Eskom	Terms of Reference	Technology

Title: **GEOTECHNICAL/ DOLOMITIC STABILITY INVESTIGATIONS SCOPE & SPECIFICATION**

Unique Identifier:	**Geotechnical Specification**
Alternative Reference Number:	**N/A**
Area of Applicability:	**Engineering**
Documentation Type:	**Terms of Reference**
Revision:	**1.0**
Total Pages:	**21**
Next Review Date:	**N/A**

Disclosure Classification: **Controlled Disclosure**

Compiled by	Approved by	Authorized by
Phenyo Mvuyana	**Andile Maneli**	**Subhas Maharaj**
Substation Engineering	**Substation Engineering**	**Substation Engineering**
Civil Engineer	**Middle Manager: Civil**	**Senior Manager: Substation**
Date: 02/11/21	Date: 02 - 11 - 2021	Date: 2/11/2021

PCM Reference: **N/A**

Scot Study Committee Number/Name: **N/A**

Content

1. Introduction

Eskom Transmission plans to put together a panel of geotechnical consultants, who will undertake geotechnical / dolomitic analysis investigation or for new 132 to 765Kv substation developments (GIS and AIS) as well as extensions on existing substations and specialised investigations on our high voltage (HV) lines.

The consultants will have to carry out preliminary geotechnical / dolomitic analysis investigations to determine the most suitable site to construct on. They will also be required to carry out detailed geotechnical in order to provide design parameters for the design of the earthworks and foundations as well as identifying of geotechnical problems and mitigation thereof at the proposed substation.

2. Supporting Clauses

2.1 Scope

This document covers the scope of work, method of investigation and deliverables of the geotechnical investigations undertaken for substation developments. The content is not all exhaustive and may change from time to time.

2.1.1 Purpose

The purpose of the document is to make available the terms of reference for undertaking geotechnical investigations for Transmission geotechnical/dolomitic analysis investigations.

2.1.2 Applicability

This document shall apply to Substation Engineering Department within Transmission Engineering in Eskom.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] ISO 9001 Quality Management Systems.

[2] SAICE Code of practice for the safety of persons working in small diameter Shafts and test pits for Civil Engineering Purposes (2007).

[3] TMH1:1979. Standard methods of testing road construction materials. National Institute for Transport & Road Research C.S.I.R. Pretoria.

[4] SANS 3001. Civil Engineering test methods

[5] Jennings J.E., Brink A.B.A. and Williams A.A.B. (1973). Revised Guide to Soil Profiling for Civil Engineering Purposes in South Africa. The Civil Engineer in South Africa, January1973.

[6] Guidelines for Soil and Rock Logging in South Africa, 2nd Impression 2001, eds. A.B.A. Brink and R.M.H. Bruin, Proceedings, Geoterminology Workshop organised by AEG, SAICE and SAIEG, 1990.

[7] Site Investigation Code of Practice, 1st Edition, South African Institution of Civil Engineering - Geotechnical Division, January, 2010.

[8] 240-96393507: Soil Resistivity testing for Substation application

[9] 240-84699047: Geotechnical investigations scope and specification template

2.2.2 Informative

[10] SANS 10160: Basis of structural design and actions for buildings; Part 5: Basis for geotechnical design and actions.

2.3 Definitions

2.3.1 General

Definition	Description
Stratigraphy	The layering of deposits, with newer remains overlaying older ones, forming a chronology of the site
Excavatability	Tractor-Loader-Backhoe
Seismic	Related to, or caused by an earthquake or other vibration of the earth
Lithology	The general composition of a rock or rock sequence
Liquefaction	Process of or state of having been made liquid
Factual report	A document that is concerned with facts or contains facts
Interpretive report	Documents which contains interpretation of analysis of results including factual and desktop reporting, ultimately reaching objective recommendations based on the interpretation of results and background information of the geotechnical field.
Consultant	A person or party who is consulted to carry out the geotechnical investigation.

