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DRAFT TANZANIA STANDARD
(Draft for comments only)

Mini-Grid Systems –

Part 4: Low voltage (LV) underground distribution network

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TANZANIA BUREAU OF STANDARDS

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TANZANIA STANDARD

0 Foreword

This Draft Tanzania Standard is part of an integrated set of specifications and standards issued to govern design and construction of mini-grid power systems in Tanzania. The mini-grid standards have been developed to support improved residential, commercial and public services for rural communities of Tanzania. The mini-grid energy systems, when properly designed, will support affordable and reliable energy supply for remote households, community services, commercial and economic activities including shops, workshops, micro-industry, fresh water pumping, secondary schools, health services, public lighting, places of worship or cultural activities, agro-processing activities and other activities.

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1 Scope

This standard covers minimum technical requirements for the design and construction of underground low voltage, single phase and three-phase, power distribution networks for mini-grid systems.

Note 1– This standard shall be read in conjunction with other relevant – Tanzania Standards, applicable standards and specifications to have uniformity, compatibility and standardization in the distribution system.

Note 2– This standard ensures safety and reliability of mini-grid power system providing low-cost solutions for small customers without compromising performance requirements. Materials or approaches that are higher in quality or provide better performance than those specified shall be acceptable.

2 References

For the purpose of this Tanzania standard, the following references shall apply:

TANESCO – *Specification S01 Supply and Installation of Plant and Equipment*

TANESCO Engineering Manuals

IEC 62257-9-2 *Recommendations for renewable energy and hybrid systems for rural Electrification-Part 9-2: Integrated systems - Microgrids*

IEC 62257 (all parts) *Recommendations for renewable energy and hybrid systems for rural electrification*

IEC TS 62257-5 *Recommendations for renewable energy and hybrid systems for rural electrification – Part 5: Protection against electrical hazards*

3 Definitions

For the purpose of this Tanzania standard, the following definitions apply:

3.1 Classification of Minigrid Networks

3.1.1 Distribution networks are classified by the amount of power they are intended to deliver and by the voltages employed.

3.1.2 Mini-grids with AC delivery systems and an installed capacity of 100 kW or less would likely deliver power at EWURA standardized user voltages, that is, at 230/400V (±10%), 50 Hz and would not require medium voltages (MV). Mini-grids in this size range may also be single phase and deliver power at 230V (±10%), 50Hz.

3.1.3 Minigrids with higher installed power capability from 100kW to 1MW would require medium voltage (MV).

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3.2 Voltage Drop

3.2.1 The primary measure of quality of service during mini-grid operation is user voltage, which shall remain within the specified range (230/400V ±10%, 50Hz).

3.2.2 Determination of voltage quality shall require consideration of length of the distribution feeder, the load and the size of the conductor and comparison of the parameters with the specified range of voltage and frequency.

3.2.3 For low voltage (LV) systems, voltage performance shall be determined from specified tables.

4 Requirements

4.1 Service Conditions

4.1.1 The distribution network composed of equipment, material and components for mini-grid system shall be suitable for satisfactory operational performance under the local service conditions in Tanzania, which are as follows:

a) Altitude above mean sea level (MSL): Up to 3,000 metres
b) Maximum/record yearly high ambient temperature: +40°C
c) High humidity promoting the growth of fungi
d) Extended periods of intense sun exposure

4.1.2 For some items of equipment such as transformers, IEC standards specify an altitude not exceeding 1000m as normal service conditions. For these types of equipment, altitudes higher than 1000m are considered as abnormal service conditions and may require special considerations in the design, manufacture or application of the materials or equipment. It is the responsibility of the proponent to recognize the particular conditions occurring on any site and call them to the attention of the manufacturer.

4.1.3 Air in coastal areas is frequently salt laden and can result in significant corrosion. It is the responsibility of the proponent to specify equipment with characteristic that resist such corrosion, including provision of additional creep distance on insulators, or specification of stainless steel for cabinets and equipment enclosures.

4.2 Electrical System Parameters

System parameters of mini-grids for low voltage underground power distribution network are as follows:

a) Nominal system low voltage (U): 230/400 V (±10%)
b) Maximum permissible system low voltage (U_m): 253/440 V
c) Minimum permissible system low voltage: 215/374 V
d) System frequency: 50 Hz
e) Neutral grounding arrangement: multi- grounded
f) Power frequency withstand voltage for 5 minutes: 3kV_p

5 Underground Distribution Layout

This specifies the design and installation practices to be applied in the construction of LV cables for the underground distribution system.

5.1 The underground distribution network should be laid out in a radial fashion, with main feeders serving branches without interconnections between feeders. Sufficient reliability can be achieved with the radial system, if it is properly designed and installed and uses high quality equipment. In the event that greater reliability is desired than can be offered by a purely radial network, normally open interconnection points between feeders can be created. Such interconnections require additional feeder construction.

