GUAM POWER AUTHORITY
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TRANSMISSION & DISTIBUTION SPECIFICATION

Specification No. E-035

For

CLASS A (SELF-SUPPORTING) and CLASS B (GUYED) CONCRETE POLES FOR TRANSMISSION AND DISTRIBUTION SYSTEMS

CLASS A and CLASS B CONCRETE POLES
FOR TRANSMISSION AND DISTRIBUTION SYSTEMS
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PRESTRESSED SPUN

CONCRETE POLE SPECIFICATIONS

1.0 SCOPE:

1.1. This specification covers the design, construction and delivery of prestressed spun concrete pole for use on GPA electric transmission and distribution systems.

1.2. Poles are to be used in high humidity, high corrosion salt-air environment subject to severe earthquakes and typhoon winds.

1.2.1 Wind speeds of 155 miles per hour (sustained) and 170 mph (3 second gust)

1.2.2 Earthquake loading per International Building Code – 2009 .

1.3 Poles are to be installed in soil foundations or in concrete foundations.

2.0 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. The latest edition shall always be used.

Substitute standards may be used for those listed below provided they have equal or superior requirements. Such standards must be submitted to GPA for review and approval.

2.1. American Concrete Institute (ACI) Publications:

211.1	Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete
214	Recommended Practice for Evaluation of Strength Test Results of Concrete
318	Building Code Requirements for Reinforced Concrete

2.2. American Society for Testing and Materials (ASTM) Publications:

A82	Cold-drawn Steel Wire for Concrete Reinforcement
A416	Uncoated Seven-Wire Stress-Relieved Strand for Prestressed Concrete
A421	Uncoated Stress Relieved Steel for Prestressed Concrete
A496	Steel Wire, Deformed for Concrete Reinforcement
A615	Deformed and Plain Billet-Steel Bar for Concrete Reinforcement
A641	Zinc Coated (Galvanized) Carbon Steel Wire (Meteric)
A706	Low Alloy Steel Deformed Bars for Concrete Reinforcement
A996	Axel-Steel Deformed and Plain Bars for Concrete Reinforcement
C33	Concrete Aggregates
C39	Compressive Strength of Cylindrical Concrete Specimen
C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

C143	Test for Slump of Portland Cement Concrete
C150	Portland Cement
C172	Sampling Freshly Mixed Concrete
C260	Air-Entraining Admixtures for Concrete
C289	Testing Potential Alkali-Silica Reactivity of Aggregates
C494	Chemical Admixtures for Concrete
C881	Epoxy-Resin-Base Bonding Systems for Concrete
C1089	Standard Specifications for Spun Cast Prestressed Concrete Poles

2.3. American Welding Society (AWS) Publication:

D1.1	Recommended Procedures for Welding, Reinforcing Steel, Metal Inserts, and Connections in Reinforced Concrete Construction
D1.4	Structural Welding Code - Reinforcing Steel

2.4. Prestressed Concrete Institute (PCI) Publication:

MNL-116	Manual for quality control for plants and production of precast prestressed concrete products
MNL -116	Tendon prestressing to be in accordance with applicable sections of this publication

2.5 American National Standards Institute (ANSI) C2, 2012 National Electric Safety Code (NESC) Part 2 Safety Rules for Overhead Lines

Section 23	Clearances
Section 24	Grades of Construction
Section 25	General Loading Requirements
Section 26	Strength Requirements

2.6 29GAR – Public Works

1301	General

2.7 International Building Code 2009

2.8 Industrial Fasteners Institute (IFI)

Fastener Standards

2.9 American Society of Civil Engineers/Prestressed Concrete Institute (ASCE/PCI) Joint Committee on Concrete Poles:

Guide for the Design of Prestressed Concrete Poles

3.0 DEVIATION AND NON-CONFORMANCE REQUIREMENTS:

3.1. Provisions indicated by asterisks, (e.g. *3.4* below), describe submittals which must be included with the bid proposal. Failure to comply is a basis for rejection of the bid.

3.2. All deviations from this specification including changes in design or materials after bid award must be approved by the GPA and acknowledged by a Purchase Order Amendment issued by GPA. If the deviations are not approved, the unit or units are considered to be non-binding.

3.3. Units received with deviations or non -conformance which are not acknowledged per Section 3.2 are subject to rejection. The Supplier of rejected units is responsible for any corrective action including, but not limited to all materials, labor, and transportation charges necessary to dispose of or to make the units conform to the specification.

3.4. Statement of Compliance - the Supplier shall provide a signed statement in the bid proposal verifying that the products being supplied fully comply with the specifications and drawings. The Supplier shall provide all preliminary design drawings and design calculations required in this specification at the time of the bid, which will be approved by GPA prior to the award of the contract and the manufacture of the poles. Items not in full compliance with the specification and drawings will be identified with a description of the deficiency and any proposed substitutions. Items not in full compliance with the specifications and drawings must be approved by the GPA Engineering Department, as described in Section 3.2. Failure to comply with this requirement will result in the units being rejected.

4.0 SUBMITTALS:

4.1. Shop Drawings: Shop Drawings indicating details of construction shall be submitted to GPA for review prior to fabrication. Refer to Section 5 design calculations to be submitted to GPA Engineering.

Information required include:

a. Birth marks and longitudinal center of gravity mark.
b. Elevation view of each pole type.
c. Section and details to indicate quantities and position of prestressing steel, reinforcing steel, spiral steel, inserts, steel strand lifting loops, through holes, etc.
d. Location and sizes of all openings and holes to be cast in the poles.
e. Storage, transportation and erection support points.
f. Dimensions and finishes.
g. Pole classifications A or B.
h. Shop drawings shall be certified by a Professional Structural Engineer.
i. Pole design calculations shall be certified by a Professional Structural Engineer.

Partial submittals will not be acceptable and will be returned without review. Submittals shall include the manufacturer's name, project specification and paragraph reference, applicable industry and technical society publication references, design calculations, detail and other information to establish contract compliance of each item the Supplier proposes to furnish.

4.2. Certified Laboratory Test Reports: Certified copies of the reports of all tests and equipment required in referenced publications or otherwise specified herein, shall be submitted to GPA. The material testing shall have been performed within one (1) year of submittal of test reports for approval, by an independent laboratory approved by GPA.

Test reports on previously tested material shall be accompanied by notarized certificates from the manufacturer and approved laboratory, certifying that the previously tested materials is of the same type, quality, manufacturer, and make as proposed for use in this project. Certified material test reports in accordance with applicable codes are required for the following:

a. Cement
b. Concrete mix design
c. Reinforcing steel
d. Prestressing steel
e. Materials for curing concrete
f. Concrete admixtures
g. Aggregates
h. Water
i. Certificate of calibration for hydraulic jack
j. Certificate of calibration for dynamometer

4.3. The pole manufacturer must have approved submittals available during site inspection.

5.0 DESIGN:

5.1. Refer to Appendices A1-A, A1-B, A2-A, A2-B, A2-C, and "D" of this specification for specific requirements and detailed information related to design criteria, pole lengths, minimum reinforcement clearance, minimum wall thickness, hole dimensions, insert placements and spacings and maximum pole circumferences.

5.2. Poles shall be designed per the design criteria as specified in Appendix D and shall satisfy the strength requirements indicated in the Appendices (A4-B and A4-C for self-supporting poles and A4-E and A4-F for guyed poles). Submit detailed calculations including sections, elevations and loading conditions for each pole. Nomenclature, symbols and abbreviations used in the calculations shall be fully explained in English. The English System of units shall be used (pounds, feet, etc.). The submittal shall include the stress-strain curve of the prestressing steel strands. As a minimum, stresses for all design conditions shall be checked at ground level, at mid-level and at any point on the pole where a number of prestressed strands change. See Appendix B for calculation of prestress losses.

5.3 Wind loading of 155 mph (sustained), 170 mph (3 second gust) at 33 feet above the ground and earthquake loading per International Building Code - 2009 shall be used in the design.

5.4 Pole designs shall be prepared from the attached configuration drawings and design loads. The pole shall be capable of withstanding all specified loading cases including wind on pole and secondary stresses from foundation deflection and rotation, and from vertical loads acting on lateral pole deflection (P-delta effect). Design of poles for these secondary stresses shall not consider the possible restraining effect of conductors or shield wires. The pole shall withstand the loads without failure and without exceeding any specified deflection limitations.

5.6. Poles shall withstand the loading conditions, including specified load factors. The pole design shall include allowances for loads from handling, transportation, and erection without failure, permanent deformation, or damage to the pole when handled according to the manufacturer's instructions.

5.7. Poles shall be designed by the ultimate strength method as explained in ACI 318. Poles shall be designed so that the ultimate strength of the pole exceeds the required strength calculated from the factored loads applied to the pole including wind on the pole, as specified by GPA. The point of fixity on the pole shall be considered at groundline or other location as specified with the embedment depths shown on the attached drawings.

5.8. Poles shall be designed so that the cracking strength of the pole exceeds the required strength calculated from the service loads applied to the pole, as specified by GPA.

5.9. Poles that are subjected to a permanent unbalanced lateral load (such as unguyed angle or unguyed deadend structures), or any other structures specified by GPA, shall be designed so that the zero tension strength of the pole exceeds the required strength calculated from the service loads applied to the pole, as specified by GPA.

5.10. Poles shall be designed in combination with the appropriate column load applied along the pole axis as a result of the guys, braces, etc. When guys are specified, the ultimate load in the guy shall not exceed 65 percent of the rated breaking strength of the guy for all load cases. For design purposes, guy wire modulus of elasticity shall be specified by GPA. The manufacturer shall advise GPA if the specified guy size is inappropriate prior to submitting a bid.

5.11. Poles shall be designed to withstand a one-point (tilting) pickup during erection. The manufacturer shall include the weight of the pole with all insulators and hardware attached. The poles shall be designed for two-point pickup for horizontal handling. All pickup points shall be clearly shown on the fabrication drawings. All poles shall be designed for the loads generated from handling and erecting without exceeding the cracking moment capacity of the poles.

5.12. The design of each pole shall be performed using the applicable codes and standards listed in Section 2.0 of this specification.

5.13. Pole design and design calculations shall be the responsibility of the manufacturer.

6.0 PRODUCTS:

6.1. Concrete Mix: Design concrete mix in accordance with ACI 211.1 The concrete shall have a minimum 28 day compressive strength of 6,000 pounds per square inch with a maximum aggregate size of ¾ inch and a maximum water-cement ratio of 0.40. Higher strengths and lower water-cement ratios are encouraged and may be necessary to offset steel cover requirements.

6.2. Cement: The cement shall be either Type I or II Portland cement conforming to ASTM C 150. All cement for exposed concrete surfaces shall be of the same manufacturer.

6.3. Water: Water, including free moisture and water in the aggregates, shall be fresh, clean, potable and free from undesirable amounts of oils, acids, alkalis, salts, organic materials, or other deleterious substances.in amounts harmful to concrete and steel.

6.4. Aggregates: ASTM C 33. Obtain all aggregates for exposed concrete surfaces from one source. Aggregates shall be free from any substances which may be deleteriously reactive with the alkalies in the cement. (Three-fourths inch maximum aggregate size unless indicated otherwise).

6.4.1. Fine aggregate shall be a natural sand, consisting of clean, strong, hard, durable uncoated particles conforming to ASTM C33, and all specifications included therein. The aggregate shall be well graded from No. 4 to No. 200 sieve. Deleterious substances shall not comprise more than 5 percent of the sample.

6.4.2. Coarse aggregate shall be clean, tough, crushed stone conforming to ASTM C33, and all specifications included therein. The aggregate shall be well graded from a 3/4 inch to a No. 8 sieve with no more than 5 percent of the sample passing a No. 8 sieve. Deleterious substance content shall not exceed 5 percent of the sample. Resistance to abrasion shall not exceed 40 percent as tested in conformance with ASTM C131. Absorption shall be less than 4 percent or aggregate shall be saturated with water prior to use in concrete.

6.4.3. Aggregate shall be tested in accordance with ASTM C289 to determine an alkali-aggregate reaction. Crushed rock or partially crushed rock shall be the source of the aggregate.

6.5. Admixtures: ASTM C 260 (air entraining); ASTM C 494 (chemical). All admixtures shall have prior approval of GPA, shall be from a single manufacturer, and shall be certified by the manufacturer to be free of chlorides.

6.6 The chemical properties of materials used in the manufacture of the poles shall meet the requirements of the applicable ASTM specification and be such that noticeable pyrite staining or efflorescence due to sulfates and/or chlorides does not occur.

6.7. Concrete mix design requirements listed above can be altered with GPA's approval.

6.8. Reinforcement: Prestressing steel mechanical properties, reinforcing steel and spiral reinforcement shall be in accordance with the applicable ASTM specifications listed in Section 2.0 of this specification.

6.8.1. Reinforcing Bars: ASTM A 615, Grade 60 or approved equal. Welded splices shall be in accordance with AWS D1.4.

6.8.2. Spiral Wire: ASTM A 82, cold-drawn steel or approved equal.

6.8.3. Prestressing Steel: High tensile stress-relieved wire stand. ASTM A 416, Grade 270 or approved equal. The wire shall be free of substances that would prevent bond to the concrete.

7.0 PROVISIONS FOR GROUNDING

Poles shall be supplied with an approved method for grounding.

7.1. Preinstalled grounding provisions shall include the following:

7.1.1. Stranded copper conductor minimum size #2 AWG.

7.1.2. Copper or copper alloy connection block located where ground sleeves are shown in the Appendices (A1-A, A1-B, A2-A, A2-B and A2-C).

7.2. Design

7.2.1. Ground wires shall be continuous run, with no splicing, inside the hollow space of the pole and not embedded in the concrete. The wires shall be welded to the connection

blocks provided or connected (not soldered) so as to prevent disconnection of the wire from the connection block.

7.2.2. Ground sleeves shall be placed in the middle between the 11/16 inch and 13/16 inch holes, unless shown otherwise. Ground sleeves holes shall be 2 inches in diameter. The ground sleeve located at the bottom of the pole is to be placed two feet above the groundline, unless otherwise indicated.

