

THE ISLAMIC REPUBLIC OF PAKISTAN

DETAILED DESIGN STUDY

ON

WEST WHARF

THERMAL POWER PLANT PROJECT

FINAL REPORT-II

LOT IIB (VOLUME 2)

JANUARY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

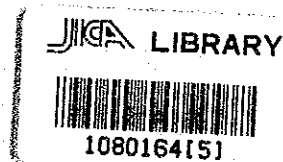
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VOLUME 2

SECTION I

TECHNICAL GENERAL CONDITIONS

LOT II B Vol 2-1

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PART I. TECHNICAL GENERAL CONDITIONS

1. GENERAL DESCRIPTION OF THE PROJECT

1.1 INTENT

- (1) The Technical General Conditions state the specific requirements for design, storage, erection, safety, etc., which are not specified in Sections I through IV, Volume I. The Technical General Conditions, together with the applicable Technical Specifications plus the Instruction to Tenderers, the Tender and Appendices, the Conditions of Contract, the Conditions of Particular Application and the Drawings for Tendering shall form the Tender Documents which will ultimately become a part of the Contract between the Owner and the successful tenderer.

- (2) These Specifications and the Drawings for Tendering outline the Owner's basic design requirements. Therefore, the Contractor shall carry out the design in conformity with the requirements specified.

The Contractor's reliance thereon shall not relieve the Contractor nor his subcontractors of their responsibilities for meeting the performance and availability guarantee defined hereinafter and in the Contract.

In case that the Contractor requires to revise parts of the Owner's basic requirements, he shall submit the explanation, calculations, drawings, etc., to the Owner and the Engineer for approval.

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1.2 PARTICULAR SITE CONDITIONS

The West Wharf Thermal Power Station Project is a redevelopment and innovation project of the old power station, that is, the existing West Wharf Thermal Power Station, calling for the construction of 2 units of 200 MW oil fired thermal power generating units.

The existing West Wharf Thermal Power Plant is located in the West Wharf area facing Karachi Bay.

This site area is located near the load center of Karachi, and its north side is adjacent to the Caltex Oil Terminal.

The west side faces Dockyard Road, with land owned by the Pakistan Navy on the south side of this road.

Further on toward the west side of this road are found the Pakistan Oxygen & Acetylene Co., Ltd., and the Karachi Shipyard & Engineering Works Ltd. (KSY).

The east side border of this site faces a wharf, belonging to Karachi Port Trust (KPT) and has a width of approximately 150 m. Found within a total site area of about 37,000 m² is the power station comprising Stations "A", "B" and "BX".

However, Station "A" had been decommissioned and almost all equipment and machinery were dismantled. Only a few vacant buildings and machine foundations remain.

In 1987, "B" Station (15 MW x 2) had also been decommissioned, and only the "BX" Station is presently operating.

The "BX" Station (33 MW x 2) plays an important role in the KESC electrical power supply system. It generates power and maintains system stability, by supplying power to the nearby city center and the West Wharf area via 66 kV transmission lines and an 11 kV distribution system.

1.3 CONCEPTION OF SCOPE OF WORK FOR EACH LOT

The Owner will request the following items of works and services under separate contracts. The Contractor of Lot II B shall coordinate his works with the works and services executed by other separate contractors.

(1) Lot I (Power Plant)

- o West Wharf Thermal Power Plant including civil and architectural works

(2) Lot II A (Substation and underground cable)

- o 220/132 kV substation inside the power station, including civil and architectural works
- o 220 kV extension bays in the Baldia Grid Station, including civil and architectural works
- o Underground cable between West Wharf Thermal Power Station to No. 1 transmission tower, including civil works

(3) Lot II B (Transmission line)

- o 220 kV transmission line facilities between No. 1 transmission tower approx. one kilometer from the West Wharf Thermal Power Station and the Baldia Grid Station,

including transmission towers and related facilities

(4) Lot III (Dismantling work)

- o Dismantling of the existing equipment, buildings, foundations, etc.
- o Removal work of existing piles
- o Site preparation work, cleaning and leveling work of the site area

2. SCOPE OF WORK

2.1 GENERAL

These Specifications call for the supply of materials and construction of the 220 kV transmission line from the terminal point of 220 kV underground cable, which will be extended from the West Wharf Thermal Power Plant, to the Daldia Grid Station and the 132 kV transmission line mounted on the same towers of the 220 kV line, starting from the same point as the 220 kV line and up to the No. 4 transmission tower.

The Contract includes, but shall not be limited to, designing, manufacturing, galvanizing, painting, testing, packing for export, insuring, shipping, unloading, customs clearance, delivery to site, storing, installing, field tests and preparations for commissioning, including dismantling of the section of No. 1 tower to No. 5 tower of the existing 66 kV Mauripur and S.I.T.E. lines and the connection of new 132 kV line to the existing 66 kV line at new No. 4 tower.

2.2 OUTLINE OF THE FACILITIES TO BE PROVIDED

The 220 kV line shall start at the end of the 220 kV underground cable and continue about 3.5 km toward the Mauripur Grid Station.

Nearby the Mauripur G/S, the 220 kV line runs westward taking a coastal route, turns northward and again westward through a sparsely populated area to reach the Baldia Grid Station.

The route forms a semi-circle surrounding the Pakistan Air Force Base, and its total length is about 24 km.

Tower heights are limited, as shown in DWG. No. WLT - 1001, due to the taking off and landing of aircraft.

The section of about 1 km between the No. 1 transmission tower and the No. 4 transmission tower shall comprise composite towers for a 220 kV line and a 132 kV line to be constructed along the same route as the existing 66 kV lines which will be dismantled under the Lot II B contract.

The 220 kV line has 2 circuits of ACSR/AS 330 mm² of twin bundled conductors and 2 OPGW 120 mm² as ground wire. The 132 kV line consists of 2 circuits of single conductor of ACSR/AS 680 mm.

2.3 TERMINAL POINTS OF THE CONTRACT

The respective terminal points for the work to be provided under Lot II A and Lot II B Contracts shall be as follows. (Refer to Fig. 2.1)

(1) 220 kV line

- (a) Tension insulator string sets and tension clamps for ground wires at the gantry structures near No. 1 tower and the Baldia G/S shall be provided for under the contract for Lot II B.
- (b) Plates on the gantry structures for tension sets of conductors and ground wires shall be provided for under the contract for Lot II A.

- (c) T sleeves and lead conductors for lightning arresters shall be provided for under the contract for Lot II B.
- (d) Terminals of lead conductors for lightning arresters shall be provided for under the contract for Lot II A.
- (e) The lead down OPGW, fixing clamps, rack and terminal box for OPGW to be installed on the gantry structures as well as connection work of OPGW to the optical fiber approach cable at the terminal box shall be provided for under the contract for Lot II B.

(2) 132 kV line

- (a) Tie down conductors and insulator strings shall be provided for under the contract for Lot II B.
- (b) The structure and foundation for insulator strings of tie down conductor shall be provided for under the contract for Lot II A.
- (c) Parallel groove clamps and lead conductors for lightning arresters shall be provided under a separate contract.

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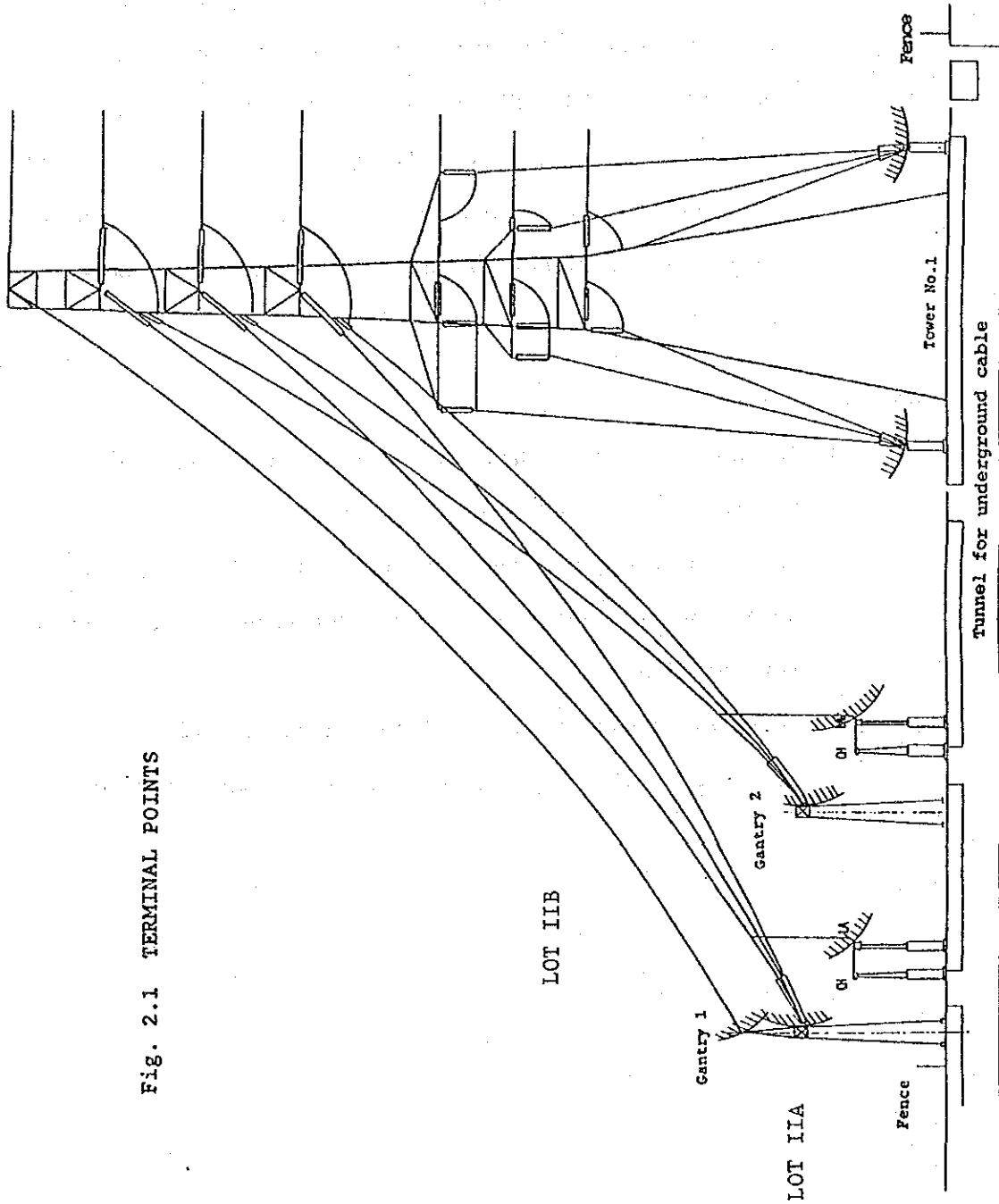


Fig. 2.1.1 TERMINAL POINTS

TC02-4

3. APPLICABLE STANDARDS, CODES AND REGULATIONS

The equipment and materials shall be designed and constructed in accordance with the following standards, codes and regulations.

The standards, codes and regulations applied in each case shall be the latest revisions adopted and published at the date of receiving tenders.

Equivalent standards, codes and regulations of other authorities may be considered when submitted to and approved by the Engineer in the English language. If the proposed substitute standards, codes or regulations are acceptable to the Owner and the Engineer, their use shall be authorized by the Engineer in writing.

- (1) Japanese Industrial Standard (JIS)
- (2) Standards of Japanese Electro-Mechanical Committee (JEC)
- (3) Japan Electric Manufacturer's Association Standards (JEM)
- (4) Japanese Society of Civil Engineers (JSCE)
- (5) International Electrotechnical Commission (IEC)
- (6) British Standards (BS)
- (7) American Society for Testing and Materials (ASTM)
- (8) International Standardization Organization (ISO)
- (9) Architectural Institute of Japan (AIJ)
 - (a) Standards for Design of Steel Pile Foundations for Buildings
 - (b) Standards for Structural Design of Building Foundations
 - (c) Standards for Design of Steel Structures
 - (d) Standards for Design of Reinforced Concrete Structures

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- (10) Japan Road Association (JRA)
- (11) Japan Architectural Standard Specifications (JASS)
- (12) Japan Society of Civil Engineers (JSCE)
 - (a) Standard Specifications for Concrete
- (13) Steel Structures Painting Council (S.S.P.C. - U.S.A.)

4. ENVIRONMENTAL CONDITIONS

4.1 GENERAL

The following information provides a general indication of the conditions at the Site. This information is intended to assist the Contractor in formulating the construction program, but shall not relieve the Contractor in any way from his obligation to grasp and make use of all available data. The Owner and the Engineer will take no responsibility whatsoever for the accuracy of the interpretation involved therein and any risk consequent on the interpretation thereof is to be entirely borne by the Contractor.

4.2 TRANSMISSION LINE ROUTE

As the construction site is situated in Karachi City, the transmission line runs very close to the Arabian Sea.

The section of composite towers runs parallel to and alongside a road. The route then turns left at the No. 4 transmission tower and approaches an area close to the Mauripur Grid Station after crossing over a swampy area, reclaimed land and the mouth of Layari River.

From this point, the route passes the waterfront area and enters the salt flats. The transmission line then proceeds through an uninhabited desert area and arrives at the Baldia Grid Station by taking a round about way of the Pakistan Air Force Base.

4.3 CLIMATIC CONDITIONS

(1) Ambient temperature

The climate in the Karachi area comprises moderate temperatures and warm, sunny days. The temperature in summer at times rises above 40°C. However, in August, the weather is rather cloudy, particularly in the mornings and evenings when the temperature naturally drops. In winter the daytime temperature hovers between 5°C to 30°C.

The following values shall be adopted for the design bases.

Maximum temperature	48°C
Mean temperature	25°C
Minimum temperature	0°C

(2) Humidity

Humidity in the winter is normally lower than 40%, but climbs to as high as 90% in the summer.

(3) Rainfall

Karachi has almost no rainfall during the winter months, and only a few centimeters of rainfall in the summer. Annual precipitation is less than 200 mm.

(4) Wind

Cyclonic storms occur mostly in May, June, October and November. As such, the maximum wind velocity for the design shall not be less than 38 m/sec. Measures for the protection of all steel structures shall be carefully taken into account. The Contractor shall also bear in mind measures for the

protection against corrosion caused by the salty air and
windblown sand.

TC04-3

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5. MATERIALS AND WORKMANSHIP

All work shall be performed and completed in a neat and skillful manner and shall follow modern practices in the design and manufacture of the types of the materials specified herein. Only persons skilled in the relative professions or trades shall execute work under this Contract.

All materials shall be new and of the best quality, and shall be finished to a uniform high standard. Surface finishes shall be smooth and shall conform to the best commercial practice. Defects such as flaws, rusts, cracks, etc., will not be accepted. Filling or plugging of any defective parts shall not be permitted without the written consent of the Engineer.

The design of all conductor fittings, insulator fittings, etc., shall avoid sharp corners or projections which would produce high electrical stress under normal operation.

Metal parts in contact with each other shall be designed and manufactured to prevent corrosion of the contact surfaces and to maintain good electrical contact under service conditions.

Particular care shall be taken during the manufacture of the conductors and fittings and during subsequent handling to ensure smooth abrasion free surfaces.

6. WELDING

In all cases where fabrication welds are likely to receive high stress, such as parts subjected to reversals or operation, stress the Contractor shall submit to the Engineer a general arrangement drawing of the fabrication and, at a later date but before fabrication commences, a detailed drawing of all proposed weld preparations for the fabrication.

Before such welding commences, the Contractor shall show the Engineer that welders or welding operators are qualified in accordance with the requirements of the appropriate section of BS 4871 or such other approved standards. The Contractor shall be required to submit evidence of the welders' capability whenever so requested by the Engineer.

After scrutinizing the general arrangement and welding detail drawings, the Engineer will inform the Contractor of the stages at which inspection will be required. The Contractor shall notify the Engineer when each of the inspection stages has arrived and no further work is to be carried out until after the Engineer has inspected and approved the work at that stage. The Contractor shall be fully responsible for notifying the Engineer of the heretofore mentioned times of inspection.

In addition to the above, the Engineer reserves the right to visit the Contractor's works at any reasonable time during fabrication of the items of plant and to familiarise himself with the progress made and the quality of the work to date.

In the event the Contractor wishes to make an alteration to any part of the approved weld preparations, he shall first submit to the Engineer a copy of the revised drawing showing details of the amended preparation and wait for confirmation of the Engineer's decision before proceeding with the altered preparation.

7. CASTINGS

All castings are to be free from blowholes, flaws and cracks wherever practicable. No welding, filling or plugging of defective parts shall be done under any circumstances. All cast iron shall be of close-grained quality and approved by the Engineer.

8. GALVANIZING

All iron and steel parts and members shall be galvanized upon completion of the fabrication. The galvanizing shall be carried out by the hot dip process for all parts.

The minimum weight of galvanizing shall be as specified in the relevant Technical Specifications herein.

Galvanized surfaces shall be smooth and free from harmful defects.

The coating shall have good adhesion to the base metal and be capable of withstanding rough handling.

9. PAINTING

Painting on tower materials shall be carried out in accordance with JIS standards or equivalent. Particular measures shall be taken so that paint will not peel off the galvanized surface of the steel. All paints shall be of the best quality and durability of their kind.

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10. UNITS OF MEASUREMENT AND LANGUAGE

The Contractor shall use the metric unit of measurement for all correspondence, technical drawings, requests, etc., for this Project. On drawings or printed pamphlets where other units have been used, the equivalent metric measurement shall be added. All documents, correspondence, drawings, reports, schedules and instructions shall be in the English language.

11. SHOP TESTS AND INSPECTIONS

- (1) The Contractor shall give the Owner and the Engineer reasonable notice of at least 30 days in advance whenever shop tests are to be made on equipment and materials specified in each section of these Specifications, so that the Owner and Engineer can have representatives present during such tests, if the Owner and the Engineer so desired.

When the Contractor gives the Owner and the Engineer notice of shop tests, he shall submit in detail the method and extent of the tests to be made, so that a decision can be made by the Owner and the Engineer as to whether they will witness the same or not.

- (2) The Contractor shall submit to the Owner and the Engineer certified copies of all tests, data and results signed by the manufacturer's inspector. Under no circumstances shall equipment be shipped without advance submittal of test certificates to the Owner and the Engineer for approval, or without copies to the Owner. Upon approval of the test results by the Owner and the Engineer, the equipment shall be packed for shipment.

(a) Shop Inspection and Tests

During manufacture, equipment and materials may be inspected and tested witnessed by the Owner and the Engineer whenever the Owner or the Engineer so desires.

(b) Procedures

All material, mechanical and electrical tests carried out during manufacture shall be in accordance with the applicable test procedures submitted by the Contractor to the Owner and the Engineer and as approved by the Owner and the Engineer. The Contractor shall describe in detail the degree to which each unit, auxiliaries or any part thereof will be assembled in the factory, as well as the material, mechanical and electrical tests to be carried out on the parts assembled.

(c) Test Reports

All test reports with proceduress shall be in the English language.

- (3) The Contractor shall permit the Owner and the Engineer free access at all times to his manufacturing facilities for the purpose of inspection and expediting.
- (4) All tests, including material, electrical and mechanical operational checks, calibrations, etc., may be witnessed by the Owner and the Engineer, if they so desire, and adequate notice of such procedures shall be given to the Owner and the Engineer.
- (5) The approval of the Engineer of the results of any such inspection or tests shall not prejudice the right of the Owner to reject the plant if any part, when erected, fails to comply with these Specifications or fails to fulfil the

purpose for which it was supplied. The cost of tests, including the provision of the necessary test equipment at the manufacturer's works, shall be included in the Contract price.

