ASSEMBLY AND INSTALLATION OF AMBOR TRANSMISSION STRUCTURES

The following information is intended to be a helpful guide in preparing construction specifications. This is general information about typical Ambor products and cannot cover all situations or the special features that may be unique to a specific utility. Therefore it is essential that the utility and contractor not rely only on these guidelines to determine the steps to be followed, but carefully plan all aspects of the installation process, complying with all requirements of the utilities design specification. Care must be taken during installation to avoid structural damage which could weaken the members and prevent them from supporting the intended loads. Ambor cannot be liable for damage of that type.

IDENTIFICATION OF COMPONENTS

1. Each major component includes an identification tag welded to the member. The Ambor assembly number are stamped on each tag. The drawings show:

    a. The location of each tag.
    b. The identification number on each tag.

ANCHORAGE

1. An evaluation of local soil conditions should be made by a competent foundation designer. The foundation size and reinforcing must be adequate to withstand the maximum reactions which might be applied by the pole base.

2. Concrete foundations should be installed well ahead of the installation of the poles. Standard concrete requires about 28 days to develop its full design strength.

3. In designing and installing the foundation, consideration should be given to the possible need for underground wiring and grounding.

4. Projection of the anchor bolts should allow for the thickness of the base plate, nuts (including leveling nuts), and raking if required. The suggested projection dimensions are shown on the drawings of the anchor bolt cage assemblies.

5. Orientation of the anchor bolts in relation to the direction of the transmission line must be checked carefully using data from the drawings and the utility's plans and specifications. A V-notch is included in the top plate of the anchor bolt cage assembly for this purpose. The anchor bolts must also be vertical. This is typically checked by levelling the top cage plate.

6. *Prior to installing the anchor bolt cage verify the part number on the cage. Several anchor bolt cage assemblies can appear to be similar. Also, inspect the cage assembly for shipping or handling damage. In addition to the proper part number for the location, verify the anchor bolt cage assembly squareness and the anchor bolt circle roundness against the assembly drawing (a cage that has been dropped can become ovalized). This check will avoid an out-of-round anchor bolt cage not fitting the structure base plate later. If the anchor bolt cage is found to be out-of-round, contact the appropriate representative.*

7. Reinforcing steel must not be welded to the anchor bolts.

8. Care must be taken not to disturb the position of the anchor bolts while pouring concrete.

9. After the concrete sets, the top cage plate should be removed and the nuts should be retained for installation of the structure.

10. Levelling nuts should be adjusted before installing the pole. Typically they should be in a horizontal plane. However they can be used to obtain a desired rake. The bottom of the base plate should be no more than 2 times the diameter of the anchor bolt above the top of the concrete foundation.

11. In the case of structures which utilize embedded base installation, typically the bottom (embedded) section of the pole is installed in the ground first. The specified embedment depth shall be satisfied. Care should be taken to assure that the bottom section is vertical before proceeding with the erection of the rest of the pole since there is no adjustment to this type installation as there is with the levelling nuts on anchor bolt type foundations.

ASSEMBLY

1. General

a. Where space near the foundation and lifting capabilities permit, it is preferable to assemble the complete structure on the ground and erect it as a unit (except see "Anchorage—Item 11" concerning embedded base poles). The sections of the pole should be aligned on the ground and supported, typically with wood blocks, in such a manner that they will readily fit together. Care should be taken to prevent dirt, stones, etc. from getting trapped between the mating surfaces.

b. If the structure is assembled vertically, extra care may be needed to assure that all joints are properly assembled as indicated in the following paragraphs.

c. Proper alignment of the pole sections is usually facilitated by the location of the identification tags, but need to pay attention that tags are not always on the same face of pole. These tags are positioned on the sections so that aligning them on the same side for the entire pole length will assure proper orientation of all conductor attachment points, arm attachments, camber, etc.