7.2.3 Connection blocks shall be installed at all ground sleeves locations to allow for ease of external connection of copper conductor sizes between #6 AWG to #2 AWG. The connection block shall be rigid designed to prevent from being dislodged from the pole.

7.2.4 A minimum of one longitudinal steel strand shall be bonded electrically to the ground wire at the top and bottom of the pole. Each bond shall be located within the top 2 feet of the pole and at one foot below the groundline. This bonding system shall be noncorrosive and shall be approved by GPA.

8.0 SAMPLING AND TESTING:

8.1. General: Samples and tests are to be made by and at the supplier's expense. The tests shall be performed on calibrated equipment, as required by MNL-116, by an independent commercial testing laboratory or, if approved by GPA, at the precaster's quality control laboratory. Compressive strength tests made prior to tensioning of the prestressing strands may be performed in the precaster's quality control laboratory. Certified test reports shall include all test data and results.

8.2. Concrete Tests: For manufacturers that batch their own concrete, the manufacturer shall take a minimum of 8 concrete test cylinders per representative sample. Samples shall be taken at minimum intervals of one per day, one per 25 cubic yards of concrete batched, and with each change in raw material supplier for batches used to make GPAs' poles. The test cylinders for each day's concrete that is batched shall be tested for compressive strength as follows:

a. Minimum of one for determining release strength;
b. Minimum of one at 7 days;
c. Minimum of one at 14 days; and
d. Minimum of one at 28 days.

8.3. For manufacturers that acquire concrete from outside sources, test cylinders shall be taken from each truck load of concrete and tested in accordance with this specification.

8.4. Test cylinders shall be prepared, then cured in the same curing environment as the pole itself or cured per the applicable ASTM specification.

8. 5. Slump: Determine slump in accordance with ASTM C 143.

8.6. Concrete used on GPAs' poles shall have the quality to meet the design strength and other requirements included in this specification.

8.7. Upon request from GPA, the manufacturer shall provide GPA statistical data on concrete strength quality in accordance to applicable ACI and ASTM specifications. A correlation

factor between rodded cylinders and the spun concrete, substantiated by test data, shall be provided.

9.0 QUALITY CONTROL:

9.1. The Supplier shall have a quality control program to assure compliance with the requirements of this specification. The program shall be documented and a copy provided to GPA at the time of bid submittals.

9.2 Particular attention must be paid to the materials used. It is required that:

9.2.1. The Manufacturer will make the required test cylinders of the concrete used, protect and cure the cylinders in accordance with ACI 318 and perform the compressive tests on these specimens to ensure compliance with the strength requirements for tendon release and final compressive strength of the concrete.

9.2.2 The reinforcement materials shall be clean and made free of oil and scale.

9.3. The Supplier shall ensure that the water used in mixing concrete shall be clean potable and free from harmful amounts of silt, oil, acids, alkalies, salts, and other detrimental substances.

9.4. Notification of defective poles discovered before or after installation believed to be inherent to the manufacturing process or design shall be forwarded to the Supplier. This notice will include documentation of the problem and suggestions for follow-up actions expected by GPA. Supplier's response shall be made in thirty (30) days unless an extension is acknowledge and approved in writing by the GPA Manager of Engineering.

10 FABRICATION:

10.1. TOLERANCES AND PERMISSIBLE VARIATIONS:

10.1.1. CROSS SECTIONAL DIMENSIONS: Cross sectional dimensions shall not deviate from design dimensions by more than ¼-inch. Wall thickness shall not deviate from the design dimension by more than ¼ inch or +20 percent – 10 percent, whichever is greater.

10.1.2. LONGITUDINAL DIMENSIONS: Longitudinal dimensions shall not deviate from the design dimensions by more than 1 inch, or ⅛ inch per 10 feet.

10.1.3. The pole shall have a uniform taper from top to butt.

10.1.4. Deviation of the pole from straightness is allowed in one plane and one direction only. A straight line joining the edge of the pole at the butt and the edge of the pole at the top shall not be further from the surface of the pole at any point by more than the accumulated value of 0.25 inches for each 10 feet of length between the two ends. The detensioning operation shall be performed in a manner to keep the prestressing forces symmetrical.

10.1.5. There shall be a minimum specified wall thickness of 2.5 inches of spun concrete at all points along the pole.

10.1.6. LOCATION OF HARDWARE AND HOLES: The hole locations on the pole as to be placed as indicated in the Appendices and shall not deviate more than 1/16 inch from the nominal design dimensions. The hole spacing shall not deviate more than 1/16 inch from the nominal design dimensions where there is a pattern of holes for material to be bolted on at a later date.

10.1.7. GPA shall have the right to reject any pole in which the performance of a bolted connection may be reduced due to the lack of a clearly preformed or drilled hole.

10.1.8. The hydraulic jack equipment used to tension cables must be calibrated per manufacturer's operation manual. The GPA representative shall:

10.1.8.1. Verify the last time equipment was calibrated. This date should be in accordance with the operation manual.

10.1.8.2. Verify how often (number of poles) the equipment requires calibration.

a. The person or company calibrating the equipment shall be a calibrator certified by the manufacturer. GPA shall obtain a copy of the certification from the supplier or contractor.

10.1.8.3. Verify that the equipment tension setting stress is applicable to the structural design criteria requirements. At release of strands, 4,500-psi minimum stresses shall be maintained otherwise the pole is defective.

10.1.9. The GPA representative shall check the formwork placement and ensure that thesteel mold for the concrete pole is correct for the application. Check the following:

10.1.9.1. Type of pole (Class A or Class B).

10.1.9.2. Pole length measured.

10.1.9.3. Pole diameter measured bottom and top.

10.1.9.4. Complete concrete pole checklist.

10.1.9.5. Sleeve aligned to opposite sleeve and firmly attached to form.

10.1.9.6. Mold is cleaned of debris.

10.2. Placing of Reinforcement:

10.2.1. Steel reinforcement shall be fabricated as shown on the shop drawings and placed in position in the forms within the tolerances specified in ACI 318. Reinforcement shall be adequately secured so as to remain in the proper position during the placement of the concrete.

10.2.2. Reinforcement shall have a minimum of 1.8 inch concrete cover on the exterior, and 0.75 inches on the interior.

10.2.3. Reinforcement shall be free from loose scale.

10.2.4. GPA shall be notified as soon as possible of any poles with less than ¾ inch of spun concrete inside cover within 3 feet of the pole tip. At GPA's sole discretion, GPA may reject the pole or may allow the pole to be repaired by swabbing the interior with an epoxy liner (per ASTM C881 - Type V, Class B or C) and plugging with 3,000 psi concrete to GPA's satisfaction to a distance of 42 inches from the tip. No pole shall be plugged or considered for acceptance by GPA unless assurance is made by the manufacturer that the repaired pole can meet all requirements of this specification.

10.2.5. Spiral reinforcement shall cover the entire pole length. The minimum clear spacing of spiral reinforcement in the top 2 feet and bottom 2 feet of the pole shall be 4/3 of the maximum coarse aggregate or three times the strand diameter, whichever is larger, but not less than one inch. The maximum clear spacing for the remainder of the pole shall not exceed 4 inches.

10.2.6. The longitudinal steel shall not be cut for any reason unless approved by GPA – GPA may reject any pole in which the longitudinal steel is cut. All exposed steel resulting from drilled holes shall be covered with an epoxy paste per ASTM C881 Type III. Areas with moderate or severe spalling shall be cleaned and reformed with an epoxy paste or epoxy concrete per ASTM C881 Type II.10.3. Anchors, Inserts and Hole Formers: All anchors, inserts and hole formers shall be firmly positioned so as not to become displaced during the placing of concrete. They shall not be in contact or attached to the reinforcement. They shall be firmly attached to the forms.

10.2.7. All non-corrosive through-bolts and inserts provided by the manufacturer shall be of a noncorrosive material. Cadmium-plated and aluminum material shall not be used. All inserts shall be constructed of plastic PVC designed and manufactured for the intended purpose and used according to manufacturer's recommendations. If the manufacturer considers lifting devices necessary or desirable, suitable flush inserts may be cast into the pole with removable lifting attachments.

10.2.8. Where the sketches indicate holes for thru-bolts, these shall be made by using plastic held firmly in place and shall be full length of pole diameter for all through holes having internal diameters as required and shown in the Appendices. Unless otherwise noted on the drawings, holes shall be perpendicular to and pass through the centerline of the pole.

10.2.9. The use of porcelain or other ceramic type inserts is not permitted.

10.2.10. Inserts shall not fail before the pole reaches ultimate strength, unless permitted by GPA.

10.2.11. The pole manufacturer shall provide preformed inserts at two locations to allow air circulation within the pole. Inserts shall be 1 inch minimum diameter and shall have a louvered opening. The inserts shall be located within 10 feet of the tip and within 10 feet above the groundline.

10.2.12. Holes may not be drilled through the pole wall, except as specifically necessary to correct errors or omissions and only if approved by GPA.

10.4. Prestressing: Measure the required elongation of the prestressing steel prior to and after transfer of the prestressing force. Verify and record the stress in the steel by measuring and recording the elongation of the steel and the jacking pressure reading on an approved calibrated gage. Provide means for measuring the elongation of the steel to the nearest 0.125 inch. If the difference between any of the results of the measurements and gage reading is more than five percent, correct the cause of the discrepancy prior to construction of additional poles and mark the affected pole for additional testing. Provide the tensioning steel with a uniform prestress prior to being brought to design prestress. Transfer the prestressing force when the concrete has attained 0.80 of the minimum ultimate compressive strength of the pole. Induce the same initial prestress in each unit when several units of prestressing in a pole are stretched simultaneously. A complete record of the stressing of the strands shall be submitted to GPA as part of the Pole Manufacturing Data.

10.4.1. Clear distance between prestressing steel strands shall be either 4/3 times the maximum aggregate size or 3 times the strand diameter, whichever is larger. In the event that this condition is not met at the pole tip, closer spacing would be permitted provided that the placement of concrete can be accomplished satisfactorily, adequate stress transfer can take place, and appropriate provisions are used for maintaining spacing between the prestressing steel strands.

Prestressing steel stress limits shall not exceed:

a. 80 percent of the ultimate strength or 94 percent of the yield strength or the maximum value recommended by the manufacturer of prestressing steels or anchorages for jacking force;

b. 74 percent of the ultimate strength or 82 percent of the yield strength immediately after prestress transfer; and

c. 70 percent of the ultimate strength for post-tensioned steel at anchorages and couplers immediately after anchorage.

10.4.2. Strands shall be properly tensioned, secured and tied to spiral wire. At release of strands, 4,00-psi minimum stresses shall be maintained otherwise the pole is defective.

10.5. Consolidation of Concrete: All concrete shall be centrifugally spun in the forms. For external form vibration, forms must be of a design adequate to prevent distortion or failure.The poles shall be centrifugally spun using prestressed strands, rod, wire or with additional mild strength reinforcement.

10.6. Curing: Curing shall be accomplished in accordance with PCI MNL -116. The casting bed for concrete members cured by steam shall be enclosed completely with a suitable enclosure to minimize moistened heat losses. Curing methods shall be maintained until the specified strength of 4,500-psi minimum stress strength for detensioning has been reached.

10.6.1. Moist Curing: Moist cure for not less than 10 days. Proportionally increase the curing when the ambient air temperature falls below 50 degrees Fahrenheit.

10.6.2. Steam Curing: Include with the shop drawings methods and procedures for steam curing. Moist cure for not less than four hours prior to steam curing. During the application of steam, increase the air temperature at a rate not exceeding 40 degrees Fahrenheit per hour until the air temperature is maintained between 140 and 160

degrees Fahrenheit until the concrete has reached the required strength; air temperature above 160 degrees Fahrenheit will not be permitted. In discontinuing the steam application, decrease the air temperature at a rate not exceeding 40 degrees Fahrenheit per hour until reaching a temperature of 20 degrees Fahrenheit above .the temperature of the air to which the concrete will be exposed. Use a recording type thermometer for measuring temperature within the steam curing chambers.

10.6.3. Accelerated Curing: Other means of accelerated curing, where standard with the manufacturer, shall be subject to the temperature controls specified for steam curing. Moist cure for not less than four hours prior to other means of accelerated curing. Take precautions to prevent the concrete surface from drying out during the curing period.

10.7. Finishing

10.7.1. The surface of the pole shall have a smooth finish with no unsealed cracks. Cracks shall be sealed either by use of an epoxy injection system following the epoxy manufacturer's specifications, or by V-notching the crack on a 1:1 slope to a minimum depth of ¼ inch, then filling the V-notch with an epoxy seal per ASTM C881 Type IV. Covering the crack with an epoxy coating will not be allowed.

10.7.2. Small cavities caused by air bubbles, honeycomb spots, or other small voids, shall be cleaned thoroughly, saturated with water and then carefully pointed with a cement mortar. A small cavity is defined as one not larger than ½ inch in diameter or deeper than ¼ inch.

10.7.3. If any cavities or voids absorb water which indicate the void extends into wall of the pole, then the pole shall be rejected.

10.7.4. The manufacturer shall seal both ends of the pole and protect the steel stands from corrosion. The system used shall be approved by GPA.

10.7.5. The center void at the top end of the pole shall be sealed with a minimum 6 inch thick 1000 psi strength concrete plug and the pole tip capped. The pole tip cap shall be a suitable epoxy-aggregate mortar securely bonded to the pole, or shall be a metal or polymer cap securely held in place with set screws. Sharp edges shall be tooled to form smooth, chamfered corners. The manufacturer shall assure that the capping method will prevent weather intrusion into the pole and prevent pole tip deterioration.

10.7.6. The center void at the bottom end of the pole shall remain unsealed.. The pole manufacturer shall meet the concrete cover requirements at the bottom end of the pole where the concrete plug is omitted. The concrete cover requirements are referenced in this specification. The pole must meet these requirements or the pole will be rejected.

