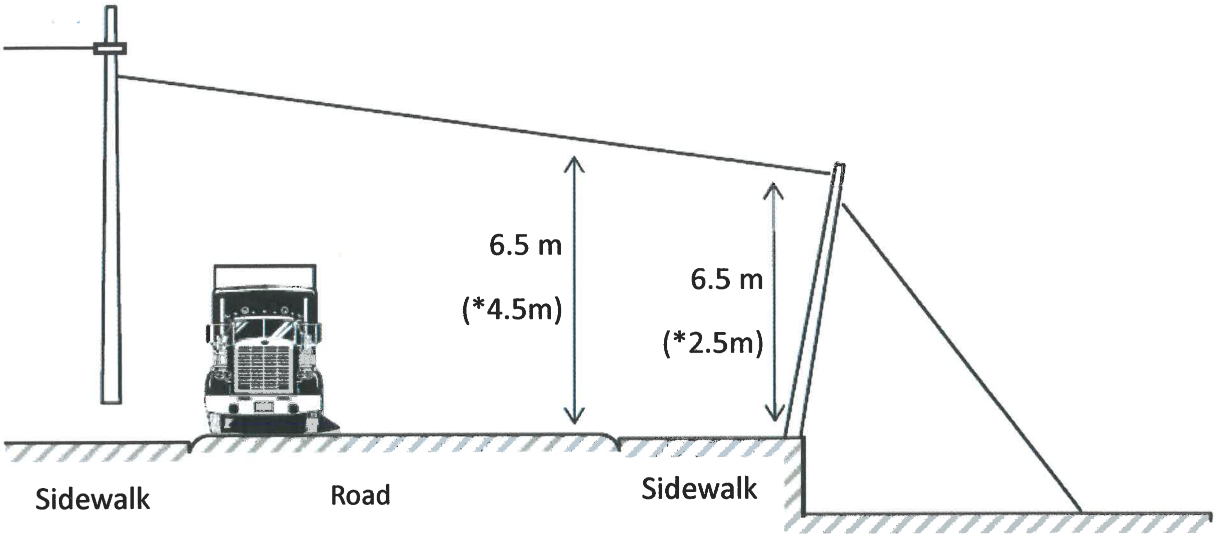
3.5.2 Ground side

- the location not to disturb the traffic.
- the location not to disturb the underground object such as water, gas pipes.
- not to install around the entrance of building structure
- not to install above the building construction site.
- the location not to disturb the cultivating of the rice field.
- the location on the soft soil such as swamp.
- not to install the place where the landslide may occur.

3.6 Minimum height of guys

As per requirement of Electric Power Technical Standard of the Kingdom of Cambodia (article 40 clause 5) the minimum height of guys is set as follow:

Location	Height	Note
Road crossing	6.5 m (* 4.5 m minimum)	If this is impossible for technical reasons, (*) or more are allowed ONLY if there is no danger of interfering with traffic
Road sidewalk crossing	6.5m (* 2.5m minimum)	

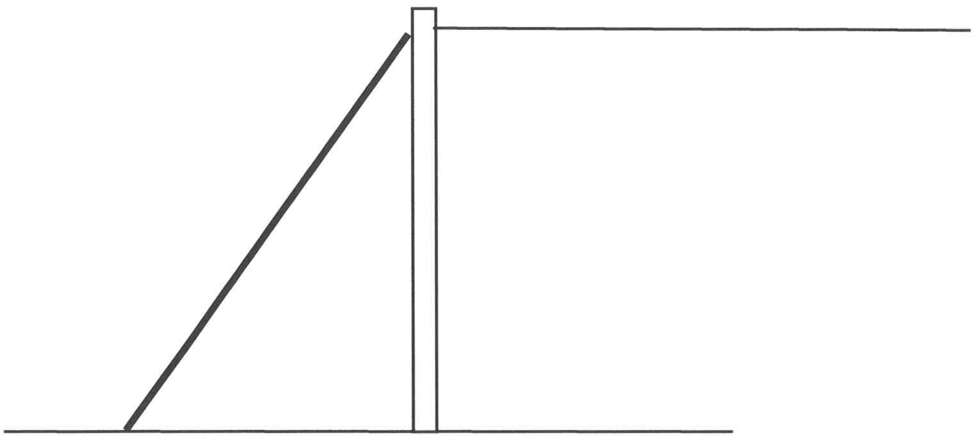


3.7 Classification of guy

The following type of guys can be installed:

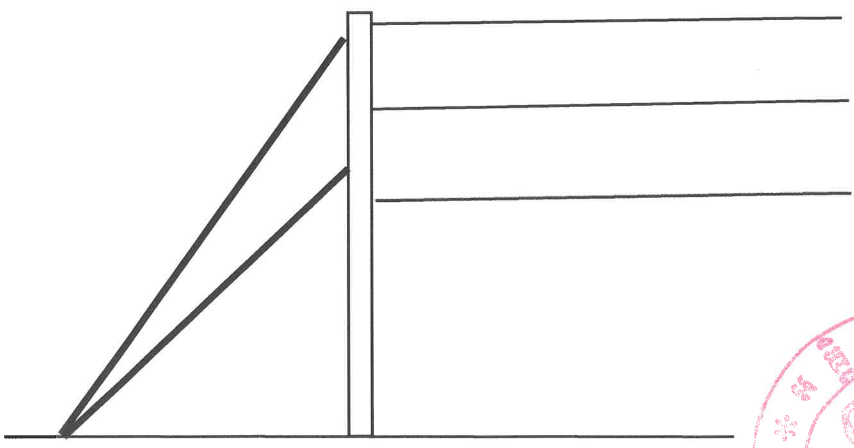
3.7.1 Regular guy

Regular case of guy.



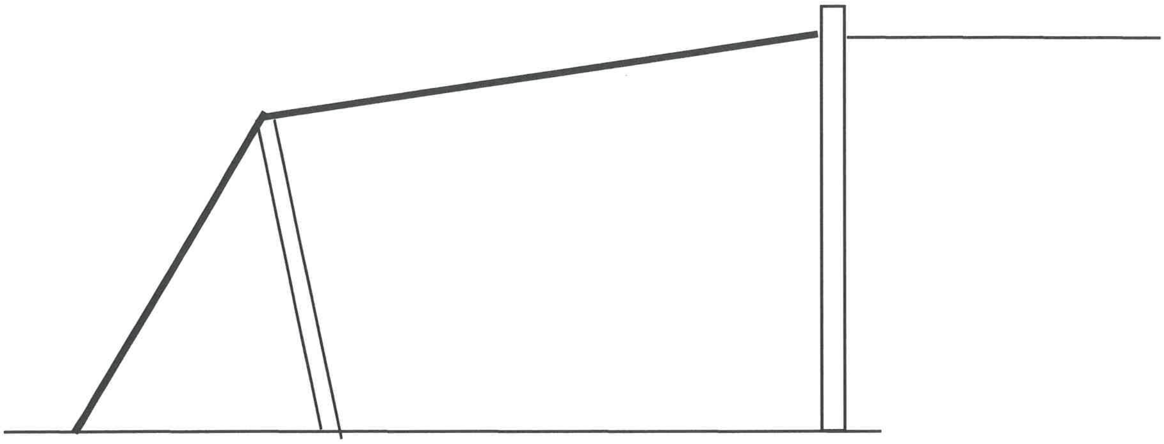
3.7.2 V shape guy

To separate the tension of the conductors

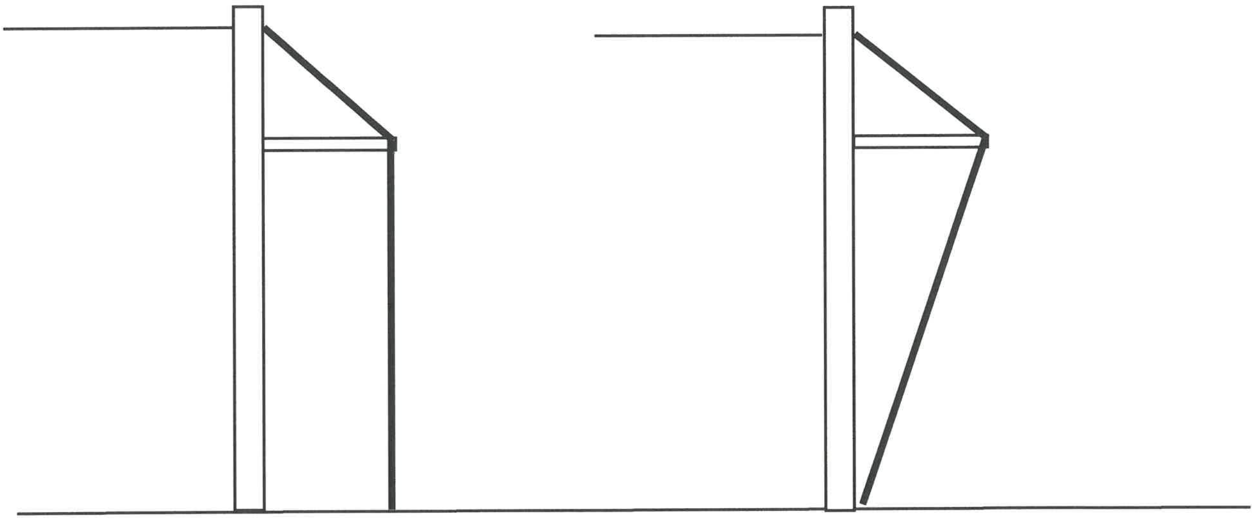


3.7.3 Strut guy

If a regular guy is not able to be installed as road or specific land use.