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5.2 All connections to the feeders and branches shall be made above ground in pedestals. It is recommended that the use of breakers within the network be minimized to avoid spurious tripping and that connections between cables be made with removable links so that open points can established for fault finding.

5.3 Service drop connections shall be made at pedestals designed for the purpose. Each service drop shall be protected by a breaker whose trip current is near the available fault current at the location. The use of low tripping point breakers is not recommended as they will respond to faults in the consumer premises and will require utility attention to reset. Their purpose is to respond to faults occurring in the service drop cable, which may result from dig-ins or other mechanical damage to the service drop cable.

6 Right of Way

If required by local authorities, the right-of-way (ROW) for the proposed route of an underground cable shall be obtained from the relevant authorities during planning and design stage of the project by developers. Guidelines for obtaining the ROW are given below:

a) ROW drawings shall be prepared showing proposed route of the underground cable, cross-section of the trench or duct bank (if required) and location of other utilities (telephone, water, sewer etc.) lines along the proposed route.

b) It is recommended that alignments be chosen carefully to avoid potential construction activity that could harm the cable.

c) The ROW drawings along with the covering letter and supporting documents shall be submitted to the relevant department in the concerned Agency for obtaining necessary permission.

d) Actual construction work shall be started once permit is granted from the relevant authorities for execution of job.

7 Low Voltage Cables

Low voltage cables intended for underground mini-grid application shall comply with the requirements of Tanzania Board of Standards, Standard 5239: “Technical Specification for Low Voltage Power Cables (600/1000) for Underground Network”.

7.1 Cable Installation

7.1.1 Low voltage cables may be installed either via direct burial or in conduit. The provisions of this standard apply to both direct buried cables and to those that are installed in conduit, except where noted.

7.1.2 If cables are installed in conduit, suitable reductions in the allowable ampacity shall be made, in accordance with manufacturer’s recommendations to allow for the reduced cooling capacity of such installation. Conduits shall be sized taking into account manufacturers recommendations considering that cables will be installed by being pulled into the conduit.

7.1.3 Regardless of how installed, cables or conduit shall be protected where the cable route crosses a road, highway or street. Such protection shall take the form of a concrete cap or tile the width of the trench and not less than 10cm in thickness installed 30cm above the cable or conduit. The purpose of this cap is to spread the weight of traffic loads so that they do not crush the cable or conduit. Such a protective cap shall be installed anytime the cable crosses any location where unusually heavy loading is anticipated, such as the entrance to an industrial facility. Conduit by itself is not a suitable protective cover for cables, and it is not acceptable that normally direct buried cable be installed in conduit under roads or other high traffic locations.

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7.2 Trench Specification

The figures in Annex A give details of the trench construction for direct buried cables. In the event it is planned to install cable in conduit, the burial depth of the conduit shall be the same as that of the direct burial cable, but the trench depth may be reduced slightly as it is not necessary to provide the sand bedding for conduit systems.

Before proceeding with the actual work, the following activities shall be completed.

a) Survey of cable routes, preparations of drawings, ROW permissions, digging permits and inspection of cable route from end to end.

b) Decision regarding locating cable drums after unloading at site keeping in view the actual cable lengths on the drums.

c) For cables installed in conduit, taking into account the maximum allowable pulling length, considering bends.

d) Knowledge about locations of cable joints. All joints should be made above ground in pedestals or equipment. No underground joints are allowed in the initial construction.

e) Obtaining necessary permissions from local police/traffic police authorities for work schedule, warning and lights and design detours.

f) Keeping necessary number of night warning lamps, stands, wooden/steel bridges for pedestrian protection.

g) Arrangement of necessary manpower and machines keeping in view the nature of work schedule and expiry date of digging permits.

7.3 Excavation

7.3.1 After the depth of the trench has been decided, excavation work shall be started. It is necessary to take in to consideration the changes being made in the existing level due to any earth cutting or back filling work to be carried out later. Such information should be gathered from the relevant authorities, so that ultimately the cable depth in the trench shall be achieved.

7.3.2 Trenches may be dug by hand or if site conditions permit, a mechanical excavator can be used. Asphalt shall be cut by a motor driven saw. Manual digging shall be used where existing underground facilities are encountered. Existing facilities uncovered during excavation shall be protected, shored, braced and supported, as deemed necessary. All protective covers, warning tapes, position markings etc., pertaining to the existing underground utilities shall be preserved during the excavation work and restored in actual position during backfilling.

7.4 Cable Placing

7.4.1 At the time the trench is ready for cable installation, the first task is to clear the bottom of the trench and remove rocks, trash, or other materials that could harm the cable or conduit.

7.4.2 Prior to placing direct buried cables, an underlayment of fine sand of the depth specified in the relevant figure of Annex A shall be placed in the bottom of the trench.

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7.4.3 For direct buried cable, cables shall preferably be installed by the layout method, in which a vehicle with a cable reel passes the length of the trench and the cable is payed out into the trench. If this is not possible due to obstructions or conflicting underground facilities, the cable may be pulled into place over the sand bedding, using appropriate means to prevent damage to the cable from contact with the sides of the trench or other obstructions.