2.3.2 Disclosure Classification

Controlled disclosure: controlled disclosure to external parties (Both Discretionary and enforced by law).

2.4 Abbreviations

Abbreviation	Description
TLB	Tractor-Loader-Backhoe
CBR	California Bearing Ratio
TMH	Technical Methods for Highways

Abbreviation	Description
SAICE	South African Institution of Civil Engineering
SAIEG	South African Institute for Engineering and Environmental Geologists
SANS	South African National Standards
SHE	Safety, Health & Environment
MTS	Major transmission substation
EA	Engineer Assistant
HV	High Voltage

2.5 Roles and Responsibilities

The appointed Technician/Technologist/Engineer/Geologist shall ensure that this document is compiled with the standards noted in this document or any other approved appropriate form of literature and shall also ensure that the document is issued with all required associated documentation.

2.6 Process for Monitoring

Not applicable.

2.7 Related/supporting Documents

A typical Bill of Quantities

Typical transformer plinth layout

Typical transformer outline

Typical medium foundation layout

Typical large foundation layout

3. Scope and Specification Information

3.1 Project Overview

3.1.1 Proposed Developments

Eskom Transmission plans to put together a panel of geotechnical consultants, who will undertake geotechnical / dolomitic analysis investigation for new 132 to 765Kv substation developments (GIS and AIS) as well as extensions on existing substations.

The consultants will have to carry out preliminary geotechnical / dolomitic analysis investigation to determine the most suitable site to construct on. They will also be required to carry out detailed geotechnical in order to provide design parameters for the design of the earthworks and foundations as well as identifying of geotechnical problems and mitigation thereof at the proposed substation.

The proposed developments would include the installation of the following typical equipment:

- Power Transformers
- Shunt reactors
- HV switchgear
- Instrument transformers
- Surge arrestors
- Control and ancillary buildings
- Platforms
- Steel structures and foundations
- Access roads
- GIS building

The following civil engineering structures will be constructed as part of the project:

- Soil pavement
- Steel structures and foundations
- Access roads
- Fences

Typical bearing pressures in excess of between 200 - 300kPa can be expected at foundation level. Typical foundations layouts have been included as part of this report.

The investigation should provide geotechnical parameters on which the foundation and ancillary structure designs may be based. Soil parameters of the in-situ materials, which allow for the computation (as well as the actual computation) of the following mechanical properties shall be provided as part of the report:

- Shear strength
- Lateral earth pressure
- Consolidation
- Bearing capacity
- Slope stability
- Flood analysis

3.2 Site Description

3.2.1 Location

The proposed developments will be located throughout South Africa.

3.3 Information Available

The following drawings are available and are attached to this document:

- Bill of quantities and estimated quantities (Appendix A)
- Typical transformer plinth and transformer outline (Appendix B)
- Typical medium foundation layout and typical large foundation layout (Appendix C)
- Test pit plan layout and long sections (Appendix D)
- 240-96393507: Soil Resistivity testing for Substation application (See Appendix E).

The above information, where applicable, is also available in electronic format.

3.4 Professional services required

Substation engineering department may require the service of a geotechnical Advisor, who has more than 5 years' experience after professional registration as a geotechnical engineer or engineering geologist (based on SANS competence levels for geo-professionals). **The advisor will be required to guide a candidate geotechnical engineer in compiling a geotechnical investigation report for the** proposed development. The advisor will be responsible for ensuring that:

- The document is wholly compiled by the candidate, with the exception of the resistivity studies scope
- The advisor guides the candidate through the compiling of a safety file to be approved by an ESKOM SHE Manager. The candidate has to ensure approval of the file under the guidance of the Advisor
- The advisor plans for the site investigation and ensures all necessary services are procured for the site investigation, including the resistivity studies.
- The advisor allows the candidate to profile the test pits and boreholes under complete supervision of the advisor. The advisor is to review and approve all test pit and/borehole profiles
- The advisor provides all the necessary tools, equipment, and relevant literature for the candidate to be able to make the correct analysis on all project specific available data.
- Guides the candidate to full understanding on sections the candidate has no prior experience or knowledge, taking into consideration the time constraints of the task order.
- The advisor reviews, comments and provides guidance to the candidate for the correct analysis of all the sections of the report.
- The advisor has in their employ all the necessary human resources, i.e. pavement/earthworks designer, transport (road design) engineer, structural engineer to assist the candidate in all the relevant sections of the report.
- The advisor signs off the geotechnical report as the approver of all the content in the document.