12. ERECTION

- (1) Prior to erection work, the Contractor shall conduct thorough research and investigation on preliminary work methods, safety and scheduling, so that the erection work can be smoothly conducted and the erected plant can exhibit the expected performance.
- (2) The Contractor shall assign the Contractor's representative at the job site from the beginning through to completion of the work. The Contractor's representative shall be given the authority effective during the period of work which allows him to take all the necessary emergency measures so as to execute the said work. However, the Contractor's representative shall be approved by the Owner.
- (3) The Contractor's representative shall supervise quality control, safety control and maintenance of the facilities with a strong sense of responsibility. He shall also be responsible for retaining order and preventing trouble at the work site.
- (4) In case the Owner determines that the Contractor's representative is unsuitable for the position, the person shall be replaced at the Contractor's expense. When the Contractor's representative is absent from the job site for two weeks or more for a business trip or other reasons, approval to this effect shall be obtained from the Owner, and a proxy shall be assigned during this period.

- (5) Equipment, instruments and materials shall be handled with special care at the time of transporting, handling, and storing the said items in order to prevent loss and damage.
- (6) The Contractor shall closely consult with the Owner and the Engineer about such matters as erection, installation, adjustment and inspection of equipment and materials. The Contractor's representative shall maintain close contact and cooperation with the Owner and the Engineer, and exert his best effort to conduct the said work in a proper and satisfactory manner.
- (7) In case inconvenience or trouble arises in relation to other facilities or work in progress during the installation work, the Contractor shall report to the Owner and the Engineer and shall then, under the coordination of the Owner and the Engineer, conclude an agreement with the other contractor(s) of the work in a manner that all work can proceed in smooth and trouble-free fashion.
- (8) The Contractor shall exert every effort to maintain things in order so as to prevent accidents at the work site and to facilitate smooth progress of the work. After each work is completed, scaffolding and related materials and machines employed for executing the work shall be removed immediately, and the work site shall be cleaned and put in proper order.
- (9) The Contractor shall exercise extreme care to prevent any fire whatsoever, particularly at the work site or at the workmen's

quarters.

- (10) Waste oil, dust and trash, and materials which accumulate as the work progresses shall be disposed of in a manner approved by the Owner and the Engineer.
- (11) Prior consultation shall be conducted to prevent accidents which might occur between two different working levels. Such consultation between and/or among other contractors shall be conducted in the presence of the Owner and the Engineer.
- (12) Should human accident, facility accident, public nuisances or other emergencies develop in relation to the work, appropriate emergency measures shall be taken immediately, and any accident occurring thereof shall be reported to the Owner and the Engineer at once.
- (13) Should the Contractor employ a subcontractor(s), the Contractor shall submit a report describing the background and experience of the subcontractor(s) to the Owner and the Engineer for approval.
- (14) The Contractor's representative and/or related persons shall attend the periodic meetings held by the Owner and the Engineer during the progress of the work so as to discuss all work methods and progress.
- (15) The Contractor shall prepare all temporary materials required for erection work.
- (16) The Contractor shall submit a work report (Number of persons

by job, contents of work, etc.) to the Owner and the Engineer daily.

(17) The Contractor shall submit the installation specifications to the Owner and the Engineer for approval.

(18) All welders shall be qualified for their specialized work areas, and the Contractor shall submit their certificates of qualification to the Owner and the Engineer.

(19) Welding rods shall be carefully boxed and sufficiently protected from damage caused by high humidity during shipment and storage at the site.

The Contractor shall take measures to prevent incorrect use of welding rods by welders during construction work in the field.

(20) The Owner and the Engineer shall have the right to inspect and approve each stage of the work so as to ensure smooth work progress and completion.

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13. SAFETY

13.1 SAFETY ASSURANCE

- (1) The Contractor shall continuously take special care to ensure the safety and prevention of human and equipment accidents and maintain good sanitary conditions on and around the site in accordance with all pertinent labor standards and laws.
- (2) During the execution of the work, the Engineer will inspect the Contractor's safety measures from time to time and will instruct the Contractor to enforce such measures or to take additional measures, to which the Contractor shall strictly and immediately follow.

13.2 SAFETY FACILITIES

- (1) The Contractor shall take all necessary safety precautions regarding the facilities to protect any worker, third party or on-site personnel.
- (2) The Contractor shall maintain at his own expense all lights, guards, fencing and human watch when and where necessary or as required by the Owner and the Engineer or their duly constituted representative for the protection of the works and for the safety and convenience of the public.
- (3) The Contractor shall take sufficient measures so as not to cause any danger, hazard or obstruction to the public.

- (4) The Contractor shall maintain close communication with the police and the administrators of the roads and rivers in advance regarding traffic and other security measures.
- (5) The Contractor shall install any/all other proper guard facilities necessary for the execution of the works.
- (6) Scaffolds and steps needed for work at/in high places shall be provided wherever necessary. All measures shall be taken to prevent falling accidents, such as by preparing safety ropes, catch nets, etc.
- (7) In case there exist any holes or openings within the construction site into which workers may fall, safety measures against this shall be provided by covering the said area or by constructing handrails when the said holes or openings are not in use.
- (8) All personnel working at/in high places considered dangerous shall wear life ropes, and preventive measures against the droppage of tools and materials shall be taken.
- (9) All work in the vicinity of equipment and facilities having live electricity shall be avoided whenever possible. However, when work in the vicinity of such places is unavoidable, the area of danger shall be clearly indicated and a person in charge of safety shall be present at all times during the work.
- (10) Before heavy equipment is transported, sufficient

investigation to ensure the strength of roads and road shoulders shall be carried out.

13.3 MEASURES IN CASE OF ACCIDENT

The Contractor shall carry out all necessary measures and submit the report to the Owner or the Engineer without delay when a human and/or facilities accident occurs or damage to a third party occurs.

13.4 SAFETY PLANS

The Contractor shall submit to the Owner and the Engineer plans on accident prevention as directed by the Owner.

13.5 ORDERLY SITE

The Contractor shall maintain a safe and orderly work site and maintain the site in a clean, neat and easy-workable condition throughout the period of work execution.

14. TESTS AT SITE

- (1) The Contractor shall be responsible for operation during the period commencing with individual operation test and extending through trial operation.

The Owner will furnish electrical power, and will provide an operator(s) to assist the Contractor's operating personnel. However, the Contractor shall be fully responsible for all operation as well as consumable materials to be used for start up, trial operation and performance tests.

- (2) The Contractor shall prepare all test procedures and submit the reports to the Owner and the Engineer for approval.

SECTION II

TECHNICAL SPECIFICATIONS

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SECTION II. TECHNICAL SPECIFICATIONS

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1. GENERAL

- (1) These specifications cover the requirements for design, manufacture, shop tests, delivery storage at the Site, installation, start up field tests, and work related commissioning from the terminal point of 220 kV underground cable to the Baldia Grid Station, including the construction and maintenance of all temporary facilities.
- (2) The Technical Specifications and the Owner's Drawings show the Owner's basic design requirements. Therefore, the Contractor shall carry out the design in conformity with the requirements specified.

In case the Contractor desires to revise parts of the Owner's basic requirements, he shall submit his explanations, calculations, drawings, etc., to the Owner and the Engineer for approval.

- (3) The materials to be supplied shall be carefully protected from corrosion.
- (4) Dismantling and construction of transmission line for the section from tower No. 1 to tower No. 4 will be carried out in the condition of shutdown of the existing line. As the shorter the period of shutdown is and the better the power supply system becomes, the Contractor shall coordinate the construction schedule with the Contractor for Lot IIA, and shall submit it to the Owner and the Engineer for approval by indicating the shutdown period requested by the Contractor.

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2. CONDUCTOR

2.1 GENERAL

The line conductors shall be the concentric-lay standard aluminum conductors aluminum-clad steel reinforced (ACSR/AS), and shall comply with the requirements specified in these specifications, ASTM B232, ASTM B230 and ASTM B502.

2.2 REQUIREMENTS

All wires making up the conductor shall be uniform and smooth and shall have no defects such as points, sharp edges, abrasions, or other imperfections that would tend to increase radio interference and corona loss. The conductor shall also be free of metal particles and dirt. The make up and lay of the conductor strands shall be such that all conductors are free from the tendency to untwist or spring apart when cut.

Aluminum shall be of the highest purity commercially obtainable. Purity shall not be less than 99.5 per cent. The Contractor shall submit certificates of analysis giving the percentage and nature of any impurities in the metal from which the wires are made. In all constructions the successive layers shall have opposite directions of lay, the outermost layer being right handed (Z-stranding). The wires in each layer shall be evenly and closely stranded.

The conductor for 220 kV line shall be ACSR/AS 330 mm² and ACSR/AS 680 mm² for 132 kV line.

2.3 CHARACTERISTICS AND GUARANTEED VALUES

(1) ACSR/AS 330 mm²

(a) Composite wire

Sectional area	379.6 mm ²
Construction	
Al	26/4.0 mm
AS	7/3.1 mm
Minimum ultimate tensile strength	10,950 kg
Overall diameter	25.3 mm
Weight per km	1,239 kg
DC resistance at 20°C	0.0835 ohm/km

(b) Aluminum wire

Diameter	4.0 mm
Minimum tensile strength	16.17 kg/mm ²
Minimum elongation in 250 mm	1.9%
Minimum conductivity at 20°C	61%

(c) Aluminum-clad steel core wire

Diameter	3.1 mm
Minimum tensile strength	130 kg/mm ²
Minimum elongation in 250 mm	1.5%
Minimum conductivity at 20°C	23%
Minimum stress at 1% extension	110 kg/mm ²
Minimum number of twisting before stranding	20 times

(2) ACSR/AS 680 mm²

(a) Composite wire

Sectional area	766.8 mm ²
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Construction

Al	54/4.0 mm
AS	7/4.0 mm
Minimum ultimate tensile strength	20,180 kg
Overall diameter	36.0 mm
Weight per km	2,446 kg
D.C. resistance at 20°C	0.0408 ohm/km
(b) Aluminum wire	
Diameter	4.0 mm
Minimum tensile strength	16.17 kg/mm ²
Minimum elongation in 250 mm	1.9%
Minimum conductivity at 20°C	61%
(c) Aluminum-clad steel core wire	
Diameter	4.0 mm
Minimum tensile strength	130 kg/mm ²
Minimum elongation in 250 mm	1.5%
Minimum conductivity at 20°C	23%
Minimum stress at 1% extension	110 kg/mm ²
Minimum number of twisting before stranding	20 times

3. GROUND WIRE

3.1 GENERAL

Composite fiber-optic overhead ground wire (OPGW) of 120 mm² shall comply with the requirements of these specifications, ASTM B415 and ASTM B416.

OPGW 120 mm² shall be optical fiber cored cable surrounded by 7 strands of round aluminium-clad steel wire, and the direction of the outer layer shall be right-handed (Z-stranding).

The construction shall be so designed that the optical fiber can be released from the tension caused by the longitudinal elongation of OPGW.

3.2 CHARACTERISTICS AND GUARANTEED VALUES

(1) OPGW 190/90 mm²

Construction	1/5.2 mm OP unit + 7/4.0 mm AS + 12/4.47 mm HAL
Overall diameter	22.2 mm
Cross sectional area	283.59 mm ²
Minimum ultimate tensile strength	10,500 kg
Weight per km	1,136 kg
DC resistance at 20°C	0.129 ohm/km
Maximum continuous operating temperature	150°C
Maximum one second operating temperature	300°C

System fault current 40,000 A x 1 sec.

(2) Optical cable

Optical fiber type Single mode
Number of optical fiber 5
Optical attenuation at wavelength 1.3 μ m Max. 0.5 dB/km

(3) Aluminum-clad steel wire

Diameter 4.0 mm
Minimum ultimate tensile strength 116 kg/mm²
Minimum elongation in 250 mm 1.5%
Minimum conductivity at 20°C 20.3%
Minimum stress at 1% extension 125 kg/mm²
Minimum aluminum thickness 0.22 mm

(4) Aluminum wire

Diameter 4.47 mm
Minimum tensile strength 16.17 kg/mm²
Minimum elongation in 250 mm 1.9%
Minimum conductivity at 20°C 61%

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4. INSULATOR

4.1 SUSPENSION INSULATOR

The insulators shall be fog type corrosion-proof of 254 mm of diameter, and shall comply in all aspects with the requirements of the IEC Recommendations Nos. 120, 305, 372, 383 and 575.

The insulators shall be made of the highest grade, dense, homogeneous, wet-process, high strength alumina porcelain, completely and uniformly vitrified throughout to produce uniform mechanical and electrical strength and long life in service. The porcelain head of the suspension insulators shall be cylindrical headed with sanded surfaces.

The glaze shall be continuous, uniform and unaffected by adverse climatic condition and storms, rapid changes of temperature, acids and alkaline.

The design of insulators and fittings shall be such as to avoid local corona formations and discharge likely to cause radio interference.

The size of the ball and socket parts of the suspension insulators shall be of 16 mm A, and the ball pin shall have a pure zinc sleeve. The zinc sleeve shall be well fused to the pin shank and shall have a fused area of more than 80% of the total area of the interface between zinc sleeve and pin shank.

The ball sockets shall be hot-dipped galvanized, and shall have no

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defects such as rust, strain, cracks, etc., and they shall be designed so correctly as to be mutually jointed and facilitate easy assembly and disassembly.

The zinc coating quantity shall be 500 g/m^2 in minimum value.

Self-locking type stainless split pins shall be applied for the sockets.

4.2 CHARACTERISTICS AND GUARANTEED VALUES

Type of insulator	Fog type suspension insulator (Ball and socket type)
Color of glaze	Brown
Disc diameter	254 mm
Unit spacing	146 mm
Leakage distance	432 mm
Power frequency puncture voltage	130 kV
Electromechanical failing load	More than 12,000 kg
Flashover voltage	
Dry (50 Hz)	95 kV
Wet (50 Hz)	55 kV
Impulse (1 x 40 us) positive	135 kV
Impulse (1 x 40 us) negative	145 kV
Withstand voltage	
Power frequency	45 kV
Impulse	125 kV
Puncture voltage	130 kV

4.3 INSULATOR STRINGS

V-suspension insulator strings shall be applied for 220 kV line. The characteristics of the suspension insulator strings with no arching horn shall be as follows.

Nominal voltage	220 kV		132 kV	
Type of strings	V-suspension string	Tension string	Suspension string	Tension string
No. of discs/string	22	23	14	15
Withstand voltage (kV)				
Power frequency (wet)	500	515	360	380
Impulse	1,705	1,775	1,115	1,190
Flashover voltage (kV)				
Impulse positive	2,010	2,090	1,345	1,430
Impulse negative	2,010	2,095	1,310	1,400
Electromechanical failing load (kg)	----- 12,000 -----			

Suspension and tension insulator sets to be supplied shall consist of single or double strings of insulator units with all fittings complete, including clamps and arcing horns as specified in the drawings DWG No.

4.4 MATERIALS

Porcelain shell	High strength alumina porcelain brown glazed
Socket cap	Ductile iron or steel, hot-dip galvanized
Ball pin	High tension steel with pure zinc sleeve,

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hot dip galvanized. The material of zinc sleeve shall be pure zinc with a purity of not less than 99.7%.

Cotter pin	Stainless steel
Cement	Portland cement

4.5 GENERAL REQUIREMENTS

(1) Identification of the insulator

Each string insulator unit shall be marked with the name or trade mark of the manufacturer. In addition, each string insulator unit shall be marked with the specified electromechanical or mechanical failing load and year of manufacture. These markings shall be legible and unerasable.

(2) Qualification

As reference for evaluation, the Tenderer shall include in his tender the following evidence from the manufacturer of the offered insulator. A tender without this evidence is may be rejected.

(a) Type test certificate

Tenderers shall include with their tenders test certificates for the offered insulator, including thermal and mechanical performance carried out in accordance with IEC 575 for the tension disc insulator with judging criteria of three standard deviation.

This Type Test certificate shall be issued by an approved internationally acknowledged reputable and independent

testing laboratory. Proof shall be given that the laboratory has performed testing services for known insulator manufacturers from all over the world, and this laboratory shall be outside the country of the manufacturer.

- (b) Certification that the same insulators have been sold to foreign customers for a period of at least five years.
- (c) A list of at least five foreign purchasers of these insulators, giving time of delivery, quantities supplied, and full name and address of these purchasers shall be provided.

5. STEEL TOWERS

5.1 GENERAL

The support structures of the transmission line shall be self-supporting zinc coated steel towers of square based lattice type for the 220 kV 2 circuits line and for the composit structures of 220 kV and 132 kV lines of 2 circuits each.

The design of steel towers shall be in accordance with JEC-127 (1965) or equivalent.

Suitable lock nuts, subject to the approval of the Engineer, shall be applied at site on the transmission line towers.

5.2 BASIC DESIGN CONDITION

Nominal voltage	220 kV	132 kV
No. of circuit	2	2
Conductor		
Name and site	ACSR/AS 330 mm ²	ACSR/AS 680 mm ²
No. of subconductors	2	1
Weight	1.239 kg/m	2.446 kg/m
Overall diameter	25.3 mm	36.0 mm
Maximum tension	4,000 kg	6,000 kg
Maximum temperature	80°C	80°C

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Ground wire

Name and size	OPGW 190/90 mm ²
No. of wire	2
Weight	1.136 kg/m
Overall diameter	22.2 mm
Maximum tension	3,600 kg

Environmental data

Maximum temperature	48°C
Minimum temperature	0°C
Mean temperature for EDS	25°C
Maximum wind velocity	38 m/sec.
Isokeraunic level	9.7 days per year

Maximum working tension of conductor shall be so calculated that every day stress (at 25°C temperature in still air) does not exceed 25% of ultimate strength, and the safety factor shall be not less than 2.5 against ultimate strength at worst design condition.

Maximum working tension of ground wire shall be so calculated that sag of ground wire is approximately 80% of conductor sag at lowest ambient temperature in still air.

5.3 CLEARANCE

(1) Clearance between conductor and tower members

	220 kV	132 kV
Standard clearance	160 cm	105 cm
Minimum clearance	140 cm	90 cm

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(2) Clearance diagram

	220 kV	132 kV
Tension tower		
In still air	165 cm	110 cm
Under conductor swing of 15°	165 cm	110 cm
Under conductor swing of 30°	155 cm	107 cm
Depth of jumper	300 cm	200 cm
Suspension tower		
In still air	200 cm	168 cm
Under conductor swing of 20°	-	168 cm
of 40°	-	138 cm
of 55°	-	107 cm

(3) Clearance from ground level or other obstacles

Normal ground, open and agricultural land	7.75 m
Main road	9.2 m
Trees	4.0 m
Railway	12.0 m
Telecommunication line	4.0 m
Shield wire of power line	4.0 m
Highest water level of large river	15.0 m
Residential building	6.0 m

5.4 TOWER TYPE

Tower types to be applied in this Project are classified as follows.

Tower type	Circuit No.	Deviation angle ($^{\circ}$)	Wind span (m)	Weight span (m)	Insulator string
AS	2	3	250	300	Suspension
A	2	3	400	500	"
AL	2	3	500	550	"
B	2	15	300	300	Tension
C	2	35	350	400	"
D	2	0,60	300	300	"
DR	2	90	300	350	"
A4	4	3	350	400	Suspension
D4	4	0	250	300	Tension
DR4	4	75	350	350	"

Tower types A4, D4 and DR4 are composite towers for 220 kV and 132 kV lines, while others are for 220 kV line only.