7.4.4 For cables installed in conduit, it is not necessary to provide a sand underlayment and the conduit may be placed on the bottom of the trench.

7.4.5 Conduit used for cable installations shall be PVC-U, of the type used for water line, with a pressure rating of 16 bar. PVC pipe normally used for drain and vent line is unacceptable. Because PVC is susceptible to degradation from sun exposure, any exposed conduit such as equipment risers shall be rated for UV exposure. Conduit sections should be fully assembled and glued or sealed together to prevent ingress of water prior to installation of the cable.

7.4.6 Cables installed in conduit shall be pulled into place using suitable equipment and lubricants, and over a maximum section length in accordance with the recommendations of the cable manufacturer.

7.5 Backfillig and Reinstatement

7.5.1 After placing the direct burial cable, all stone rubble, cans, trash, etc. that have fallen into the trench during the cable laying shall be removed. A cover of clean, fine sand shall be placed over the cable. The thickness of sand bedding/cover shall be as per the relevant trench construction drawing. The sand bedding and cover shall be spread by hand tools to maintain an even thickness.

7.5.2 Following completion of the sand bedding, the trench shall be backfilled with clean fill. There shall be no rocks larger than 25mm in diameter in the fill and no trash, broken concrete or other debris. The backfill shall be tamped to approximately 90% of original density.

7.5.3 If cable has been pulled into conduit, the trench shall be back filled as in given in clauses 7.5.2. There is no need for sand bedding or cover for conduit installed cable.

7.5.4 Reinstatement of the trench shall be in accordance with the requirements of the relevant authorities under whose jurisdiction the area falls. Warning tapes shall be placed/laid in the backfill and any pavement cuts shall be restored to their prior condition.

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8 Connections

8.1 All connections between cables such as cable splices, taps to sub-feeders and taps for consumer services shall be made above ground in pedestals located and designed for the purpose**.**

8.2 All connections shall be made with terminations that are appropriate for the connection at hand. For instance, bolted studs on equipment shall be mated with terminal lugs compressed onto the cable. Cable to cable connections shall be executed with compression splices.

8.3 Cable entries into equipment or junction boxes shall be sealed with cable glands to prevent entry of vermin, dirt or water, and cables under load shall be supported independently of connections.

9 Grounding of LV System

9.1 The LV system shall be a multi-grounded system, which means that the neutral of the distribution system shall be connected to ground in a number of locations as follows:

a) At any source, such as an inverter feeding the system from a PV or other renewable resource or battery, or the low voltage side of a distribution transformer interconnecting the mini-grid with the main grid.
b) At any piece of equipment on the AC side of the system, such as an inverter or a distribution pedestal.
c) At any interconnection point between feeders or at any feeder tap.
d) At the point that a customer service drop is tapped off the feeder line.

9.2 The metal work of all LV network equipment such as LV distribution pillar housings, and the metal parts of any racks or support frames shall be bonded to the system neutral conductor and to any ground rod or grounding counterpoise using a suitable bonding conductor. The bonding conductor shall be sized to carry the anticipated fault current but in no case, shall be of smaller cross section than $10mm^2$ copper-equivalent. The actual material of the bonding conductor may be copper or such other material as may be appropriate considering corrosion and risk of theft.

9.3 The ground connections at the equipment locations mentioned in clause shall be executed using two driven ground rods, each 16mm in diameter and 2,400mm long. The rods shall be separated by at least 4meters and shall be individually interconnected to each other and to the ground bus of the equipment being grounded by a conductor of suitable cross section, but not less than $10mm^2$ copper-equivalent. The ground rods shall be either hot dip galvanized or copper coated, depending upon the corrosivity of the soil, and the interconnecting wire may be annealed galvanized steel ground wire or copper. Connections shall take into account the potential for corrosion between dissimilar metals, if any are used in the system.

9.4 In rocky ground where it is difficult to install ground rods, a counterpoise may be used consisting of a loop of ground wire of length not less than 12 meters installed at a depth of 300mm in a trench around the equipment or pedestal such that the ground wire is located everywhere at least 1m distant from the equipment.

9.5 It is recommended that the resistance to ground of the system neutral, as measured at any point using industry standard methods and with all grounds attached, not exceed 1 ohm. It is further recommended that the resistance to ground of any individual piece of equipment, such as a distribution pedestal, not exceed 10 ohms. In the event these values are exceeded, the system operator can install additional ground rods in parallel with the existing rods. No rod should be closer to any other than its own length (2.4m) to prevent undesirable interactions.