3.5 Scope of Work

3.5.1 Purpose

The primary objective of a preliminary investigation is to assess the soil and rock profile across the sites for site selection purposes.

The following specific items should be dealt with in the investigation:

- Site geology and stratigraphy.
- Soil and rock classification.
- Identification of geotechnical problems.
- Earthworks and terrace construction recommendations
- Excavatability of material on site as per SANS1200 specifications
- establish the sources available to obtain the G6/G7 material for fill
- Comment on cost estimates for each site
- Structural design requirements of the fill
- Recommended foundation solutions
- Seismic assessment and classification of the site needs to be part of the report

The primary objective of a detailed investigation is to assess the soil and rock profiles across the site so as to provide foundation recommendations, foundation and pavement design parameters as well as earthworks/pavement designs.

The following specific items will be dealt with in the investigation:

- Site geology and stratigraphy.
- Soil and rock classification.
- Identification of geotechnical problems.
- Bearing capacityof in-situ soils and import material to be used
- Settlement of in-situ soils
- Heave of in-situ soils
- Earthworks and terrace construction recommendations
- Excavatability of material on site as per SANS1200 specifications
- Establish the sources available to obtain the G6/G7 material for fill
- Comment on cost estimates for construction of final design
- Structural design requirements of the fill
- Recommended foundation solutions
- Corrosivity and aggressiveness of the soils as well as corrosion protection of buried structures
- Ground resistivity
- Seismic assessment and classification of the site

The investigation should present practical recommendations for site preparation (earthworks and terracing) and for the design and construction of foundations, substation platforms and access road.

The actual design of foundations, roads, and other geotechnical structures are not part of the scope of work of this investigation.

3.5.2 Investigation Methodology

3.5.2.1 Desk Study

Review of existing regional, site and surface information. Sources of information should include:

- Topographical maps, geological maps, aerial photo interpretation - to be able to identify topographical, drainage channels and erosion features of the site.
- Geological data, such as lithology of nearby rock outcrops landforms, erosion patterns that surrounds the proposed site.
- Existing geotechnical information available of the area in the surrounds of the site.
- Data on the performance of existing engineered structures in the area.
- Data on the bodies of groundwater levels in the surrounds of the proposed site.
- Data on seismic aspects, such as ground motion, liquefaction potential.

3.5.2.2 Scanning for underground services

Underground scanning shall be undertaken to ensure that no underground services traverse the site prior to undertaking the investigation.

3.5.2.3 SOIL RESISTIVITY TESTS

Soil resistivity tests are to be carried out as per the 240-96393507: Soil Resistivity testing for Substation applications (See Appendix E).

3.5.2.4 Excavation of Test Pits

In order to profile the sub-soil stratigraphy and to obtain disturbed samples, undisturbed samples and bulk samples for laboratory testing, test pits (max depth 5m) should be excavated across the site using an excavator or TLB (where shallow bedrock is anticipated). The test pits should be excavated in a minimum grid of 50m x 50m /as shown in a test pit layout/with increased density as required during field work.

All test pits should be profiled by a registered Geotechnical Engineer or a registered Engineering Geologist in accordance with the latest standard of South African practice (after Jennings et. al.1973).The positions all test pits should be coordinated with a valid calibrated hand-held GPS and in accordance with the WGS84 coordinate system.