10.7.7. Where application of epoxy-aggregate mortar is specified, the surface of the pole where the mortar is to be applied shall first be coated with the epoxy coating. This coating shall be allowed to cure to a tacky, but not hardened state, before the mortar is applied. After the mortar has been applied and allowed to cure for 24 hours, a top coat of epoxy coating, 5 mil thick, shall be applied over the mortar and the surrounding area of the pole.

11.0 POLE ACCEPTANCE TESTS:

11.1. Prior to acceptance of the poles all required submittals and reports are to be approved and a strength test shall be performed on two poles selected by GPA.

11.2. The strength test method to be used is to place the pole horizontally in a test frame seven feet from the butt of its length held firmly into place. Using a dynamometer, a force equal to the specified ultimate load is applied at a point one foot from the top. Should the test pole fails any of the criteria at the cracking, deflection and breaking test loads, another pole shall be tested. Failure of the second pole will be the cause of rejection of the complete group. See Appendix B for details of the test apparatus.

11.3. During the application of the allowable cracking load there shall be no visible cracking.

11.4. The maximum deflection at the allowable load is to be calculated as L/12.

11.5. The breaking load for the pole is to be taken as the ultimate load/0.90

11.6. The Test Procedure for Testing Concrete Poles is provided in the Appendices. Details of all test procedures contained herein and methods of measuring and recording test loads and deflections shall be specified by the manufacturer and approved by GPA prior to manufacture.

11.7. Manufacturer shall provide Certificate of calibration for hydraulic jack and dynamometer from an ISO/IES 17025:1999 Accredited Laboratory.

11.8. Material procurement for test poles shall be identical to material procurement procedures for regular production run poles.

11.9. The number, location, direction, holding time, sequence, and increments of the test loads along with the number, location, and direction of deflection readings for an individual pole test shall be approved by GPA prior to pole testing.

11.10. The method of attaching the test loads to the pole, applying the test loads, measuring and recording the test loads, and measuring and recording the deflections shall be approved by GPA prior to pole testing.

11.11. A full report listing results shall be submitted to GPA after completion of all testing. Copies of mill test reports shall be included in the load test report. The report shall also include a complete description of the load tests with diagrams and photographs. If required, the manufacturer shall provide GPA with the following testing data:

a. Location of testing;
b. Method of full scale testing: upright or horizontal; and
c. The pole tester shall issue GPA three (3) copies of the Pole Test Report. This report shall include descriptions, tools, and drawings describing the above test.

11.12. Use of any factory tested poles to meet order requirements shall be determined by GPA.

11.13. Manufacturing and testing procedures shall be in compliance with applicable codes and standards listed in Section 2.0 in this specification.

11.14. Upon request, the manufacturer shall furnish GPA with certified test reports for the steel and concrete used.

11.15. The manufacturer shall make adequate tests and inspections to determine that each of the poles furnished is in strict accordance with this specification. At the request of GPA, the manufacturer shall submit a quality assurance report to GPA prior to the shipment of each pole and shall include the following minimum information:

- Fabrication number;
- Minimum and maximum tip wall thicknesses and steel coverages (to inside and outside) measurements shall be made at 3 inches from the tip;
- Minimum and maximum butt wall thicknesses and steel coverages (to inside and outside) measurements shall be made at 3 inches from butt;
- Condition of pole interior and evidence of exposed rings or reinforcement steel;
- Proper hole and insert locations and sizes;
- Evidence of cracking during or after two-point handling.
- Actual manufactured pole weight;
- Report of any repairs made to the pole;
- Date of manufacture and inspection(s); and
- Inspector's seal.

11.16. All material and workmanship shall be subject to inspection, examination, and test for conformance to the requirements of this specification by GPA. The inspection, examination, or testing could be done at any time during material procurement, manufacturing, storage periods, transit, or at the pole destination. Inspection, examinations, and tests may be waived by GPA, but in no case shall this be interpreted as releasing the manufacturer from the manufacturer's responsibilities for delivering poles that meet the requirements of this specification.

11.17. The manufacturer shall furnish certified test reports to GPA, upon request, showing the results of all of the tests required by this specification and applicable reference specifications.

11.18. Tests shall be in accordance with all applicable standard specifications and codes.

11.19. Failure of the manufacturer to comply with these specifications will be sufficient reason for rejection of any or all poles which do not comply with these specifications.

12.0 BIRTHMARK:

12.1. Each pole shall bear indented markings located 5 feet above the ground hole and in line with the center of gravity mark and ground hole. This birthmark shall include the following:

- Supplier's identity mark
- Month and year of manufacture
- Pole height
- Pole class

- Batch or lot number identification
- Pole index number:

SSOP1127 - 55 FT. Class A Pole

SSOP1128 - 55 FT. Class B Pole

SSOP1105 - 45 FT. Class A Pole

SSOP1106 - 45 FT. Class B Pole

SSOP 1103 - 35 FT. Pole

12.2. Supplier shall also provide a mark indicating the longitudinal center of gravity of each pole and a lifting mark for erection.

12.3. Substitution of stencilling or similar method of marking for indented birthmarks is not acceptable and shall be the cause for rejection. Suppliers should obtain GPA approval of their marking method.

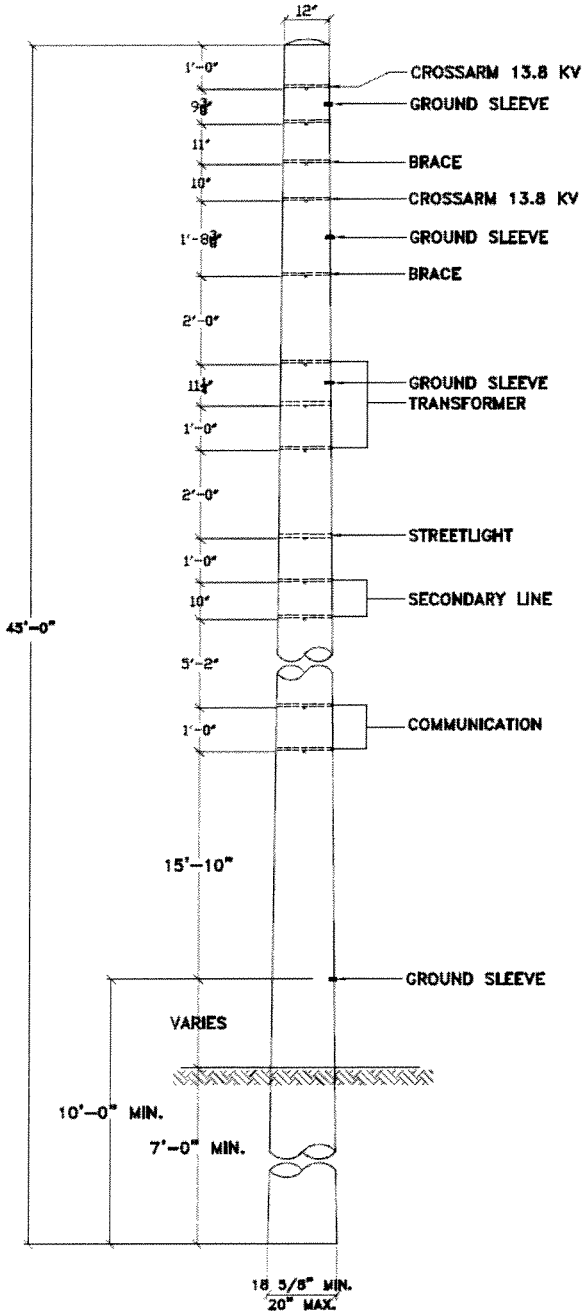
12.4. The birthmark shall be a 2 inches diameter white porcelain tile by ¼ inch thick with blue lettering, embedded in the pole and flush with exterior surface.

12.5. The center of gravity mark shall be a ¾ inch diameter red porcelain tile by ¼ inch thick embedded in the pole and flush with exterior surface.

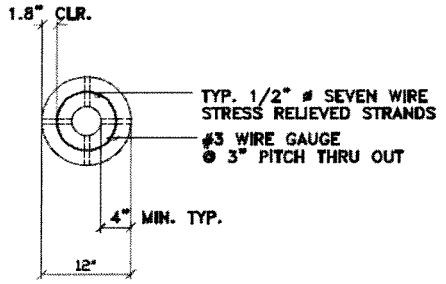
13.0 SHIPPING AND DELIVERY REQUIREMENTS:

The Supplier shall have sufficient instructions for handling, storage, shipping and delivery to prevent against injury or damage to the poles. Poles shall be securely blocked in position to prevent shifting during shipment and delivery.

APPENDIX A1-A 45 FOOT CLASS A CONCRETE POLE (SELF SUPPORTING)



45 FOOT CONCRETE POLE
(CLASS A SELF-SUPPORTING)



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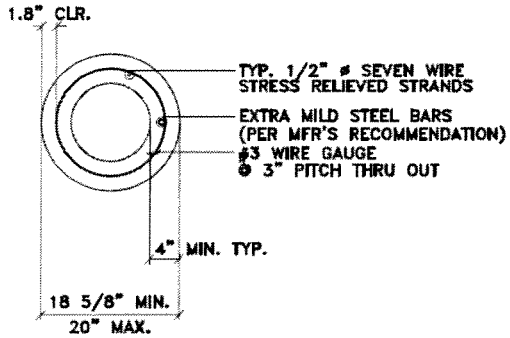
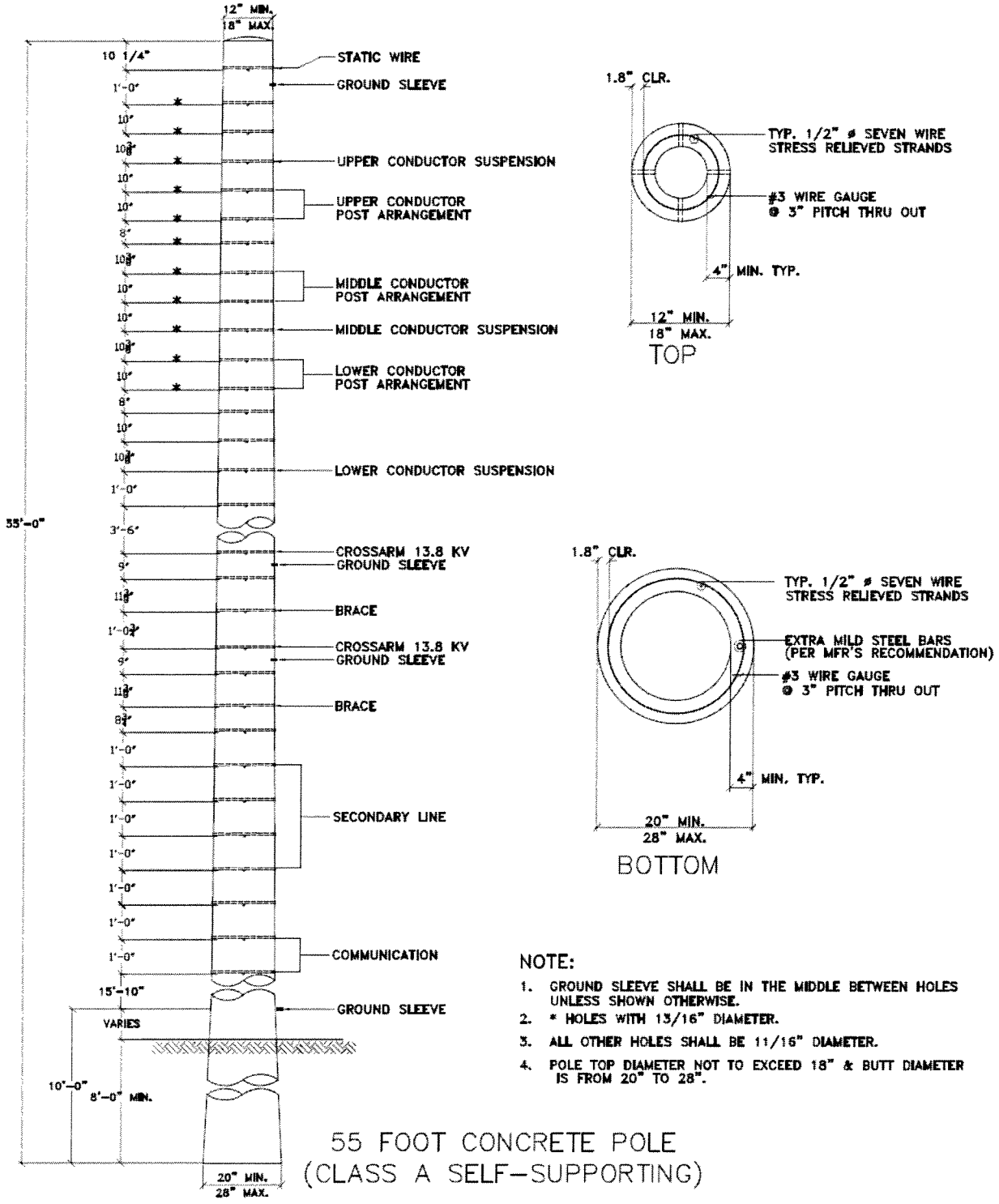


BOTTOM

NOTE:

1. GROUND SLEEVE SHALL BE IN THE MIDDLE BETWEEN HOLES UNLESS SHOWN OTHERWISE.
2. ALL HOLES SHALL BE 11/16" DIAMETER.
3. POLE TOP & BUTT DIAMETERS NOT TO EXCEED 12 & 20 INCHES RESPECTIVELY.