10 Installation of LV Distribution Pillars

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The following points are required to be considered at site during the installation of the distribution pillars:

a) The minimum clearance between the distribution pillar and any other utility service such as telephone and water boxes shall not be less than 2m.

b) The distribution pillar shall be easily accessible from the front of consumer's boundary without any obstruction.

c) Bottom part of the distribution pillar shall be direct buried to the ground and back filled, after fixing the bottom legs with unarmored fine cement mortar.

d) In case of bulk consumers, it can be allowed to terminate more than one cable feeding the same consumer.

e) The distribution pillar shall not be located on the top of sewerage system.

f) The fixation of the distribution pillar into the frame shall be in such a way that the used tools and fasteners will not damage the body of the cabinet.

g) All cable loops between the cabinets shall pass through the cable trench.

h) The area assigned for installing the distribution pillar shall be finished clean regardless the finishing of the surrounding area.

11 Customer Service Drops

11.1 Customer service drops shall be derived from feeders or branches in a distribution pedestal and shall consist of underground cable to the consumer's residence. The service drop shall be metered, but this metering function may be met in a number of ways that may or may not involve the installation of equipment in either the pedestal or the consumer's premises. In either case, the pedestal should be secured against unauthorized access.

11.2 The service drop cable shall be protected by a breaker of suitable rating installed in the distribution pedestal. The purpose of the breaker is to protect the system against faults in the service drop, so that the rating of the breaker should be only slightly less than the available fault current at the location to prevent nuisance tripping resulting from faults in the consumer's premises.

11.3 The cable of the consumer service drop shall be of a cross section consistent with the anticipated consumer demand but shall in no case be less than 2.5mm^2.

11.4 The service drop conductor/cable shall be rated for underground, direct buried installation in wet locations but need not comply with the Tanzania Standard TZS 5239.

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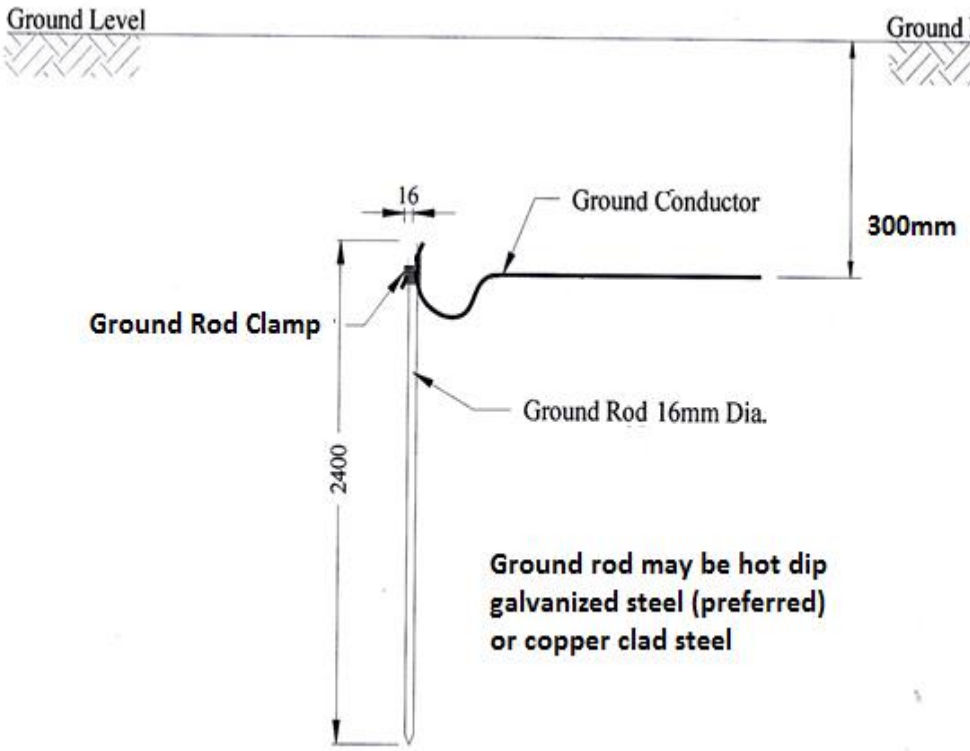
12 Annex A

Figures

Fig 1: Standard arrangement for ground rod installation



All dimensions in mm

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Fig 2: LV Trench Configuration (Single Cable)