The configurations of each tower type are shown in the drawings attached in the Specifications.

5.5 EXTENSION OF TOWER

The tower height shall be increased or decreased by every 3 m as body extension and 1.5 m as leg extension.

5.6 LOADING CONDITION

(1) Wind pressure

On single conductor	90 kg/m ²
On twin conductor	81 kg/m ²
On insulator string	126 kg/cm ²

On steel tower

Tower height less than 40 m	280 kg/m ²
" 50 m	300 kg/m ²
" 60 m	320 kg/m ²
" 70 m	340 kg/m ²

In designing a tower, the same value of wind pressure shall be assumed to act uniformly over the total height of the tower.

The wind load value on a tower shall be obtained by multiplying the wind pressure to the exposed area of component members of one face of a tower, since the specified wind pressure on a tower has been determined on the basis of the wind force coefficient for both windward and leeward faces of towers.

(2) Combination of design loads

For each type of towers, the combination of simultaneous design loads under normal working and broken wire conditions shall be applied in accordance with Table 5.1 "Combination of Design Loads."

Wind direction

The wind shall be assumed to act in the directions of 90°, 60° and 0° to the line separately.

Each design load prescribed in Table 5.1 shall be defined as follows:

Vertical loads

Wt : Weight of tower.

Wc : Weight of conductors, ground wires, insulators and

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fittings.

Transverse loads

- Ht : Wind pressure on tower
- Hc : Wind pressure on conductors, ground wires, insulators and fittings
- Ha : Transverse component of maximum working tension due to specified horizontal angle of the line
- qn : Normal torsional force
- qa : Torsional force caused by unbalanced tension (Pa) due to wire breakage

Longitudinal loads

- H't: Wind pressure on tower
- H'c: Wind pressure on conductors, ground wires, insulators and fittings
- Pn : Horizontal longitudinal component of the unbalance tension which develops as a result of terminating conductors to a dead-end tower
- Horizontal longitudinal component of the unbalance tension of conductors on a section tower
- Pa : Unbalanced tension due to the breakage of conductor or ground wire
- q'n: Normal torsional force
- q'a: Torsional force caused by unbalanced tension (Pa) due to wire breakage

Table 5.1 Combination of design loads

Tower type	Condition	Wind direction	Vertical load		Transverse load				Longitudinal load						
			Wt	Wc	Ht	Hc	Ha	qn	qa	H't	H'c	P'n	P'a	q'n	q'a
AS, A	Normal	0°	0	0			0			0					
		90°	0	0	0	0	0								
AL, B		60°	0	0	0	0	0			0					
A4															
D(60°)	Broken	0°	0	0			0		0	0			0		0
		90°	0	0	0	0	0		0				0		0
D(0°)	Normal	0°	0	0						0		0			
		90°	0	0	0	0						0			
D4	Broken	0°	0	0					0	0		0*			0
		90°	0	0	0	0			0			0*			0
DR	Normal	0°	0	0			0	0		0	0	0		0	
		90°	0	0	0	0	0	0				0		0	
	Broken	0°	0	0			0	0	0	0	0	0*		0	0
		90°	0	0	0	0	0	0	0			0*		0	0
C	Normal	0°	0	0			0			0		0			
		90°	0	0	0	0	0					0			
	Broken	0°	0	0			0		0	0			0		0
		90°	0	0	0	0	0		0				0		0
DR4	Normal	0°	0	0			0	0		0		0		0	
		90°	0	0	0	0	0	0				0		0	
	Broken	0°	0	0			0	0	0	0		0	0	0	0
		90°	0	0	0	0	0	0	0			0	0	0	0

Note;

* : Not applied on the broken conductor

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(3) Normal working condition

Design loads under the normal working condition shall be simultaneously applied to the towers with all wires intact as prescribed in Table 1.

One third of maximum tension of all conductors and ground wires in the same span shall be applied on tower type C as the section tower.

(4) Abnormal condition

Unbalance tension and torsional force caused by breakage of any one conductor or two conductors in one phase, in case of bundle conductors or ground wire, shall be added to the normal condition.

Unbalance tension on suspension tower may be decreased but shall not be lower than 60% of assumed tension of conductor.

This deduction shall not be applied on ground wire.

In addition to these working loads, the loads which may be generated during the construction work shall be taken into account in the designing of the tower.

5.7 SAFETY FACTOR

Safety factor shall be more than 1.8 for normal condition and more than 1.2 for abnormal condition based on yield strength or buckling strength.

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5.8 TENSION OF SLACK SPAN

Tensions for conductors and ground wires applied for slack span shall not exceed 1,000 kg for conductors and 500 kg for ground wire.

5.9 DESIGN OF TOWER

All components of steel towers shall be designed and fabricated in accordance with JEC-127 or other equivalent standard.

- (1) The horizontal members shall be taken into account so as to withstand the weight of man and equipment (100 kg) applied in the middle of the member with 1.2 of the safety factor on the yield point.
- (2) Tension members shall obtain the stipulated safety factor on the yield point against assumed maximum stress.
- (3) Compression members shall be designed so as to have an adequate safety factor in buckling strength obtained from the approved formula.
- (4) Broken wire condition on crossarm design shall be deemed as the normal condition, i.e., 1.8 of the safety factor, in consideration of unexpected load which may be generated during stringing work.
- (5) Tower type DR4 shall be designed in following two cases.
 - (a) All conductors of 220 kV and 132 kV lines and ground wires are installed on both sides of the tower.
 - (b) The same as above, except for no conductors of 132 kV

line on one side of the tower. Only the normal condition shall be taken into account.

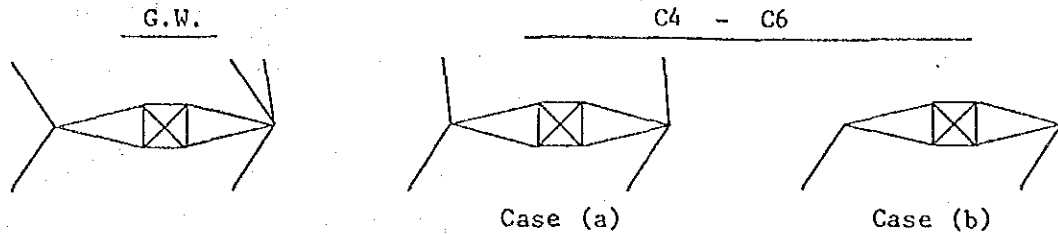


Fig. 5.1 Loading conditions

(6) The Contractor shall show in the detail drawings the dimensions required for setting of foundation components in the field. Dimensions shall be given in metric system.

(7) Requirements for members

(a) Slenderness ratio (l/r)

The maximum ratio of the distance of members between supporting points (l) to the governing radius of gyration (r) shall not exceed the following:

Main posts and main members of crossarm	200
Bracing and other compression members	220
Redundant or secondary member	250
Tension member	300

(b) Minimum size of member

The minimum thickness shall be 6 mm for main post and main members of crossarm and 4 mm for other members.

The minimum width of flange shall be 60 mm for main post and main members of crossarm and 45 mm for other members.

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5.10 CONSTRUCTION

The towers shall be of approved design and construction. Tension members, such as crossarm ties, which are liable to vibration, shall consist of rolled angle steel and not flats.

The design shall be such as to reduce the number of different parts as much as possible and to facilitate transport, erection and inspection. Pockets and depressions likely to hold water shall be avoided and, if not avoidable, shall be properly drained. The holes necessary for accommodating the specified grounding counterpoise connections shall be provided on each leg of every tower.

The plates of the crossarm ends of the tension towers shall be so arranged that two holes for the attachment for tensioning of conductors and maintenance tackle are provided adjacent to each hole of tension set shackles. It shall be possible to apply full tension of conductors safely.

5.11 MATERIAL

The tenderer shall estimate two kinds of materials for tower. One is ordinary steel which shall comply with JIS G3101 Class SS41 and SS55 or equivalent. The other is anti-weather steel which shall comply with JIS G3114 Class SMA41AW and SMA50AW. The steel shall be free from blisters, scales, laminations or other defects.

High tensile steel, when stored in the fabricators stockyard prior to fabrication and galvanising, shall be marked continuously

throughout its length with a colored water paint line for distinction.

In addition, the grade number of the steel shall be painted on and ringed round with paint.

Tower material shall be rolled steel and the mill sheet shall be submitted to the Engineer for approval.

5.12 ERECTION MARKS

Before leaving the manufacturer's works, all tower members shall be stamped or marked in the approved manner with distinguishing numbers upon approved drawings or material lists to be submitted by the Contractor. The erection marks shall be stamped before galvanizing or painting, and shall be clearly legible after galvanizing or painting. Care shall be taken to distinguish among various grades of steel.

5.13 BOLTS AND NUTS

All metal parts shall be secured by means of bolts, nuts and single washers. The minimum diameter shall be 16 mm. All bolts and nuts shall comply with the JIS G 3101, Class SS41 and SS50, and JIS B 1180, or equivalent.

Bolts and nuts shall be of steel with hexagonal heads. The nuts of all bolts shall be locked by means of locknuts. Screw threads shall not form part of the shearing plane between members. Bolts of any given diameter shall be of one grade of steel and marked

for identification. All bolts, screwed rods and nuts shall be galvanized, including the threaded portions.

Single-bolted connections will be allowed, but crossarm ties shall be connected with at least two (2) bolts.

Use of gusset plates shall be kept to a minimum.

(a) The bolt pitches for the parts shall be as follows:

Nominal size of bolts	M16	M20	M22	M24	Unit
Standard	50	60	65	75	mm
Minimum	40	50	55	60	mm
Maximum	125	160	175	190	mm

(b) The minimum edge distances measured from the center of the bolt to any edge shall not be less than the following.

(unit: mm)

Nominal size of bolts	Main leg, main member in crossarm etc.		Bracing	
	Rolled edge	Sheared edge	Rolled edge	Sheared edge
M16	24	35	21	25
M20	30	40	26	30
M22	33	45	29	35
M24	36	50	32	40

(c) The hole diameters of bolts shall be in accordance with the following.

Nominal size of bolts	Diameter of bolt holes
M16	17.5 mm
M20	21.5 mm
M22	24.0 mm
M24	26.0 mm

(d) The projection length of the bolt beyond the nut after being tightened shall not be less than the following.

Nominal size of bolts	Diameter of bolt holes
M16	6 mm
M20	7 mm
M22	8 mm
M24	9 mm

All bolts, nuts and fillers shall be furnished with some allowance. The allowance shall be at least five percent (5%) of the actual requirements.

5.14 GALVANIZING

Except where specified otherwise, all iron or steel to be used in the construction shall be galvanized after treating of all shearing, drilling, punching, bending, etc.

Galvanizing of all tower material shall be in accordance with JIS H 8641, or equivalent.

The hot dip process shall be applied for galvanizing, and shall consist of a suitable thickness of zinc coating of not less than

900 g/m² for steel members and 350 g/m² for bolts and nuts. The zinc coating shall be smooth, clean, of uniform thickness and free from defects.

Unsatisfactorily galvanized material shall be replaced. The whole of the expense involved in the replacement of the such material shall be borne by the Contractor.

5.15 PAINTING

Painting work shall be carried out in the factory under careful work attention.

(1) Surface treatment of material

Foreign matter, such as grease, white stain, etc., shall be completely removed from the surface of the material.

The surface treating shall be made as smooth as possible, and in all cases, shall comply with the specifications of S.S.P.C-SP-3.

(2) Chemical treatment

Galvanized steel shall be applied with phosphatizing compounds to ensure the adhesion of paint. After phosphatizing compounds becomes dry, non-reactioned liquid shall be removed by washing with water. Powder remaining on the surface shall be removed by brushing. If white rust or rust is created on the galvanized surface, it shall be removed completely with wire brush or power tool before applying phosphatizing compounds. Surface

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treatment and chemical treatment shall be done with scrupulous care so as to ensure the durability of paint.

(3) Undercoat painting

Undercoat paint shall be anticorrosive paint of special epoxy resins, and shall be applied as early as possible after completing chemical treatment.

(4) Final coat painting

Final coating shall be anti-weather type and of polyurethane resins. This paint shall be applied twice.

5.16 DANGER PLATE AND NUMBER PLATE

Two danger plates and two number plates shall be provided on every towers, one each on the front and back faces on left side leg and right side leg, respectively. The details of danger plate and number plate shall be as shown in the Drawing.

Phase indication of approved type colored red, yellow and blue to indicate the line phase shall also be provided. Prices are to be entered in the Price Schedule for the supply of danger plates and number plates, complete with fixing bolts, nuts flat bars, etc., if necessary.

All plates shall be of anti corrosive materials. If enamelled iron plates are applied, the whole surface of each plate, including the back and edges, shall be properly covered so as to resist corrosion. On all plates the colors shall be permanent and free from fading.

Bolts and nuts for fixing of danger or number plates shall be 12 mm in diameter. Thickness of all plates shall be 1.6 mm. The danger plates and number plates shall be fixed at a height approximately 3.0 m from the ground.

5.17 CLIMBING STEPS

An anti-climbing device shall be provided on every tower at a height no more than 5.0 m above the ground.

The details of anti-climbing device shall be as shown in the

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Drawing. Step bolts assembled with double nuts shall be provided on two (2) diagonally opposite legs, from immediately above the anticlimbing device to the top of the tower at a space of about 400 mm.

Holes for removable step bolts below the anti-climbing devices on the same legs shall be provided.

The step bolts shall be at least 120 mm in length and 16 mm in diameter.

5.18 GROUNDING DEVICE

All structures shall be provided with grounding device in each leg. Holes for connecting of grounding devices shall be provided in each leg and stub angle.

The grounding device shall consist of galvanized angle steel (L 50 x 50 x 4 mm, 1.0 m in length) and lead wire of copper (38 mm² copper 2.0 m in length) with terminal and 16 mm bolt.

5.19 STUB SETTING TEMPLATE

The Contractor shall supply nine stub setting templates as follows.

<u>Tower Type</u>	<u>No. of sets</u>
AS	4
A, AL	2
B, C	1
D, DR, D4, DR4	1
A4	1

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The templates are tools for installing the foundation stubs of the flat leg towers, and shall be of trussed structure with zinc coated steel angles.

Each template shall be assembled and disassembled easily, and shall be of common use for several body extensions in each type of the tower, including the case of superstructure concretings.

Drawing No. WLT-1505 shows an example of the template. The Contractor shall design the templates, which shall be subject to the approval of the Engineer, and shall be delivered together with the foundation stubs. It is advisable to supply several kinds of templates according to tower type and tower height.

6. HARDWARE AND FITTINGS

6.1 GENERAL

The composition of insulator hardware for the tower and line side shall be that specified in the drawings, but not limited thereto. The ultimate strength of such hardware shall be not less than 120 kN (12,000 kg).

All hardware components for line conductor, groundwire and insulator strings shall be so fabricated that no electrolytic action will occur between the accessories and the conductor and between the components. All parts and components of hardware shall be made of good commercial grade malleable cast iron, steel or aluminum alloy.

No metal parts shall have any rust, risings, lumps, etc., and the jointed parts shall be adequately smooth. All ferrous material, excluding stainless steel, shall be fully zinc-galvanized. Minimum quantity of zinc-coating shall be 500 g/sq.m, and that for bolts, washers and nuts shall be 300 g/sq.m. Excessive zinc remaining after galvanizing shall be removed.

All bolts, nuts and cotter pins shall be locked in order to prevent dislocation.

The design of all line conductor fittings, spacers, etc. shall avoid sharp corners or projections which would produce high electrical stress in normal working.

6.2 ARCING HORNS

The arcing horns for 220 kV and 132 kV transmission lines shall be made of steel conforming to SS 41 specified in JIS G 3101 or equivalent, and shall be fixed by 12 mm bolts to the line side and the earth side of the insulator strings. The arcing horn for the tension strings shall be fixed only to the side opposite to the side of jumper conductors. Each arcing horn, when flashover occurs by impulse voltage, shall carry arc currents so as to protect the clamps and the conductors from damages due to arc currents and to prevent cascading arc from occurring along the insulators. The arcing horns shall be provided on all suspension and tension insulator strings, except the insulator strings for jumper support, and shall be so made as to be fixed tightly to the hardware fittings of the insulator assemblies.

Arcing horn gaps shall be as shown in the drawings of insulator strings.

6.3 SUSPENSION CLAMPS

Suspension clamps shall be free to pivot in the vertical plane containing the conductor (envelope type) with a strain strength of more than three (3) times of 60% of the maximum working tension of the conductor and overhead ground wire, and shall be so designed that no slipping or damage to conductor or overhead ground wire occurs at the load less than 60% of their maximum working tension. The conductor supporting groove shall be curved at its ends in the vertical plane to a radius of 150 mm and for a sufficient distance

to allow the conductor to leave the clamp at the maximum angle of inclination obtained in service. The mouth of the supporting groove shall be slightly flared in plane. The grooves in the clamping piece or pieces shall be bell-mouthed at each end. All conductor grooves and bell-mouths shall be smooth and free from waves, ridges or other irregularities.

6.4 TENSION CLAMPS FOR CONDUCTOR

The tension clamp to be applied for the conductor shall be in accordance with the following specifications.

The tension clamp shall be of compression type and have a strength of more than 95% of that of the conductor. The electrical resistance shall be less than that of the conductor of the same length, and no cracks or damage shall be caused when it is compressed with a die suitable for the clamp.

The tension clamp shall be composed of galvanized steel part, steel sleeve, aluminium body and jumper socket.

The steel sleeve shall be galvanized by a hot dipping method. An aluminium collar shall be supplied on the steel sleeve. The jumper socket shall have a strength of more than 30% of that of the conductor, and compression position shall be marked on the surface of the jumper socket.

6.5 TENSION CLAMPS FOR GROUND WIRE

The tension clamps for the ground wire shall be of bolted type and

have a strength of more than 2.5 times the maximum working tension of the ground wire.

The construction shall be so designed that no damage or attenuation on the optical fiber is applied. The clamp shall have a bonding measure to the tower to ensure grounding.

6.6 ARMOR ROD

The armor rod to be mounted on the conductor and ground wire shall be of preformed type, and shall be of anti-corrosion aluminium alloy having an equivalent anti-corrosion property to the conductor. It shall be uniform and have no such defects as corrosion or cracks. The armor rod shall be designed so as to be applicable to the conductor specified in Clause 4, and to effectively protect the conductor from vibration and fatigue.

The direction of the preformed armor rod lay shall be the same as the direction of the outermost layer of the conductor.

6.7 JOINT SLEEVE

The compression type joint sleeve applied for the conductor shall have the following specifications.

Joint sleeve shall have a strength of more than 95% of that of the conductor. All of the sleeves shall have less resistance than that of the conductor of the same length, and shall not be damaged or cracked when compressed with dies suitable for the sleeves.

The compressing position of the sleeves shall be clearly marked on the surfaces. On the occasion of compression of the sleeves, anti-corrosion coating shall be provided on the conductor inside the sleeve. The coating materials shall be accommodated in a proper container and supplied together with an instruction manual. A requested number of gauges used to check the dimensions of compressed parts and the length of wire to be inserted into sleeves shall be supplied for the purpose of compression work.

All steel sleeve installed inside the aluminium sleeve shall be galvanized by a hot dipping method.

Aluminium collar shall be applied on the steel sleeves.

6.8 T-SLEEVE

- (1) The T-sleeve to be used for branch connection of conductors shall be of compression type, and conform to JIS H2110, or equivalent, and the construction shall be as shown in the Owner's Drawing GT-1027.
- (2) The T-sleeve shall have a tension strength of more than 30% of that of the conductor and shall have less resistance than that of the conductor of the same length.
- (3) The T-sleeve shall not have any damage or cracks when compressed with dies suitable for the sleeve.
- (4) The compressing position of the sleeves shall be clearly marked on the surface.