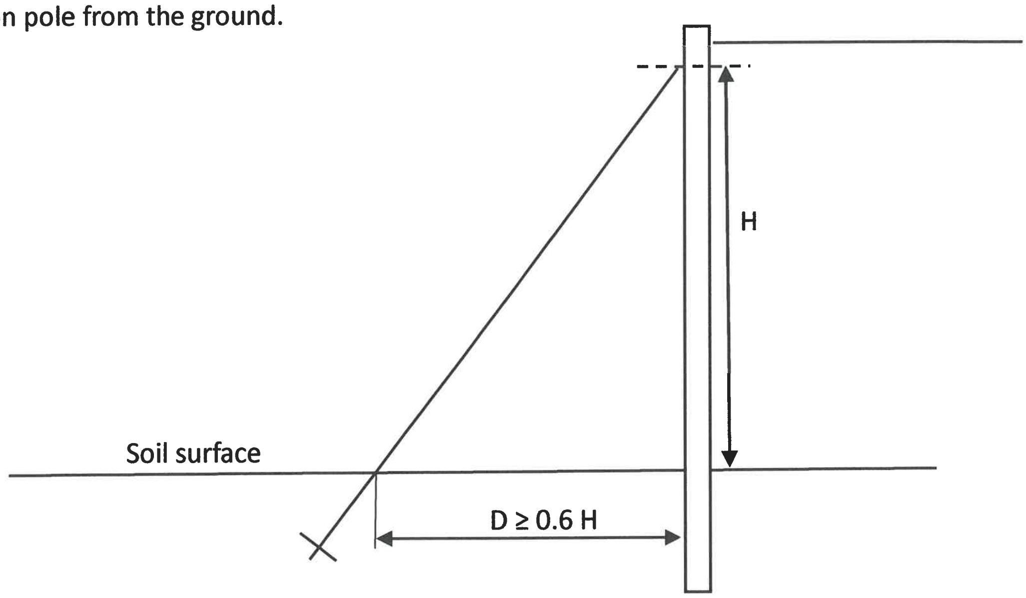
3.7.4 Bow shape guy



3.8 Guy anchor in the ground

3.8.1 Distance from the pole

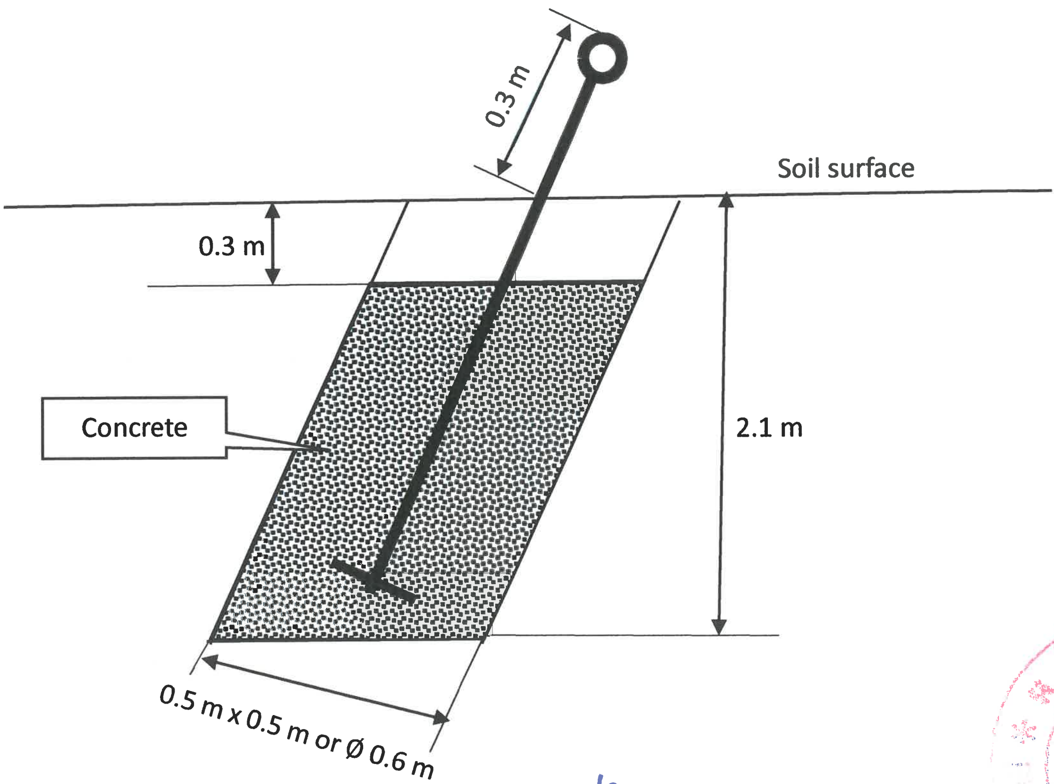
The **minimum** distance of the guy anchor block from the pole is equal to 0.6 x the height of the guy attaching on pole from the ground.



Nevertheless, everywhere possible, this distance shall be about 7.5 m.

3.8.2 Guy foundation block

Guy anchor blocs shall be installed as the concrete foundation block in following figure. Guy anchor shall be hardly corrodes. For the portion near ground, that is, from the underground portion of the guy to 30cm above the ground, the rod of guy shall be strictly conform to chapter 10 of EDC-DTS-016 technical standard (Stay rods).



The guy anchor rod shall be mandatorily installed in straight line with the cable guy. Any guy anchor rod vertically installed in the ground and folded above soil level will result in the rejection of the guy anchor block that must be redone according the requirements.

3.9 Twin and strut poles

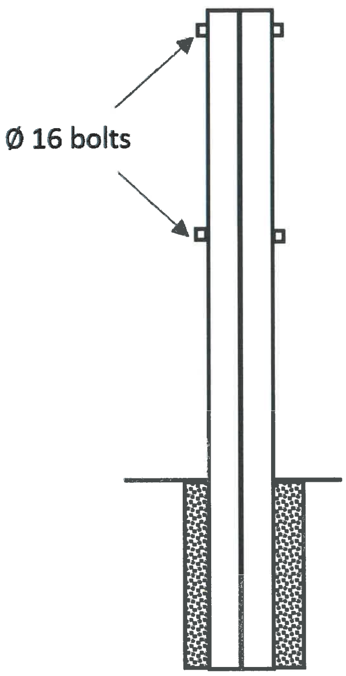
Twin and strut pole can replace guys more efficiently and occupied smaller space on ground.

They are strongly recommended in urban and peri-urban areas where space on pavement is limited.

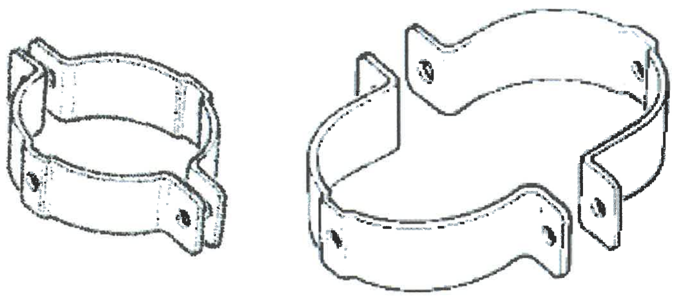
3.9.1 Twin poles

Twin poles of class A and T are mostly used for LV ABC networks but they can be implemented also for MV overhead lines when there is not enough place on the soil for implementing a guy or a strut pole.

Two poles of the same length and class (A or T) are twinned together by the concrete block at soil level and by two bolts (one on the top and one nearly at the pole middle.



In case hole is not available in the middle of the pole, Hot dip galvanised collars may be used

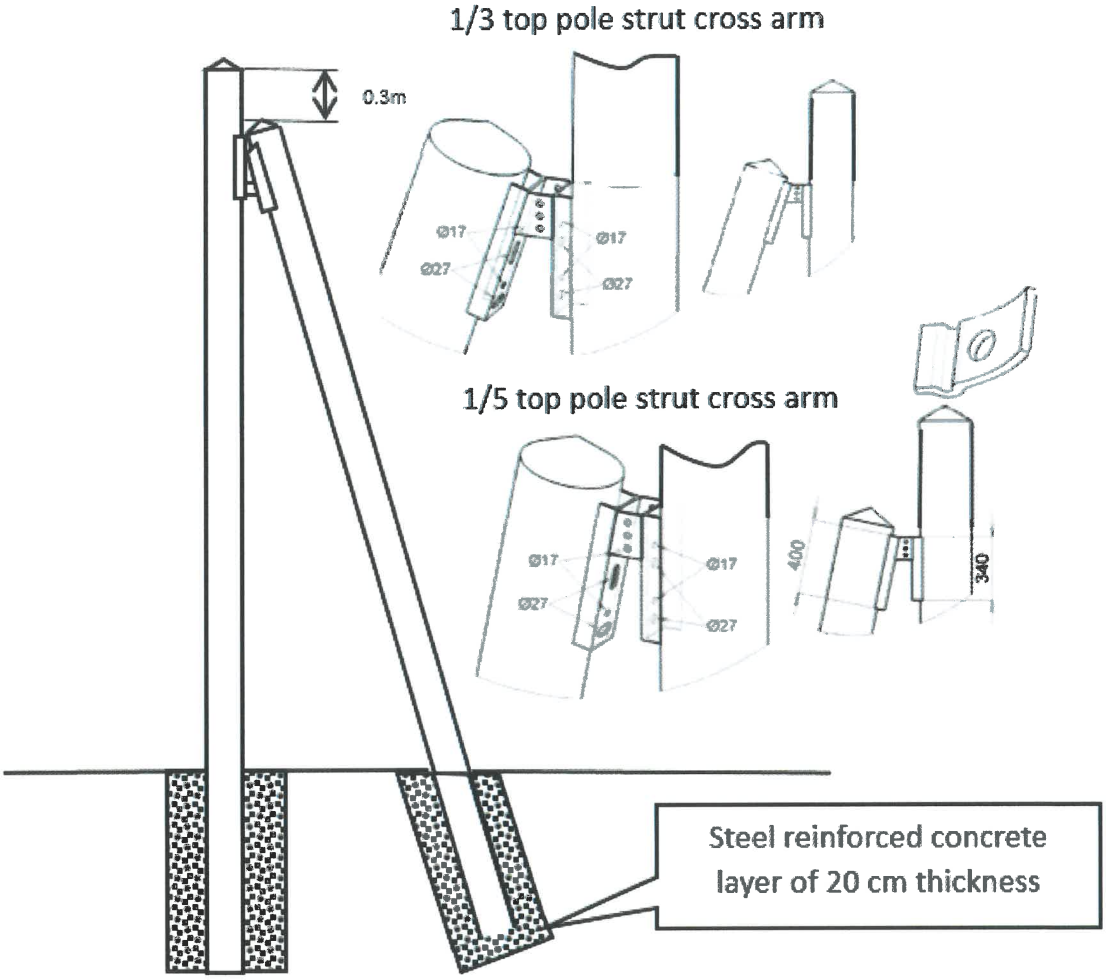


3.9.2 Strut poles

As mentioned in Electric Power Technical Standard of the Kingdom of Cambodia (Figure ES40B), strut poles may be installed instead of guys. A strut pole is stronger than a guy.