APPENDIX A1-B 55 FOOT CLASS A CONCRETE POLE (SELF SUPPORTING)

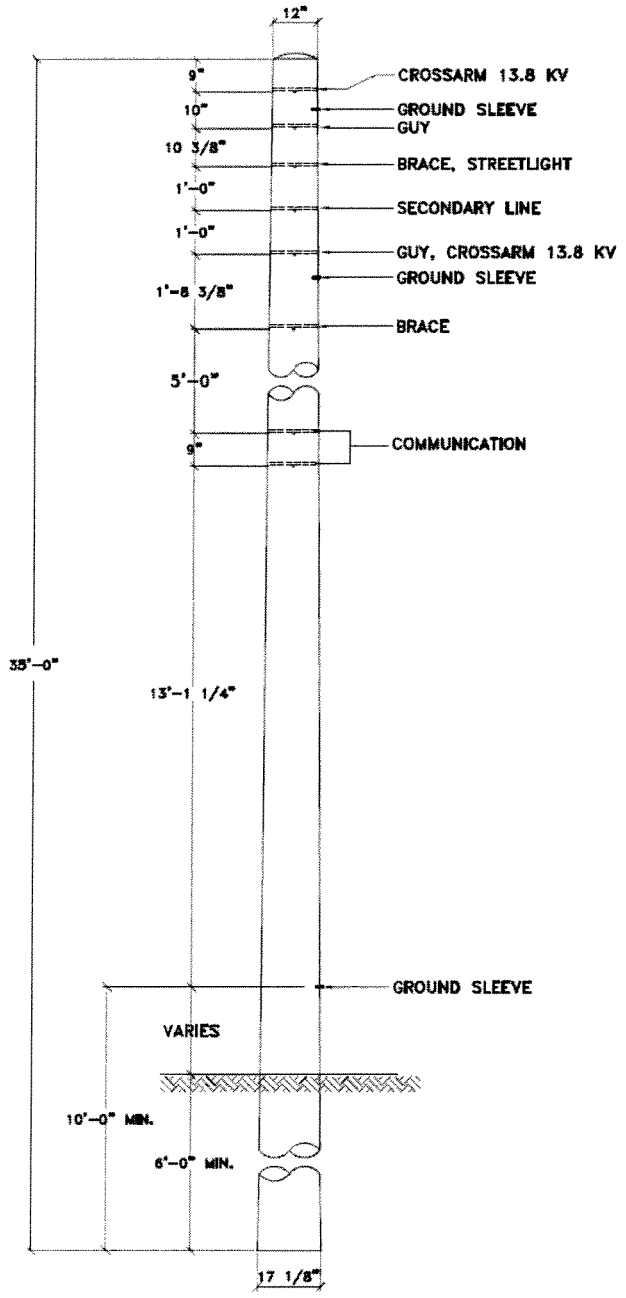


NOTE:

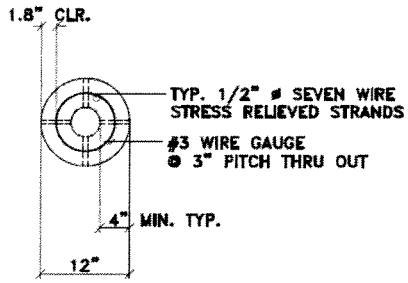
1. GROUND SLEEVE SHALL BE IN THE MIDDLE BETWEEN HOLES UNLESS SHOWN OTHERWISE.
2. * HOLES WITH 13/16" DIAMETER.
3. ALL OTHER HOLES SHALL BE 11/16" DIAMETER.
4. POLE TOP DIAMETER NOT TO EXCEED 18" & BUTT DIAMETER IS FROM 20" TO 28".

55 FOOT CONCRETE POLE
(CLASS A SELF-SUPPORTING)

APPENDIX A2-A 35 FOOT CLASS B CONCRETE POLE (GUYED)



35 FOOT CONCRETE POLE
(CLASS B GUYED)



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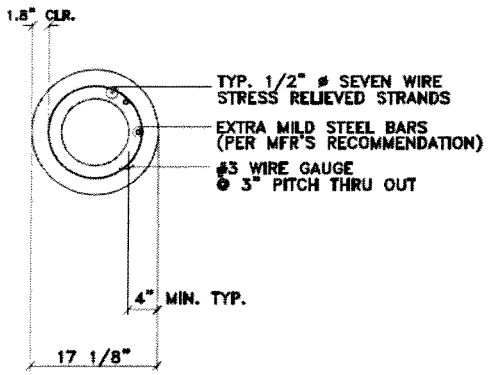
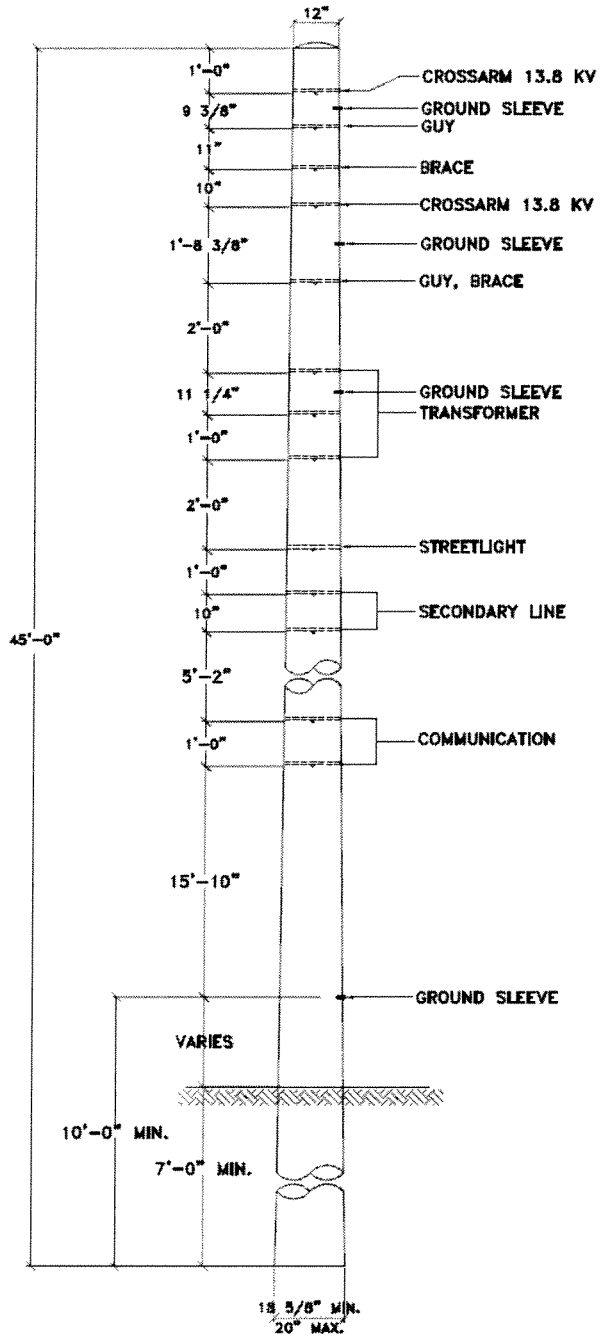


BOTTOM

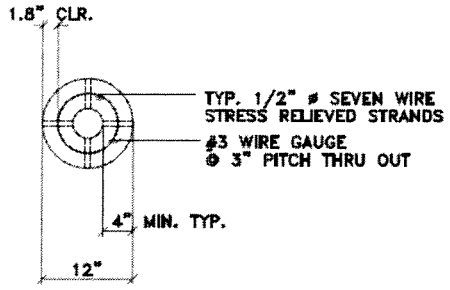
NOTE:

1. GROUND SLEEVE SHALL BE IN THE MIDDLE BETWEEN HOLES UNLESS SHOWN OTHERWISE.
2. ALL HOLES SHALL BE 11/16" DIAMETER.
3. POLE TOP & BUTT DIAMETERS NOT TO EXCEED 12 & 20 INCHES RESPECTIVELY.

APPENDIX A2-B 45 FOOT CLASS B CONCRETE POLE (GUYED)



45 FOOT CONCRETE POLE
(CLASS B GUYED)



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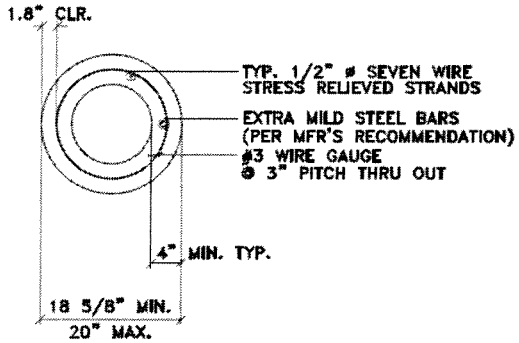
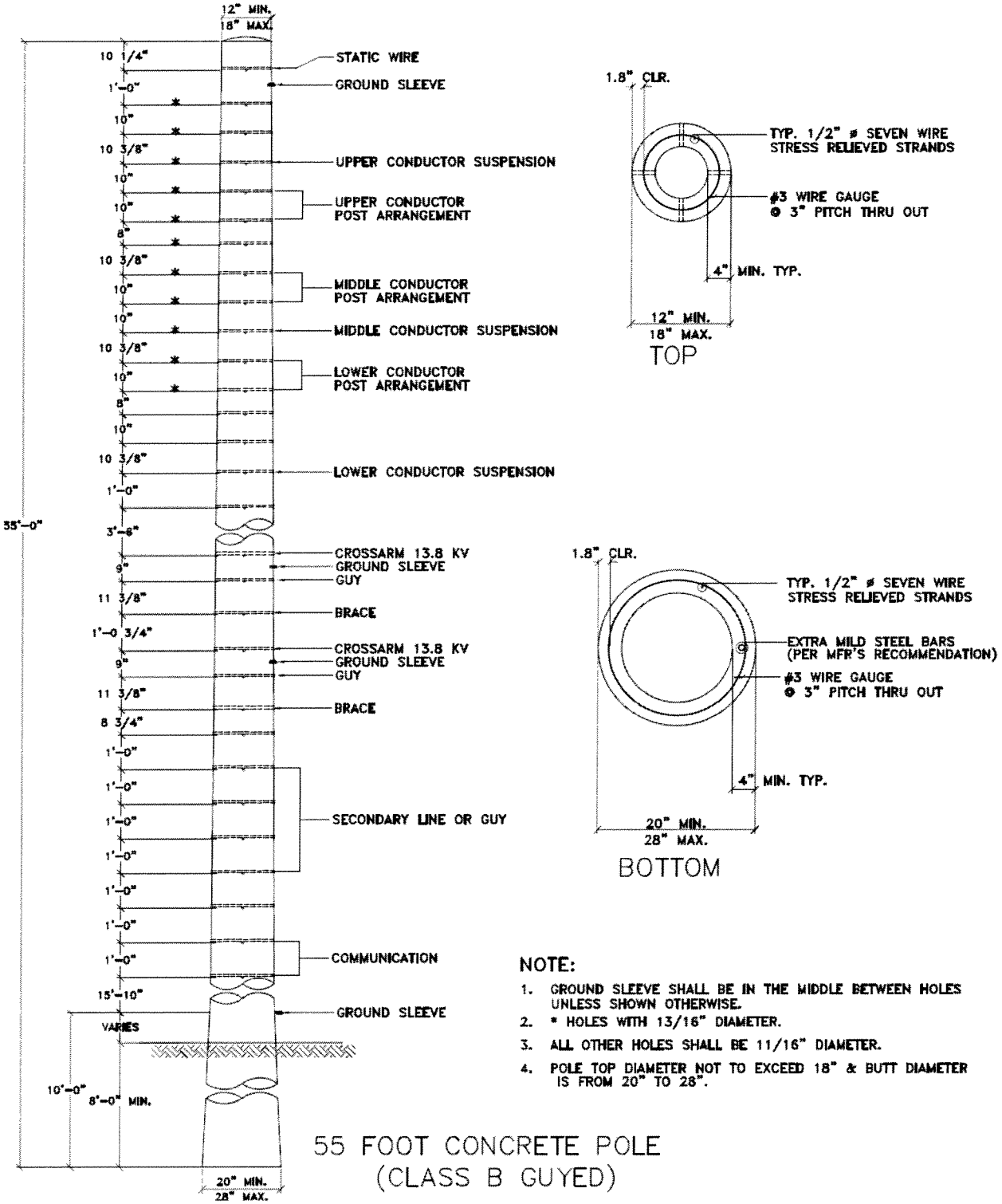


BOTTOM

NOTE:

1. GROUND SLEEVE SHALL BE IN THE MIDDLE BETWEEN HOLES UNLESS SHOWN OTHERWISE.
2. ALL HOLES SHALL BE 11/16" DIAMETER.
3. POLE TOP & BUTT DIAMETERS NOT TO EXCEED 12 & 20 INCHES RESPECTIVELY.

APPENDIX A2-C 55 FOOT CLASS B CONCRETE POLE (GUYED)



NOTE:

1. GROUND SLEEVE SHALL BE IN THE MIDDLE BETWEEN HOLES UNLESS SHOWN OTHERWISE.
2. * HOLES WITH 13/16" DIAMETER.
3. ALL OTHER HOLES SHALL BE 11/16" DIAMETER.
4. POLE TOP DIAMETER NOT TO EXCEED 18" & BUTT DIAMETER IS FROM 20" TO 28".

55 FOOT CONCRETE POLE
(CLASS B GUYED)

APPENDIX A3 DESIGN CRITERIA

Permissible stresses in concrete

Stresses in concrete (after allowance for all pre-stress losses) shall not exceed the following:

(a) Extreme fiber stress in compression due to pre-stress plus sustained load.....0.45 f'c psi
Extreme fiber stress in compression due to pre-stress plus total load.....0.60 f'c psi

(b) Extreme fiber stress in tension ..... $7.5\sqrt{(f'c)}$ psi

Permissible stresses in pre-stressing tendons

Tensile stress in pre-stressing tendons shall not exceed the following:

(a) Due to tendon jacking force ..... 0.94 fpy
but not greater than 0.85 fpu or maximum value
recommended by manufacturer of (pre-stressing) tendons.

(b) Immediately after pre-stress transfer ..... 0.82 fpy
but not greater than 0.74 fpu.

Loss of pre-stress

To determine the effective pre-stress (fse) allowance, the following sources of loss of pre-stress shall be considered:

(a) Elastic shortening of concrete
(b) Creep of concrete
(c) Shrinkage of concrete
(d) Relaxation of tendon stress

Computation of losses

The following shall be used for computation of pre-stress losses for pre-tensioned bonded tendons:

Elastic Shortening of Concrete (ES)

$$ES = E_S \frac{fcir}{Eci}$$

Creep of Concrete (CR)

$$CR = 2 \frac{E_S}{Ec} (f_{Cir} - f_{CdS})$$

Shrinkage of Concrete (SH)

$$SH = 8.2 \times 10^{-6} E_S (1 - 0.06\ V/S) (100-RH)$$

Relaxation of Tendon Stress (RE)

$$RE = [K_{re} - J (SH + CR + ES)] C$$

In which the values of K_{re}, J and C are taken from Tables 2 and 3.