6.9 REPAIR SLEEVE

- (1) The repair sleeve of compression type shall be used for repairing slightly damaged line.
- (2) The repair sleeve shall conform to JIS H2110.
- (3) The repair sleeve shall have a strength of more than 95% of that of the conductor, and shall have less resistance of that of the conductor of the same size.
- (4) The repair sleeve shall be applied only when the number of the damaged strands may be less than 10% of total strands.
- (5) The compressing position of the sleeve shall be clearly marked on the surface.

6.10 VIBRATION DAMPER

The vibration damper shall be of a double torsional type and composed of a clamp, stranded steel wire and a weight.

The damper shall be designed so as to be applicable to the conductor specified and to effectively protect the conductor from fatigue caused by vibration, and shall be of a construction suitable to hold each conductor without sliding due to vibration.

The damper clamp shall be manufactured of anti-corrosion aluminium alloy.

The damper shall be applied in accordance with the following.

14 pounds for ACSR/AS 330 mm²

18 pounds for ACSR/AS 680 mm²

12 pounds for OPGW 190/90 mm²

6.11 SPACER

The spacer to be applied for the span shall be of rod type and composed of conductor holder, spacer bar, etc., as indicated in the DWG. No. WLT-1311.

The spacer shall be applicable to the conductor specified, and the spacer to be applied for span shall be designed so as to prevent mutual contact and twisting of conductors.

In addition, it shall be of a construction where excessive force shall not be added even due to the relative movement of conductor in the longitudinal direction.

6.12 JOINT BOX AND TERMINAL BOX FOR OPGW

Joint box and terminal box for OPGW 190/90 mm² of 1 - 10 cores to be mounted on the tower shall be of waterproof type. Joint box and terminal box shall be supplied together with the hardware to enable installation on the tower.

6.13 OTHERS

Fixing clamps of OPGW 190/90 mm² for tower and all other required accessories shall be supplied.

It shall be possible to secure all clamping screws in a form locking manner as to avoid their getting loose during service.

7. TESTS AND INSPECTIONS AT WORKS

7.1 GENERAL

Acceptance tests or reference tests shall be provided depending upon necessity. The acceptance test shall be provided on the occasion of delivery of products so as to confirm the quality of the said products specified in the Specifications.

The number of samples shall be decided by the Owner and/or Engineer when the Contractor's proposals for the inspection and testing methods and details are approved with reference to various standards and general practices.

The tests mentioned in this clause will be witnessed by the Engineer/Owner.

7.2 CONDUCTOR

The inspection and testing shall be carried out on individual wires and stranded conductors in conformity with IEC 209 and ASTM B-502.

The test items are as follows.

- (1) Aluminium wire
 - o Appearance test
 - o Diameter
 - o Tensile test
 - o Wrapping test

- o Electric conductivity
- (2) Aluminium-clad steel wire
 - o Appearance test
 - o Diameter
 - o Tensile test
 - o Torsion test
 - o Elongation test
 - o Thickness of Aluminium
- (3) Stranded conductor
 - o Appearance test
 - o Construction test
 - o Weight
 - o Tensile strength

7.3 GROUND WIRE⁹

(1) Kinds of test

The test shall be classified into three kinds as follows;

- 1) Type test: to be made once at the time of first shipment.
- 2) Routine test: to be made by the manufacturer throughout production.
- 3) Sample test: to be made as the "witness test" of the above item 2), when required in advance.

(2) Test item

The test items for type test, routine test and sample test

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are as shown in Table 7.1, respectively.

(3) Number of sample for each test

1) Type test

- a) OPGW 190/90 mm²: one sample for each test.
- b) Aluminum-clad steel wire before stranding: three samples for each test.

2) Routine test

- a) OPGW 190/90 mm²: each one sample from 10% of the reels. (Minimum number shall be 3.)
However, measurement of optical attenuation shall be made for all fiber of each reel.
- b) Aluminum-clad steel wire before stranding: 10% of the lot.

3) Sample test

- a) OPGW 190/90 mm²: three samples for each test
- b) Aluminum-clad steel wire before stranding: three samples for each test

Table 7.1 Test Items

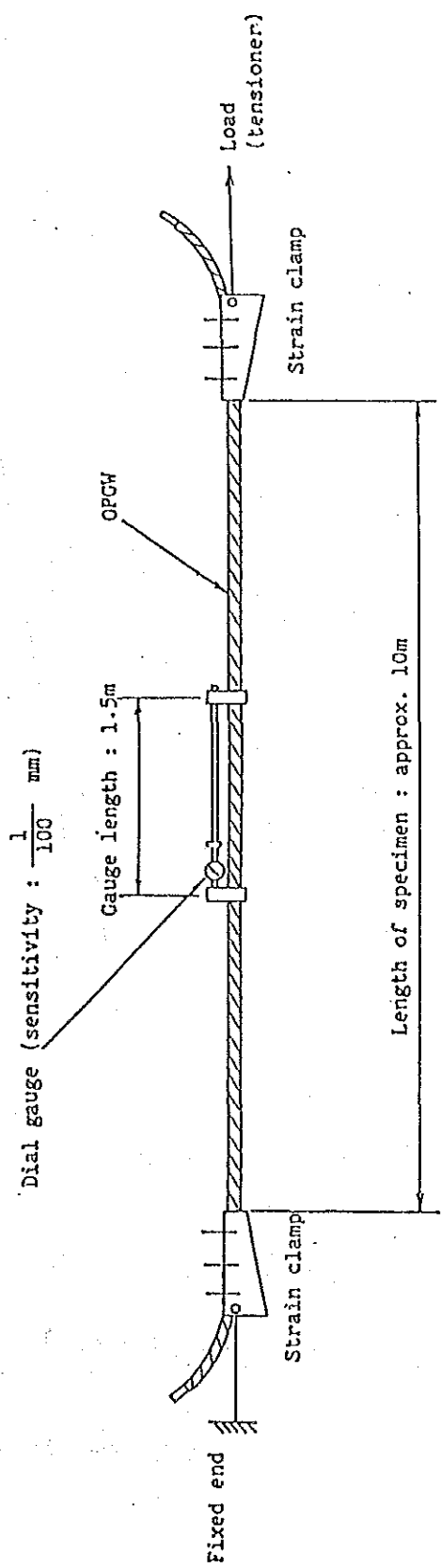
0: Applicable
-: Not Applicable

Test item	Type test	Routine test	Sample test	Note (test method)
Diameter				
Construction	0	0	0	
Ultimate tensile strength	0	0	0	
D.C. resistance at 20 deg. C	0	-	-	
Weight	0	-	-	
Modulus of elasticity	0	-	-	description 1
Lay ratio (times)	0	0	0	
Lay direction	0	0	0	
Number of optical fiber	0	0	0	
Max. attenuation at 1,300nm wavelength	0	0	0	description 3
Max. allowable temperature	0	-	-	description 2
Fiber diameter	0	-	-	CCITT G652 Appendix
Chromatic dispersion coefficient (1.3 m)	0	-	-	description 4
Cut off wavelength	0	-	-	description 5
Finish and appearance	0	0	0	
Packing, Marking, Quantity	-	0	0	
Diameter	0	0	0	
Ultimate tensile strength	0	0	0	
Conductivity at 20 deg. C	0	0	0	
Min. thickness of aluminum	0	0	0	
Number of twist	0	0	0	
Elongation in 250 mm	0	0	0	
Weight	0	-	-	
Appearance test	0	0	0	
Diameter	0	0	0	
Tensile test	0	0	0	
Wrapping test	0	0	0	
Electric conductivity	0	-	-	

DESCRIPTION 1

Test Method of Initial and Final Modulus of Elasticity

- (1) Test specimen: OPGW 190/90 mm²
- (2) Length of the specimen: approx. 10 m
- (3) Strain measuring device:
 - i) Gauge length 1.5 m
 - ii) Dial gauge of sensitivity $\frac{1}{100}$ mm
- (4) Outlines of the test device: as shown in Fig. 7.1
- (5) Loading schedule to OPGW: as shown in Fig. 7.2
 - i) Zero setting at 8Z UTS loading
 - ii) 30Z UTS loading x 0.5 hour hold
 - iii) Return to 8Z UTS loading
 - iv) 50Z UTS loading x 1 hour hold
 - v) Return to 8Z UTS loading
 - vi) 70Z UTS loading x 1 hour hold
 - vii) Return to 8Z UTS loading
 - viii) Loading up to breaking
- (6) Temperature for test: room temperature



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Fig. 7.1 Outlines of the test device

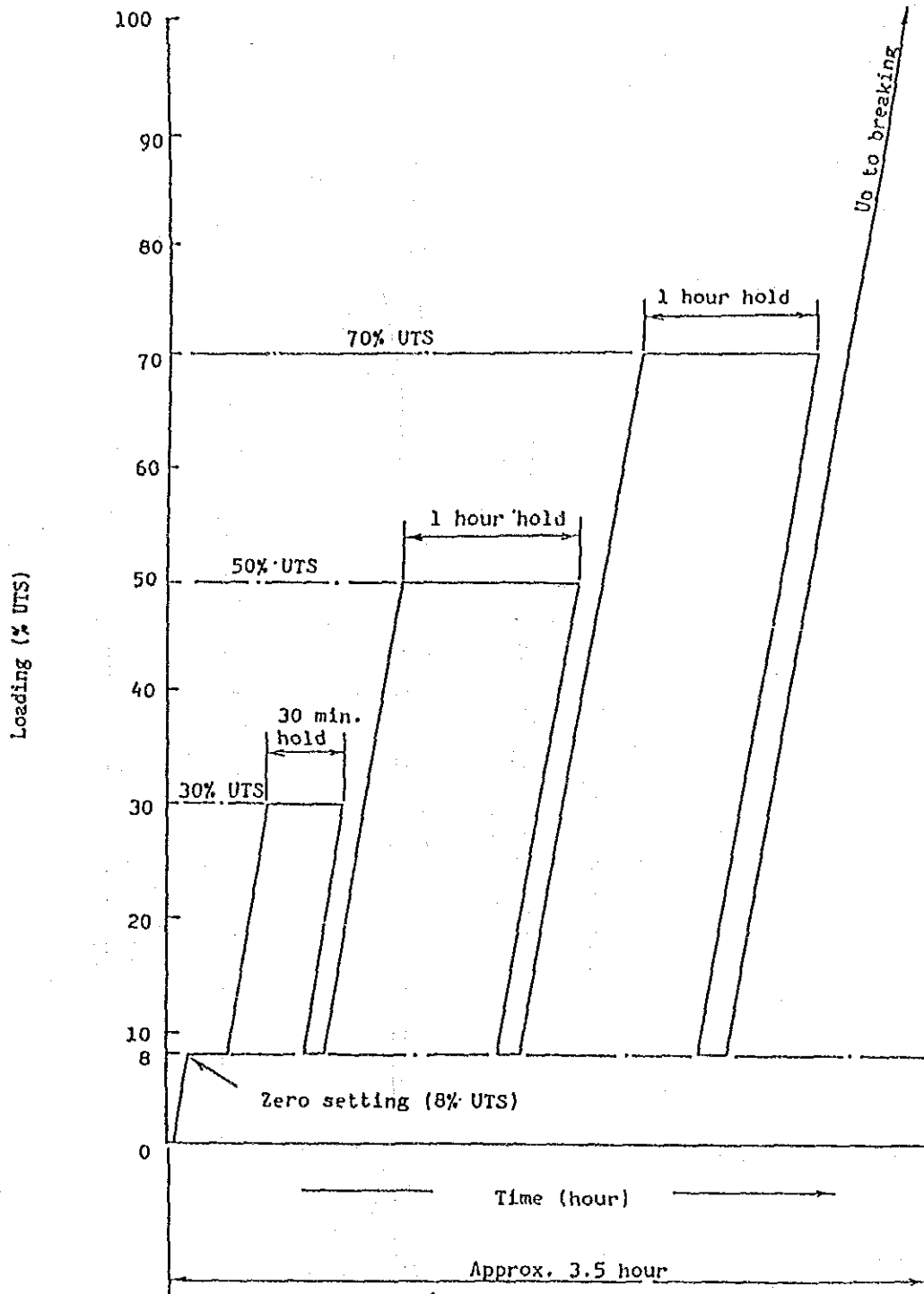


Fig. 7.2 Loading schedule to OPCW specimen

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DESCRIPTION 2

TEST FOR MAX. ALLOWABLE TEMPERATURE AT FAULT CURRENT RATING

- (1) Test specimen: OPGW 190/90 mm² (5SM)
- (2) Length of specimen: approx. 5 m
- (3) Outline of test: as shown in Fig. 7.3.
- (4) Tension of specimen: Tension to OPGW shall be approx. 20% of the specified ultimate tensile strength constantly.
- (5) Temperature and current rating OPGW: Electric current shall be rated to the OPGW in order to raise the temperature of OPGW up to 300°C. The current rating shall then be stopped and the temperature change shall be monitored simultaneously.
- (6) Optical attenuation:
Four optical fibers shall be spliced in series, and the optical attenuation shall be monitored simultaneously by an optical power meter.

① ~ ⑤ Measurement points of the temperature

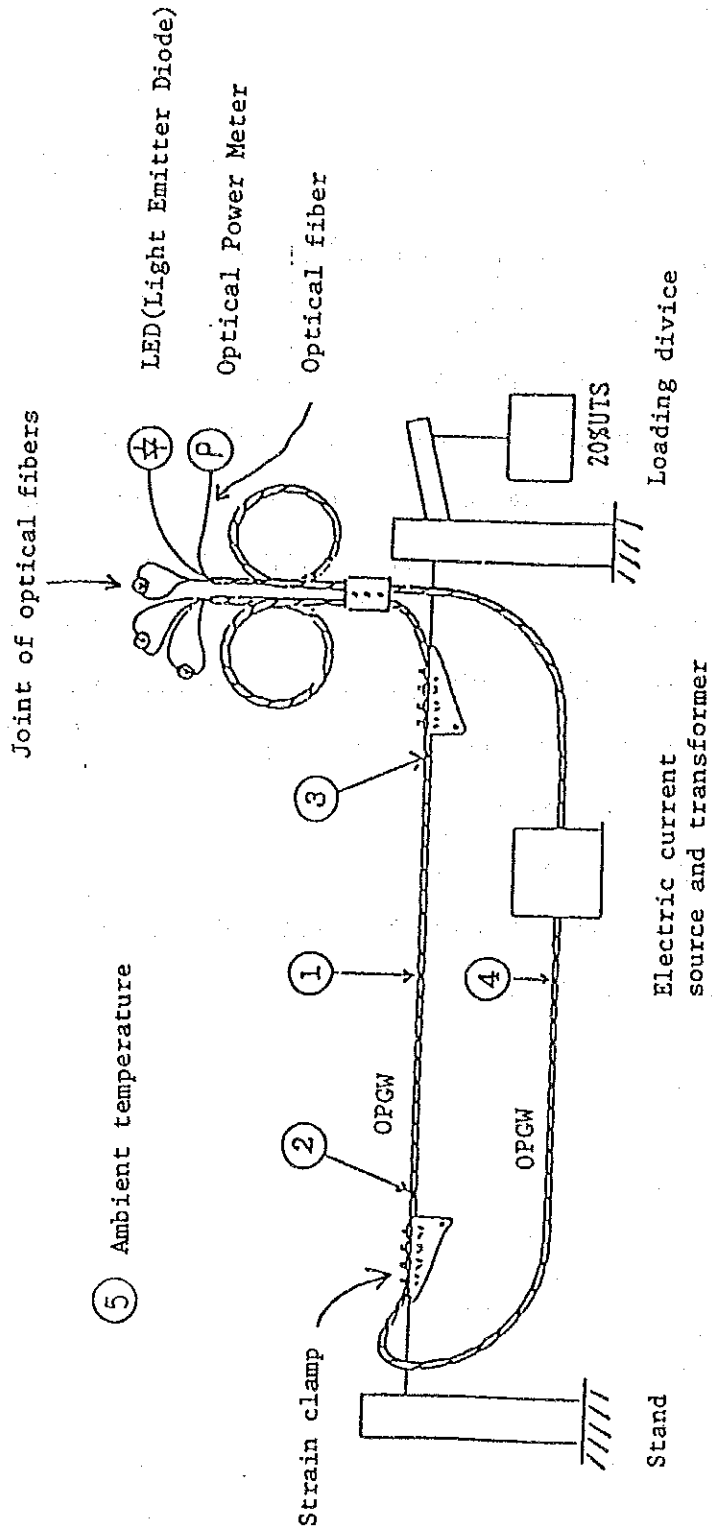


Fig. 7.3 Outline of test method for max. allowable temperature at fault current rating

DESCRIPTION 3

Optical Attenuation Test of Fibers

- (1) Test specimen: OPGW 190/90 mm² (single mode fiber)
- (2) Length of specimen: approx. 2 km on one reel
- (3) Temperature for test: room temperature
- (4) Measuring method of attenuation
 - 1) Test method, so-called "Cut back technique"

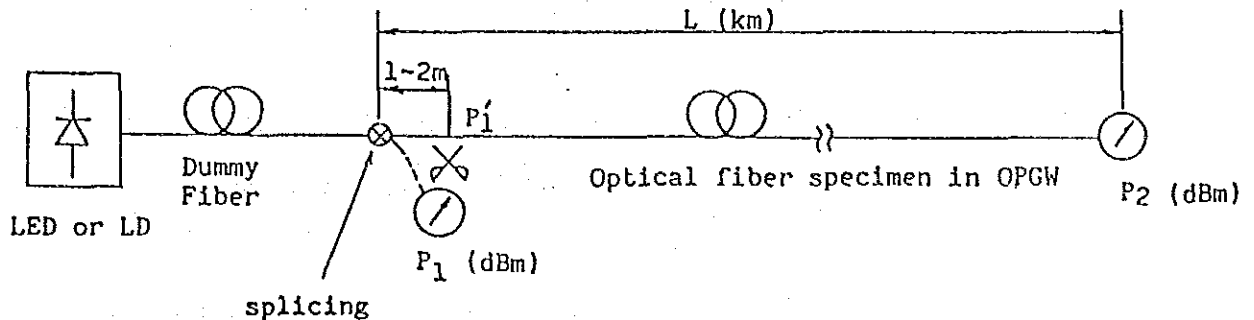


Fig. 7.4 Outline of test method for optical attenuation test of fibers

where

- L : Length of optical fiber for test (approx. 2 km/reel)
- LED : Light Emitting Diode of wavelength 1.3 μm
- LD : Laser diode of wavelength 1.3 μm
- P₁ : Optical power meter to measure attenuation of dummy fiber and spliced part
- P₂ : Optical power meter to measure entire attenuation, including dummy fiber, spliced part and optical fiber specimen in OPGW

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ii) Measuring procedures

- 1 Splicing of dummy fiber with the optical fiber specimen by fusion.
- 2 Measurement of the whole attenuation including dummy fiber, spliced part and optical fiber specimen by LED or LD and optical power meter P_2 .
- 3 Cutting of the point P'_1 of optical fiber specimen, which shall be within the small distance of 1 - 2 meters from the spliced part.
- 4 Measurement of the attenuation of dummy fiber and spliced part at the point P'_1 by LED or LD and optical power meter P_1 .
- 5 Obtaining the difference between the reading of P_2 and P_1 , which shall be the required attenuation of optical fiber specimen.

$$\text{Optical attenuation} = P_2 - P_1 \text{ (dB per length L)}$$

$$\text{Optical attenuation in km}$$

$$= (P_2 - P_1)/L \text{ (dB/km)}$$

DESCRIPTION 4. Test method of optical chromatic dispersion
co-efficient

Test method of phase-shift technique

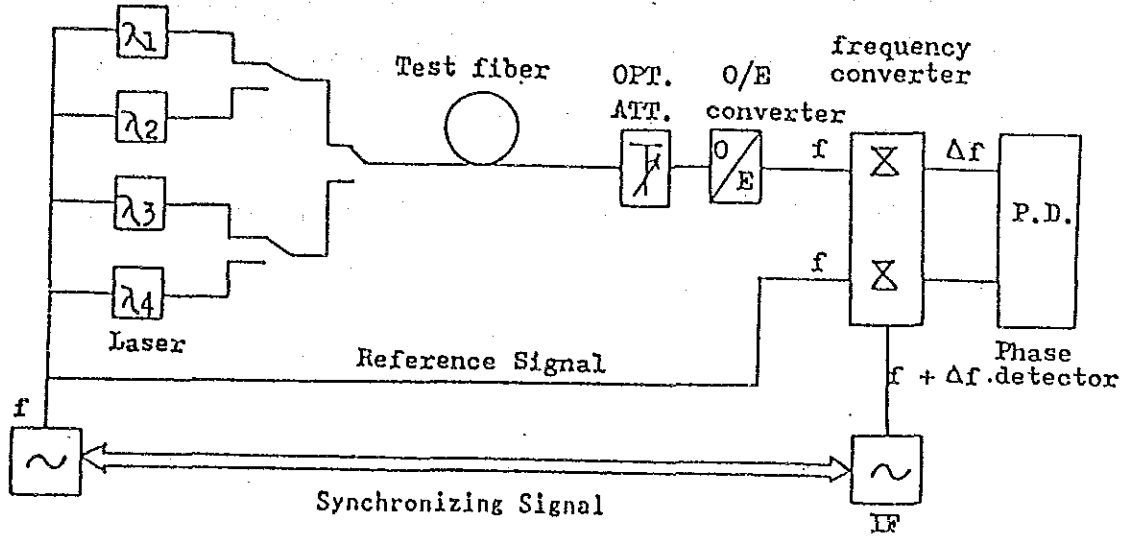


Fig. 7.5 Typical arrangement of dispersion measurement by phase shift technique

The lasers having wavelength λ_1 , and λ_3 are sinusoidally modulated. The phase delay difference between λ_1 and λ_3 at sending point and receiving point are $\theta_s(1, 3)$ and $\theta_R(1, 3)$ respectively. $\theta_s(1, 3)$ and $\theta_R(1, 3)$ is described as

$$\theta_R(1, 3) - \theta_s(1, 3) = 2\pi f \cdot \tau(1, 3)$$

where; $\tau(1, 3)$ is delay time of propagations.