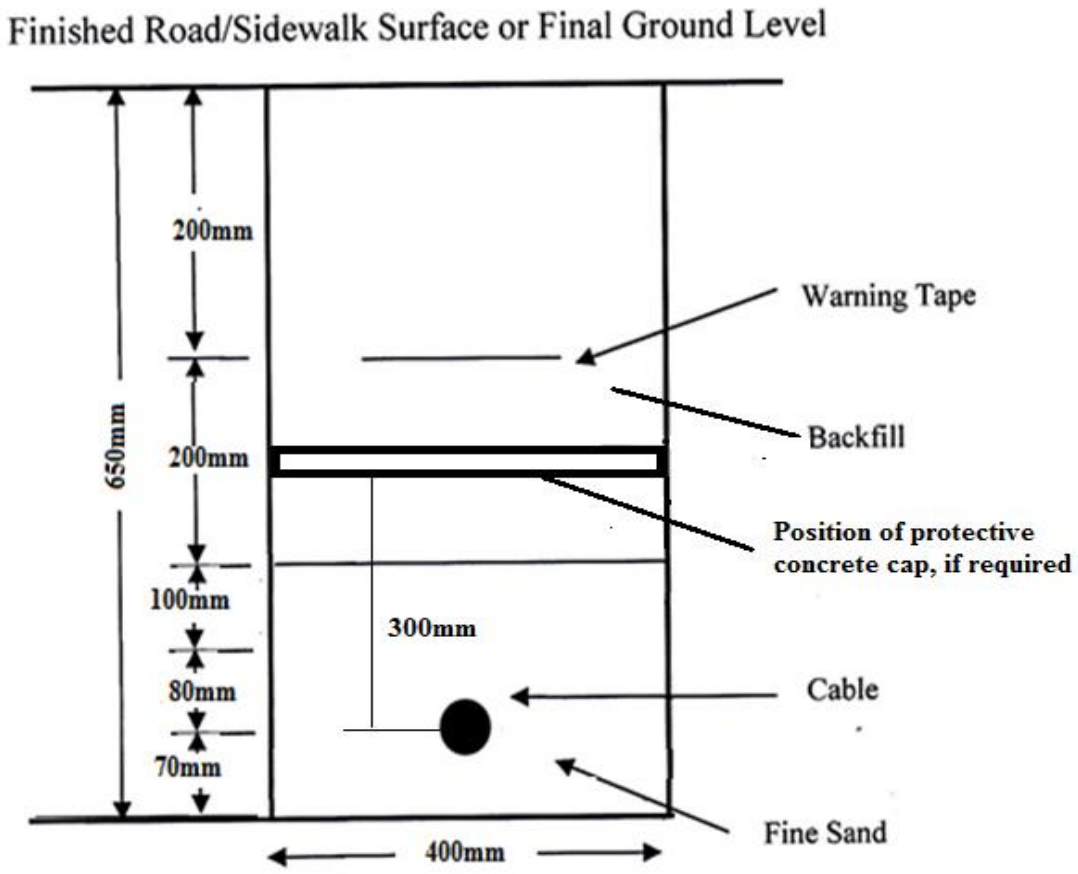

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Fig 3: LV Trench Cable Configuration (Two LV cables)