TABLE 2- Values of K_{re} and J

Type of Tendon	K_{re}	J
270 Grade stress-relieved strand or wire	20,000	0.150
250 Grade stress-relieved strand or wire	18,500	0.140
240 or 235 Grade stress-relieved wire	17,600	0.130
270 Grade low-relaxation strand	5,000	0.040
250 Grade low-relaxation wire	4,630	0.037
240 or 235 Grade low-relaxation wire	4,400	0.035
145 or 160 Grade stress-relieved bar	6,000	0.050

TABLE 3 Values of C

f_{pi} / f_{pu}	Stress relieved strand or wire	Stress relieved bar or relaxation strand or wire
0.80		1.28
0.79		1.22
0.78		1.16
0.77		1.11
0.76		1.05
0.75	1.45	1.00
0.74	1.36	0.95
0.73	1.27	0.90
0.72	1.18	0.85
0.71	1.09	0.75
0.70	1.00	0.70
0.69	0.94	0.66
0.65	0.89	0.61
0.64	0.68	0.49
0.63	0.63	0.45
0.62	0.58	0.41
0.61	0.53	0.37
0.60	0.49	0.33

Maximum Loss

The total amount of pre-stress loss (psi) due to elastic shortening, creep, shrinkage, and relaxation need not be more than the values given below if the tendon stress immediately after anchoring does not exceed $0.83f_{py}$:

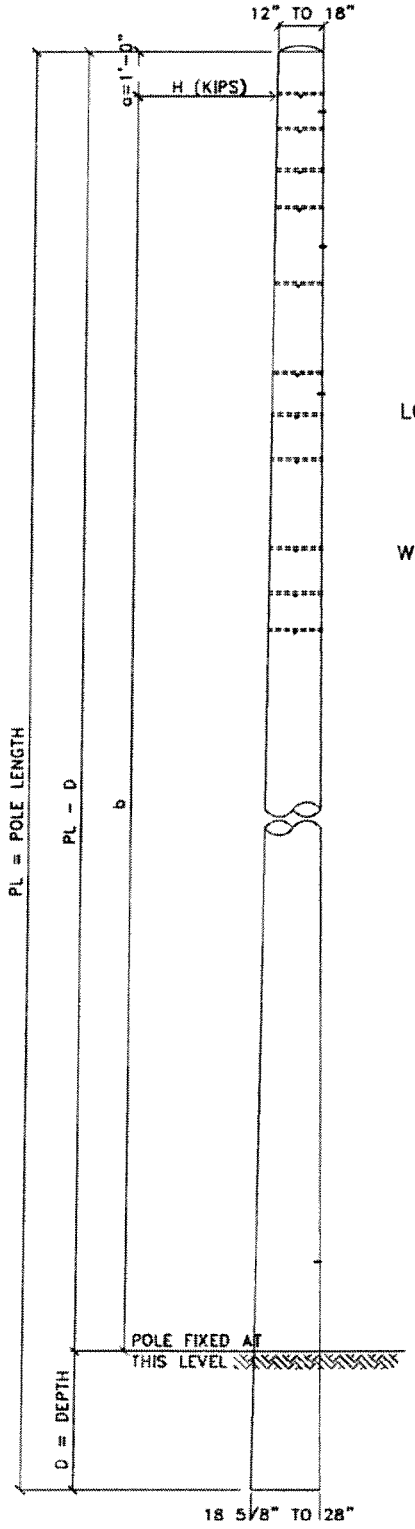
Type of Strand

Stress relieved strand 45,000

Low-relaxation strand 40,000 (for normal concrete)

Refer to Appendix D; Basic Design Criteria, for applicable codes, references, material stresses and loading requirements.

APPENDIX A4-A CLASS A LOADING SET-UP



CLASS "A" POLES
(SELF-SUPPORTING POLES)

LOADING CONDITIONS:

1) 0.75 (1.7 H + 1.7 HL (w))
2) 0.75 (1.7 H + 1.87 HL (s))

WHERE: HL(s) IS HORIZONTAL LOAD DUE TO SEISMIC FORCES. THE SEISMIC LOADING IS DISTRIBUTED ALONG THE POLE ACCORDING TO HL(s) = 0.34 (Weight)

HL(w) IS HORIZONTAL LOAD ON POLE DUE TO A UNIFORM PRESSURE OF 61.5 psf x HEIGHT CORRECTION FACTOR FOR THE POLE, CONDUCTORS AND APPURTENANCES.

MOMENTS DERIVED FROM THE ABOVE LOADING SHALL BE LESS THAN OR EQUAL TO 0.9 x ULTIMATE MOMENT CAPACITY OF THE SECTION BEING ANALYZED:

MOMENT $\leq$ 0.9 x ULTIMATE MOMENT CAPACITY

THE ULTIMATE MOMENT CAPACITY IS TO BE CALCULATED IN ACCORDANCE WITH THE CURRENT EDITION OF ACI 318. CRACKING MOMENT SHALL BE EQUAL TO ONE-HALF OF THE ULTIMATE MOMENT CAPACITY OF THE POLE.

POLE HEIGHT	DEPTH D
45'-0"	7'-0"
55'-0"	8'-0"

APPENDIX A4-B 45 FOOT CLASS A DESIGN DATA

45' CLASS A – SELF-SUPPORTING POLES
MUST SATISFY STRENGTH DESIGN AS FOLLOWS:

HORIZONTAL DEFLECTION ANGLE (Θ)	HORIZONTAL LOADS @ 1' BELOW TOP		MOMENT @ GROUND LEVEL	
	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)	WORKING STRESS (FT-KIPS)	ULTIMATE STRENGTH (FT-KIPS)
5°	5.63	7.18	208.38	265.68
10°	5.79	7.38	214.11	272.99
15°	5.93	7.56	219.51	279.88
20°	6.07	7.74	224.56	286.31
25°	6.19	7.90	229.19	292.22
30°	6.31	8.04	233.38	297.56
35°	6.41	8.17	237.07	302.27
40°	6.49	8.28	240.25	306.31
45°	6.56	8.37	242.86	309.65
50°	6.62	8.44	244.89	312.23
55°	6.66	8.49	246.30	314.03
60°	6.68	8.51	247.07	315.01
65°	6.68	8.52	247.17	315.14
70°	6.67	8.50	246.60	314.42
75°	6.63	8.45	245.34	312.81
80°	6.58	8.39	243.39	310.32
85°	6.51	8.30	240.73	306.93
90°	6.42	8.18	237.37	302.65

NOTE: ABOVE VALUES ARE BASED ON 200 FEET POLE SPACING.

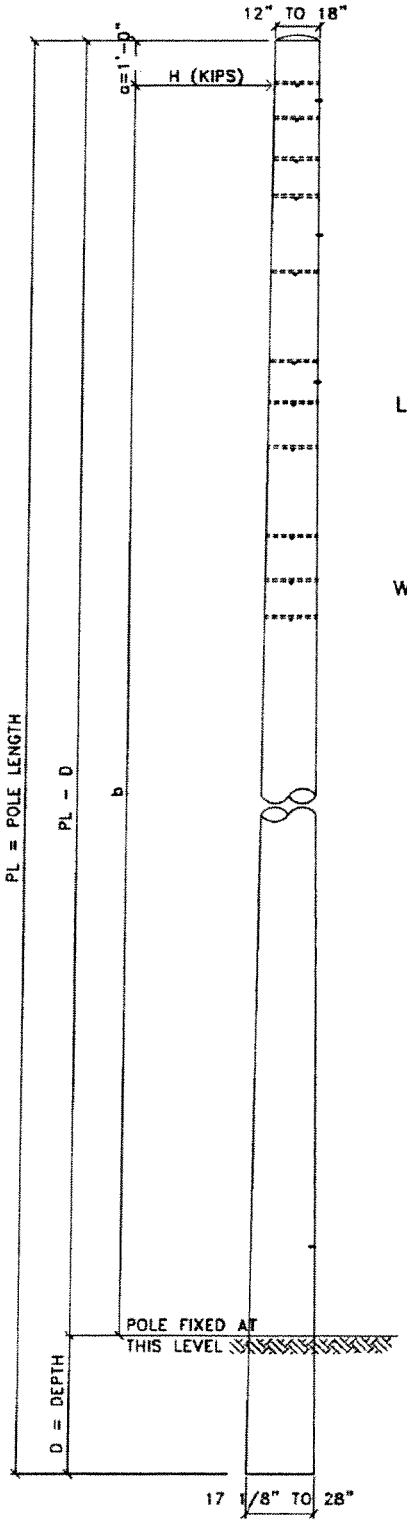
APPENDIX A4-C 55 FOOT CLASS A DESIGN DATA

55' CLASS A – SELF-SUPPORTING POLES
MUST SATISFY STRENGTH DESIGN AS FOLLOWS:

HORIZONTAL DEFLECTION ANGLE (Θ)	HORIZONTAL LOADS @ 1' BELOW TOP		MOMENT @ GROUND LEVEL	
	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)	WORKING STRESS (FT-KIPS)	ULTIMATE STRENGTH (FT-KIPS)
5°	9.79	12.48	450.16	573.95
10°	10.33	13.17	475.09	605.73
15°	10.85	13.83	499.03	636.26
20°	11.34	14.46	521.79	665.28
25°	11.81	15.06	543.19	692.57
30°	12.24	15.61	563.05	717.89
35°	12.64	16.11	581.20	741.04
40°	12.99	16.56	597.49	761.80
45°	13.30	16.96	611.75	779.98
50°	13.56	17.29	623.86	795.42
55°	13.78	17.56	633.69	807.96
60°	13.94	17.77	641.14	817.45
65°	14.05	17.91	646.10	823.78
70°	14.10	17.98	648.50	826.84
75°	14.09	17.97	648.28	826.56
80°	14.03	17.89	645.40	822.89
85°	13.91	17.73	639.82	815.78
90°	13.73	17.51	631.55	805.22

NOTE: ABOVE VALUES ARE BASED ON 200 FEET POLE SPACING.

APPENDIX A4-D CLASS B LOADING SET-UP



CLASS "B" POLES
(GUYED POLES)

LOADING CONDITIONS:

1) 0.75 (1.7 H + 1.7 HL (w))
2) 0.75 (1.7 H + 1.87 HL (s))

WHERE: HL(w) IS HORIZONTAL LOAD ON POLE DUE TO A UNIFORM PRESSURE OF 61.5 psf x HEIGHT CORRECTION FACTOR FOR POLE, CONDUCTORS AND APPURTENANCES.

HL(s) IS HORIZONTAL LOAD DUE TO SEISMIC FORCES. THE SEISMIC LOADING IS DISTRIBUTED ALONG THE POLE ACCORDING TO HL(s) = 0.34 (Weight)

MOMENTS DERIVED FROM THE ABOVE LOADING SHALL BE LESS THAN OR EQUAL TO 0.9 x ULTIMATE MOMENT CAPACITY OF THE SECTION BEING ANALYZED:

MOMENT $\leq$ 0.9 x ULTIMATE MOMENT CAPACITY

THE ULTIMATE MOMENT CAPACITY IS TO BE CALCULATED IN ACCORDANCE WITH THE CURRENT EDITION OF ACI 318 CRACKING MOMENT SHALL BE EQUAL TO ONE-HALF OF THE ULTIMATE MOMENT CAPACITY OF THE POLE.

POLE HEIGHT	DEPTH D
35'-0"	6'-0"
45'-0"	7'-0"
55'-0"	8'-0"

APPENDIX A4-E 35 FOOT and 45 FOOT CLASS B DESIGN DATA

35' CLASS B – GUYED POLES
MUST SATISFY STRENGTH DESIGN AS FOLLOWS:

HORIZONTAL DEFLECTION ANGLE (Θ)	HORIZONTAL LOADS @ 1' BELOW TOP		MOMENT @ GROUND LEVEL	
	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)	WORKING STRESS (FT-KIPS)	ULTIMATE STRENGTH (FT-KIPS)
5°	4.52	5.76	126.56	161.37
10°	4.51	5.75	126.31	161.04
15°	4.50	5.73	125.88	160.50
20°	4.47	5.70	125.29	159.74
25°	4.45	5.67	124.52	158.77
30°	4.41	5.63	123.59	157.58
35°	4.37	5.58	122.50	156.18
40°	4.33	5.52	121.24	154.58
45°	4.28	5.46	119.82	152.77
50°	4.22	5.38	118.25	150.76
55°	4.16	5.31	116.52	148.56
60°	4.09	5.22	114.63	146.16
65°	4.02	5.13	112.60	143.57
70°	3.94	5.03	110.43	140.80
75°	3.86	4.92	108.12	137.85
80°	3.77	4.81	105.67	134.73
85°	3.68	4.69	103.09	131.44
90°	3.59	4.57	100.38	127.99

NOTE: ABOVE VALUES ARE BASED ON 200 FEET POLE SPACING.

45' CLASS B – GUYED POLES
MUST SATISFY STRENGTH DESIGN AS FOLLOWS:

HORIZONTAL DEFLECTION ANGLE (Θ)	HORIZONTAL LOADS @ 1' BELOW TOP		MOMENT @ GROUND LEVEL	
	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)	WORKING STRESS (FT-KIPS)	ULTIMATE STRENGTH (FT-KIPS)
5°	5.34	6.80	197.41	251.70
10°	5.33	6.79	197.07	251.26
15°	5.31	6.77	196.50	250.54
20°	5.29	6.75	195.70	249.52
25°	5.26	6.71	194.68	248.22
30°	5.23	6.67	193.43	246.63
35°	5.19	6.62	191.97	244.76
40°	5.14	6.56	190.28	242.61
45°	5.09	6.49	188.38	240.18
50°	5.03	6.42	186.27	237.49
55°	4.97	6.34	183.95	234.54
60°	4.90	6.25	181.43	231.32
65°	4.83	6.16	178.71	227.85
70°	4.75	6.06	175.80	224.14
75°	4.67	5.95	172.70	220.19
80°	4.58	5.84	169.41	216.00
85°	4.49	5.72	165.96	211.60
90°	4.39	5.60	162.33	206.98

NOTE: ABOVE VALUES ARE BASED ON 200 FEET POLE SPACING.