Two kind of strut pole shall be used as follow:

Network	Poles	Pole Slope
LV ABC	9 m Class A or T	1/5
MV (OHL and ABC)	12 and 14 m Class A or T	1/3



Dimensions of foundations						
Pole Type	**Vertical pole**			**Strut**		
	Length	**Width**	**Depth**	**Length**	**Width**	**depth**
9 m Class A	0.7 m	0.7 m	1.5 m	0.7 m	0.7 m	According slope and pole length to be measured on site with a rope.
9 m class T	0.7 m	0.7 m	1.5 m	0.7 m	0.7 m	
12 m class A	0.9 m	0.9 m	2 m	0.7 m	0.7 m	
12 m class T	1.1 m	1.1 m	2 m	0.7 m	0.7 m	
14 m Class A	0.9 m	0.9 m	2.35 m	0.9 m	0.9 m	
14 m class T	1.1 m	1.1 m	2.35 m	0.9 m	0.9 m	

4 Concrete

4.1 Composition of concrete

The concrete will be composed of cement, water, sand, and gravel and, if permitted or required by the Employer, additives accelerators.

The composition of the mixture will give a concrete plasticity in relation to the difficulties of implementation and after its implementation a hardness, waterproofness and resistance in compliance with the requirements of the foundation calculation.

The water-cement ratio shall not exceed 0.60. Account will be taken of the water content of the aggregates to determine the amount of water required for mixing.

The minimum amount of cement for unreinforced concrete foundations will be at least 270 kg / m3 of finished concrete.

The concrete for the foundation will be of the B15 quality class according to DIN 1045 or equivalent and present the compressive strength after 28 days that is not less than 25 N / mm².

The proportion of sand and gravel will be determined according to local arrangements to obtain the required strength concrete.

4.1.1 Quality of Materials

4.1.1.1 Cement

The cement used will be an artificial PORTLAND cement Z35 class according to DIN 1164 or equivalent. The Contractor is required to order the cement in time and a copy of the order shall be handed over to EDC.

Upon arrival on site, the cement will be stored in a dry warehouse and protected from the weather by suitable means in order to avoid or absorb any moisture. Any cement containing blocks or is damaged will not be used. The cement temperature at the time of its use cannot exceed approximately room temperature.

The Contractor shall not mention the poor quality of a batch of cement to request an extension of implementation schedule; it will be required to store on site an adequate supply of good quality cement.

If the dosage of cement is not made by special mixtures balance, the concrete mixing shall be made with whole bags or barrels. The Employer or his delegate is entitled to weigh the contents of the packages; tolerance on weight is 1%.

4.1.1.2 Sand

The Contractor will choose sand supply places that shall be approved by EDC.

The sand will be natural or grinding grains and will have no more than 5 mm size. The natural sand is composed of granular dry grains, crunching hand; it is clean, free of any earthy part and other foreign bodies, and if necessary, passed to the rack.

The weight percentage of earthy and ethereal materials may not exceed 2%. The sand obtained by crushing can be used if it has elements whose largest dimension exceeds 1.5 times the smallest dimension.

The sand will be stored so as to prevent any intrusion of foreign bodies in concrete and segregation or deterioration.

4.1.1.3 Gravel

The Contractor will choose gravel supply places to be approved by EDC.

The gravel is natural type or hard rock crushing, size between 5 and 33 mm. However, for slabs whose thickness is greater than 50 cm, more coarse gravel may be used without their higher dimension cannot exceed 50 mm.

The gravel should be comprised of well-proportioned elements, hard and heavy quality. Each piece must have at least two breaking faces. The flat stones (platelets) or elongated (needles) are excluded. The materials are compact, angular, making crisp, are purged of all earthy and organic materials.

The storage area will be constructed to prevent any contamination of materials.

4.1.1.4 Mixing water

The mixing water should be clean and the content of materials such as acids, alkalis, sulphates, sweet, oily materials, organic materials, should be limited.

It should not come from swamps or muddy areas and shall not contain more than 5 grams of suspended impurities and 20 grams per litter of dissolved impurities.

Doubtful waters must be submitted to chemical analysis at the expense of the Contractor.

4.1.2 Verification of the Concrete Quality

During the concrete work, control tests on concrete cubes on will be done regularly to any request from EDC.

The Contractor will prepare at its own expense and in accordance with the requirements of EDC concrete cubes that will be tested in a laboratory approved by the latter.

The tests shall be conformed to DIN 1045 standards or equivalent. A sufficient number of cubes will be made to obtain a sample of the results of the strength of concrete casting each day.

EDC reserves the right to request a change in the composition of the concrete mixture, if the compressive strength is less than the required strength.

4.2 Manufacturing Facilities and Requirements Concrete Mixing

Facilities for manufacturing and installation of the concrete mixing will be subject to the approval of EDC, who may require the Contractor to improve its facilities, or increase the capacity if the quality of the concrete was unsatisfactory or if the performance of the manufacturing process was insufficient.

The concrete will be prepared in a concrete mixer with mechanical drive whose type and capacity will have to be approved. In addition, by design, the concrete mixer shall ensure a uniform distribution of all components in the mixture.

The bottom of the mixer discharges the mixture without occurrence of segregation. The materials of the concrete will be carefully measured on the loading platform. The cement weight will be measured. Sand and aggregates volume will be measured in calibrated tanks that have been approved by the Employer or his delegate.

4.3 Transport and Pouring

The concrete cannot be poured without the presence of EDC, and only after he inspected the excavation funds and formwork.

The pouring of the concrete will be prohibited if EDC determines that the conditions for proper installation are not met.

The pouring of concrete under water is forbidden. In any case, the water shall be removed from the excavation before pouring the concrete except in case of agreement of EDC and in the presence of one of its representatives.

Only methods of transport and set up that will avoid segregation and any loss of concrete will be permitted. In addition, the means will bring at work a concrete required consistency. Anyway, the concrete will have been transported on a considerable distance shall be properly mixed before pouring at the point of use.

The concrete will be poured within 30 minutes after its preparation and in the best case, as soon as possible.

The Contractor is required to take the necessary precautions to protect Concrete against rain or sun.

4.4 Finishing of the Concrete Blocks

a) For concrete poles, the blocks are flush at 3 cm above the soil level of the soil by smoothing the surface with a slope for flowing the water.
b) In the case of implantation in crops or grasslands, the massifs must exceed the ground surface by 10 centimetres in the form of one "over-block" carefully done in diamond point shape with a smooth surface.
c) For steel tower, the massifs shall exceed the surface of the ground by at least 10 centimetres in uncultivated land and 20 centimetres in crops or grasslands. At the top, they terminate in a tip-like Diamond in cement-rich mortar, with a slope of at least 10% for facilitate the flow of water. The angles of the angles or profiles are lined with mortar to avoid any stagnation of water.

4.5 Site Rehabilitation

a) After completion of the foundation, the embankment is carried out with excavation heavily pounded by successive layers so as to reconstitute the better possible the compactness of the original floor, a prerequisite for to provide foundations with the required resistance to uplift.
b) The remaining topsoil is placed on the surface last.
c) The whole is regaled so that after settlement, the soil returns to its normal level.
d) Excess spoil is removed by the contractor and transported by in the places of deposit of his choice for which he is responsible to obtain the necessary authorizations.
e) Runs, ditches, roads, hedges, fences, etc. Are rehabilitated, all at its expense.
f) Failure by the Contractor to comply with the foregoing, EDC may, at the expense of the Contractor in order to avoid claims of the concerned persons (owners, operators, etc...)

5 Concrete Poles

5.1 Specifications

The contractor is obliged to provide concrete pole from an EDC approved manufacturer. All provided poles shall be in accordance with the requirement of EDC-DTS-MV013 EDC standard.

Except in exceptional cases and upon request of EDC specific concrete poles may be requested.

After completion of the construction work, the poles shall be controlled by EDC in order to check if they had not suffered any damage resulting from their transport or their erection.

5.2 Pole Curing Time

The poles must only be removed from the factory after expiration of the curing time necessary to obtain the mechanical qualities intended for concrete.

This period, which varies according to the season and the place of manufacture, is indicated by the concrete pole manufacturer under his own responsibility.

Regardless of the manufacturing process, this period shall not be less than 28 days.

5.3 Handling and Transport

a) In operations involving pole weight (transport, lifting, etc), the pole must be in its sense of greater inertia and taking account of information's provided by the manufacturer: mass, position of centre of gravity and slinging points.

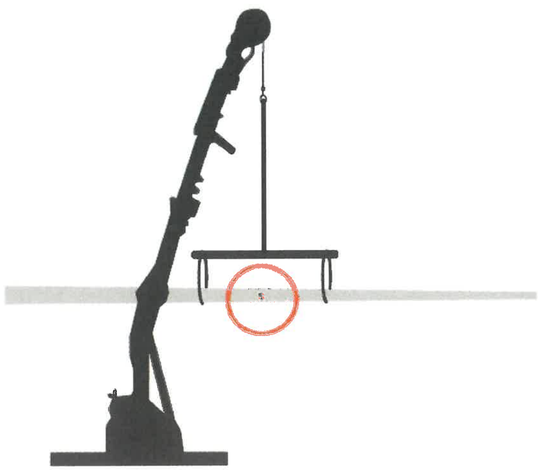
b) It must not be subjected to shocks or abrupt forces.