Then, delay time of propagations corrected to unit length of fiber is described as

$$\Delta T_{(1,3)} = \frac{\theta_R(1,3) - \theta_s(1,3)}{2\pi f} \cdot \frac{1}{L} \quad (\text{PS/km})$$

where; L is length of fiber (km).

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Next, $T(2,4)$ is measured in the same manner as shown previously.

Wavelength of each laser is slightly different, $\lambda_1 < \lambda_2 < \lambda_3 < \lambda_4$.

Utilizing the measurement data, the delay time against the wavelength is expressed by a polynomial approximation with the aid of the root mean square technique.

Finally, the dispersion is calculated by differentiating the above approximation.

DESCRIPTION 5. Test method of cut-off wavelength

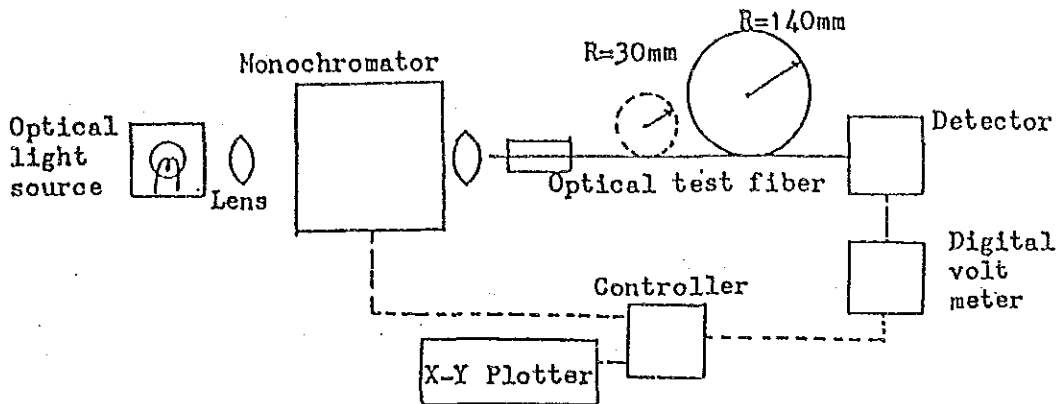


Fig. 7.6 Typical arrangement of the cut-off wavelength test set up

The 2-3 meter length of optical fiber is inserted into the test apparatus. First, the output optical power $P_1(\lambda)$ of the optical test fiber which is bent to form two single loops with radius of 30 mm and 140 mm, is recorded at each wavelength over a suitable range.

Next, the output optical power $P_2(\lambda)$ of the optical test fiber, which is bent to form one single loop having a radius of 140 mm only, is recorded at the same wavelength range.

The ratio between $P_1(\lambda)$ and $P_2(\lambda)$ is calculated as follows.

$$R(\lambda) = -10 \log (P_1(\lambda)/P_2(\lambda)) \text{ (dB)}$$

Cut off wavelength is determined as the longest wavelength at $R(\lambda) \geq 0.1\text{dB}$ (see Fig. 7.7).

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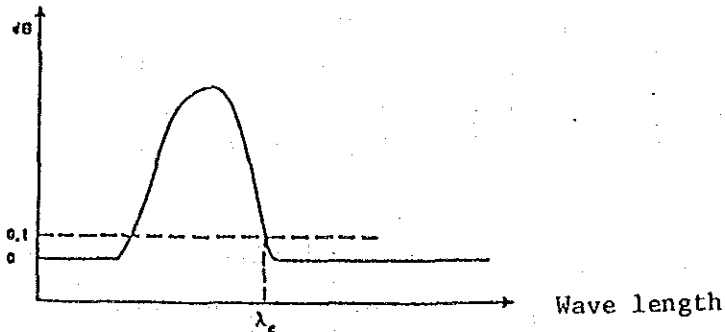


Fig. 7.7 Typical cut-off wavelength plot

7.4 INSULATOR

The tests shall be carried out in accordance with IEC 383, 507 and 575.

(1) Type tests

- a) The following tests shall be made on three (3) insulator units and one (1) insulator string taken at random.
 - o Dry lightning impulse withstand voltage test
 - o Wet power-frequency withstand voltage test
- b) Thermal mechanical performance test shall be made on ten (10) insulator units in accordance with IEC 575.
- c) Artificial pollution tests shall be performed upon request of the Owner or the Engineer. The pollution test shall be made in accordance with IEC 507.

It shall be verified that the insulator string of 22 units withstands the test voltage of 173 kV at equivalent salt deposit density of 0.5 mg/cm^2 .

(2) Sample test

The insulators for sample test shall be selected at random from the batch.

The number of test pieces shall be p , or the nearest whole number greater than p given by the following formula.

$$P = 4, \text{ when } n < 500$$

$$P = 4 + \frac{1.5 n}{1,000}, \text{ when } 500 \leq n \leq 20,000$$

$$P = 19 + \frac{0.75 n}{1,000}, \text{ when } n > 20,000$$

where; n = the number of insulators in the batch.

After having withstood the routine test described in (3) hereunder, the test pieces of insulators shall be subjected to the following tests.

- a. Verification of dimensions
- b. Temperature cycle test
- c. Electromechanical failing load test
- d. Puncture test
- e. Porosity test
- f. Galvanizing test

(Verification of the mass of zinc per unit surface)

The group of selected samples shall be divided, as nearly as possible, into three equal parts and subjected to the applicable tests in the following order:

1st and 2nd parts: a, b, c and e

3rd part : a, b, d and f

(3) Routine tests

Those tests which are applicable shall be applied to every insulator in the following order:

The Owner or the Engineer shall have the right to witness routine tests on insulators which are representative of the type ordered.

- a. Visual examination
- b. Mechanical routine test
- c. Electrical routine test

7.5 LINE HARDWARE FITTINGS

The tests of line hardware fittings shall be carried out in accordance with BS3288: Part 1 (1973), "Performance and General Requirement".

(1) Sample test

The line hardware fittings for sample tests shall be selected at random from the batch.

The number of test pieces shall be p , or the nearest whole number greater than p given by the following formula.

$$P = 0 \text{ (No test), when } n < 100$$

$$P = 4, \text{ when } 100 \leq n \leq 500$$

$$P = 4 + \frac{1.5 n}{1,000}, \text{ when } 500 \leq n \leq 20,000$$

$$P = 19 + \frac{0.75 n}{1,000}, \text{ when } n > 20,000$$

where; n = the number of hardware fittings in the batch.

- a. Verification of dimensions
- b. Mechanical test
- c. Galvanizing test

(2) Reference test

The following test shall be made on one (1) suspension clamp taken at random:

- a. Slip load test

7.6 TOWER

(1) Shop assembly

One tower of each type, including every combination of body extensions, shall be assembled in the extent necessary to ensure a correct fitting of parts, adequate bolt lengths and proper field erection.

Shop assembled parts shall be dismantled for shipment. The Contractor shall notify the Engineer at least two (2) weeks in advance, in order that his representative may visit the Contractor's facilities and witness shop assembly of each tower before the fabrication proceeds. However, the Engineer has the right to waive the witnessing of shop assembly.

(2) Tower test

The loading test shall be carried out on one (1) fullscale tower of A +9.0 in accordance with IEC Publication 652 or equivalent. The prototype to be tested shall comply in all respects with the specifications, except for galvanizing and painting, which will not be performed on the prototype, and shall be fabricated in the method equivalent to that for the

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"production run" towers. The test procedures shall be subject to approval by the Engineer. The Engineer may change the order of the tests, request to conduct further tests or substitute certain tests.

For the final 100% step, the load shall be maintained for five (5) minutes without any collapse.

In addition to the loading test, destruction test of the prototype shall be carried out.

Upon satisfactory completion of the loading test, eight (8) members chosen at random from the prototype shall undergo physical tests at an approved testing laboratory to establish the yield points.

If any condition is not satisfied, the loading test shall not be valid and the prototype shall be rejected.

Subsequent to approval of the tower tests and member tests, the Contractor shall collect all data, and prepare a test report and submit it to the Engineer not later than four (4) weeks after completion of all testing of the tower, and three (3) copies of the approved report shall be forwarded to the Engineer.

Prototype test and acceptance of the design shall only be considered complete when the design drawing and loading test report submitted by the Contractor has been approved. After completion of testing, the tested towers shall become the property of the Contractor. No tested towers nor any part thereof shall be shipped to the site or used in the construction for the Project.

8. LAND FOR CONSTRUCTION PURPOSE AND CLEARING WORK

8.1 LAND FOR CONSTRUCTION PURPOSE

The Owner will settle the following items at his own expense prior to the commencement of construction work or appropriately in advance of each phase of construction work to be performed by the Contractor;

- (1) Acquisition of right-of-way with an area each of 15 meter width on both sides from the center line of the proposed transmission line and a square of land of 60 m x 60 m at each tower location for access.
- (2) Removal of huts, houses and other structures within the acquired right-of-way which would interrupt the construction and operation of the transmission line.
- (3) The obtaining of permits from the relevant authorities for permanent crossings of the transmission lines over rivers, railroads, public roads, communication lines, distribution power lines and so on.

8.2 CLEARING WORK

8.2.1 LIMITS OF RIGHT-OF-WAY

- (1) The Contractor shall use access and wayleave as specified in Clause 8.1.
- (2) The Engineer will provide the Contractor with copies of

drawing showing the details of the wayleave.

8.2.2 CLEARING

- (1) The Owner will designate the areas to be cleared within the right-of-way.
- (2) Clearing shall consist of cutting and disposing of all trees, shrubs, debris and all other perishable materials, including fallen trees, etc., which may be visible on the ground within the areas to be cleared. Payment of compensation for the damage to the above and crops is the liability of the Contractor to the owners of the property. This cost shall be included in the unit rate for clearing work.
- (3) Small trees and shrubs shall be cut off at a height of six (6) inches or less from the natural ground surface. Large trees shall be cut off to within a distance of the natural ground surface. Bamboo stumps shall be entirely grubbed up and cleared with the roots.
- (4) The regrowth of trees and shrubs shall be retarded by the treatment of an approved plant inhibitor. All cleared and grubbed-up material shall be disposed of so as not to interfere with work operations.
- (5) All waste material for disposal shall be either burnt or disposed of in a manner and within a period of time acceptable to the Engineer or the Owner.

8.2.3 ASSISTANCE BY THE OWNER

In the event the Contractor encounters difficulty in the compensation settlement for trees or crops with landowner or others, the Owner shall assist the Contractor in the settlement of such problems.

8.3 DISMANTLING WORK

Dismantling of ground wire, conductors and towers from No. 1 to No. 5 of existing 66 kV Mauripur and S.I.T.E. lines shall be carried out by the Contractor by paying strict attention to public safety, and in cooperation with other contractors regarding the construction schedule. The foundations of towers of approximately 1 m below ground level shall be removed and back filled.

9. CHECK SURVEY

- (1) The survey of the transmission line route from Tower No. 1 to the Baldia Grid Station has already been performed by the Owner. The Contractor shall carry out the check survey according to the following.
- (2) Immediately after signing of the Contract, the Owner will furnish the Contractor with three (3) copies each of route map, profiles and plans prepared by the Owner.
- (3) The Contractor shall carry out checking work of survey results based upon the survey markers already placed by the Owner as well as the survey data and maps furnished by the Owner.
 - (a) The Contractor shall be responsible for pegging at reference points so as to establish each tower location and the center line of the transmission line route. In the event that the stakes become displaced or destroyed by any cause whatsoever, they shall be re-positioned at Contractor's expense as required by the Engineer.
 - (b) In case any tower location in the profile drawing is judged by the Contractor as topographically or geographically improper, the Contractor shall present his opinion to the Engineer and may move the position upon receiving written approval by the Engineer. The Contractor shall submit for the approval by the Engineer profile drawings and plans with the same reduced scales

as the profile drawings, showing the crossing positions
to existing roads, railways, other transmission lines,
etc.

10. FOUNDATION

10.1 SOIL INVESTIGATIONS

Immediately after receipt of the Letter of Intent, the Contractor shall carry out subsoil investigations at locations determined by the Engineer and wherever considered necessary by the Contractor for determination of foundation design.

Standard routine tests on soil together with the boring log shall be done at every third tower location to a depth of approximately 10 m. Where the Engineer or the Contractor finds it necessary, deep soil testing shall be executed and, if necessary, more than once in one tower location, for example in the West Wharf area.

The subsoil investigation shall, in principle, consist of:

- Drilling adequate holes
- Collecting core samples at every change of soil strata and storing the same in boxes marked with the depths at which the samples were extracted.
- Carrying out standard penetration tests using a split spoon sampler. The samples obtained shall be stored in glass jars marked with the bore hole number and depth of extraction. The penetration test shall be carried out in cohesive or non cohesive soils at 1.0 m intervals.
- Submittal of bore charts or log sheets for each bore hole and submittal of reports on the observations together with

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the recommendations for the type of foundations at all tower locations. The Contractor shall establish in his report the capacity of the soil and the depth of ground water table encountered.

10.2 DESIGN OF FOUNDATION

10.2.1 SOIL CONDITION (FOR TENDERING)

As the soil conditions at the various tower locations are not known yet, the actual type of tower foundations cannot be designated before execution of soil tests.

However, for tendering purposes, the soil conditions are assumed as follows:

(1) Soft stratum

In the area from WWTPP to Maripur G/S, the ground to a depth of 10 m to 15 m consists of loose fine SAND, loose sandy SILT and soft clayey SILT with N-values of 1 to 10. Deeper than these strata, the ground consist of hard silty CLAY and dense fine SAND with N-values of over 50.

A total of 9 towers, Nos. 1 through 9, will be constructed on these strata. Pile foundations may be provided in this area.

(2) Coastal Sand

In the ground conditions along the coastal area, the ground to a depth of 2 m to 4 m consists of dense silty coarse SAND with N-values of 20 or over. Deeper than this stratum, the ground consists of hard silty SHALE, CONGLOMERATE, and SANDSTONE. Conventional spread footing type foundations shall be provided.

However, as the ground water table is high in this area, buoyancy shall be considered in the foundation design.

A total 40 towers, Nos. 10 through 49, will be constructed in this area.

(3) Dune Sands

For the area inland, the ground surface is covered with dense sandy SILT with N-values of over 30.

Under this stratum, the ground consist of dense coarse SAND having GRAVEL or LIMESTONE, with N-values of over 50.

Ground water is not encountered in this area. Therefore, a conventional spread footing type foundation shall be considered.

A total of 43 towers, Nos. 50 through 92, will be constructed in this area.

10.2.2 SOIL PROPERTIES

Item	Soft Stratum	Coastal Sand	Dune Sand
Internal friction angle, ϕ (degrees)	20	35	40
Cohesion, C (ton/m ²)	0	0	0
Unit weight, γ (ton/m ³)	*1 1.6 (0.6)	1.8 (0.8)	1.8
Underground water level (m)	GL \pm 0	GL \pm 0	None
Shear strength, τ (ton/m ²)	0	0	*2 5

*1 Submerged unit weight of soil

*2 This value is given for the rack which is deeper than 2 m from ground surface.

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The bore logs attached to this document shall be used for tendering purpose.

10.2.3 TOWER TYPES AND SOIL CONDITIONS

Each tower type shall be classified in accordance with the following soil conditions.

Tower Type Classification of soil	As	A	AL	B	C	D	DR	A4	D4	DR4
Soft stratum (S)	-	*2	*3	-	-	-	-	2	1	1
Coastal sand (C)	30	-	-	4	2	3	1	-	-	-
Dune sand (D)	18	16	-	-	3	2	4	-	-	-
Total	48	18	3	4	5	5	5	2	1	1

* Each value includes one rigid frame type foundation which is located in the Rayari River.

The name of the foundation type in the Price Schedule represents the name of tower type and the initial of soil condition; for example, AL-S, DR-C.

The name of the foundations of rigid frame type is referred to as A-R and AL-R.

10.2.4 DESIGN

In accordance with the results of the soil tests, the Contractor shall design and construct suitable tower foundations.

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- (1) Foundations to be applied to this project are as classified as follows.

Spread foundation (one per tower leg)

I-type: to be applied to hard soil area having a yield bearing capacity (varical) of 20 t/m^2 or more.

Mat foundation

IV1-type: to be applied to places where water covers the ground surface during the rainy season, or where ground water is shallow so that the foundation body is in a state of submergence.

Pile foundation

The following pile foundations will be applied to soft soil areas.

- III-type Individual type pile foundation
- IV2-type Pile cap with tie beam special foundation
- Rigid frame-type (In river)

- (2) Concerning the foundation of the rigid frame type in the Layari River, the beam of foundation shall be kept over the high water level of the Rayari River. For tendering purposes, the height from the ground to the lower portion of the beam is assumed to be 5.0 m. 1.83 m/sec of fluid velocity at deluge time shall be considered in the foundation design.