2. Slipover joints

a. To facilitate the assembly, mating surfaces may be lubricated. Care should be taken not to use a lubricant that will later leak from the joint and stain the pole. Soapy water has been used successfully for this purpose.

b. Each identification tag is positioned to indicate maximum splice. The mating section should never exceed this position. In addition, this tag can be used to determine if minimum splice has been achieved.

c. A sound slip joint depends on the application of the necessary force to achieve a tight joint. Although the method selected may depend upon the size of the pole sections, the type of pole design and the equipment available to the contractor, Ambor highly recommends the use of a hydraulic jacking device which is available for rent or purchase. Alternatively, two ratchet chain hoists or similar devices on opposite sides

of the pole tube have been used. These may pull on cables secured to the pole sections with a choker type hitch or attached to 1" bolts installed in the jacking nuts. Equal forces must be applied by the devices simultaneously. If the jacking nuts are used, forces must be applied no more than 1.5 inches from the surface of the pole and the forces must be distributed equally to all the nuts at each joint.

A tight, sound slip joint is determined by:

1. The force used in assembly is at least the minimum specified below table

PULL FORCE REQUIREMENT	
Inner diameter (flat to flat) of the female end (mm)	Minimum Pull Force "A" Per side (kN)
<300	20
300-500	30
500-700	40
700-900	50
900-1200	60
1200-1400	80
1400-1600	100
1600-1800	120
1800-2000	150
>2000	200

2. Any additional force applied to the joint does not result in additional movement of the joint;
3. The overlap length achieved is at least the minimum and not more than the maximum specified on the Ambor drawings;
4. The joint shows no more than small gaps (which can be caused by slight mismatch in the shapes of the mating sections).

Forces should be applied in a slow steady pull and the assembly be facilitated by oscillating the advancing section with the supporting crane or by striking the pole in the area of the joint with a hammer using a cushioning block of wood.

3. Bolted joints

a. Multiple-bolt, moment connections (e.g. arm-to-pole connections, flange connections): These bolts should be tightened in accordance with AISC guidelines, excerpts of which are attached. Threads may need to be lubricated in the field in order to achieve bolt tension in accordance with AISC recommendations. Hardware suppliers use beeswax and various commercial waxes as lubricants.

b. Single-bolt, pinned connections (e.g. swing brackets, cross-bracing, pinned crossarms): These bolts should be tightened until the bolt head and nut are snug against the outer plates and the nut locking device is fully engaged. All plates do not need to be in contact.

c. Anchor bolts: After plumbing the structure, all nuts should first be uniformly snugged against the base plate. Then some provision should be made to prevent unauthorized loosening of the nuts. The most common method: A slight amount of additional tightening of each top nut.

d. Cantilever arms: Before tightening the arm attachment bolts, the arm should be rotated toward the base of the structure to remove all play in the connection. While tightening the bolts, care should be taken to assure that the arms all remain in the same plane. BOLT TIGHTENING BEYOND THE ABOVE RECOMMENDED PRETENSION IS NOT REQUIRED JUST TO BRING THE CONNECTION PLATES INTO CONTACT. A SMALL GAP BETWEEN THE ARM BRACKET AND CONNECTION VANGS IS ACCEPTABLE.

e. H-frame structures: Bolts in connections that are part of the frame assembly (i.e. not attachments of cantilever sections) should be left loose until all such bolts are installed. After all bolts are installed, the nuts should be tightened in the following sequence.

1. Connections between main pole sections.

2. Connections between cross-arms and poles.

3. Connections between cross-braces and poles.

4. Connections between cross braces.

Care should be taken to maintain all alignments during this tightening operation.

CORROSION PROTECTION and STORAGE

1. After assembly, any damage to the protective coating on the structure should be repaired.
2. An on-going maintenance program must include periodic inspection for normal deterioration of the protective coating and for any indication of corrosion, which may be localized. Rehabilitation of the protective coating must be done to preserve the structural integrity of each assembly.
3. Structures should not be stored longer than 6 months prior to use. All stored structures should be kept well ventilated. Sections should be blocked off the ground and separated if sections are stacked on top of each other. Wooden blocks should be non-treated wood (wood treatments can be caustic to steel) and metal blocking should be coated (rusting steel will stain the sections). Remove all packing and shipping materials to avoid finish deterioration through holding moisture against the surface. Provide adequate drainage so water, including any caused by condensation inside the pole, does not accumulate inside the pole or on outside surfaces. Rotation of the poles should be performed to equalize any finish aging. All finishes are subject to aging and gradual deterioration. Deterioration comes from many causes such as:
   a. corrosive elements in the atmosphere.
   b. salt spray from road surfaces or a marine environment.
   c. moisture from rainfall or condensation.
   d. UV exposure.