APPENDIX A4-F 55 FOOT CLASS B DESIGN DATA

55' CLASS B – GUYED POLES
MUST SATISFY STRENGTH DESIGN AS FOLLOWS:

HORIZONTAL DEFLECTION ANGLE (Θ)	HORIZONTAL LOADS @ 1' BELOW TOP		MOMENT @ GROUND LEVEL	
	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)	WORKING STRESS (FT-KIPS)	ULTIMATE STRENGTH (FT-KIPS)
5°	9.14	11.65	420.22	535.78
10°	9.12	11.62	419.33	534.64
15°	9.08	11.58	417.85	532.76
20°	9.04	11.52	415.78	530.11
25°	8.98	11.45	413.12	526.73
30°	8.91	11.36	409.89	522.60
35°	8.83	11.26	406.08	517.75
40°	8.73	11.13	401.70	512.17
45°	8.63	11.00	396.77	505.88
50°	8.51	10.85	391.29	498.89
55°	8.38	10.68	385.27	491.21
60°	8.23	10.50	378.72	482.87
65°	8.08	10.30	371.66	473.86
70°	7.92	10.09	364.10	464.22
75°	7.74	9.87	356.05	453.96
80°	7.56	9.63	347.53	443.10
85°	7.36	9.38	338.55	431.65
90°	7.16	9.12	329.14	419.65

NOTE: ABOVE VALUES ARE BASED ON 200 FEET POLE SPACING.

APPENDIX A5 SUMMARY OF ABBREVIATIONS ,NOTATIONS AND DEFINITIONS

SUMMARY OF ABBREVIATIONS AND NOTATIONS

CR	=	stress loss due to creep of concrete
E_{ci}	=	modulus of elasticity of concrete at time pre-stress is applied
E_c	=	modulus of elasticity of concrete at time pre-stress is applied
E_S	=	modulus of elasticity of pre-stressing tendons. Usually 28,000 psi
ES	=	stress loss due to elastic shortening of concrete
f_{cds}	=	stress in concrete at center of gravity of tendons due to service loads
f_{cir}	=	net compressive stress in concrete at center of gravity of tendons immediately after the pre-stress has been applied to the concrete
f_{pu}	=	specified tensile strength of pre-stressing tendon, psi
RE	=	stress loss due to relaxation of tendons
RH	=	average ambient relative humidity
SH	=	stress loss due to shrinkage of concrete
V/S	=	volume to surface ratio. Usually taken as gross cross-sectional area of concrete member divided by its perimeter
f'c	=	specified compressive strength of concrete, psi
fpy	=	specified yield strength of pre-stressing tendons, psi
fy	=	specific yield strength of reinforcing bars, psi
E.W.	=	each way
H	=	horizontal load in kips
HL(s)	=	horizontal load in kips due to seismic forces
HL(w)	=	horizontal load in kips due to wind forces
K_{re}	=	coefficient
J	=	coefficient
C	=	coefficient
PL	=	pole length

DEFINITIONS

Admixture - Any material other than water, aggregate, or cement that is used as an ingredient of concrete and added to concrete before or during its mixing to modify its properties.

Appurtenance - Any hardware or structural members that are attached to the concrete pole to make a complete structure.

Bonding, electrical - The electrical interconnecting of conductive parts, designed to maintain a common electrical potential.

Cant hole - A through hole in the pole which is used in rotating the pole about its axis during setting. The hole is typically 1-1/2" in diameter and located approximately 4 feet above the groundline.

Circumferential cracks - Cracks that parallel a cross-section of a concrete pole.

Cracking moment - The moment which is developed in the pole at the time the cracking strength of the pole is experienced.

Cracking strength - The point at which the concrete just begins to separate due to exceeding the tensile strength of the concrete on the tension face of the pole.

Deadend structure - A type of guyed or unguyed structure on which the conductors are connected by strain insulators, with the usual purpose of terminating the conductor tension.

Deleterious substance - Any substance that is not desirable in a mixture, usually causing harm in sufficient quantities.

Dropout, steel cable - The terminating point of any longitudinal steel that is not continuous for the length of the pole.

Efflorescence - The formation of a white film on the surface of the pole, typically caused by the emergence of chlorides during curing.

Embedment - That portion of the pole which is designed to be located in the ground or other supporting medium.

Factored load - See Ultimate Load.

Foundation deflection - The magnitude and direction of displacement of the embedded portion of the pole or supporting foundation which is expected to occur with the response of the soil or supporting medium to the applied loading conditions. It is usually expressed in inches from the plumb position at the groundline or point below the groundline where supporting soil begins.

Foundation rotation - The degree and direction of rotation of the embedded portion of the pole or supporting foundation about the groundline or point of fixity, if specified, which is expected to occur with the response of the soil or supporting medium to the applied loading conditions.

Groundline - The point at which the embedment begins. Groundline is used for transmission line design such as determining ground clearances. Resistance from the supporting soils or other medium begins at or below groundline.

Group of bolt holes - All of the holes in which a single hardware assembly will be attached.

Guyed structure - A structure in which cable supports are used to increase its lateral load resistance.

In-line face - The face of the pole which "faces" an adjacent structure in the line.

Load cycle - The point at which a structure has undergone the range of loadings that are expected to occur over the life of the structure.

Load case - A group of loadings, restraints, (foundation deflections and foundation rotations) which are simultaneously applied to the structure at a particular point in time. Additional structural performance requirements may also be included.

Load factor - A multiplier which is applied to each of the vertical, transverse, and longitudinal structure loadings to obtain an ultimate factored load. The multiplier takes into account the variability of climatic events as well as the importance of the structure.

Longitudinal cracks - Cracks in concrete that parallel to the long axis of the pole.

Longitudinal reinforcement - The reinforcing steel which is installed along the long axis of the pole.

Manufacturer - The company responsible for the fabrication of the poles. The manufacturer makes the poles based on the design drawings developed by the structural designer, which is the engineer responsible for the structural design of the poles and is usually employed by the manufacturer.

Modulus of elasticity - The slope of the stress-strain diagram within the proportional range of an elastic material.

P-delta (P-Δ) moment - The secondary moment created by vertical loads acting on the structure which deflects from its unloaded position.

Pole end squareness – A measure of how perpendicular the finished surface of the pole butt is to the longitudinal axis of the pole.

Point of fixity - The point on the pole at or below groundline where the maximum moment occurs. Location of this point is dependent on the characteristics of soils around the embedded portion of the pole.

Pole failure - The point at which the maximum strength of the pole is realized. Failure usually occurs with crushing of the concrete or permanent deformation.

Pole sweep - The measure of deviation from straightness along the length of the pole.

Post-tensioned steel strand - The longitudinal reinforcement that has been tensioned after the concrete has hardened.

Prestressed concrete - Reinforced concrete in which internal stresses have been introduced to reduce potential tensile stress in concrete resulting from loads.

Pretensioned steel strand - The longitudinal reinforcement that has been tensioned before concrete is placed. Also referred to as prestressed steel strand.

Pyrite staining - A pale brass-yellow colored stain in the concrete caused from the concrete mixture containing an excess amount of iron disulfides.

Reinforcing steel - Any steel for the purpose of reinforcement of the concrete, including longitudinal reinforcement, spiral reinforcement, and deformed reinforcing bars.

Release strength - The minimum concrete strength that is necessary before the pretensioned strands can be released.

Secondary stresses - The additional stresses created by continued application of the loads as the structure displaces or deflects from its unloaded position.

Service load - The loading which is usually synonymous to the NESC district loadings without load factors applied, and sometimes referred to as unfactored district load or working load. The service load may also be a greater ice and/or wind load when compared to the NESC district loads. Any service load, multiplied by the appropriate load factor will give the ultimate load.

Spiral reinforcement - Steel reinforcement, continuously wound in the form of a cylindrical helix, that encloses the longitudinal steel.

Spun concrete pole - A pole which is manufactured by placing prestressed steel strands and spiral reinforcement in a mold, adding fresh concrete and spinning the mold to form the pole.

Structural designer - The engineer(s) responsible for structural design of the poles, usually employed by or is a hired consultant of a company which fabricates concrete pole structures.

Ultimate load - The maximum design load which includes the appropriate load factor specified.

Ultimate moment capacity - The moment which is developed in the pole at the time the ultimate strength of the structure is realized.

Unbalanced lateral load - Any loading of a significant duration and magnitude which is not restrained or offset by guys or cables which generates bending moments along a section of the pole.

Ultimate strength - The maximum strength in the stress-strain diagram. For the pole, this is considered to be the point at which the pole fails, usually with crushing of the concrete.

Unfactored district load - See Service Load.

Unfactored extreme load - The extreme wind, ice, or other extreme loading without considering a load factor.

Unfactored load - A loading in which the load factor has not been applied.

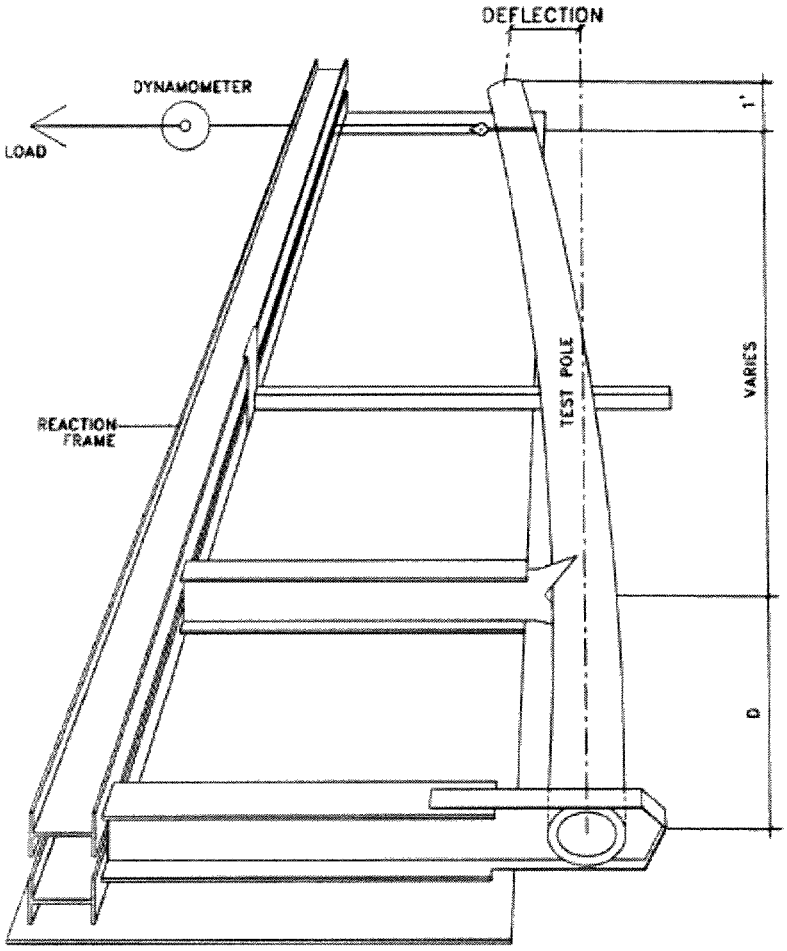
Working load - See Service Load.

Yield strength - The minimum stress at which a material will start to physically deform without further increase in load or which produces a permanent strain. This is known as the elastic limit of the material.

Zero tension strength - The moment at which a crack that was previously created by exceeding the cracking moment strength will open again. Under this condition, an applied moment will not cause any tensile stress in the concrete. It will always be less than the cracking moment strength.

APPENDIX B POLE TEST SET-UP

POLE TEST SETUP



POLE HEIGHT	DEPTH D
35'-0"	6'-0"
45'-0"	7'-0"
55'-0"	8'-0"

APPENDIX B1 CLASS A TEST LOADS

CLASS A – SELF-SUPPORTING POLES

HORIZONTAL DEFLECTION ANGLE (Θ)	45' POLE HORIZONTAL LOADS		55' POLE HORIZONTAL LOADS	
	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)
5°	5.63	7.18	9.79	12.48
10°	5.79	7.38	10.33	13.17
15°	5.93	7.56	10.85	13.83
20°	6.07	7.74	11.34	14.46
25°	6.19	7.90	11.81	15.06
30°	6.31	8.04	12.24	15.61
35°	6.41	8.17	12.64	16.11
40°	6.49	8.28	12.99	16.56
45°	6.56	8.37	13.30	16.96
50°	6.62	8.44	13.56	17.29
55°	6.66	8.49	13.78	17.56
60°	6.68	8.51	13.94	17.77
65°	6.68	8.52	14.05	17.91
70°	6.67	8.50	14.10	17.98
75°	6.63	8.45	14.09	17.97
80°	6.58	8.39	14.03	17.89
85°	6.51	8.30	13.91	17.73
90°	6.42	8.18	13.73	17.51

NOTE: ABOVE VALUES ARE BASED ON 200 FEET POLE SPACING.