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(3) The Contractor is free, subject to economic considerations, to choose the type of foundations to be employed.

The Owner reserves the right to change the quantities and types of towers and foundations to meet final requirements.

Fig. 10-1 Foundation types

Foundation Type		Configuration
SPREAD	I Type	
	IV1 Type	
PILE	III Type	
	IV2 Type	
	Rigid Frame	

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(4) Safety factors

(a) For spread footing under normal conditions, the minimum safety factor against ultimate uplift capacity or bearing capacity shall be 3.0.

Under broken wire conditions, the minimum safety factor shall be 2.0.

(b) For pile foundations the ultimate uplift capacity or the compressive bearing capacity shall include a minimum safety factor of 3.0 under normal conditions and 2.0 for broken wire conditions.

(5) Design calculation formulas for spread foundation

(a) For spread footing, the bearing capacities of foundations shall be determined by formula developed by Terzaghi, 1942 Mayer-hof, 1951 or equivalent.

(b) Yield uplift capacity

As shown in Fig. 10-2, in vertically excavated and backfilled areas, the uplift capacity shall be calculated according to the following equation using the shearing method.

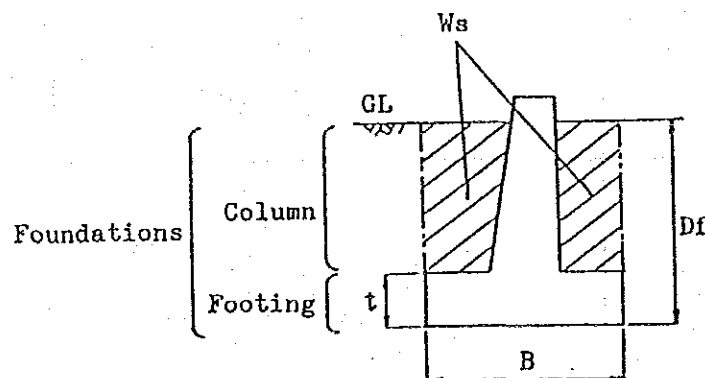


Fig. 10-2

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$$q_{ty} = K\{W_c + W_s + 1/1.5 \cdot L \cdot D_f \cdot (C + 1/2 \gamma_{s2} D_f \cdot \tan \phi / (1 + \sin \phi))\}$$

$$q_{ty} = K\{W_c + W_s + 1/1.5 \cdot L \cdot t \cdot \tau\} \text{ (rocky area)}$$

where:

K = Reduction rate in uplift capacity due to overturning moment

$$K = \frac{1}{1 + 6 e B / (B^2 + b^2)} \quad (\geq 0.67)$$

B = Footing width (m)

e = $Q_B H / (T - W_{CT})$ (m)

b = Bottom width of column (m)

Q_B = Horizontal component of brace member force (ton)

H = Column height (m)

T = Uplift acts on foundation from tower (ton)

W_{CT} = Sum weight of a column and a part of footing under the column area (ton)

W_c = Foundation weight (ton)

(Submerged weight shall be considered for a portion under the ground water surface)

W_s = Backfilled soil weight (For a portion under the ground water surface, the submerged weight shall be considered)

L = Surrounding length (m) - 4 x B

D_f = Embedment depth from the ground surface (m)

C = Average cohesion of soil on footing (ton/m^2)

γ_{s2} = Unit weight of soil on footing (ton/m^3)

(The submerged weight shall be considered below the ground water surface)

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ϕ = Internal friction angle of soil on footing (degree)

τ = Shear strength (ton/m²)

10.2.5 UNIT RATE

- (1) The unit rate of soil investigation in the Price Schedule shall include provision of all necessary materials, equipment, tools and transportation.
- (2) The unit rate of foundation work in the Price Schedule shall include, but not be limited to, the following soil investigation, design, temporary work, earth work, concrete work, piling work and other necessary work in order to supply foundations for the transmission line as listed below.
 - (a) Design includes the detailed design drawings, calculations and working drawings for the construction.
 - (b) Temporary work includes the furnishing of all appliances materials, tools, transportation and services required to perform and complete all preliminary work and temporary construction.
 - (c) Excavation work includes provision of all necessary materials, equipment and tools, clearing of work site, blasting of rock, if required, excavation, dewatering, necessary protection of excavated surface from collapse, hurdling for prevention of efflux of excavated soil on slope, sounding test and other related works stipulated hereunder.

- (d) Concrete work includes supply and transportation of all necessary materials, equipment and tools, protection of excavated surface, dewatering, stub setting, setting of grounding angles, form work, concreting, test of concrete, removal of forms, removal of other materials from pits and other related work stipulated hereunder.
- (e) Piling work includes supply and transportation of all necessary materials, piling equipment and tools, pile driving, treatment of pile top, connection of steel bars of piles to foundation bars, and pile tests, if required.
- (f) Steel work includes supply and transportation materials and tools, bending and placing of steel reinforcing bars and other related works stipulated hereunder.
- (g) Backfilling work includes provision of all necessary equipment and tools, backfill, compacting, density tests as required, surface finishing, removal of surplus excavated soil or other unsuitable materials for backfill or spoils in peaty ground, importing suitable fill materials from other places and other related works stipulated hereunder.
- (h) In water-logged areas, foundation work shall comprise dewatering by pumping or other approved means during excavation, concreting and backfilling. Those costs shall be deemed to be included in the rate for the foundation work.

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(3) Should the Owner or the Engineer request extra works, the adjustment of the rate of the work shall be made based on the unit prices of related items of excavation, concrete work and backfill entered in the Price Schedule.

For this purpose, the tenderer shall submit the detailed cost breakdown of each foundation work and backfill. No other work item shall be considered for the adjustment.

10.3 FOUNDATION WORK

10.3.1 TEMPORARY WORK

(1) Immediately after awarding of the Contract, the Contractor shall submit to the Engineer in writing the schedules for machinery and equipment and temporary work to be supplied, used and erected by the Contractor in connection with the execution of the work.

However, the schedules for minor and simple work need not be submitted but may be carried out upon instructions from the Engineer.

(2) When the need for temporary enclosures is recognized for safety of work or for other reasons, these shall be provided by direction from the Engineer.

(3) Obstructions which may cause trouble during construction shall immediately be removed by the Contractor in accordance with the direction of the Engineer.

(4) In order to complete the construction, the Contractor shall furnish and maintain all required scaffolding, runways, platforms and other necessary pertinents.

(5) Temporary transportation road

(a) The Contractor shall carry out investigation, design and construction of the temporary transportation road required for execution of the work at the expense of the Contractor, and submit such design in writing to

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the Engineer and obtain his approval.

- (b) The Contractor shall, at his expense, carry out maintenance and management of the temporary transportation road.
 - (c) After completion of the work, the Contractor shall dismantle or leave the temporary transportation road as it is upon discussion with the pertinent parties, and obtain approval from the Engineer in whichever case, so that no trouble will arise in the future.
- (6) The Contractor shall, in connection with the Works, provide and maintain at his own cost all guards, fencing and supervision when and where necessary or as requested by the Engineer, or by any duly constituted authority, for the protection of the works, or for the safety and convenience of the public or others.
- (7) The Contractor shall use every reasonable means to prevent any part of highways or bridges communicating with or on the routes to the site from being damaged or harmed by any traffic of the Contractor or any of his sub-contractors and, in particular, shall select routes, choose and use vehicles and restrict and distribute loads so that any such extraordinary traffic as will inevitably arise from the moving of equipment and materials from and to the site shall be limited, as far as reasonably possible, and so that no damage or harm may be occasioned to such highways and bridges.

- (8) Should it be found necessary for the Contractor to move one or more loads of equipment, machinery or pre-constructed units or parts of units of work over part of a highway or bridge, the moving whereof is likely to damage any highway or bridge unless special protection or strengthening is carried out, then the Contractor shall, before moving the load on to such highway or bridge, give notice to the Engineer of the weight and other particulars of the load to be moved and his proposals for protecting or strengthening the said highway or bridge.

10.3.2 EXCAVATION

- (1) The Contractor shall check the correctness of the tower location referring to the tower center pegs before starting the foundation work and peg out the foundation pits.
- (2) Excavation shall be made in correct dimensions and levels according to the erection drawings. Pit for spread foundation (I-type) shall be excavated preferably vertically, unless otherwise instructed by the Engineer. Meanwhile, shallow pit for mat foundation (IV1-type) and pile foundation (III, IV2-type) shall be with inclination 1:0.5 to preserve pit wall without sheeting or strutting.
- (3) The bottom surface of the pit shall be finished clean and free from disturbed materials unsuitable for bearing the specified load. Adequacy of the bottom soil for foundation shall, if necessary, be checked by the Engineer.

If bottom soil becomes loose or soft, crushed stone or gravel of 20 cm shall be laid beneath the foundation bottom and well compacted.

- (4) If the Contractor carries out any excavation exceeding the design level and/or width, the bottom surface and/or side wall of the pit shall not be rectified by means of earth filling but shall be filled as stated above or by the concrete as instructed by the Engineer at the expense of the Contractor.
- (5) Where excavation is made in cultivated land, top soil shall be preserved separately from the excavated material and reinstated later to the original ground after backfilling of the foundation.
- (6) Where necessary, close timbering or steel sheeting shall be applied as directed by Engineer to protect the walls from collapse, the cost for which shall be deemed to be included in the rate of the foundation work. The supporting frames shall be strong enough to avoid collapse of pit.
- (7) Blasting operation in rock excavation shall be made in an approved manner and with utmost care so as to ensure the safety of human life and properties nearby, the cost for which shall be deemed to be included in the foundation work quoted in the Price Schedule. Care shall be exercised to avoid over-excavation.

- (8) The Contractor shall be responsible for performing the sounding test by means of an approved type penetrometer or Swedish sounding tester at the level of less than 50 cm above the designed bottom level of all foundation pits, and for reporting the results in an approved form to the Engineer who shall decide whether there should be any modification of the foundation design. The cost for this test shall be deemed to be included in the unit price for the foundation work entered in this Price Schedule.

10.3.3 BACKFILL

- (1) Unless otherwise approved, backfill shall not commence until the foundation concrete has been completed and cured.
- (2) Filling material unsuitable for foundation backfill or grading shall be disposed of as directed by the Engineer, and suitable materials shall be used in backfill or in graded embankment around the tower at the Contractor's expense.
- (3) The backfill of all types of foundation shall be thoroughly rammed. Ramming shall be carried out to each layer of not greater than 30 cm in depth using "Vibro-rammer" or other approved tools. Selection of fill materials and control of moisture content thereof shall be made so as to produce a well compacted homogeneous backfill.
- (4) Density tests shall be carried out by the Contractor when

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so required by the Engineer.

- (5) Where excavation is made in peaty ground, spoils shall be wasted and the pit shall be backfilled with selected materials from the approved source at the Contractor's expense.

10.3.4 STUB SETTING

- (1) Foundation stubs shall be set in correct positions and made level by means of trussed beam templates or by a method approved by the Engineer. The stubs shall be securely fixed in correct position before and during concrete placing so as to avoid any displacement of stubs. The template shall not be removed until at least 24 hours after placing concrete.
- (2) Accuracy of stub setting shall be the responsibility of the Contractor. Tolerance of stub inclination of stub angles shall be less than 2 mm. Other tolerances of stub settings shall be 7 mm in back to back distance, 10 mm in difference of two diagonal distance and 5 mm in difference of level at tops of stubs after placing concrete. The Engineer will check accuracy of stub setting on completed foundation and approve the foundation.
- (3) Steel members shall not directly contact soil after backfilling, land formation or clearing of the site. When necessary, tower stubs shall be protected by concrete

wrapping or other means as approved by the Engineer. Ladders shall be used for climbing in and out of the pit to carry out the work of stub setting and concreting in order to avoid harmful impact, stress, displacement or soiling of stubs.

10.3.5 CONCRETE WORK

- (1) All cement to be used shall be Portland cement meeting the requirement of ASTM C 150 or JIS R 5210 from an approved manufacturer. Cement shall be adequately protected from moisture or contamination during transport and storage at site. Cement in bags shall be limited within a heap of 13 bags in the store and 7 bags at site. No cement containing lumps or deleterious matter shall be used.

As the ground water level is comparatively high in the coastal area, and as the ground water and ground have a high salt content, the foundations are to be constructed of durable concrete suited to the local conditions and provided with the necessary protective painting or coating. Cement shall be sulphate-resisting type conforming to ASTM standard C-150-66 for Type V cement or equivalent.

- (2) Fine and coarse aggregate shall be clean and free from dust, earthy or organic matter or salt. Fine aggregate shall be natural sand and shall be sharp, clean and free from dust, salt, clay, vegetable matter or other impurities and screened through a mesh not more than 5 mm in the

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clear.

Coarse aggregate shall be of well grading as approved by the Engineer to be retained on a mesh not less than 5 mm and of a maximum size to pass a mesh not more than 40 mm square.

Fine and coarse aggregate shall consist of hard, dense durable and uncoated rock fragments.

- (3) Water for concrete mixing shall be clean and free from all earthy and organic matter, alkaline substances or oil either in solution or in suspension.
- (4) The steel reinforcing bars shall be of deformed type and of approved quality conforming to an international standard or equivalent, and shall have a minimum yield strength of 3,000 kg/cm².

All materials used for reinforced concrete shall be subject to the Engineer's inspection and approval.

- (5) It is the Contractor's responsibility to carry out tests on samples for concrete mixture design which the Contractor proposes to employ for concrete foundations meeting the requirements undermentioned. The cylindrical test pieces shall be 15 cm in diameter and 30 cm in height. The test result of the proposed mixture together with data for water cement ratio and slump shall be submitted to the Engineer for approval at least four (4) weeks before the commencement of concreting operation.

The Contractor shall be responsible for maintaining the mixture control and testing of concrete throughout the working period. Minimum 28th day compression strength shall be 210 kg/cm².

Slump shall be 10 cm or less and cement content shall be not less than 250 kg/m³.

- (6) Lean concrete of 1-3-6 mixture and/or tamped cobble stone base as gravel layer shall be placed underneath the foundations without extra cost and where so instructed by the Engineer.
- (7) The Contractor shall, at his own expense, take all necessary measures for curing and for preventing occurrence of concrete cracks which may develop out before hardening.
- (8) The concrete shall be mixed with an approved concrete mixer. The size of the mixer shall, in principles, be not less than 0.2 m³, unless otherwise approved by the Engineer. In no case shall hand mixing be allowed. The Contractor shall provide the measuring equipment and shall maintain and operate the equipment as required to accurately determine and control the amount of each separate ingredient entering the concrete. The amounts of cement, sand and each size of coarse aggregate and water entering each batch of concrete shall be determined by weighing or volume measurement. The equipment shall be constantly maintained in first-class workable condition during the working period. The concrete

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mixes shall be cleaned and inspected at suitable intervals in the presence of the Engineer.

- (9) Concrete shall, in all cases, be placed in the presence of the Engineer or his representative. No concrete shall be placed until the Engineer has approved the excavated surface, stub-setting, inspection of reinforcing bars, setting of all form work and completion of all preparation works. No concrete shall be placed in water, unless approved by the Engineer.

Adequate chutes or other approved method shall be employed to place concrete. All concrete shall be consolidated to the maximum practicable density with a concrete vibrator and to a smooth surface free from pockets or honeycomb.

- (10) The Contractor shall perform concrete sample tests for quality control in concreting in such a manner that three (3) pieces of test specimen shall be molded at every tower, and these shall be tested on the 28th day after molded in accordance with JIS A 1108 or equivalent at an approved laboratory without any extra cost to the Owner. Test samples molded shall be carefully cured under the Contractor's responsibility until the testing day. A slump cone shall be provided by the Contractor at all concrete placing sites for inspection by the Engineer. In case that strength of test specimen does not meet the specified requirement, the Engineer may order the Contractor to remove and replace such concrete at the

expense of the Contractor.

- (11) Forms to be used shall be steel or timber plates with frames so as not to allow deformation of foundation or leakage of mortar. The inside of steel or wooded form shall normally be coated with non-staining mineral oil or, if required, an equivalent approved by the Engineer. The forms shall be kept in place for not less than 24 hours after placing concrete. Concrete shall be cured by being kept moist for a period of at least 5 days after placing.

The cost of form works and curing shall be deemed to be included in the rate of the foundation work.

- (12) Concrete foundation shall extend to at least 250 mm above ground and shall be sloped off around steel leg sections and smoothly finished to ensure drainage away from the steelworks.

- (13) Minimum concrete coverage to stub materials shall be 15 cm, and the same to reinforcing bars shall be 10 cm, except for piles which shall be reduced to 5 cm.

- (14) Mixing temperature of concrete shall be under 25°C to avoid material segregation or excessive mortar expansion that may lead to quality deterioration.

10.3.6 DISPOSAL AND SURFACE FINISHING

- (1) Surplus materials or waste materials from excavation and backfill may be graded in the tower site area, and its surface shall be finished. However, when directed by the Engineer, the surplus materials shall be disposed of outside of the tower site area at the Contractor's expense.
- (2) Where directed by the Engineer, the Contractor shall construct drain ditches to divert surface water from the tower site.
- (3) Backfilled surface shall be made flat or heaped to avoid puddles caused by depressions or settlement of ground. Backfilled ground around foundations that may have settled or eroded before taking-over of the work and/or structure or facilities damaged by such settlement or erosion shall be compacted and leveled to conform to the adjacent ground surface. Damage facilities shall be repaired in a manner acceptable to the Owner or the Engineer.
- (4) The cost of disposal of surplus materials and surface finishing shall be deemed to be included in the rate of foundation work in the Price Schedule.

10.3.7 TERRACING, REVETMENT AND PROTECTION

- (1) The natural ground at each tower site on slope shall, wherever practicable, not be disturbed during construction.

Where instructed by the Engineer, the hurdle shall be provided around foundation slopes for prevention of efflux of sub-soil from foundation at the Contractor's expense.

- (2) Ground cutting shall be executed by the Contractor in steep sloped areas so that the tower legs present a pleasing appearance to the site, and shall be done when so instructed by the Engineer. Before ground cutting, the Contractor shall prepare cutting plans and submit them to the Engineer for approval. The cost for the work shall be deemed to be included in the rate of foundation work in the Price Schedule.

10.4 PILING WORK

10.4.1 GENERAL

Type of piles to be used shall be of precast concrete pile, steel pipe pile or cast-in-place concrete pile.

Piling work shall be designed and executed in accordance with the requirements of Clause 6 of "Applicable Standards and Codes" in the Technical General Conditions.

10.4.2 STEEL PIPE PILES

All materials to be supplied by the Contractor shall be in accordance with the following Japanese Industrial Standards or equivalent.

Materials	JIS
Steel Pipe Piles	G344 Class 2 (STK41)
Backing Plate and Pile Tip Reinforcement	G3101 Class 2 (SS41)
Welding Rods	Z3211

All materials shall be the best quality of their kind, well graded and within allowable tolerances as specified in JIS A5525, or equivalent.

The Contractor shall submit the mill sheets to the Engineer for approval, prior to starting the fabrication.

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10.4.3 SHOP DRAWINGS

The Contractor shall submit the complete shop drawings to the Engineer for approval, prior to starting the work.

10.4.4 WORKMANSHIP

(1) General

Each steel pile shall be supplied in a set of several pieces in accordance with the Drawings.

Each piece of a pile, excluding the lower part, shall have a backing plate of 6 mm thickness at the bottom end and a stopper of 16 mm thickness at the top end for field welding.