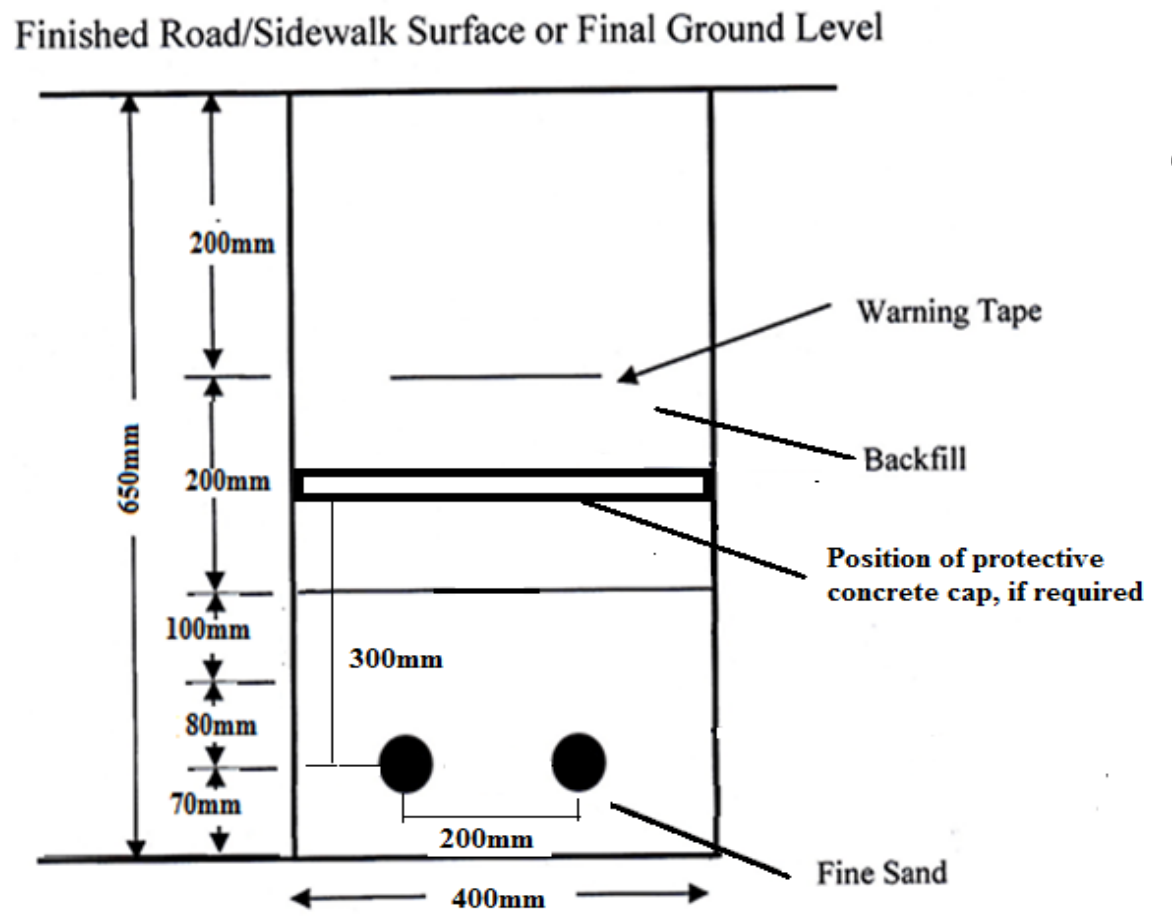

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Fig 4: LV Trench Configuration (Three LV Cables side by side)