ASSEMBLY AND INSTALLATION OF AMBOR TRANSMISSION STRUCTURES

ERECTION

1. Prior to lifting the structure, any slipover joint below the crane attachment point should be securely lashed to prevent any possibility of separation during lifting.

2. The lifting crane must be attached:

   a. above the center of gravity of the entire assembly including the weight of all equipment mounted on the structure before erection.

   b. to the main pole member(s) or, if to the arms, the attachment(s) must be close to the pole(s).

   c. as high as possible since higher attachment will result in more nearly vertical alignment of the assembly while suspended above the foundations.

3. H-frame structures may require a spreader bar to achieve two points of attachment to the structure and to assure that all lifting forces are applied vertically.

4. Care should be taken to operate the crane very smoothly since jerkiness will cause impact loads which could damage some portion of the assembly.

5. At least a few anchor bolt nuts should be installed as quickly as possible after the base plate is in place. If the pole is eccentrically loaded such as in the case of arms on only one side, the nuts on the side opposite the direction of eccentricity should be installed first.

6. The use of grout between the base plate and the concrete foundation is not recommended or structurally required. Galvanized structures require a method of drainage for any moisture that may enter the pole section and weathering steel structures should not have a surface that could hold moisture against the bottom of the base plate. If grouting under the base plate is used, it is critical that sufficient drainage is provided from the inside of the pole.

ATTACHMENT OF EQUIPMENT

1. Transmission structure components may be affected by vibrations induced aerodynamically or from other sources. Although rare, these vibrations can be severe enough to cause damage. This is believed to be more likely to happen when structures (or components such as arms) are installed without insulators and conductors which contribute damping to the system. It is considered good practice for installers to attach at least some equipment to each arm at the time of installation of the structure. The proposed IEEE “Guide to the Assembly and Erection of Metal Transmission Structures” mentions the following methods:

   a. suspending weights or insulators from the arms.

   b. tying the arm tips together and to the structure.

   Also damping devices such as the Stockbridge type may be effective.

ASSEMBLY AND INSTALLATION OF AMBOR TRANSMISSION STRUCTURES

The following are excerpts from Research Council on Structural Connections Specification for Structural Joints Using ASTM A325 or A490 Bolts, June 23, 2000. Refer to the complete document if interested in any references outside these excerpts.

2.3.3 Reuse

ASTM A490 bolts and galvanized ASTM A325 bolts shall not be reused. When approved by the Engineer of Record, black ASTM A325 bolts are permitted to be reused. Touching up or re-tightening bolts that may have been loosened by the installation of adjacent bolts shall not be considered to be a reuse.

8. Installation

Prior to installation, the fastener components shall be stored in accordance with Section 2.2. For joints that are designated in the contract documents as snug-tightened joints, the bolts shall be installed in accordance with Section 8.1. For joints that are designated in the contract documents as pre-tensioned or slip critical, the bolts shall be installed in accordance with Section 8.2.

8.1 Snug-tightened Joints

All bolt holes shall be aligned to permit insertion of the bolts without undue damage to the threads. Bolts shall be placed in all holes with washers positioned as required in Section 6.1 and nuts threaded to complete the assembly. Compacting the joint to the snug-tight condition shall progress systematically from the most rigid part of the joint. The snug-tightened condition is the tightness that is attained with a few impacts of an impact wrench or the full effort of an ironworker using an ordinary spud wrench to bring the connected plies into firm contact.

8.2 Pre-tensioned Joints

One of the pre-tensioning methods in Sections 8.2.1 through 8.2.4 shall be used, except when alternative-design fasteners that meet the requirements of Section 2.8 or alternative washer-type indicating devices that meet the requirements of Section 2.6.2 are used, in which case, installation instructions provided by the manufacturer and approved by the Engineer of Record shall be followed. When it is impractical to turn the nut, pre-tensioning by turning the bolt head is permitted while rotation of the nut is prevented, provided that the washer requirements in Section 6.2 are met. A pretension that is equal to or greater than the value in Table 8.1 shall be provided. The pre-installation verification procedures specified in Section 7 shall be performed using fastener assemblies that are representative of the condition of those that will be pre-tensioned in the work.