(2) Tip reinforcement

The lowest piece of each pile shall have a reinforcing band of the thickness indicated in the attached pile list and a 300 mm length connected to the pile at the tip end by shop welding.

(3) Cutting and groove face finish

Cutting and groove face finish shall be done by automatic gas cutting machine.

The groove and/or root faces to be welded in field shall be coated with strip paint.

(4) Welding

Welding shall be done by welders having qualification A-2F and/or A-2V as specified in JIS Z3801 or equivalent, and

having more than 6 months experience.

(5) Shop test and inspection

Material tests shall be carried out in the manner as specified in JIS G3444.

All welding lines shall be tested by an ultrasonic inspection device.

The Contractor shall, before shipment of the materials, submit the test results to the Engineer for approval.

(6) Others

(a) 50 mm length seam reinforcement on inner face from the top of each pile shall be ground flat so as to set the backing plate.

(b) Each steel pile piece shall be marked with the following symbols.

- . Pile mark
- . Pile size; diameter and length
- . Level indicating line

(every 50 cm)

10.4.5 MANUFACTURE OF CONCRETE PILES

(1) The length of each precast concrete piling shall be 15 meters.

The manufacturing procedure and schedule of precast concrete pile shall be submitted to the Engineer for approval.

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- (2) The dimension of precast concrete pile and arrangement of reinforcing steel bars shall be submitted to the Engineer for approval.

Prefabricated steel shoe plate shall be attached at the tip of concrete pile. The steel plates shall be attached at the pile end.

All corners of piles shall be chamfered to 40 mm or rounded to a radius of 50 mm. All precast concrete pile shall be lifted at the two points, and the lifting point shall be clearly indicated.

- (3) The concrete for precast concrete pile shall be as specified below.

(a) The concrete minimum compressive strength shall be 270 kg/cm² at 28 days.

(b) The maximum dimension of coarse aggregate shall be 25 mm.

(c) The water-cement ratio of concrete shall be 50% in maximum.

(d) The placed concrete shall be cured in a wet condition for at least three days, and the forms shall then be removed.

The concrete shall be cured in a moist condition for at least four days.

The concrete pile shall not be moved or transported during the above conditions. The form shall be made of plywood and the surface of concrete shall be finished smooth.

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- (4) No lapped joints of reinforcing bars in the axial direction shall be applied, except for welded joints of 100% welding efficiency.
- (5) The piling works shall be started 28 days after aging of concrete. No concrete pile shall be used without inspection by and approval of the Engineer.
- (6) All concrete to be used for pile shall be checked for concrete compressive strength, and all piles shall be inspected for size, appearance, dimension and arrangement of reinforcing bars.
- (7) The allowable tolerance of dimensions of concrete pile shall be as follows.

Length	$\pm 0.3\%$ of total length
Sectional area	+10 mm, or -5 mm
Warp	7 mm for length of 5 m or less 10 mm for length of 6 to 12 m 13 mm for length of 13 m or larger

Steel plate at the pile end shall be attached within the tolerance of $\pm 0.28^\circ$.

- (8) The concrete to be used for pile shall be tested for compressive strength after 7 and 14 days aging, and after 28 days aging. The slump test shall be carried out during placing of concrete. The above tests shall be executed every day during manufacturing of concrete pile.

If the manufacturing quantity for one day exceeds 30 piles,

an additional test shall be required for every 30 concrete piles. Three test pieces shall be required for each test.

(9) The following items shall be clearly painted on the surface of the concrete pile.

- . Dimensions
- . Date of concrete placing
- . Inspected mark and date
- . Marks at every 50 cm

10.4.6 PILE DRIVING

(1) Piles shall be driven by a pile driver, suitable for the type and size of the piles, geological conditions and construction environment, and in such a manner as to cause no public nuisance, such as noise, to the third party.

(2) The method of pile driving and for construction joint of piles shall be submitted in writing to the Engineer, and shall be subject for approval by the Engineer.

(3) Records of piles indicating the length, diameter and type of piles, soil condition, foundation type, date, driving machine and equipment, rammer size and weight as well as other pertinent matter related to design, shall be kept during the piling operation, and these shall be submitted to the Engineer.

(4) Piles shall be driven vertically and at the exact locations indicated in the drawings. Pile driving shall be

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continuous without interruption to avoid deviation of pile head.

- (5) Caps and other suitable materials, as driving cap, shall be used as a cushion to protect the head of piles.
- (6) Should it be difficult to drive any pile up to the specified depth, the Contractor shall carry out such piling work in accordance with the instructions from the Engineer.
- (7) When driving a group of piles, driving shall begin from the center and gradually moved outward.
- (8) When eccentric error exceeds the allowable values shown in the table below or when a pile is damaged or cracked during piling operation, it shall be reported to the Engineer, and the pile shall be replaced or an additional pile shall be driven.

Type of Foundation	Allowance	Remarks
All foundations	10 cm or less	

- (9) Upon completion of piling, any void portions inside piles shall be filled with soil obtained from at-site excavation.

10.4.7 FIELD JOINING OF PILES

- (1) Field joining of piles shall be carried out by arc welding.
- (2) Welders shall have not less than 6 months continuous experience in welding of pile, and shall be qualified by JIS Z-3801, "Standard Qualification Procedures for Welding

Technique", or equivalent.

Prior to execution, the Contractor shall submit to the Engineer for approval the list of welders showing the name, age, length of experience, types of test passed, qualifications and employment particulars.

- (3) Arc-welding rods shall be standard items specified in JIS Z-3211, "Covered Electrodes for Mild Steel", or equivalent. Welding rods shall be completely dry prior to use.
- (4) The welding surface of parent metal shall be carefully cleaned of slag, moisture, dust, rust, oil, paint or other foreign matter.
- (5) Welding shall be performed carefully by selecting welding current and welding speed which ensure complete penetration of welding rod to avoid cracks in any portion of the weld.
- (6) Welding shall not be performed when the parent metal is wet from rainfall or when strong winds are blowing. However, when the portion to be welded is suitably protected, welding may be performed upon approval by the Engineer.
- (7) If harmful defects or cracks have been found in the weld, the deposited metal shall be carefully chipped off and the affected part shall be rewelded and then inspected by the Engineer.

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10.4.8 TREATMENT OF PILE HEAD

- (1) The head of the piles attached with protection, such as steel ring, shall be cut to the designated level without damaging or cracking the pile body through cutting works. Pile heads shall be inspected by the Engineer or photographed to obtain approval by the Engineer. Reinforcing bar shall be welded to the pile head and anchored into the footing. In no case shall a pile be embedded into the footing.
- (2) The concrete piles shall be anchored into the footing with sufficient embedment by a method approved by the Engineer.

10.4.9 TRANSPORTATION AND HANDLING

Care shall be taken in transportation and handling of pile so as to prevent damage to them.

If the pile is damaged or deformed to the extent that it is impractical for the intended use, the Contractor shall repair it prior to driving, and it shall be inspected and approved by the Engineer.

10.4.10 DRIVING RECORD

- (1) Every pile for each foundation shall measure rebound and penetration amounts when driving into the bearing stratum or at the designed depth. Every one out of 10 piles shall be counted and the total number of driven piles shall be

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recorded. The Contractor shall report to the Engineer the results of measurement and the estimated capacity of piles from the measurement and total driven number. The driving record shall be approved by the Engineer. The Engineer may order design modification or additional piling at the expense of the Contractor in case the capacity estimated is lower than the design capacity.

10.4.11 CAST-IN-PLACE CONCRETE PILES WORK

(1) Construction method

The Contractor shall submit a detailed description of the method of construction for the piling work, including the construction schedule, to the Engineer for approval prior to commencement of the work.

(2) Materials

Concrete and reinforcing steel for cast-in-place concrete pile shall conform to the requirements specified as follows.

- (a) The concrete minimum compressive strength shall be 270 kg/cm² at 28 days.
- (b) The maximum dimension of coarse aggregate shall be 25 mm.
- (c) The water-cement ratio of concrete shall be 60% in maximum.

(3) Boring

(a) Boring

Boring shall be carried out by either rotary or percussion equipment, grabbing equipment or by reverse or direct mud circulation method. Walls of borehole shall be stabilized by using casing/liners with or without drilling fluid depending upon the soil conditions. In soils likely to flow, the bottom of casing/liners shall be kept ahead of the boring in all cases to prevent the entry of soil into the bore. Formation of cavities or settlements in the adjoining ground shall be avoided.

The Contractor shall be responsible for prompt removal from the site of all spoil resulting from the boring to the places specified by the Engineer.

Foundation elevation of each pile shall be individually approved by the Engineer on the basis of his observations and the data at his disposal in regard to the soundness of the end bearing stratum. Piles shall be socketed at a minimum of one diameter into the stratum or as directed by the Engineer.

(b) Drilling fluid

The specific gravity and composition of the fluid shall be such as to suit the requirements of the ground conditions and to maintain the fine materials from boring in suspension. When water is used as drilling fluid, the fluid level in the boring shall be maintained at a level not less than 2.0 m above the

level of the ground water or high water level, as the case may be, until concreting is completed.

When bentonite or other approved material is used in drilling fluid, it shall be mixed thoroughly with clean fresh water to create a suspension which will maintain the stability of pile excavation for the period necessary to place concrete and complete construction.

Quality control tests shall be carried out on bentonite suspension using suitable apparatus. The frequency of testing the drilling fluid and the method and procedure of sampling shall be as directed by the Engineer. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed.

(c) Concreting

Each cast-in-place pile shall be filled with concrete to ensure sound concrete at cut-off elevation. The space to be filled shall be free of mud, trash or other foreign matter. After cleaning pile shells, if water remains, concrete shall be placed by bottom-dump buckets on tremies through a funnel by pump or other means, so that splashing or segregation is avoided. The concreting of the piles shall be brought up to a minimum of 60 cm above the cut-off level of the pile to allow for complete removal of slush, foreign matter, etc., from the main pile and thus

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obtain sound and uniform concrete. The concreting procedure shall be sufficiently strong to withstand, without injury, all stresses and pressures to which the piles are to be subjected during placing, concreting or driving. Shells which are damaged or broken during installation shall be replaced.

10.4.12 DEFECTIVE PILES

(1) Any pile damaged in driving by reason of internal defects, or by improper driving, or driving out of its proper location, or driven below the elevation fixed by the drawings or by the Engineer shall be corrected by the Contractor without additional compensation by one of the following methods approved by the Engineer for the pile in question.

- The pile shall be pulled out and replaced by a new and, when necessary, longer pile.
- The new pile shall be driven adjacent to the defective pile.
- The pile shall be sliced or built up as otherwise provided herein or a sufficient portion of the footing extended to embed the pile properly.

10.4.13 PILE TEST

(1) The Engineer may instruct the Contractor to carry out pile tests for uplift and compression loading as necessary so as

to ascertain the arrangement of the foundation piles. The Contractor shall furnish test piles and execute pile load test, including the pulling out test, at the locations designated by the Engineer. The number and location of test piles will be decided by the Engineer, but this number shall be not more than one for each tower foundation.

(2) Load tests shall be made by the Contractor in accordance with the methods approved by the Engineer. The Contractor shall submit to the Engineer for approval detailed drawings of the loading apparatus with the test method he intends to use. The apparatus shall be so constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles. If the approved method requires the use of tension (anchor) piles, such tension piles shall be of the same type and diameter as the test pile. Loads for the load tests shall not be applied until the concrete has attained a minimum compressive strength of 95 percent of the design 28-day compressive strength.

(3) Suitable approved apparatus for determining accurately the load on the pile and the settlement of the pile under each increment of load shall be applied. The apparatus shall have a working capacity of three times the design load for the pile being tested. Reference points for measuring pile settlement shall be located sufficiently away from the test pile so as to preclude all possibility of disturbance.

- (4) All pile loads and settlements shall be measured by adequate devices and gauges. Increments of deflection shall be read just after each load increment is applied and at 15-minute intervals thereafter. A safe allowable load shall be considered as 50 percent of the load which, after 48 hours of continuous application, has caused not more than 6.5 mm of permanent settlement, measured at the top of the pile.
- (5) The test load shall be twice the pile design load. The first increment of load to be applied to the test pile shall be less than the pile design load. The load on the pile shall be increased step by step by about ten (10) percent of the test load. No load increment shall be added until a settlement of less than 0.12 mm is observed for a 15-minute interval under the previously applied increment.
- (6) If there is a question as to whether the test pile will support the test load, the load increments shall be reduced by 50 percent, upon instruction by the Engineer, so that a more closely controlled failure curve may be plotted. The full test load shall then be removed for permanent settlement.
- (7) When requested by the Engineer, loading shall then continue beyond the double design load in an increment directed by the Engineer until the pile fails or the capacity of the loading apparatus is reached, whichever is the lesser.

(8) After the completion of loading tests, the load used shall be removed and the piles, including tension piles, shall be utilized in the structure if found by the Engineer to be satisfactory for such use. Test piles not serving the purpose as a test or tension pile, if found unsatisfactory for utilization in the structure, shall be removed if so ordered by the Engineer, or shall be cut off below the ground line or footings, whichever is applicable.

(9) A report shall be prepared by the Contractor for each load test, and the report shall be accompanied by the following documents:

- plan of the foundation
- stratigraphy of the soil
- calibrating curve of gauge
- drawing of jack diameter of piston
- graph of the test, having for abscissae the loads (tons) and for ordinates the settlement in fractions of mm
- tables showing, as a function of the times (date and hours), the readings of the gauge in atmosphere, the loads in tons, the settlements and average of the settlement.

11. TOWER ERECTION

11.1 INSTALLATION OF TOWER LEGS

- (1) To ensure precise installation of tower legs buried in the tower foundation, the Contractor shall apply setting templates and measure the various dimensions for installation before and after concrete placing, and shall report the measured data to the Engineer before assembly of tower members.
- (2) The tolerance of tower legs setting shall be in accordance with the following.

Root width : ± 7 mm
Diagonal : ± 10 mm
Height : ± 5 mm
Inclination : ± 2 mm

11.2 MEASURING OF GROUNDING RESISTANCE

- (1) Before starting erection of steel work, measuring of grounding resistance shall be carried out for each tower leg as well as for four leg-composite at a 10 meter electrode distance, and the results shall be reported to the Engineer.
- (2) At the place where measured results indicates more than ten (10) ohm, counterpoise wire shall be installed as directed by the Engineer. The Contractor shall measure and report the grounding resistance after the installation

of the counterpoise wire for approval by the Engineer.

11.3 ERECTION WORK

- (1) No tower superstructures shall be erected until 7 days after placing of the foundation concrete and before proper backfill and compaction without the Engineer's approval.
- (2) Tower members delivered to the site with slight distortion or damage to galvanized coating, due to handling during transportation, shall be straightened or repaired by the Contractor at his own expense by using approved means or applying zinc rich paint. The work shall then be inspected by the Engineer. All rejected work shall be redone.
- (3) Erection/assembly of steel towers shall be carried out in strict accordance with the Erection Drawings and Bill of Materials approved by the Engineer and the conditions stated hereinafter.
- (4) On the occasion of assembling the joining parts of the posts of each section, all bolts to be applied for the section shall be inserted by hanging up the posts, and at least four (4) pieces of bolts for upper and lower positions and both sides shall be completely finish-fastened.
- (5) Bracing material shall be attached to each section, and finish-fastening shall be carried out so that no torsion of whole of the steel tower or no gap between each part is produced.

- (6) Sufficient attention shall be paid so as not to make a mistake in applying the classification of bolts, post joint parts, common step bolts and nuts.
- (7) All bolts shall be so installed that their heads are in the "down and in" position. Contact surfaces of bolts connection shall be cleared of dirt or foreign matter before assembly.
- (8) Tower members shall not be strained or bent during erection. No gin poles or wire ropes shall be directly mounted on tower members without adequate protection with burlap. Contact surface of joints shall be cleaned and cleared of foreign material and dirt before assembly. Spanners or wrenches used shall be of the well shaped and approved type and shall fit exactly on the hexagon surface to avoid damage to nuts and bolt heads.
- (9) Reaming or drilling of bolt holes to enable connection to be made at the site shall not be permitted without approval by the Engineer. Such drilling or reaming, if approved, shall be repainted with zinc rich paint as directed by the Engineer. The Contractor shall verify the propriety of tightness of bolts with calibrated torque wrenches in the presence of the Engineer. The standard and maximum torques of bolt tightening shall be as follows.

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Fastening torque (kg-cm)

Nominal dimensions	Material properties	Fastening torque (kg-cm)	
		Standard	Maximum
M-16	SS-41	500	600
M-20	SS-41	1,000	1,300
	SS-50	1,400	1,700
M-24	SS-50	3,100	3,700
	SCr-4	5,700	6,200
M-30	SCr-4	9,000	11,000

- (10) Bolts, nuts and damaged parts on painted or galvanized surface shall be brushed, washed and painted in the manner stipulated in Clause 11.4.
- (11) Number plates and danger plates shall be fixed on front and back faces of each tower at a height of approximately 3.0 m from the ground as indicated in the Erection Drawings. Anti-climbing devices shall be fitted at a height of no more than 5.0 m above the ground as instructed by the Engineer. The cost of installation of the danger plates and number plates shall be deemed to be included in the rate of tower erection in the Price Schedule.
- (12) After erection, all towers shall be cleaned of all foreign materials and dirt. Climbing step bolts below the anti-climbing devices shall be removed from the towers immediately after the stringing work is completed and they shall be returned to the Owner, as directed by the Engineer, immediately before the completion of the line.

11.4 REPAIR PAINTING

Repair painting for damaged portions during transportation or construction shall be carefully done as follows.

- (1) Rust and loose paint coat shall be completely removed by chipping, brushing or with motor driven tool from the surface of the tower members. All foreign matter such as dirt, grease, salt, etc., shall be removed by using cloth with thinner and/or others. The surface treatment shall comply to S.S.P.C-SP-3. This work shall be carried out with utmost care so as to avoid peel off or corrosion under the repainted coat.
- (2) Two coats of anticorrosive repair paint shall be applied on the surface where rust or loose paint have been removed. This paint shall be the same kind of paint as the undercoating made in the factory.
- (3) Two coats of anti-weather type final coating shall be applied. This paint shall be the same kind of paint made in the factory.

12. STRINGING WORK

12.1 STRINGING SCHEDULE

- (1) At least two months prior to commencement of the stringing work, the Contractor shall submit to the Engineer/Owner for approval a fully detailed account of his proposed method of stringing and a list of quantities and particulars of the tools to be used.
- (2) A detailed schedule giving the location of drum site, engine site and joints, length of conductors, direction of tensioning, the spans where sags shall be observed, tables of sags, etc., in approved forms shall be submitted to the Engineer/Owner at least one week in advance of the stringing work for the corresponding section.

12.2 STRINGING EQUIPMENT

- (1) Whether tension stringing equipment is used or not, the conductor and ground wire reels shall be firmly anchored and shall be equipped with breaking devices so as to provide sufficient tension to prevent overrun.
- (2) One hundred (100) ton hydraulic compression tool shall be used to install all compression fittings for conductor. The Contractor shall ensure that the processes are kept in good working order and that broken, defective or worn dies are replaced so that all compression fittings are mechanically

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and electrically sound.

- (3) The diameter of groove of the stringing sheaves or travellers shall, in principle, be more than 18 times the cable diameter. At a tower position with large horizontal deviation angle or heavy vertical loading, the diameter shall be more than 20 times that of the conductor. If not, series double stringing sheaves or travellers shall be applied.