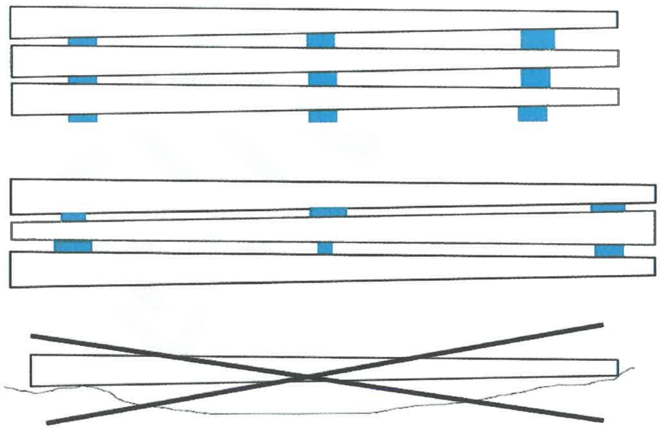
c) Lifting devices are provided with flexible fittings effectively guaranteeing concrete against any risk of spalling.

d) Loading and unloading must take place through means of hoists, cranes, monorail or removable gantries or another mechanical device. Where it is not possible to access at work site by motorized means, it will be possible to use drays or special devices with wheels.

e) The poles must be handled using slings textiles or similar (preferably with sheath) in order to avoid possible scalping and guarantee a good adhesion between the concrete product and the sling. Choose slings that are clean, suitable for the weight and the dimension of the post.

f) The poles can be handled using a lifting beam with a minimum length of 2 m. It is imperative to place the axis of lifting of the lifting beam in line with the centre of gravity on the pole and materialized on the pole by the letter G.





g) In all cases, the drag of poles on the ground is strictly prohibited.

h) Road transport is carried out by means of a long enough truck or rigid trailer and the length shall be compatible with that of the poles to be transported. Cantilever overhang shall not exceed the values indicated by the manufacturer with a maximum of 2 meters, unless special provisions, such as guying. This trailer is equipped with two unloading jib cranes. However, the presence of one single crane is allowed provided it is fitted with a lifting beam.

i) The rectangular poles must never be carried on the flat.

j) When using 2 wheels trailer, the metallic frame of the trailer shall be long enough for supporting the pole in the 2 lifting points. The pole shall never be used as drawbar.

k) The repository poles at work place shall be based on at least 3 wooden blocks or another suitable device. Poles shall mandatorily not put directly on the ground if this one is not flat.

5.4 Pole erection

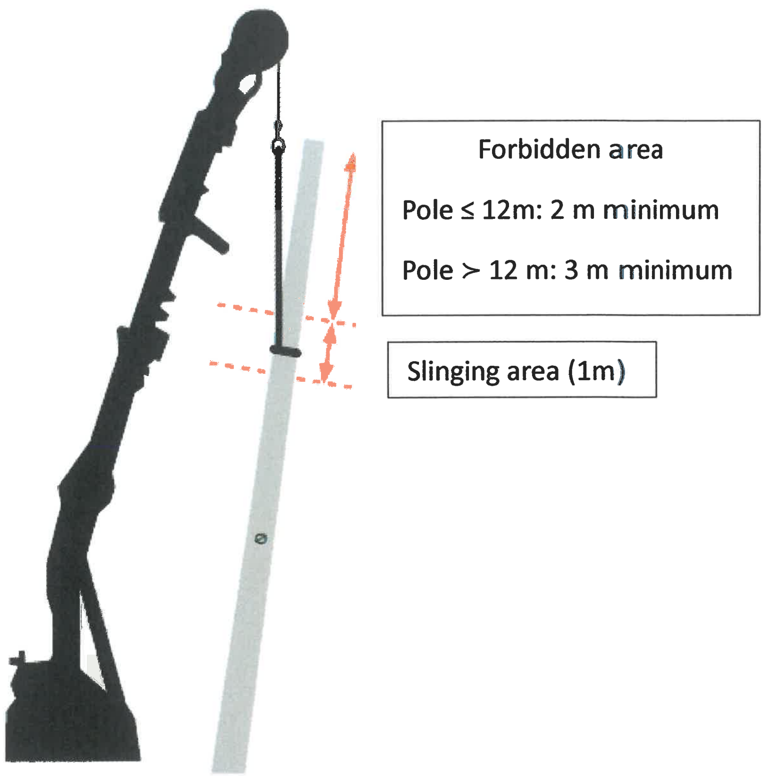
a) Poles shall be erected true to face, plumb, and be vertical following the tensioning of all conductors. At angle positions the face of the pole and the cross arm shall bisect the angle of deviation of the line conductors

b) The installation and centring of poles in the foundation excavation will be made with due care. It will not be tolerated a misalignment or centring of more than 5 cm from the centre of the excavation.

c) The pole verticality defect will not exceed 5 mm/m in the parallel and perpendicular directions to the line for the alignment poles and in the parallel and perpendicular directions to the bisector of the angle of the line for the angle poles.

d) After adjustment of the conductors, it will not be tolerated vertical fault of more than 5 mm/m between the head and the ground level of the pole.

e) Before erection, the Contractor shall submit for approval to EDC, the process he intends to use for erecting poles. He will always have the means to assess the efforts that will be imposed on the pole erecting during operation



6 Steel Towers

The steel towers are delivered, carefully marked, in riveted or welded bars or panels.

They have a base to be embedded in the foundation concrete.

The contractor must know, at the time of delivery, the details of the packing, the assembly plans and the nomenclature of the bolts and gussets.

6.1 Assembly and Lifting

Separate elements are assembled on the ground and bolted.

a) If, during assembly, there are problems of assembly or defects on certain parts requiring replacement the contractor shall notifies EDC.
b) In no case shall the Contractor modify any part or any modification without EDC as well as the manufacturer prior agreement.
c) No bent, twisted, or otherwise damaged iron shall be used.
d) Adjustments must be made with the agreement of EDC with a process which does not damage the metal coating
e) Between the completion of a foundation and the lifting of the pylon; at least 15 days must elapse in case of lifting and three weeks in the case of rotational lifting, except derogation granted by EDC.
f) Lifting operations shall be carried out in such a way that no part should not be excessively solicited. In any case, the efforts must be much less than the elastic limit of the metal. Any deterioration is the responsibility of the contractor.
g) After erection and before unwinding the conductors, the nuts of the bolts are locked.
h) After locking, the bolts are matted, so as to prevent further loosening. For galvanized bolts, this matting is performed, using a blunt-edged blanket

6.2 Protection of Metallic Surfaces

All steel parts are hot dip galvanized in accordance with EDC standards.

7 Equipment for pole excavation and erection

Specific equipment is available on the market for pole excavation and erection.

The crane is specific and can do the two functions without fast worn: digging excavations with mechanical means solicits a lot the crane.

Mainly they are of two types:

- Crane Installed on truck behind the cabin or at the rear of the truck


Vehicle and crane that can be used for live line work pole erection

- self-propelled vehicle 4 wheels drive (4X4)


All kind of vehicle can erect poles directly with the crane of with the winch installed on this crane.

For digging pole or guy excavation several equipment is available:

- Augers:


Diameter from 0.3 m to 1 m available

- Clamshell

- Carrot maker

For use in very rocky soil and directly in full rock.

Diameter 0.3m to 0.8 m available.

- For making excavations, small excavators are also very useful.

ANNEX

Extracts from General Requirements of Electric Power Technical Standard of the Kingdom of Cambodia

4.5 Calculation of Safety Factor of Foundations of Supporting Structures

The safety factor of the foundation of a supporting structure is calculated as follows:

$$f \geq \frac{KD_0 t^4}{120P(H+t_0)^2} \quad \text{(without a guy anchor)} \qquad \text{----------- (ex40-15)}$$

Where:

f: Safety factor of the foundation of the supporting structure.

D_0: Diameter of the supporting structure at the ground level if columnar pole (m)

Edge length of the cross section of the supporting structure at the the ground level if square pole (m)

t: Embedded depth of the supporting structure (m)

H: Height of the point of action of concentrated loads from the ground surface (m)

P: Load converted into a concentrated load at the top of the supporting structure (N)

t_0: Depth of the center of gyration of the supporting structure from the ground surface (m)

$$t_o = \frac{2}{3}t \text{ (m)}$$

K: Soil coefficient taking the value given in the following table.

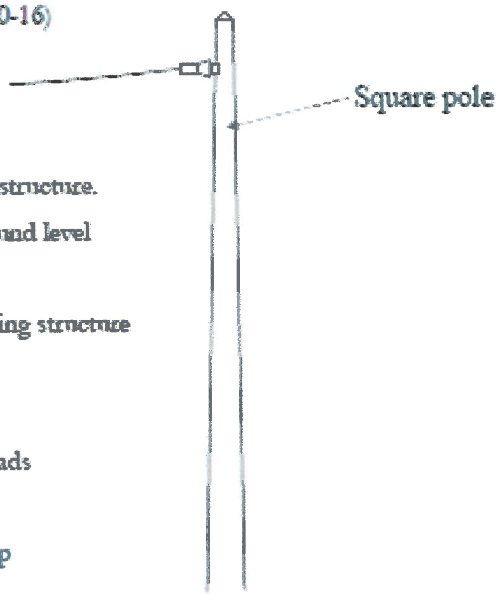
Table ES40H: Soil Coefficient

Classification of soil		Soil coefficient (N/m^4)
Normal soil	[A] Aggregated soil or sand, and soil with plenty of gravel or stone belonging under hard soil	3.9×10^7
	[B] Aggregated soil or sand, and soil with plenty of gravel or stone belonging under soft soil	2.9×10^7
Soft soil	[C] Quicksand (with no soil mixed)	2.0×10^7
	[D] Moist clay, humus, fill and other soft soils (excluding deep rice fields)	0.8×10^7

4.6 Reinforcement of the Foundation by the Foundation Block

If a foundation block will be buried to reinforce the foundation, the safety factor of the foundation of a supporting structure is calculated as follows:

$$f \geq \frac{\rho K D_0 t^4}{120P(H+t_0)^2} \quad \text{--------- (ex40-16)}$$



Where:

f: Safety factor of the foundation of the supporting structure.