Table 8.1 Minimum Bolt Pretension for Pre-tensioned and Slip-Critical Joints

Nominal Bolt Diameter d_b in.	Specified Minimum Bolt Pretension T_m kips[a]	
	ASTM A325 and F1852 Bolts	ASTM A490 Bolts
1/2	12	15
5/8	19	24
3/4	28	35
7/8	39	49
1	51	64
1 1/8	56	80
1 1/4	71	102
1 3/8	85	121
1 1/2	103	148

[a] Equal to 70 percent of the specified minimum tensile strength of bolts as specified in ASTM Specifications for tests of full-size ASTM A325 and A490 bolts with UNC threads loaded in axial tension, rounded to the nearest kip.

8.2.1 Turn-of-Nut Pre-tensioning:

All bolts shall be installed in accordance with the requirements in Section 8.1, with washers positioned as required in Section 6.2. Subsequently, the nut or head rotation specified in Table 8.2, shall be applied to all fastener assemblies in the joint, progressing systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously pre-tensioned bolts. The part not turned by the wrench shall be prevented from rotating during this operation.

Table 8.2 Nut Rotation from Snug-Tight Condition for Turn-of-Nut Pretensioning[a,b]

Bolt Length	Disposition of Outer Face of Bolted Parts		
	Both faces normal to bolt axis	One face normal to bolt axis, other sloped not more than 1:20[d]	Both faces sloped not more than 1:20 from normal to bolt axis[d]
Not more than $4d_b$	1/3 turn	1/2 turn	2/3 turn
More than $4d_b$ but not more than $8d_b$	1/2 turn	2/3 turn	5/6 turn
More than $8d_b$ but not more than $12d_b$	2/3 turn	5/6 turn	1 turn

[a] Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For required nut rotations of 1/2 turn and less, the tolerance is plus or minus 30 degrees; for required nut rotations of 2/3 turn and more, the tolerance is plus or minus 45 degrees.
[b] Applicable only to joints in which all material within the grip is steel
[c] when the bolt length exceeds $12d_b$, the required nut rotation shall be determined by actual testing in a suitable tension calibrator that simulates the conditions of solidly fitting steel .
[d] Beveled washer not used.

8.2.2 Calibrated Wrench Pre-tensioning: the pre-installation verification procedures specified in Section 7 shall be performed daily for the calibration of the installation wrench. Torque values determined from tables or form equations that claim to relate torque to pretension without verification shall not be used.

All bolts shall be installed in accordance with the requirements in Section 8.1, with washers positioned as required in Section 6.2. Subsequently, the installation torque determined in the pre-installation verification of the fastener assembly (Section 7) shall be applied to all bolts in the joint, progressing systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously pre-tensioned bolts. The part not turned by the wrench shall be prevented from rotating during this operation. Application of the installation torque need not produce a relative rotation between the bolt and nut that is greater than the rotation specified in Table 8.2.

8.2.3 Twist-Off-Type Tension-Control bolt Pre-tensioning: Twist off-type tension-control bolts assemblies that meet the requirements of ASTM F1852 shall be used.

All fastener assemblies shall be installed in accordance with the requirements in Section 8.1 without severing the splined end and with washers positioned as required in Section 6.2. If a splined end is severed during this operation, the fastener assembly shall be removed and replaced. Subsequently, all bolts in the joint shall be pre-tensioned with the twist-off-type tension-control bolt installation wrench, progressing systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously pre-tensioned bolts.

8.2.4 Direct-Tension-Indicator Pre-tensioning: Direct tension indicators that meet the requirements of ASTM F959 shall be used. The pre-installation verification procedures specified in Section 7 shall demonstrate that when the pretension in the bolt reaches 1.05 times that specified for installation and inspection in Table 8.1, the gap is not less than the job inspection gap in accordance with ASTM F959.

All bolts shall be installed in accordance with the requirements in Section 8.1, with washers positioned as required in Section 6.2. The installer shall verify that the direct-tension-indicator protrusions have not been compressed to a gap that is less than the job inspection gap during this operation, and if this has occurred, the direct-tension-indicator shall be removed and replaced. Subsequently, all bolts in the joint shall be pre-tensioned, progressing systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously pre-tensioned bolts. The installer shall verify that the direct-tension-indicator protrusions have been compressed to a gap that is less than the job inspection gap.