Sheaves shall be so designed and used that the pulling line does not damage or deposit foreign matter in the sheave which might cause damage to the conductor. Sheaves which, in the opinion of the Engineer, are found to be operating improperly or to be in such condition as to cause damage to the conductor, shall be removed and restored to proper operating condition or replaced. Grips or come-along clamps shall be subject to approval by the Engineer.

12.3 STAY AND SCAFFOLDING

- (1) All such towers which may be subjected to excessive loading during stringing and sagging of the conductors and groundwires shall be reinforced with backstays in an approved manner. Such crossarms as may be subject to heavy vertical loading shall be reinforced with armtie guy wires. Methods of stringing and sagging procedure as may be subject to unbalanced loading and torsional force on both side of arms shall be avoided whenever possible. The Contractor

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shall submit for approval to the Engineer his proposed practice of stay-wire when he submits his detailed account of the stringing procedure.

- (2) The Contractor shall provide suitable scaffolding during the stringing work where the line crosses over railways, national roads, local roads, power lines, telephone lines, etc., which the Engineer considers to be protected.
- (3) The height of scaffolding shall be such that the clearance of conductor may not be less than 7 meters to railway and road, 3.2 meters to 132 kV lines, 2.2 meter to 66 kV lines 1.5 meter to 11 kV lines and 0.6 meter to low tension power lines and telephone lines. No part of the scaffolding shall approach power or telephone lines within the distance aforementioned. The cost for the scaffolding and preliminary works shall be included in the rate of appropriate stringing works.
- (4) The Contractor shall be responsible for giving necessary notice to and obtaining the approval from the related authorities prior to the erection of such scaffolding. Two (2) copies each of such notice and approval shall be submitted to the Engineer.

12.4 HANDLING OF MATERIALS DURING ERECTION

- (1) Extreme care shall be exercised when uncrating and installing insulators so as to prevent chipping or cracking

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of the porcelain. When assembling the insulator strings, the ball sockets shall be free of sand or grit before the ball is inserted. Before installation, all insulators shall be wiped clean and visually examined for damage to the porcelain, cement, caps and cotter pins. All damaged discs shall be replaced before installing the string. The installation procedure shall avoid bending of the string of insulators. No load, other than normal conductor tension, shall be imposed on the insulator string during installation. The insulators shall not be subjected to impact loads at any time.

- (2) The Contractor shall ensure that the cotter pins in the suspension assembly are properly inserted and opened so that the eyes of the pins face the exterior of the tower in a vertical line.
- (3) Distributing, storing and handling of conductors and ground wire shall be carried out in such a manner as to eliminate damage from abrasion or from dirt or grit getting into the reel and conductor.

12.5 STRINGING OF CONDUCTORS AND GROUNDWIRES

- (1) The conductors and groundwires shall be strung with suitable tension using tensioners and, where necessary, by providing aluminum rollers or other approved method in order to keep the conductors and groundwires off the ground. Counterweights shall be used at the connected point of

messenger wires and conductors or groundwires to avoid the loosening of strands.

- (2) The Contractor may pull conductors or ground wires independently or in multiples provided the pulling tensions on the tower does not exceed the value recommended by the Engineer.

Utmost care shall be taken that no over-tensioning nor ground-rubbing of conductors and groundwires occur during stringing.

- (3) The conductors and groundwires shall not be allowed to kink, birdcage or become damaged. Damaged conductors shall be replaced or repaired with repair sleeves as instructed by the Engineer. Wherever damage exceeds the following limits for ACSR/AS, the damaged portion shall be replaced.

(a) Damage is restricted to the outer layer of aluminum strand

(b) The steel core is undamaged

(c) The number of damaged aluminum strand is less than one quarter (1/4) the total number of aluminum strands.

- (4) No tower leg or foundation stub shall be used as a temporary anchor during stringing operation without the Engineer's approval.

- (5) The stringing operation shall be executed with due regard to the safety of personnel. Flagmen and danger or warning notices shall be provided to ensure public safety. Cost of

stringing of conductors and groundwires shall be paid on the basis of horizontal line length of the route.

12.6 JOINTS

- (1) The conductors and groundwires shall be jointed by a compression joint in an approved manner. The fullest possible use of maximum conductor length shall be made so as to hold the number of joints to a minimum. Joints shall not be located within 15 meters from tension clamps or suspension clamps. There shall not be more than one joint per conductor or groundwire in any one span.
- (2) No joint shall be allowed in any span crossing a railway, a power line, a national road, a major river or any area designated by the Engineer.
- (3) Cutting of layers of aluminum strands shall be carried out so that underlying steel strands are not damaged.
- (4) The Contractor shall follow a detailed account of joints given by the Engineer including the practice of jointing, the dimensions before and after compression, device for centering the sleeves, the methods of painting, impregnation of anticorrosive materials, checking gauges for dimensions after compression, cleaning, compressing pressure and practice, etc.
- (5) Joints made at the drum site shall be protected for passing through the pulleys during stringing with approved

protectors of suitable design.

12.7 SAGGING

- (1) The Contractor shall provide suitable signing boards and theodolites mounted on towers by clamping, or other approved apparatus necessary for observing sag.

Sag shall be measured at least in one span for the section of not more than 6 spans, and two for the section exceeding 7 spans. In addition, one or more spans shall be observed should the Engineer deem this necessary.

The Contractor shall keep a sagging record listing the span where the sag was measured, temperature, the sag and any other remarks, and shall submit the records to the Engineer upon completion of the stringing work.

- (2) Immediately after the conductors have been regulated and clamped in, the mean sag of the conductors shall not deviate from the correct erection sag by more than plus or minus 2 percent. In addition, the sag of any one line conductor in a span shall not deviate by more than 15 cm from the mean sag of other line conductors in the same span.
- (3) The Contractor shall ensure that the sags in a completed section shall not be altered by the stringing and sagging operation in the adjacent section.
- (4) Where required by the Engineer, prior to the issue of the taking over certificate, the Contractor shall be responsible

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for checking the sags of the conductors and groundwires at the selected spans as requested by the Engineer.

12.8 CLAMPING

- (1) After the conductors or groundwires have been finally tensioned to their correct sags, the position of tension clamps shall be carefully marked. Tension clamps for conductors shall be compressed on the conductors in a similar manner to midspan tension joints.
- (2) When fitting the tension clamp to insulator set or tower, care shall be taken so that no excessive stress may be given to tower members.
- (3) The Contractor shall ensure that the suspension clamps are properly assembled over the armour rods in such a manner as the insulator set being hanged vertically.
- (4) All cotter pins of insulators, hardwares and clamps shall be faced toward the centre of the tower or upward.

12.9 JUMPERING

- (1) Jumper conductor shall be provided in such a manner as forming a smooth ellipse and providing necessary clearance to tower members, which shall be checked after installation of each jumper.

Where instructed by the Engineer, the jumper shall be supported by a jumper support insulator set.

(2) The cost for fixing jumper conductor shall be included in the price of installation of tension insulator sets.

12.10 VIBRATION DAMPERS

Vibration dampers for conductor or groundwire shall be fitted as specified below.

Number of dampers per conductor or groundwire in one span

i) In case of single conductor or wire

<u>Span length,</u> <u>m</u>	<u>No. of vibration damper,</u> <u>pcs/phase/span</u>
300 and under	2
Over 300 to 600	4
Over 600	8

ii) In case of twin bundle conductor

<u>Span length,</u> <u>m</u>	<u>No. of vibration damper,</u> <u>pcs/phase/span</u>
200 and under	none
Over 200 to 600	4
over 600	8

Distance from a suspension or tension clamp and spacing between dampers

ACSR/AS 330	1.4 m
ACSR/AS 680	1.7 m
OPGW 190/90	1.3 m

Double torsional type vibration dampers shall be mounted so as to maintain their damper weights horizontally and incline their

clamp axis at an angle of 60 degrees to the horizontal plane.

The first damper for each phase conductor shall be mounted so as to strengthen the twist of the outermost layer of the conductor, and the second damper, if any, to loosen the twist.

12.11 SPACER

Spacers for twin conductors shall be mounted after tensioning with the members in the proper manner and in accordance with the manufacturer's practice.

12.12 PARTICULAR ATTENTION FOR STRINGING OF OPGW

(1) General

OPGW (Composite fiber-optic overhead ground wire) is generally composed of optical fibers in the center and AS wires (aluminum-clad steel wire) for outer layer.

Accordingly, it is necessary to carefully handle OPGW during stringing to avoid damage to its mechanical, electrical and optical properties. Installation procedures for OPGW are basically similar to those for conventional overhead ground wires in overhead transmission line construction. However, particular attention shall be paid to the protection of optical components and jointing of optical fibers.

(2) Attention in general

1) Waterproofing

Each end of OPGW shall be treated for waterproofing at

the factory before shipment. Careful attention shall be paid to maintain the waterproof treatment without damage. The sealing shall be opened at the time of optical fiber jointing after completion of stringing.

2) Bending

For protection of the optical components contained inside, care shall be taken to avoid bending at sharp angle or kinking of OPGW during handling. The minimum diameter for coiling up of OPGW at site shall not be less than 1 meter, and the diameter of stringing sheave shall be more than 450 millimeters.

3) Stringing works

To avoid unbalanced tension or over tensioning of OPGW, paying off of OPGW together with phase conductors or other wires tied in parallel shall be avoided. To ensure smooth operation of stringing works, the OPGW shall be paid off one by one in length from the reel to each stretched section. The tension during stringing works shall be less than 1,000 kgs as maximum value.

4) Tightening torque

All bolts of accessories and fittings, especially for strain clamps, shall be correctly tightened to the specified torque by means of approved torque-wrenches.

Table 12-1 Tightening torque of bolts
for typical accessories

OPFW size	Fittings	Specified torque
190/90 mm ²	Strain Clamp	800 kg-cm
	FG Clamp	700
	Fixing Clamp	500
	Damper	Break a way bolts

(The above torques shall be specified by the accessory manufacturer in consideration of suitability to OPGW, in case the accessories are supplied by another maker.)

(3) Tensioning of major equipment

1) Tensioner

The tensioner shall be a double-capstan type or shoe-chain wheel type which is free from surging of tension throughout the stringing works, and shall prevent OPGW from twisting during paying off. The minimum diameter of the capstan or wheel shall be 1.2 meters.

2) Stringing sheave

Stringing sheave developed for OPGW shall be applied where line has horizontal angles. This sheave shall be designed to have an additional groove at the center of standard sheave groove bottom and shall not cause excess twisting of OPGW during stringing. The construction of the sheave shall be as shown in DWG.

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When the stringing sheaves are arranged at a heavy holding angle exceeding 60 degrees at the tower, these shall be replaced by double sheaves type so as to reduce the angle. The holding angle shall be calculated by the following formula.

$$\cos \phi = \cos \alpha - \sin^2 \frac{\theta}{2} (\cos \alpha + 1)$$

ϕ : Holding angle

$$\alpha = \alpha_1 + \alpha_2$$

$$\tan \alpha_1 = \frac{W \cdot S_1}{2T} + \frac{H_1}{S_1}$$

$$\tan \alpha_2 = \frac{W \cdot S_2}{2T} + \frac{H_2}{S_2}$$

θ : Horizontal angle (degree)

W : Conductor weight (Kg/m)

T : Stringing tension (kg)

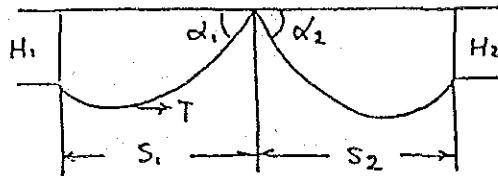
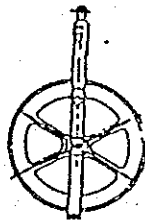
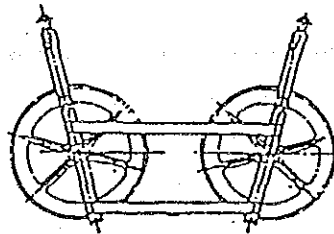


Fig. 12-1 Each figure



Single sheave

($\phi < 60^\circ$)



Double sheave

($\phi \geq 60^\circ$)

Fig. 12-2 Holding angle

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3) Running board

Running board with two counterweight tails tandem shall be applied between the wire rope and OPGW so as to prevent OPGW from twisting during stringing work.

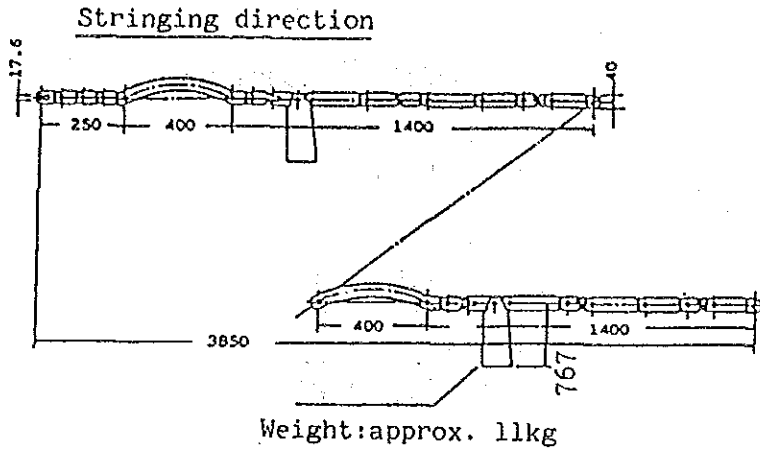


Fig. 12-3 Running board

4) Come-along clamp

Come-along clamp of wedge type shall be used for OPGW, and the wedge shall be suitable in size and diameter so as to protect the aluminum tube from excess deflection. When installing come-along Clamps on OPGW rubber tube or similar material shall be applied for protection of OPGW surface as shown below.

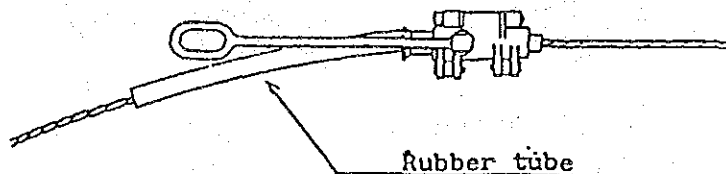


Fig. 12-4 Come-along clamp

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5) Paying out wire for OPGW

Paying out wire shall be of the equivalent weight to that of OPGW so as to avoid unbalanced sagging throughout the paying off.

(4) Arrangement of stringing equipment

Stringing equipment shall be arranged in consideration of the distance from the first tower to each tensioner, puller and temporary anchor position, as shown in the following. The tensioner shall be arranged in a straight line to the stringing sheave at the first tower. The distance "L" between tensioner and the first sheave shall be longer than the necessary OPGW length of leading down.

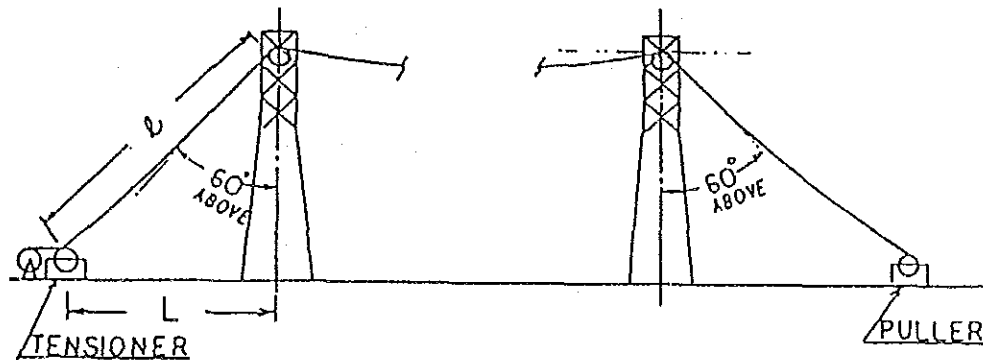


Fig. 12-5 Arrangement of equipment

The holding angle of the sheave at each tower shall be checked in advance. Any tower having a holding angle exceeding 60 degrees shall be provided with double sheaves type stringing sheave so as to avoid excess bending of OPGW during stringing work.

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The stringing tension shall be calculated in consideration of the obstacle's height, if any.

13. INSPECTION, TESTING AND COMMISSIONING AT SITE

13.1 INSPECTIONS AND TESTS

On request by the Engineer, the following inspections and tests shall be carried out by the Contractor. The tests shall cover all necessary transport, materials, tools, instruments required, etc., and the record of test results shall be submitted to the Engineer/Owner.

(1) Foundation work

- (a) Inspection of dimensions of excavated pits and stub setting
- (b) Screen test of sand and coarse aggregate before work commencement and periodic tests throughout work execution
- (c) Concrete mixture test before work commencement
- (d) Inspection of concrete mixers before work commencement and periodic tests throughout work execution
- (e) Concrete slump test
- (f) Inspection of arrangement of reinforcing bars in foundations before concreting
- (g) Inspection of concrete curing and hardness test of concrete
- (h) Inspection of backfilling of foundations and density test of backfilled soil
- (i) Inspection of land formation
- (j) Inspection of excavation and installation of

counterpoise before backfilling

(2) Tower erection

- (a) Inspection of size, direction, length, torque, etc., of members, bolts and fillers
- (b) Inspection of condition of paint on tower
- (c) Earthing resistance test on towers selected at random in accordance with the record submitted by the Contractor

(3) Stringing

- (a) Inspection of stringing tools, equipment and machines before work commencement and periodically
- (b) Inspection of scaffoldings, guys and staywires before and during stringing
- (c) Inspection of construction, perpendicularity, cleaning and arching horn gaps of insulator sets and/or groundwire sets before taking over the line
- (d) Inspection of surface conditions of conductors and groundwires during stringing and tensioning
- (e) Compression test on samples of tension joints and tension clamps before work commencement
- (f) Inspection of tension joints, repair sleeves and tension clamps
- (g) Inspection of sags of conductors and groundwires during tensioning and before taking-over the line at spans selected at random
- (h) Inspection of installation of accessories and jumper

clearance before issuing of provisional certificates

(4) Safety measures

- (a) Inspection of measures related to all required work

In addition to the inspections and tests specified herein or elsewhere in the Technical Specifications, the Contractor shall, upon order by the Engineer, undertake any engineering test necessary to satisfy the acceptability of all electrical work covered in this Contract.

13.2 RECORDS AND AS-BUILT DRAWINGS

Upon successful completion of electrical integrity test, the Contractor shall submit to the Engineer the following records and drawings for provisional acceptance and subsequent maintenance of the transmission line.

- (a) As-built drawings and inspection/test records as requested by the Engineer.
- (b) Other construction records particularly requested by the Engineer.

13.3 PROVISIONAL TAKING OVER

- (1) The appearance of constructed facilities and a clearance check of the cleared site shall be examined by the Engineer/Owner.
- (2) The Contractor shall carry out electrical integrity test on

the whole or part of the transmission line by using a 500 Volt or 1,000 Volt megger in the presence of the Engineer/ Owner, and shall report the test results to the Engineer/ Owner.

- (3) The lines shall be energized with the operation voltage before taking over. The arrangement for this and other tests that the Owner or the Engineer shall desire to make on the completed lines shall be assisted by the Contractor who shall provide such labor, transport and other assistance as is required without extra charge. Apparatus for such tests shall be provided by the Owner.

All records of the tests shall be detailed in an approved manner. Sample log sheets, charts, etc., shall be submitted to the Engineer for approval.

All data shall be submitted to the Engineer in triplicate copies upon satisfactory conclusion of the tests.

- (4) Upon successful tests under the clause, receipt of records and thirty days continuous operation test, the Owner will issue a Provisional Takingover Certificate to the Contractor.