D_0: Diameter of the supporting structure at the ground level if columnar pole (m)

Edge length of the cross section of the supporting structure at the the ground level if square pole (m)

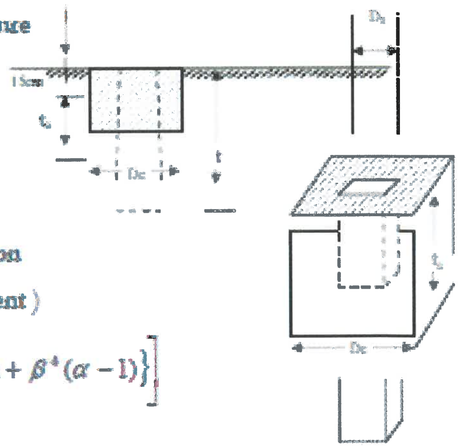
t: Embedded depth of the supporting structure (m)

H: Height of the point of action of concentrated loads from the ground surface (m)

P: Load converted into a concentrated load at the top of the supporting structure (N)

t_0: Depth of the center of gyration of the supporting structure from the ground surface (m)

$$t_o = \frac{2}{3}t \text{ (m)}$$



K: Soil coefficient

ρ: Increasing coefficient of resisting moment in the foundation by a concrete foundation block(coefficient of reinforcement)

$$\rho = 36\left[\frac{\gamma^2}{2}\{1+\beta^2(\alpha-1)\}-\frac{2}{3}\gamma\{1+\beta^3(\alpha-1)\}+\frac{1}{4}\{1+\beta^4(\alpha-1)\}\right]$$

$$\alpha : \frac{D_c}{D_0}, \qquad \beta : \frac{t_c}{t}, \qquad \gamma : \frac{t_0''}{t}$$

t_0'': Depth of the center of gyration of the supporting structure from the ground surface if a foundation block is buried (m)

$$t_0'' = \frac{2}{3}t\left\{\frac{1+\beta^3(\alpha-1)}{1+\beta^2(\alpha-1)}\right\} \text{ (m)}$$

D_c: Diameter of the foundation block if the foundation block is columnar (m),

Transverse breadth of the foundation block if the foundation block is a rectangular parallelepiped (m)

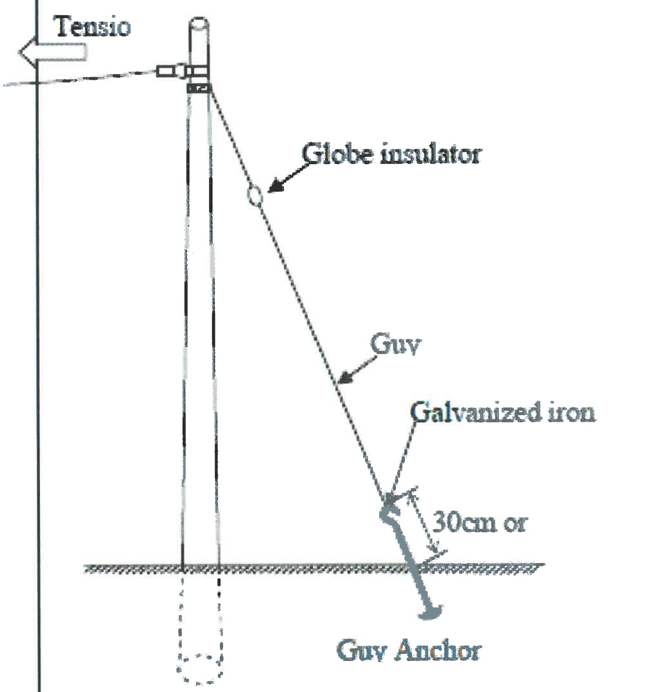
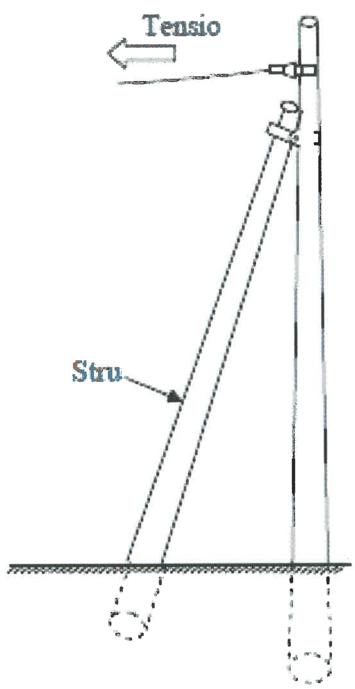
t_c: Depth of the foundation block

(It shall be taken into consideration that t_c does not include 15cm below the ground surface if soil condition is normal.)

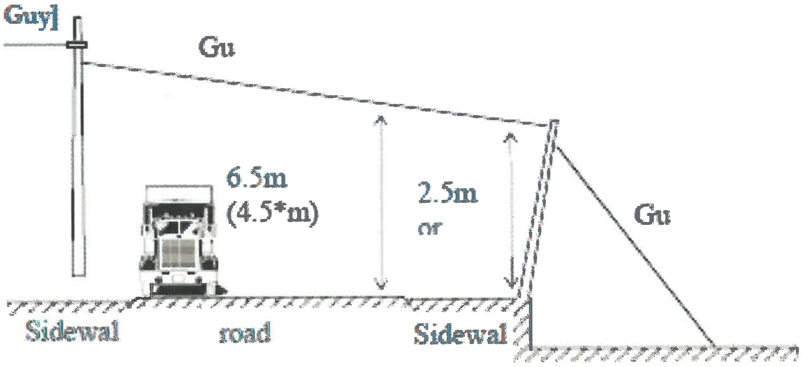
5 Reinforcement for Supporting Structures by Guys

5.1 Installation and safety factor of guys

Figure ES40B: Example of Guy and Strut

Guy	Strut
	
A globe insulator shall be inserted in the upper part of the guy, if a guy installed on an overhead distribution line in danger of touching an electrical conductor.	A strut that has equivalent or higher effect can be substitutable for a guy.

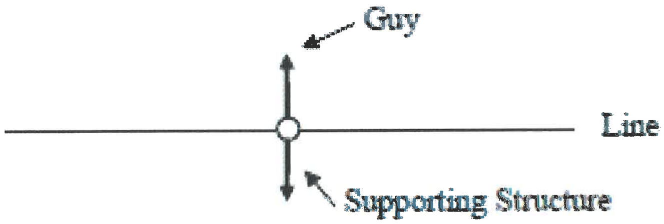
[Height of Guy]



* Only in the case that 5m is impossible for technical reasons and there is no danger of interfering with traffic.

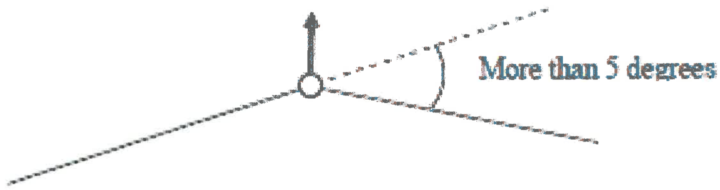
[Condition of Installation of Guys]

(1) When a supporting structure lacks the strength against the wind pressure lateral to guys, guys shall be installed at right angle to the lines.



(2) When spans on both sides of supporting structure are too different, guys shall be installed on both sides of lines.(Supporting structures are installed without strength calculation.)

(3) When lines on both side make an angle more than 5 degrees, the guy that endures the horizontal lateral component of the assumed maximum tension shall be installed. (Supporting structures are installed without strength calculation.)



(4) The guy that endures the horizontal force of all strung wires shall be installed at the end of a distribution line. (Supporting structures are installed without strength calculation.)

[Calculation of Strength of Guy]

(1) Guys for the Wind Pressure Lateral to a Line (Single Pole)

$$P \geq \frac{K}{h_0 \times 10^3}\left\{1.25K_2 S\left(\sum dh\right)+12.5K_1\left(\frac{D_0 H^2}{2}-\frac{kH^3}{3}\right)\right\}\cdot \mathrm{cosec}\theta \quad \text{----- (ex40-17)}$$

In the case of K_1=520(N/m²), K_2=680(N/m²);

$$P \geq \frac{K}{h_0 \times 10^3}\left\{850S\left(\sum dh\right)+3{,}250D_0 H^2-2{,}167kH^3\right\}\cdot \mathrm{cosec}\theta \quad \text{----- (ex40-18)}$$

Where:

P: Tensile strength of the guy (N)

h_0: Height of the installed point of the guy (m)

θ: Angle of the pole and the guy

S: Span (m)

(S is one half of the sum of spans on both sides of the pole If they are not same l length.)

d: Diameter of the conductor (mm)

h: Height of the installed point of the conductor (m)

H: Height of the pole (m)

D_0: Diameter of the pole at surface of earth (cm)

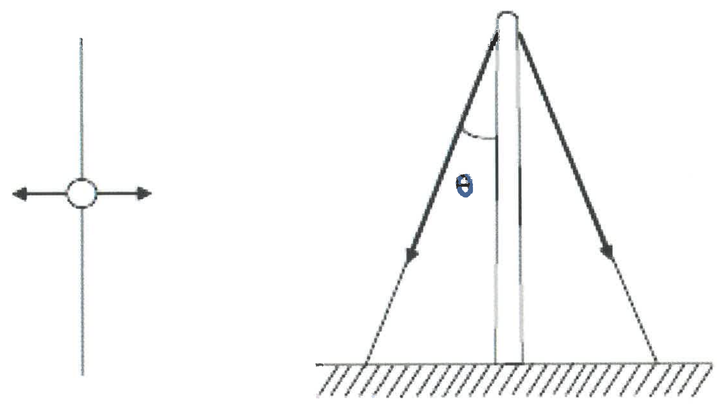
k: Increasing rate of the diameter of the pole(cm/m)

K: Coefficient for the wind pressure (K=1 is suitable in Cambodia)

K_1: Wind pressure per 1 m² of vertically projected area of the supporting structure (N/ m²)

K_2: Wind pressure per 1 m² of vertically projected area of the distribution conductors (N/ m²)

Explanation Drawing



(2) Guys for the Wind Pressure Lateral to a Line (H-type Pole)

$$P \geq \frac{K}{h_0 \times 10^3}\left\{0.625K_2S\left(\sum dh\right)+12.5K_1\left(\frac{D_0H^2}{2}-\frac{kH^3}{3}\right)\right\}\cdot \operatorname{cosec}\theta \quad \text{----- (ex40-19)}$$