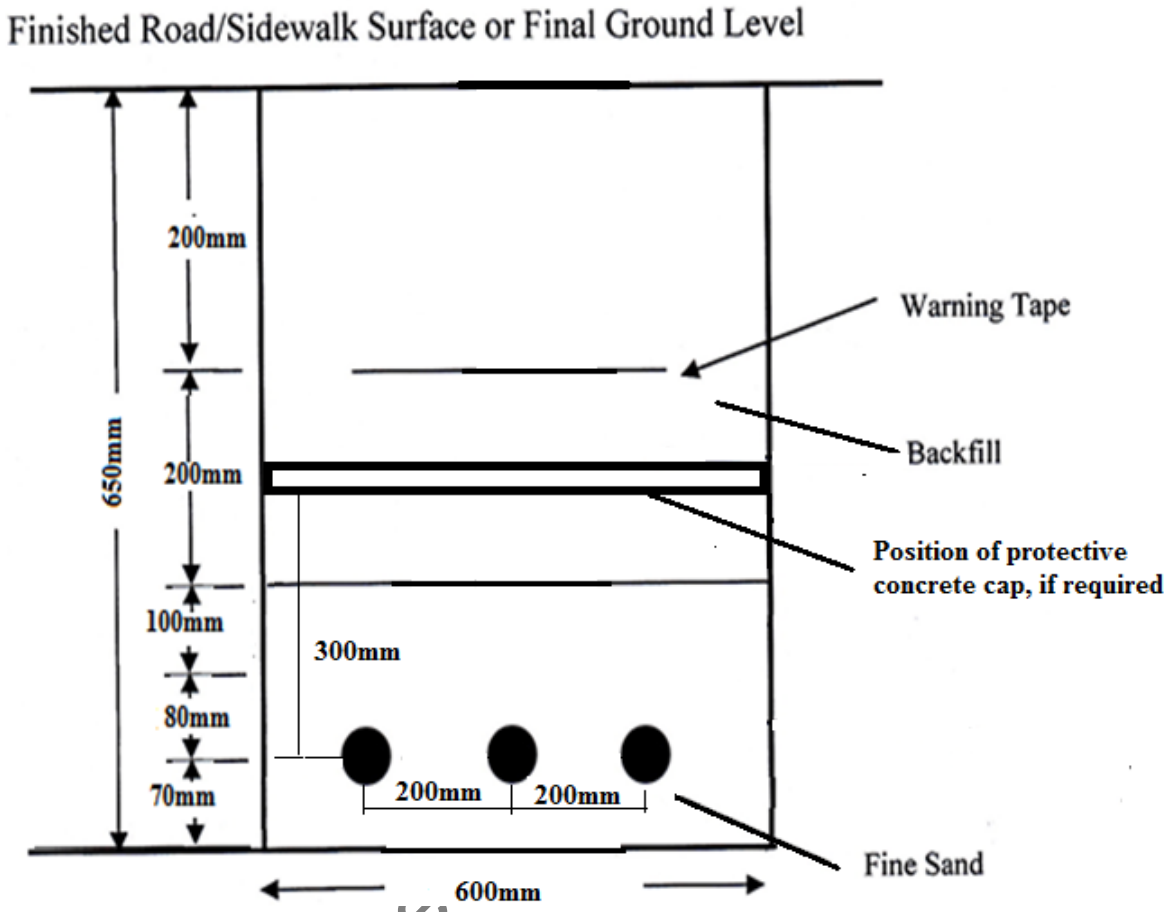

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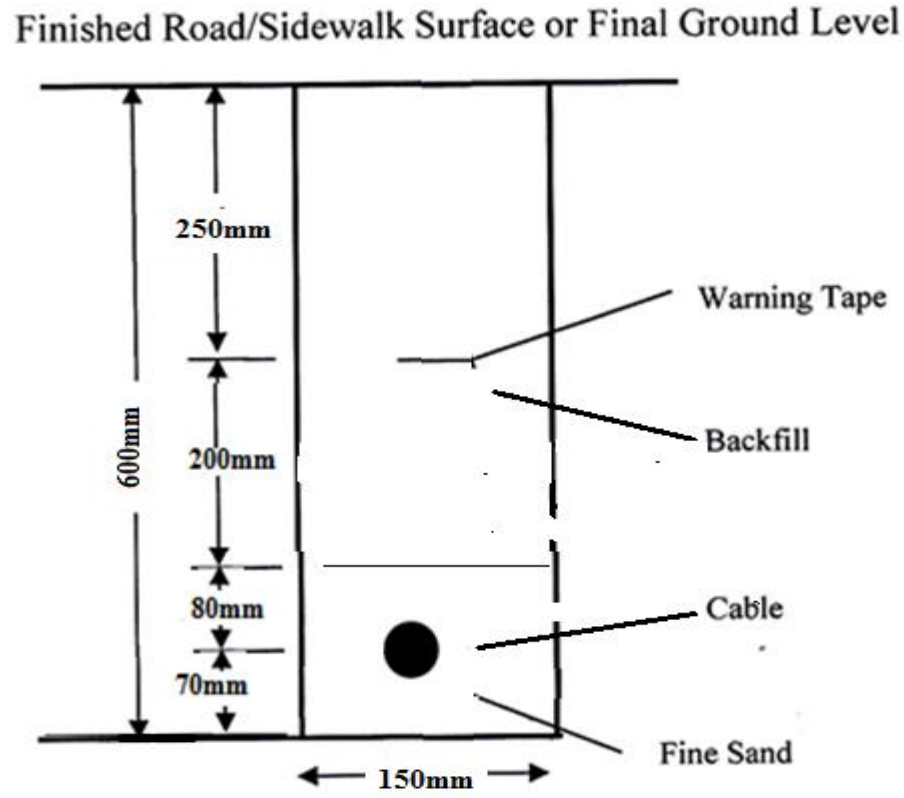
Fig 5: Service Drop Trench Configuration



All dimensions in mm

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Fig 6: Bonding and Grounding arrangement - LV Dist. Pillar