APPENDIX B2 CLASS B TEST LOADS

CLASS B – GUYED POLES

HORIZONTAL DEFLECTION ANGLE (Θ)	35' POLE HORIZONTAL LOADS		45' POLE HORIZONTAL LOADS		55' POLE HORIZONTAL LOADS	
	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)	WORKING STRESS (KIPS)	ULTIMATE STRENGTH (KIPS)
5°	4.52	5.76	5.34	6.80	9.14	11.65
10°	4.51	5.75	5.33	6.79	9.12	11.62
15°	4.50	5.73	5.31	6.77	9.08	11.58
20°	4.47	5.70	5.29	6.75	9.04	11.52
25°	4.45	5.67	5.26	6.71	8.98	11.45
30°	4.41	5.63	5.23	6.67	8.91	11.36
35°	4.37	5.58	5.19	6.62	8.83	11.26
40°	4.33	5.52	5.14	6.56	8.73	11.13
45°	4.28	5.46	5.09	6.49	8.63	11.00
50°	4.22	5.38	5.03	6.42	8.51	10.85
55°	4.16	5.31	4.97	6.34	8.38	10.68
60°	4.09	5.22	4.90	6.25	8.23	10.50
65°	4.02	5.13	4.83	6.16	8.08	10.30
70°	3.94	5.03	4.75	6.06	7.92	10.09
75°	3.86	4.92	4.67	5.95	7.74	9.87
80°	3.77	4.81	4.58	5.84	7.56	9.63
85°	3.68	4.69	4.49	5.72	7.36	9.38
90°	3.59	4.57	4.39	5.60	7.16	9.12

NOTE: ABOVE VALUES ARE BASED ON 200 FEET POLE SPACING.

APPENDIX C CONCRETE POLE TEST PROCEDURE

TEST PROCEDURE FOR TESTING CONCRETE POLES SUPPLIED TO THE GUAM POWER AUTHORITY

1.0 SELECTION OF TEST SPECIMENS

A GPA representative shall select two poles of each design at random to be tested. If testing is not to be performed immediately after selection, the poles selected shall be suitably marked.

2.0 INSPECTION AND DIMENSION VERIFICATION

2.1. A GPA representative shall measure pole lengths and pole diameters, measure the amount of concrete cover over the steel reinforcement, and count the number of reinforcing rods and wires to ensure compliance with the approved design and Sections 5.0 and 9.0.

2.2. A GPA representative shall check all hole locations and sizes to ensure compliance with the Sections 5.0 and 9.0. Refer to Appendices A1 and A2 of this specification.

3.0 BENDING TEST

3.1. Place the pole in a test support or test frame with the lower end of the pole at a distance "D" held firmly in place as indicated in the pole test set-up. If the test is to be in the horizontal position, provisions shall be made by suitable supports to minimize the bending moment induced by the weight of the pole.

3.2. Set the deflection measurement instruments at the top of the pole. Mark the pole so that the deflection can be measured.

3.3. Using a dynamometer apply the loading gradually to allow observation of the formation of cracks and the measuring of deflection. The load should be applied one foot from the top of the pole. Record the amount of deflection after each load increment is made. Check for cracking, measure the cracks found, and provide a sketch indicating location and size of cracks. Provide a written record of loading, deflection and appearance of first hairline crack.

3.4. When the test load reaches the service test load, release the load after recording the amount of deflection and observing and recording any cracks. After the load is released, record the permanent residual deflection (if any). The accuracy of the measurements shall be within 0.125 inch.

3.5. Repeat Steps 3.3 and 3.4 for 60%, 85% and 100% of ultimate horizontal load checking for visible cracking at service load. Visible sign of cracking at service load level shall be the cause for rejection.

4.0 BREAKING TEST

4.1. After completion of the bending strength test, the pole tested in Section 3.0 above shall be subjected to a breaking load test.

4.2. With the same pole secured in place, apply sufficient loading (use moderate load increments) to break the test pole. Provide suitable load recording equipment to record the maximum load applied prior to breakage.

4.3. The breaking load must equal or exceed the calculated ultimate moment capacity (of the section at D distance from the butt of the pole) divided by the moment arm (pole length – (D+1)):

$$\text{Breaking load} >= \frac{\text{Ultimate Moment Capacity}}{PL - (D + 1)}$$

4.4. Non-attainment of this breaking load criterion shall be the cause for rejection.

5.0 Repeat sections 2.0 and 3.0 for the second pole selected. The second pole, having been subjected to bending loads only, may be used for the breaking test provided it passes the bending tests.

NOTE: Cracking shall be allowed at one half the Ultimate Moment Capacity of the pole.

APPENDIX D BASIC DESIGN CRITERIA

A. Codes And References

1. ACI 318-08 Building Code Requirements For Reinforced Concrete
2. International Building Code - 2009
3. ACI Detailing Manual
4. AISC 9th Edition

B. Materials Stresses

1.	Prestressed Concrete Pole	f'c = 6,000 psi
	At Release of Strand	f'c = 4,500 psi
2.	Prestressing Steel	ASTM A416, Grade 270
3.	Reinforced Concrete (Foundation)	f'c = 3,000 psi
4.	Spiral Wire	ASTM A82
5.	Rebar	ASTM A615, Grade 60

C. Loadings

1.	Wind Load	
	Wind Velocity (sustained)	155 mph
	Wind Velocity (3 second gusts)	170 mph
	Wind Exposure Coefficient	C
	Importance Factor	I = .1.15
2.	Seismic Load	
	Mapped Spectral Response Accelerations	S_s = 1.5
		S_1 = 0.6
	Importance Factor	I = 1.25
	Site Class	Assume D if Geotechnical data is unknown

APPENDIX E CLASS A OR B – 55 FOOT CONCRETE POLE INSPECTION FORM

TEST DATE: _____/_____/_____ TEST LOCATION: _____
City, Country

TYPE OF POLE: _____ POLE MANUFACTURER: _____

DIMENSION CHECK	MEASURED	PER SPEC E-035
Weight of pole:	_____	
Pole height:	_____	55- 0"
Pole top diameter:	_____	12" min – 18" max
Pole butt diameter:	_____	20" min – 28" max
Number of 11/16 inch holes:	_____	20 each
Number of 13/16 inch holes:	_____	11 each
Number of 2 inch ground sleeves:	_____	4 each

HOLE SPACINGS: * denotes 3/16" diameter holes

FROM	TO	MEASURED	E-035	FROM	TO	MEASURED	E-035
TIP	A	_____	10 1/4"	P	Q	_____	3' – 6"
A	*B	_____	1' – 0"	Q	R	_____	9"
*B	*C	_____	10"	R	S	_____	11 3/8"
*C	*D	_____	10 3/8"	S	T	_____	1' – 0 3/4"
*D	*E	_____	10"	T	U	_____	9"
*E	*F	_____	10"	U	V	_____	11 3/8"
*F	*G	_____	8'	V	W	_____	8 3/4"
*G	*H	_____	10 3/8"	W	X	_____	1' – 0"
*H	*I	_____	10"	X	Y	_____	1' – 0"
*I	*J	_____	10"	Y	Z	_____	1' – 0"
*J	*K	_____	10 3/8"	Z	Z1	_____	1' – 0"
*K	*L	_____	10"	Z1	Z2	_____	1' – 0"
*L	M	_____	8"	Z2	Z3	_____	1' – 0"
M	N	_____	10"	Z3	Z4	_____	1' – 0"
N	O	_____	10 3/8"	Z4	Ground Hole	_____	15' – 10"
O	P	_____	1' – 0"				

Material for hole inserts (Section 9.3): _____

Concrete cover over reinforcement: _____ inches (exterior side) & _____ inches (interior side)

Reinforcing type, amount and placement

Conforms with the approved Shop Drawings? [ ] YES [ ] NO

Longitudinal center of gravity provided? [ ] YES [ ] NO

Pole birthmark provided? [ ] YES [ ] NO

CLASS A OR B – 45 FOOT CONCRETE POLE INSPECTION FORM

TEST DATE: _____/_____/_____ TEST LOCATION: _____

City, Country

TYPE OF POLE: _____ POLE MANUFACTURER: _____

DIMENSION CHECK	MEASURED	PER SPEC E-035
Weight of pole:	_____	
Pole height:	_____	45- 0"
Pole top diameter:	_____	12" min
Pole butt diameter:	_____	18 5/8" min – 20" max
Number of 11/16 inch holes:	_____	14 each
Number of 2 inch ground sleeves:	_____	4 each

HOLE SPACINGS:

FROM	TO	MEASURED	E-035
TIP	A	_____	1' – 0"
A	B	_____	9 3/8"
B	C	_____	11"
C	D	_____	10"
D	E	_____	1' – 8 3/8"
E	F	_____	2' – 0"
F	G	_____	11 1/4"
G	H	_____	1' – 0"
H	I	_____	2' – 0"
I	J	_____	1' – 0"
J	K	_____	10"
K	L	_____	5' – 2"
L	M	_____	1' – 0"
M	Ground Hole	_____	16' – 10"

Material for hole inserts (Section 9.3): _____

Concrete cover over reinforcement: _____ inches (exterior side) & _____ inches (interior side)

Reinforcing type, amount and placement

Conforms with the approved Shop Drawings? [ ] YES [ ] NO

Longitudinal center of gravity provided? [ ] YES [ ] NO

Pole birthmark provided? [ ] YES [ ] NO

CLASS A OR B – 35 FOOT CONCRETE POLE INSPECTION FORM

TEST DATE: _____ / _____ / _____ TEST LOCATION: _____
City, Country

TYPE OF POLE: _____ POLE MANUFACTURER: _____

DIMENSION CHECK	MEASURED	PER SPEC E-035
Weight of pole:	_____	
Pole height:	_____	35- 0"
Pole top diameter:	_____	12" min
Pole butt diameter:	_____	17 5/8" min – 20" max
Number of 11/16 inch holes:	_____	9 each
Number of 2 inch ground sleeves:	_____	3 each

HOLE SPACINGS:

FROM	TO	MEASURED	E-035
TIP	A	_____	9"
A	B	_____	10"
B	C	_____	10 3/8"
C	D	_____	1' – 0"
D	E	_____	1' – 0"
E	F	_____	1' – 8 3/8"
F	G	_____	5' – 0"
G	H	_____	9"
H	Ground Hole	_____	15' – 1 1/4"

Material for hole inserts (Section 9.3): _____

Concrete cover over reinforcement: _____ inches (exterior side) & _____ inches (interior side)

Reinforcing type, amount and placement
Conforms with the approved Shop Drawings? [ ] YES [ ] NO

Longitudinal center of gravity provided? [ ] YES [ ] NO

Pole birthmark provided? [ ] YES [ ] NO

CLASS A 55 - FOOT Pole
Concrete Pole Bending Test Form

	55' Pole Horizontal Loads						
	Service Stress (service load level)	Deflection Measured (FEET)		Remarks for Service Stress	Ultimate Strength	Deflection Measured (FEET)	
	Kips	(A)	(B)	(visible cracks)	Kips	(A)	(B)
1st. pull	12.24				15.61 (60%)		
2nd. pull	13.30				16.96 (85%)		
3rd. pull	14.10				17.98 (100%)		

Note: 1. Visible cracking at service load level shall be cause for pole rejection.
2. Do not perform breaking test unless passes bending test.

Concrete Pole Breaking Test

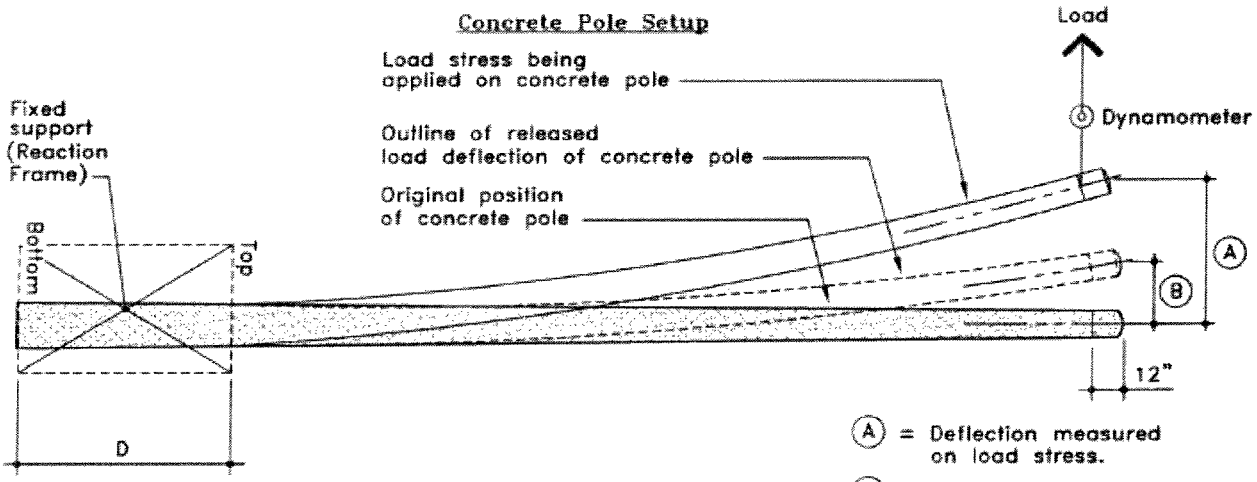
Breaking Load Stress $> \frac{\text{Ultimate Moment Capacity}}{PL-(D+1)} = $ _____

Ultimate Moment Capacity = Provide by Structural Engineer in Design Calculation .
*Non-attainment of this breaking load criteria shall be cause for pole rejection.

4th. pull • Calculated Breaking Load Stress _____ Kips, (A) = _____ .

• Breaking of concrete pole measured @ maximum Stress Load applied/ pull _____ Kips, (A) = _____ .

Concrete Pole Setup



(A) = Deflection measured on load stress.

(B) = Deflection measured on released load.

PL (Pole length) = 55'-0" and D (Depth) = 8'-0"

No. of cracks found _____, No. cracks <0.01 inch found _____ and No. cracks >0.01 inch found _____.
Draw in approximate location of cracks and indicate measurement.

CLASS B 55 – FOOT Pole
Concrete Pole Bending Test Form

	55' Pole Horizontal Loads						
	Service Stress (service load level)	Deflection Measured (FEET)		Remarks for Service Stress	Ultimate Strength	Deflection Measured (FEET)	
	Kips	(A)	(B)	(visible cracks)	Kips	(A)	(B)
1st. pull	8.38				10.68 (60%)		
2nd. pull	8.83				11.26 (85%)		
3rd. pull	9.14				11.65 (100%)		

Note: 1. Visible cracking at service load level shall be cause for pole rejection.
2. Do not perform breaking test unless passes bending test.