In the case of K_1=520(N/m²), K_2=680(N/m²);

$$P \geq \frac{K}{h_0 \times 10^3}\left\{425S\left(\sum dh\right)+3{,}250D_0H^2-2{,}167kH^3\right\}\cdot \operatorname{cosec}\theta \quad \text{----- (ex40-20)}$$

Where:

P: Tensile strength of the guy (N)

h_0: Height of the installed point of the guy (m)

θ: Angle of the pole and the guy

S: Span (m)

(S is one half of the sum of spans on both sides of the pole If they are not same l length.)

d: Diameter of the conductor (mm)

h: Height of the installed point of the conductor (m)

H: Height of the pole (m)

D_0: Diameter of the pole at surface of earth (cm)

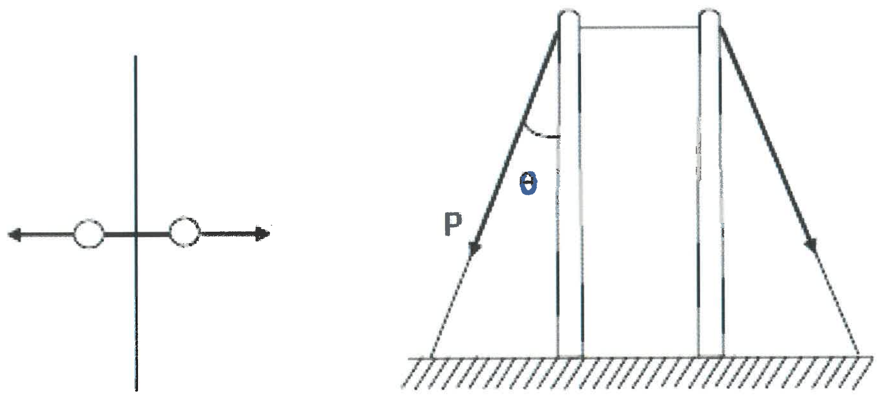
k: Increasing rate of the diameter of the pole(cm/m)

K: Coefficient for the wind pressure (K=1 is suitable in Cambodia)

K_1: Wind pressure per 1 m² of vertically projected area of the supporting structure (N/ m²)

K_2: Wind pressure per 1 m² of vertically projected area of the distribution conductors (N/ m²)

Explanation Drawing



(3) Guys for the Tension Unbalance

$$P \geq \frac{f}{h_0}\left(\sum Th\right)\mathrm{cosec}\,\theta \qquad \text{----- (ex40-21)}$$

Where:

P: Tensile strength of the guy (N)

h_0: Height of the installed point of the guy (m)

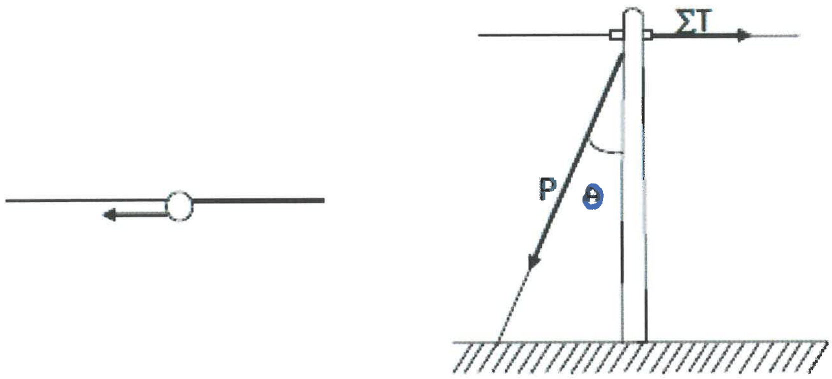
θ: Angle of the pole and the guy

T: Assumed maximum tension unbalanced of a conductor (N)

h: Height of the installed point of the conductor (m)

f: Safety factor

Explanation Drawing



(4) Guys for the Pole Supporting the End of a Line (Simplified formula)

$$P \geq f\sum T \operatorname{cosec}\theta$$

$$P \geq f\sum T\sqrt{\left(\frac{h_0}{l}\right)^2 + 1} \qquad \text{----- (ex40-22)}$$

Where:

P: Tensile strength of the guy (N)

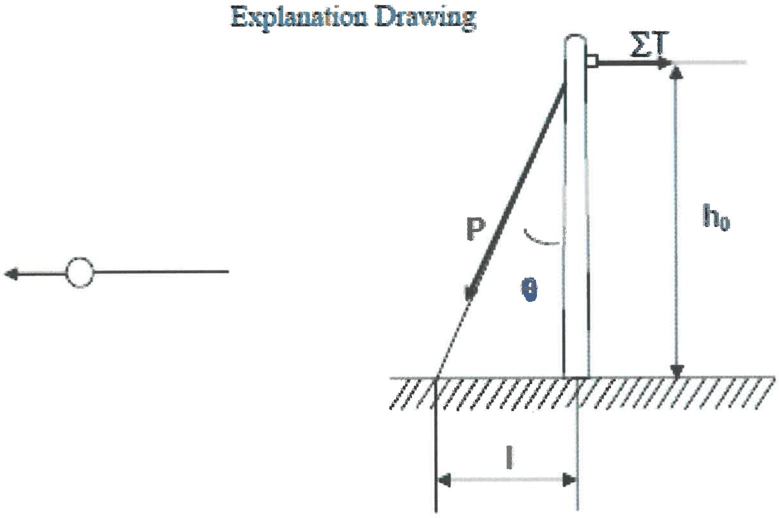
h_0: Height of the installed point of the guy (m)

T: Assumed maximum tension unbalance of a conductor (N)

l: Length between the pole and the guy at the surface of earth (m)

f: Safety factor

Explanation Drawing



(5) Guys for the Pole of which Line is not Straight (Simplified formula)

$$P \geq f\sum T\sqrt{\left(\frac{h_0}{l}\right)^2 + 1}$$

$$T = \sqrt{T_A^{\,2} + T_B^{\,2} - 2T_A T_B \cos\varphi}$$

If $T_A = T_B$, then

$$P \geq 2f\sum T_A \sin\frac{\varphi}{2}\sqrt{\left(\frac{h_0}{l}\right)^2 + 1}$$

Where:

P: Tensile strength of the guy (N)

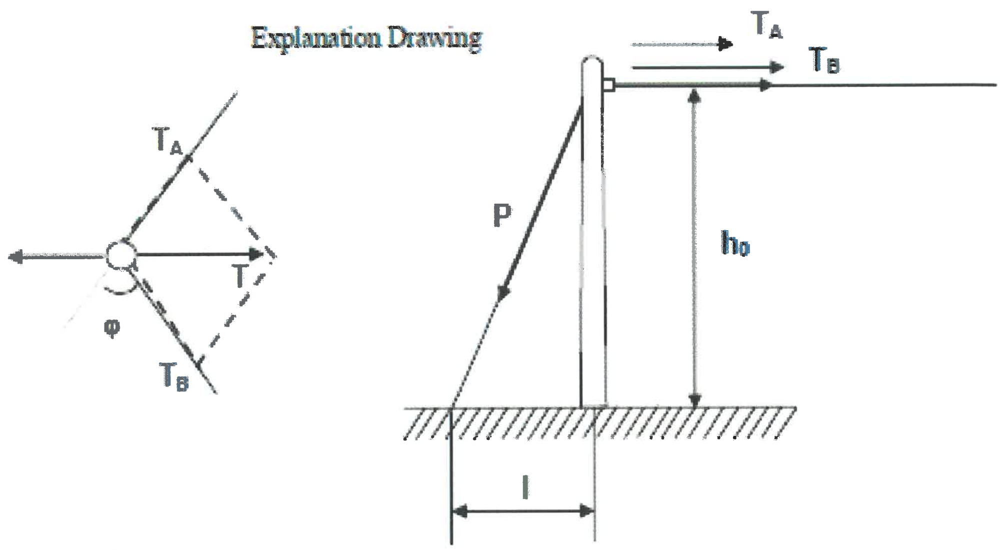
h_0: Height of the installed point of the guy (m)

T: Assumed maximum tension unbalance of a conductor (N)

l: Length between the pole and the guy at the surface of earth (m)

f: Safety factor

Explanation Drawing



[In Case of no Guys]

If the calculation of the strength of a supporting structure is surely conducted and the safety factor of foundation of the supporting structure shall be 2.0 or more prescribed in the article 40.2, guys are not necessary.

[Example 1(a. Supporting structures lacking strength against the wind pressure - Calculation of the horizontal transverse strength)]

(Condition)

(1)MV Line(AAC150mm²×3wire, Diameter d_1=0.0168m)

(2)LV Line (PVC75mm²×3wire, Diameter d_2=0.0170m)

(3)Span (S_1=60m, S_2=40m, $S=(S_1+S_2)/2$=50m)

(4)Supporting Structure (Square pole)

Top end breadth D_1=0.15m,

Ground-level breadth D_0=0.30m

Height above the ground H=11.7m

Embedded depth t = 2.3m

(5)Wind pressure to 1m² of the vertical projected area

Iron-reinforced concrete pole (square pole) : K_1=1,290Pa

Conductor : K_2= 680Pa

(6)Foundation block (a rectangular parallelepiped)

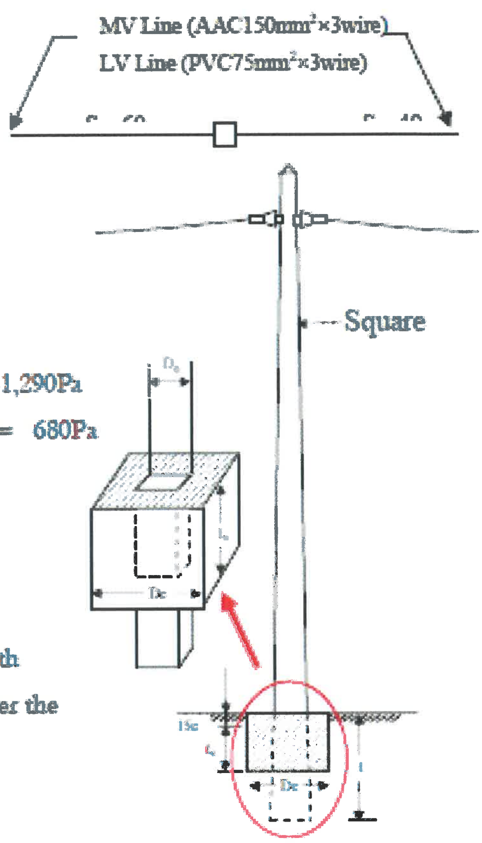
Transverse breadth D_C = 1.0m

Depth t_c = 1.5m

(7)Classification of soil

Classification : [B]Aggregated soil or sand, and soil with plenty of gravel or stone belonging under the soft coil