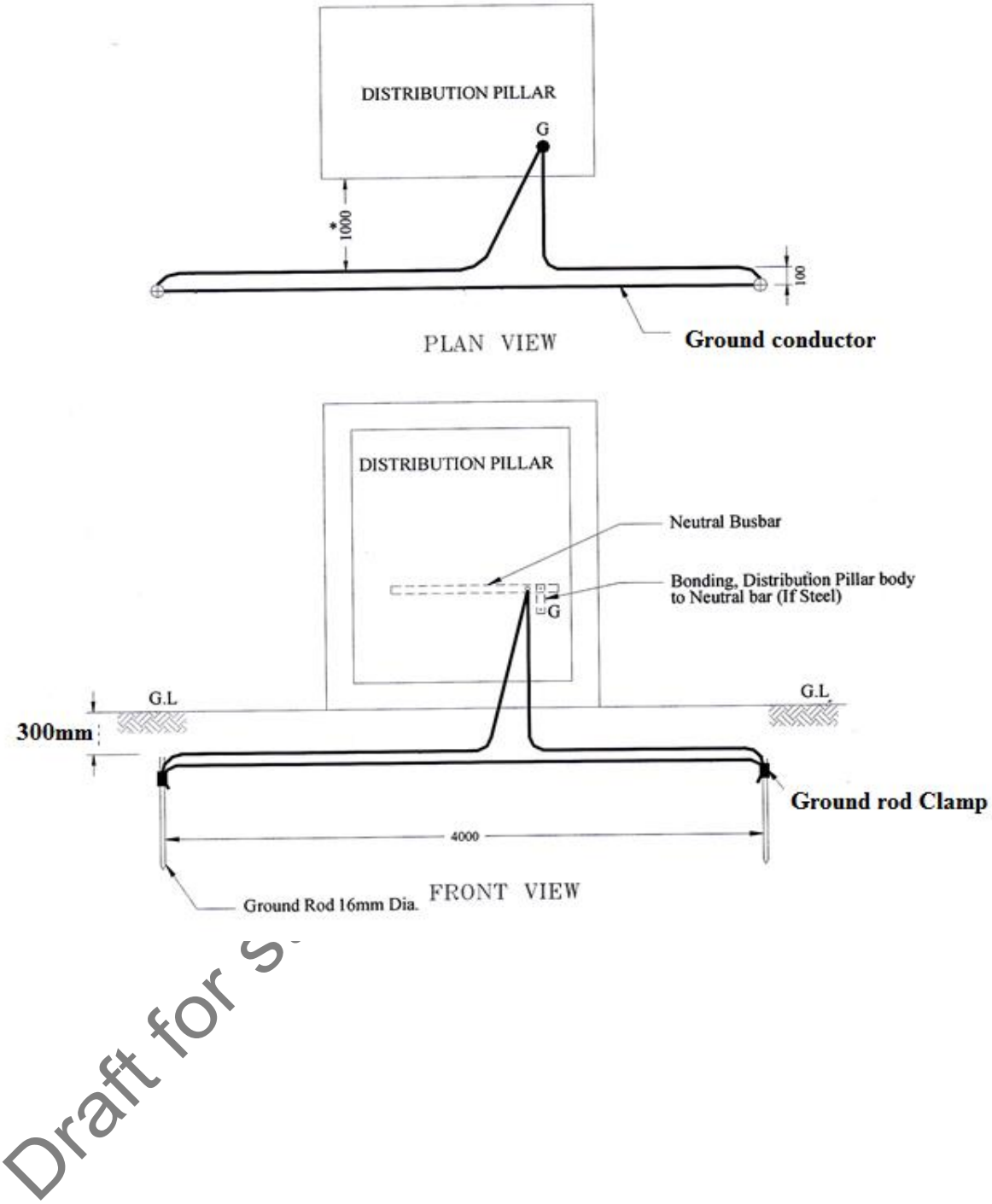

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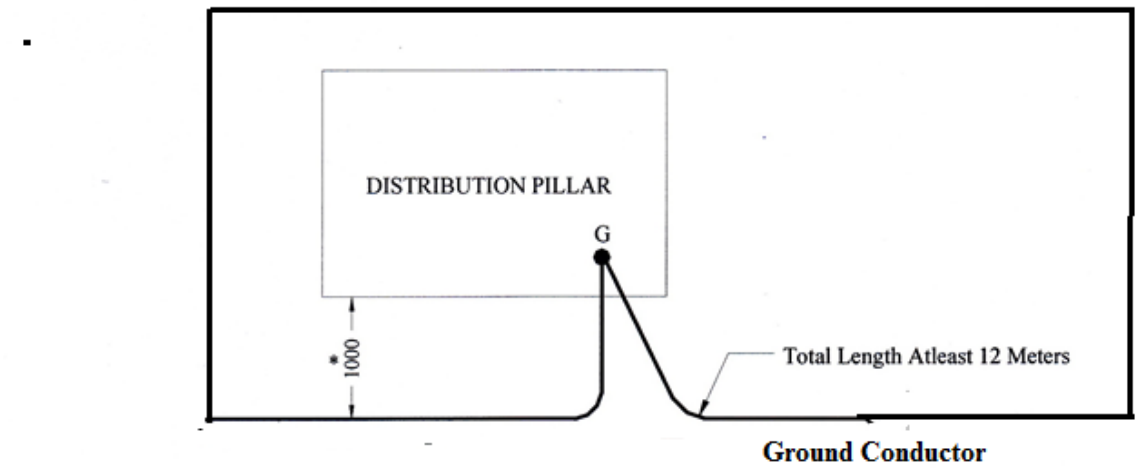
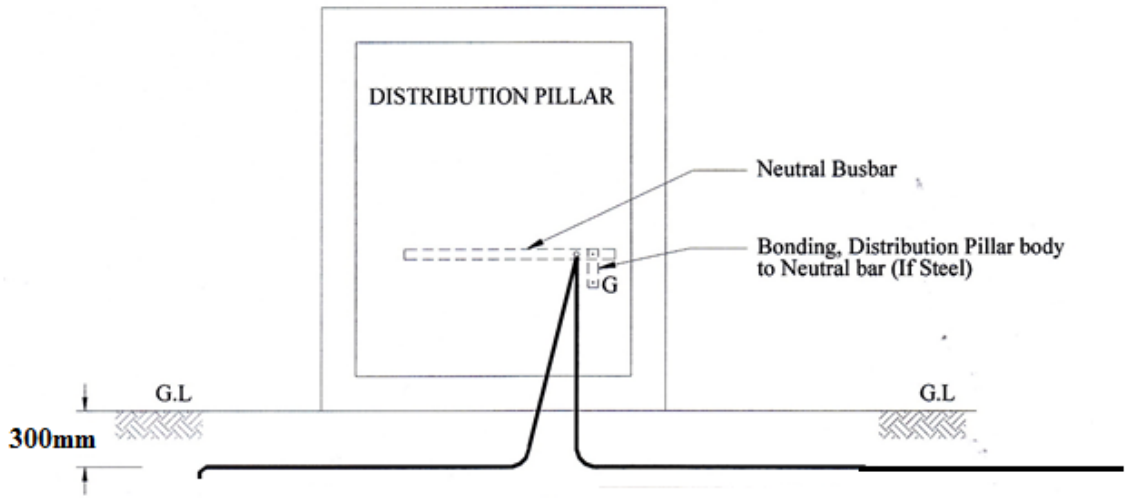
Fig 7: Bonding and Grounding Arrangement of Dist. Pillar in Rocky Soil



PLAN VIEW



FRONT VIEW