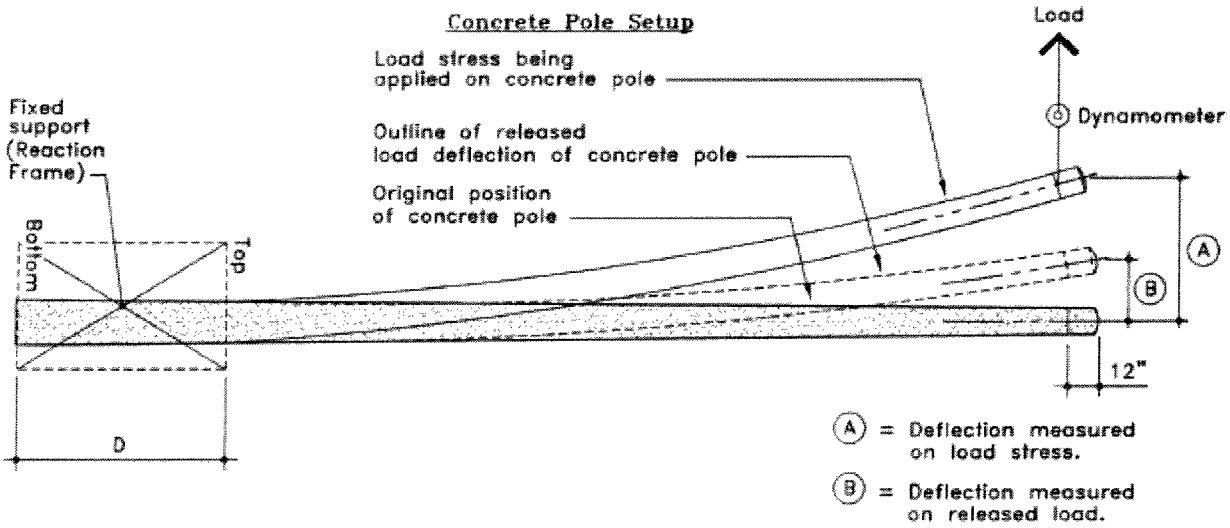
Concrete Pole Breaking Test

Breaking Load Stress $>$ $\frac{\text{Ultimate Moment Capacity}}{PL-(D+1)}$ = _____

Ultimate Moment Capacity = Provide by Structural Engineer in Design Calculation .
*Non-attainment of this breaking load criteria shall be cause for pole rejection.

4th. pull
- Calculated Breaking Load Stress _____ Kips, (A) = _____ .
- Breaking of concrete pole measured @ maximum Stress Load applied/ pull _____ Kips, (A) = _____ .

Concrete Pole Setup



PL (Pole length) = 55'–0" and D (Depth) = 8'–0"

No. of cracks found _____, No. cracks <0.01 inch found _____ and No. cracks >0.01 inch found _____.
Draw in approximate location of cracks and indicate measurement.

CLASS A 45 – FOOT Pole
Concrete Pole Bending Test Form

	45' Pole Horizontal Loads						
	Service Stress (service load level)	Deflection Measured (FEET)		Remarks for Service Stress	Ultimate Strength	Deflection Measured (FEET)	
	Kips	(A)	(B)	(visible cracks)	Kips	(A)	(B)
1st. pull	6.31				8.04 (60%)		
2nd. pull	6.49				8.24 (85%)		
3rd. pull	6.68				8.52 (100%)		

Note: 1. Visible cracking at service load level shall be cause for pole rejection.
2. Do not perform breaking test unless passes bending test.

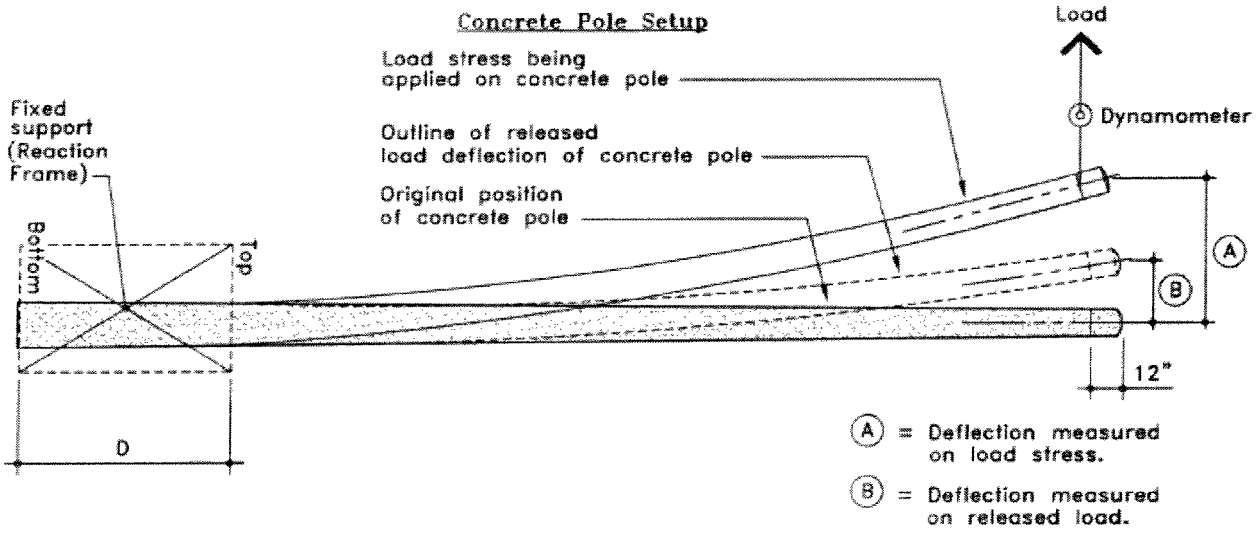
Concrete Pole Breaking Test

Breaking Load Stress $> \frac{\text{Ultimate Moment Capacity}}{PL-(D+1)} =$ _____

Ultimate Moment Capacity = Provide by Structural Engineer in Design Calculation .
*Non-attainment of this breaking load criteria shall be cause for pole rejection.

4th. pull
- Calculated Breaking Load Stress _____ Kips, (A) = _____ .
- Breaking of concrete pole measured @ maximum Stress Load applied/ pull _____ Kips, (A) = _____ .

Concrete Pole Setup



PL (Pole length) = 45'–0" and D (Depth) = 7'–0"

No. of cracks found _____, No. cracks <0.01 inch found _____ and No. cracks >0.01 inch found _____.
Draw in approximate location of cracks and indicate measurement.

CLASS B 45 - FOOT Pole
Concrete Pole Bending Test Form

	45' Pole Horizontal Loads						
	Service Stress (service load level)	Deflection Measured (FEET)		Remarks for Service Stress	Ultimate Strength	Deflection Measured (FEET)	
	Kips	(A)	(B)	(visible cracks)	Kips	(A)	(B)
1st. pull	4.97				6.34 (60%)		
2nd. pull	5.19				6.62 (85%)		
3rd. pull	5.34				6.80 (100%)		

Note: 1. Visible cracking at service load level shall be cause for pole rejection.
2. Do not perform breaking test unless passes bending test.

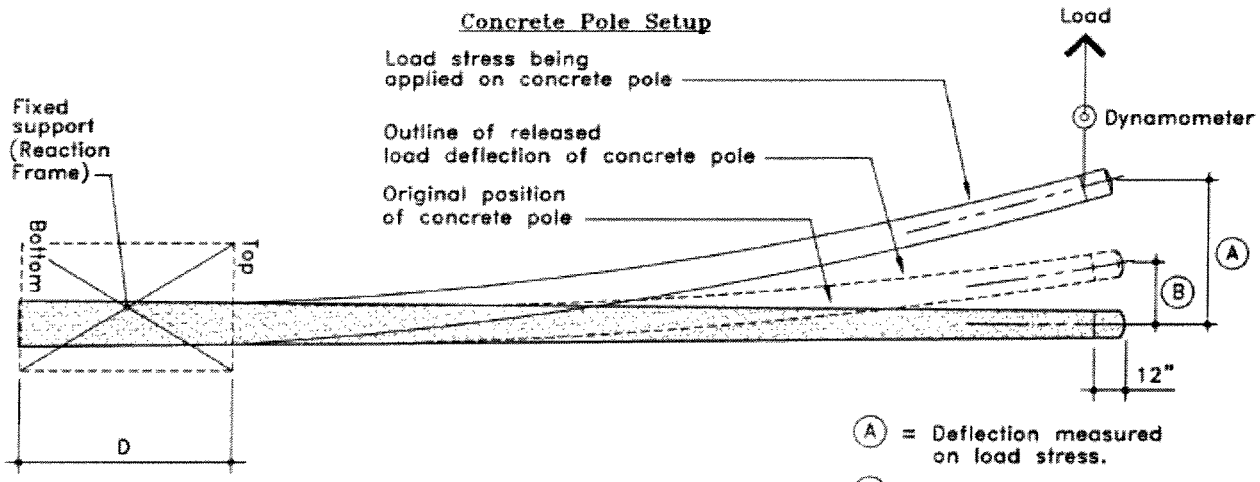
Concrete Pole Breaking Test

Breaking Load Stress $> \frac{\text{Ultimate Moment Capacity}}{PL-(D+1)} =$ _____

Ultimate Moment Capacity = Provide by Structural Engineer in Design Calculation .
*Non-attainment of this breaking load criteria shall be cause for pole rejection.

4th. pull
- Calculated Breaking Load Stress _____ Kips, (A) = _____ .
- Breaking of concrete pole measured @ maximum Stress Load applied/ pull _____ Kips, (A) = _____ .

Concrete Pole Setup



(A) = Deflection measured on load stress.

(B) = Deflection measured on released load.

PL (Pole length) = 45'-0" and D (Depth) = 7'-0"

No. of cracks found _____, No. cracks <0.01 inch found _____ and No. cracks >0.01 inch found _____.
Draw in approximate location of cracks and indicate measurement.

CLASS 35 – FOOT Pole
Concrete Pole Bending Test Form

	35' Pole Horizontal Loads						
	Service Stress (service load level)	Deflection Measured (FEET)		Remarks for Service Stress	Ultimate Strength	Deflection Measured (FEET)	
	Kips	(A)	(B)	(visible cracks)	Kips	(A)	(B)
1st. pull	4.16				5.31 (60%)		
2nd. pull	4.37				5.58 (85%)		
3rd. pull	4.52				5.76 (100%)		

Note: 1. Visible cracking at service load level shall be cause for pole rejection.
2. Do not perform breaking test unless passes bending test.

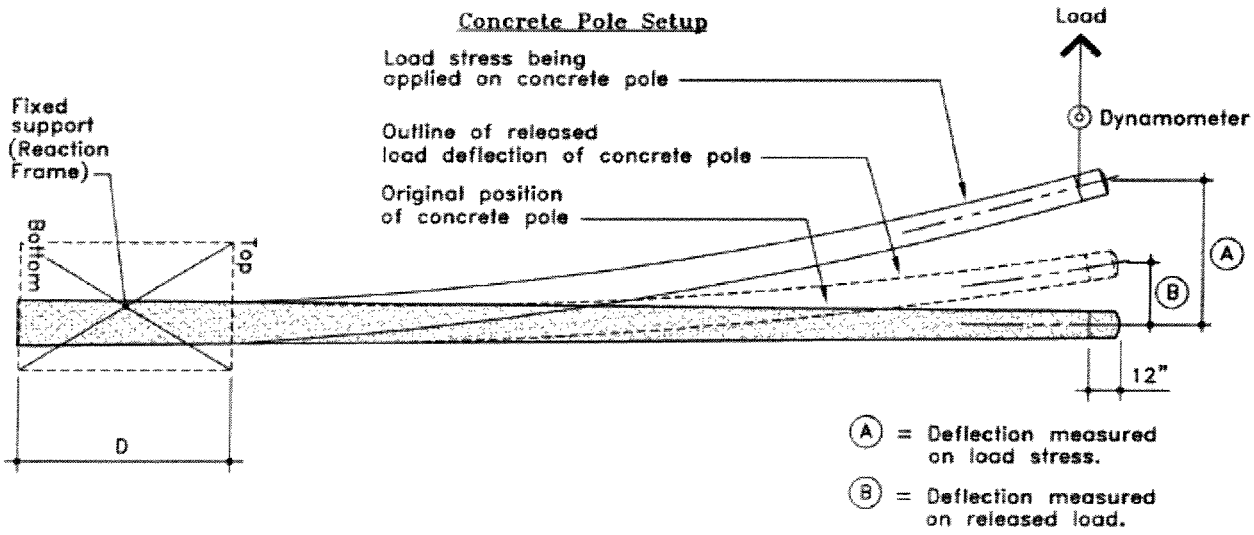
Concrete Pole Breaking Test

Breaking Load Stress $>$ $\frac{\text{Ultimate Moment Capacity}}{PL-(D+1)}$ = _____

Ultimate Moment Capacity = Provide by Structural Engineer in Design Calculation .
*Non-attainment of this breaking load criteria shall be cause for pole rejection.

4th. pull
- Calculated Breaking Load Stress _____ Kips, (A) = _____ .
- Breaking of concrete pole measured @ maximum Stress Load applied/ pull _____ Kips, (A) = _____ .

Concrete Pole Setup



PL (Pole length) = 35'–0" and D (Depth) = 6'–0"

No. of cracks found _____, No. cracks <0.01 inch found _____ and No. cracks >0.01 inch found _____.
Draw in approximate location of cracks and indicate measurement.

APPENDIX F TESTING OF CONCRETE SAMPLE FORM

Number of samples tested: _____

STRENGTH TEST RESULTS

SAMPLE NUMBER	AGE	SIZE	LOADING AT FAILURE	COMPRESSIVE STRENGTH
1	_____	_____	_____	_____
2	_____	_____	_____	_____
3	_____	_____	_____	_____
4	_____	_____	_____	_____
5	_____	_____	_____	_____
6	_____	_____	_____	_____
7	_____	_____	_____	_____
8	_____	_____	_____	_____
9	_____	_____	_____	_____
10	_____	_____	_____	_____

FOR GUAM POWER AUTHORITY

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