Soil coefficient K = 3.9×10⁷ (N/m⁴)



P = P_P (Wind pressure for the pole into a concentrated load at the top)

+ P_w(Wind pressure for the conductors into a concentrated load at the top)

$$= K_1 \times \frac{(2D_1 + D_0)H}{6} + K_2 S \sum d$$

$$= 1{,}290 \times \frac{(2\times0.15+0.30)\times11.7}{6} + 680\times50\times(0.0168\times3+0.0170\times3) = 4956.9\ [N]$$

$$\alpha = \frac{D_c}{D_0} = 3.33 \qquad \beta = \frac{t_c}{t} = 0.652 \qquad t_0'' = \frac{2}{3}t\left\{\frac{1+\beta^3(\alpha-1)}{1+\beta^2(\alpha-1)}\right\} = 1.27 \qquad \gamma = \frac{t_0''}{t} = 0.552$$

$$\rho = 36\left[\frac{\gamma^2}{2}\{1+\beta^2(\alpha-1)\}-\frac{2}{3}\gamma\{1+\beta^3(\alpha-1)\}+\frac{1}{4}\{1+\beta^4(\alpha-1)\}\right]=1.87$$

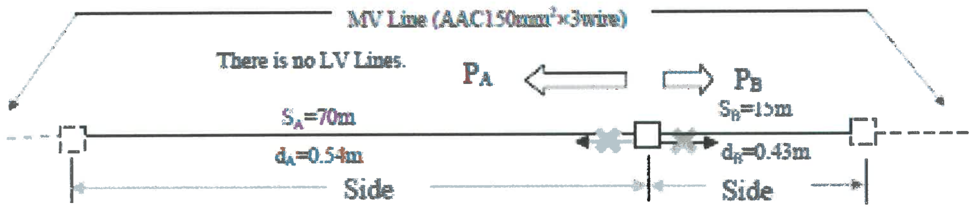
Therefore, the safety factor of foundation f is calculated as follows;

$$f=\frac{\rho K D_0 t^4}{120P(H+t_0)^2}=\frac{1.87\times3.9\times10^7\times0.30\times2.3^4}{120\times4956.9\times(11.7+2/3\times2.3)^2}=5.88$$

(t_0 : Depth of the center of gyration of the supporting structure from the ground surface (m); $t_0 = 2/3t$)

→ Because the safety factor 5.88 of foundation is more than 2, guys are not necessary.

[Example 2(b. Supporting structure of which spans on both side are too different - Calculation of the horizontal longitudinal strength))]



(Condition)

(1)MV Line(AAC150mm²×3wire, Weight W=0.434kg/m)

(2)Span S_A=70m (Side A), S_B=15m (Side B)

(3)Sag for overhead MV conductors

d_A=0.54m (Side A), d_B=0.43m (Side B)

(4)Supporting Structure (Square pole)

Top end breadth D_1=0.15m, Ground-level breadth D_0=0.30m

Height above the ground H=10.0m, Embedded depth t = 2.0m

(5)Wind pressure to 1m² of the vertical projected area

Iron-reinforced concrete pole (square pole) : K_1=1,290Pa

(6)Foundation block (a rectangular parallelepiped)

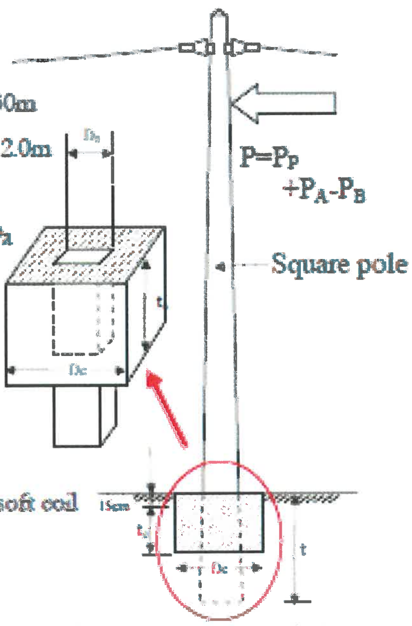
Transverse breadth D_C = 1.0m

Depth t_c = 1.5m

(7)Classification of soil

Classification : [B]Aggregated soil or sand, and soil with plenty of gravel or stone belonging under the soft soil

Soil coefficient K = 3.9×10⁷ (N/m⁴)



If the wind direction is as same as "P_A", the pole has to be burdened with the maximum load "P".

P = P_P (Wind pressure for the pole into a concentrated load at the top)

343

+ P_A (Horizontal Transverse Component of the maximum tension of Conductors on the side A)

□ P_B (Horizontal Transverse Component of the maximum tension of Conductors on the side B)

$$= K_1 \times \frac{(2D_1 + D_0)H}{6} + \left(\frac{WgS_A^{\,2}}{8d_A} \times 3 - \frac{WgS_B^{\,2}}{8d_B} \times 3 \right)$$

$$= 1{,}290 \times \frac{(2 \times 0.15 + 0.30) \times 10.0}{6} + \frac{0.434 \times 9.8 \times 70^2}{8 \times 0.54} \times 3 - \frac{0.434 \times 9.8 \times 15^2}{8 \times 0.43} \times 3 = 14{,}928 \ [N]$$

$$\alpha = \frac{D_c}{D_0} = \frac{1.0}{0.30} = 3.33 \quad \beta = \frac{t_c}{t} = \frac{1.5}{2.0} = 0.75 \quad t_0'' = \frac{2}{3} t \left\{ \frac{1+\beta^3(\alpha-1)}{1+\beta^2(\alpha-1)} \right\} = 1.144 \quad \gamma = \frac{t_0''}{t} = 0.572$$

$$\rho = 36\left[\frac{\gamma^2}{2}\{1+\beta^2(\alpha-1)\} - \frac{2}{3}\gamma\{1+\beta^3(\alpha-1)\} + \frac{1}{4}\{1+\beta^4(\alpha-1)\} \right] = 2.022$$

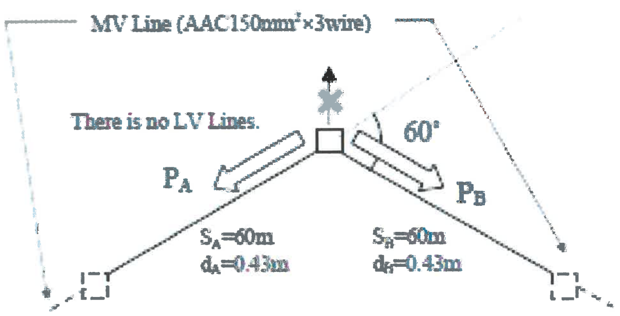
Therefore, the safety factor of the foundation f is calculated as follows;

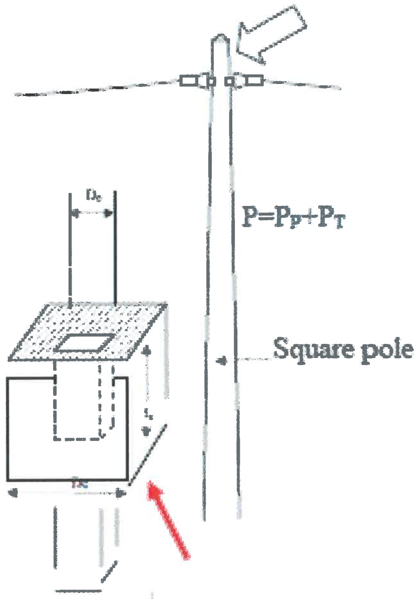
$$f = \frac{\rho K D_0 t^4}{120P(H+t_0)^2} = \frac{2.02 \times 3.9 \times 10^7 \times 0.30 \times 2.0^4}{120 \times 14{,}928 \times (10.0 + 2/3 \times 2.0)^2} = 1.64$$

(t_0: Depth of the center of gyration of the supporting structure from the ground surface (m); $t_0 = 2/3t$)

→ Because the safety factor 1.64 of foundation is less than 2, guys are necessary and cannot be omitted.

[Example 3(c. Supporting structure of which lines on both side make an angle more than 5 degrees)]





(Condition)

(1)MV Line(AAC150mm²×3wire, Weight W=0.434kg/m)

(2)Span S_A=60m (Side A), S_B=60m (Side B)

(3)Sag for overhead MV conductors $d_A=d_B$=0.43m

(4)Supporting Structure (Square pole)

Top end breadth D_1=0.15m, Ground-level breadth D_0=0.30m

Height above the ground H=10.0m, Embedded depth t = 2.0m

(5)Wind pressure to 1m² of the vertical projected area

Iron-reinforced concrete pole (square pole) : K_1=1,290Pa

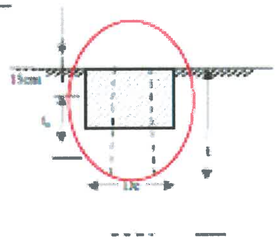
(6)Foundation block (a rectangular parallelepiped)

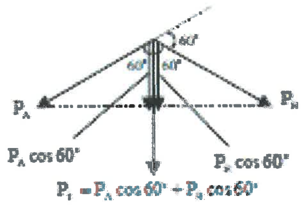
Transverse breadth D_C = 1.0m

Depth t_c = 1.5m

(7)Classification of soil : [B]Aggregated soil or sand, and soil with plenty of gravel or stone belonging under the soft coil

Soil coefficient K = 3.9×10⁷ (N/m⁴)





P = P_P (Wind pressure for the pole into a concentrated load at the top)

+ P_T (Horizontal Transverse Component of the maximum tension of Conductors)

$$(P_T = P_A \cos 60^\circ + P_B \cos 60^\circ)$$

$$= K_1 \times \frac{(2D_1 + D_0)H}{6} + \left(\frac{WgS_A{}^2}{8d_A} \times 3 \times 0.5 + \frac{WgS_B{}^2}{8d_B} \times 3 \times 0.5 \right) \qquad (\because \cos 60^\circ = 0.5)$$

$$= 1{,}290 \times \frac{(2 \times 0.15 + 0.30) \times 10.0}{6} + \frac{0.434 \times 9.8 \times 60^2}{8 \times 0.43} \times 3 \times 0.5 + \frac{0.434 \times 9.8 \times 60^2}{8 \times 0.43} \times 3 \times 0.5$$

$$= 14{,}634 \text{ [N]}$$

$$\alpha = \frac{D_c}{D_0} = \frac{1.0}{0.30} = 3.33 \quad \beta = \frac{t_c}{t} = \frac{1.5}{2.0} = 0.75 \quad t_0'' = \frac{2}{3} t \left\{ \frac{1+\beta^3(\alpha-1)}{1+\beta^2(\alpha-1)} \right\} = 1.144 \quad \gamma = \frac{t_0''}{t} = 0.572$$

$$\rho = 36\left[\frac{\gamma^2}{2}\{1+\beta^2(\alpha-1)\} - \frac{2}{3}\gamma\{1+\beta^3(\alpha-1)\} + \frac{1}{4}\{1+\beta^4(\alpha-1)\} \right] = 2.022$$

345

Therefore, the safety factor of the foundation f is calculated as follows;

$$f = \frac{\rho K D_0 t^4}{120P(H+t_0)^2} = \frac{2.02\times3.9\times10^7\times0.30\times2.0^4}{120\times14.928\times(10.0+2/3\times2.0)^2} = 1.67$$

(t_0 : Depth of the center of gyration of the supporting structure from the ground surface (m); $t_0 = 2/3t$)

→ Because the safety factor 1.67 of foundation is less than 2, guys are necessary and cannot be omitted.

[Example 4(d. Supporting structure which supports the end of a line - Calculation of the horizontal longitudinal strength)]

(Condition)

(1)MV Line(AAC150mm²×3wire, Weight W_1=0.434kg/m)

(2)Span (S_1=60m)

(3)Sag for overhead MV conductors (d_1=1.25m)

(4)Supporting Structure (Square pole)

Top end breadth D_1=0.15m,

Ground-level breadth D_0=0.30m

Height above the ground H=10.0m

Embedded depth t = 2.0m

(5)Wind pressure to 1m² of the vertical projected area

Iron-reinforced concrete pole (square pole) : K_1=1,290Pa

(6)Foundation block (a rectangular parallelepiped)

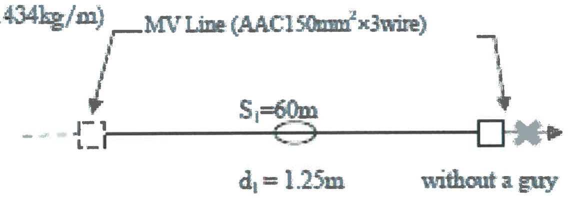
Transverse breadth D_C = 1.0m

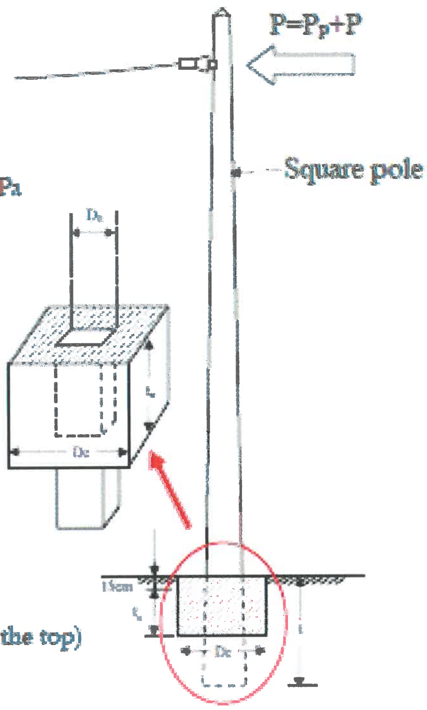
Depth t_c = 1.5m

(7)Classification of soil

Classification : [B]Aggregated soil or sand, and soil with plenty of gravel or stone belonging under the soft coil

Soil coefficient K = 3.9×10⁷ (N/m⁴)





P = P_P (Wind pressure for the pole into a concentrated load at the top)

+ P_T(Horizontal Transverse Component of the maximum tension of Conductors)

$$= K_1 \times \frac{(2D_1 + D_0)H}{6} + \left(\frac{W_1 g S_1^2}{8D_1} \times 3\right)$$

$$= 1{,}290 \times \frac{(2\times 0.15 + 0.30)\times 10.0}{6} + \frac{0.434\times 9.8\times 60^2}{8\times 1.25}\times 3 = 5{,}883 \quad [N]$$

$$\alpha = \frac{D_c}{D_0} = 3.33 \qquad \beta = \frac{t_c}{t} = 0.75 \qquad t_0'' = \frac{2}{3}t\left\{\frac{1+\beta^3(\alpha-1)}{1+\beta^2(\alpha-1)}\right\} = 1.144 \qquad \gamma = \frac{t_0''}{t} = 0.572$$

$$\rho = 36\left[\frac{\gamma^2}{2}\{1+\beta^2(\alpha-1)\} - \frac{2}{3}\gamma\{1+\beta^3(\alpha-1)\} + \frac{1}{4}\{1+\beta^4(\alpha-1)\}\right] = 2.022$$

Therefore, the safety factor of the foundation f is calculated as follows;

$$f = \frac{\rho K D_0 t^4}{120P(H+t_0)^2} = \frac{2.02\times3.9\times10^7\times0.30\times2.0^4}{120\times5{,}883\times(10.0+2/3\times2.0)^2} = 4.161$$

(t_0 : Depth of the center of gyration of the supporting structure from the ground surface (m); $t_0 = 2/3t$)

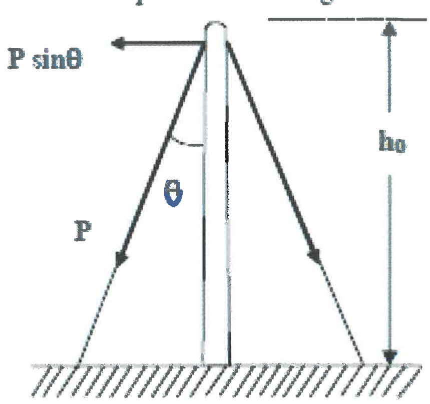
→ Because the safety factor 4.161 of foundation is more than 2, guys are not necessary.

[Calculation of the equation ex40-17, 18, 19 and 20]

(1) Guys for the wind pressure lateral to a line (Single pole)

If each guy burdens a half of the wind pressure and the supporting structure itself burdens another half of the wind pressure, the resistant moment of the guy(Mr) is

Explanation Drawing



$$Mr \geq F \cdot K \cdot \frac{1}{2}(Mp + Mw)$$

Mp : The bending moment due to the wind pressure for a pole converted into the top position of the pole

Mw : The sum of the bending moment due to the wind pressure for each conductor

F : Safety Factor

$$P\sin\theta \cdot h_0 \geq F \cdot K \cdot \frac{1}{2}\left\{\frac{K_1}{100}\left(\frac{D_0H^2}{2} - \frac{kH^3}{3}\right) + K_2 \cdot \frac{S\left(\sum dh\right)}{1000}\right\}$$

$$P \geq \frac{K}{h_0 \times 10^3}\left\{0.5F \cdot K_2S\left(\sum dh\right) + 5F \cdot K_1\left(\frac{D_0H^2}{2} - \frac{kH^3}{3}\right)\right\}\operatorname{cosec}\theta$$

In the case of the safety factor F = 2.5(referred to Table 40C), the equation ex40-17 is obtained;

$$P \geq \frac{K}{h_0 \times 10^3}\left\{1.25 \cdot K_2S\left(\sum dh\right) + 12.5 \cdot K_1\left(\frac{D_0H^2}{2} - \frac{kH^3}{3}\right)\right\}\operatorname{cosec}\theta$$

In the case of K_1=520(N/m²), K_2=680(N/m²), the equation ex40-18 is obtained;

$$P \geq \frac{K}{h_0 \times 10^3}\left\{850S\left(\sum dh\right) + 3{,}250D_0H^2 - 2{,}167kH^3\right\}\operatorname{cosec}\theta$$

(2) Guys for the wind pressure lateral to a line (H-type pole)

As the bending moment due to the wind pressure for each conductor is distributed to two supporting structure, the resistant moment of the guy(Mr) is ;

$$Mr \geq F \cdot K \cdot \frac{1}{2}\left(Mp + \frac{Mw}{2}\right)$$

$$P\sin\theta \cdot h_0 \geq F \cdot K \cdot \frac{1}{2}\left\{\frac{K_1}{100}\left(\frac{D_0H^2}{2} - \frac{kH^3}{3}\right) + \frac{1}{2} \cdot K_2 \cdot \frac{S\left(\sum dh\right)}{1000}\right\}$$

$$P \geq \frac{K}{h_0 \times 10^3}\left\{0.25F \cdot K_2S\left(\sum dh\right) + 5F \cdot K_1\left(\frac{D_0H^2}{2} - \frac{kH^3}{3}\right)\right\}\operatorname{cosec}\theta$$

In the case of the safety factor F = 2.5, the equation ex40-19 is obtained;

$$P \geq \frac{K}{h_0 \times 10^3}\left\{0.625 \cdot K_2 S\left(\sum dh\right) + 12.5 \cdot K_1\left(\frac{D_0 H^2}{2} - \frac{kH^3}{3}\right)\right\} \operatorname{cosec}\theta$$

In the case of K_1=520(N/m²), K_2=680(N/m²), the equation ex40-20 is obtained;

$$P \geq \frac{K}{h_0 \times 10^3}\left\{425S\left(\sum dh\right) + 3{,}250 D_0 H^2 - 2{,}167kH^3\right\} \cdot \operatorname{cosec}\theta$$