All excavation test pits should be carried out in accordance to SAICE – “Code of Practice 2007: The Safety of Persons Working in Small Diameter Shafts

3.5.2.5 DPSH Testing

DPSH testing should be carried out between the trial holes or next to the hole where there is no certainty of depth of bedrock and the material 3m below NGL or where the soils are predominantly of a loose-medium dense or soft-firm consistency.

3.5.2.6 DRILLING OF BOREHOLES

Rotary cored boreholes (max depth 25m or 3m into the bedrock) with SPT “N” tests, undisturbed Shelby Samples to determine collapse potential/expansiveness and/or heave of the material must be undertaken.

The drilling contractor should allow for a concrete plug to fill up the boreholes after drilling.

3.5.2.7 Laboratory Testing

Undisturbed, samples, Disturbed samples and bulk samples will be taken for laboratory testing and tests carried out as per SANS 3001 method. The following tests should be conducted on representative samples from site:

- Classification tests: grading & indicator (Atterberg Limits and Hydrometer).
- Compaction tests (Bulk density, MDD and OMC)
- Mod AASHTO moisture/density relationship and CBR Tests.
- Laboratory Conductivity tests (ms/cm) as per TMH-1.
- Chemical analysis of soil water extracts assessing corrosiveness (Basson index) as per TMH-1.
- Dynamic probe super heavy tests
- Swelling pressure tests
- Free swell test
- Specific gravity tests
- Heave test
- UCS tests on rocks (if necessary)
- Consolidated undrained triaxial tests on fully saturated samples and samples at natural moisture content. The test should be carried out on both undisturbed and remoulded samples (where necessary)
- Specialized testing should be conducted, such as slaking properties of rock where necessary
- Collapse potential tests (where necessary)
- Potential alkali reactivity of aggregates in areas where geology may give rise to the ASR attack on concrete
- ACV on yard stone aggregates
- 10% FACT on yard stone aggregates
- Durability Mill Index on yard stone aggregates
- Glycol test on yard stone aggregates
- XRD analysis on yard stone aggregates

Loose to medium dense soils below founding depth should be stabilized with 1-3% cement. Prior to stabilising the materials, test should be done to determine if the soil contain sulfate and the concentration/quantity of the sulfate in the soil. The following test should be carried out on the specimens after stabilisation:

- ICL test as per SANS 3001
- Compaction tests (MDD and OMC)
- Mod AASHTO moisture/density relationship and CBR Tests (soaked and unsoaked).
- Unconfined compression strength test
- Indirect tensile strength test
- Atterberg limits
- Laboratory Conductivity tests (ms/cm) as per TMH-1.
- 1D oedometer heave test
- Consolidated undrained triaxial tests

***All materials encountered on site should be tested.**

It is the responsibility of the Consultant to evaluate the attached schedule of "Required Laboratory. Testing and Quantities", and motivate any tests or quantities required by him, in addition to this schedule.

3.5.2.8 Source of Construction Material and yard stone aggregates

In addition the consultant needs to comment on the sources available to source G6/G7 material. They should comment on whether according to the geotechnical investigation there is sufficient material for earthworks/pavement construction, if not what are the available suppliers in the area of G6/G7 material. The name of the supplier, the distance from the site as well as the contact details of the supplier should be included in the report.

The consultant also needs to identify a minimum of three (3) quarries which have yard stone material that conforms to 240-108982466: Standard for HV Yard Stones in ESKOM Substation. They should comment on whether the quarry can provide enough volumes to cover the substation yards (100mm x area of substation yards). Samples should be taken from each quarry and subjected to ACV, 10% FACT, glycol test, Durability Mill Index and the XRD test.

3.6 Dolomitic stability investigations

On sites that are underlain by dolomitic geology, the following additional work will have to be undertaken:

3.6.1.1 Gravity survey

A gravity survey should be undertaken and a gravity map produced to determine borehole positions. The survey shall be carried out as detailed in SANS 1936:2. The gravimetric survey should cover an area 100m wider than the footprint of the development to allow for detection of geo-features at the edge of the property.

3.6.1.2 Percussion Drilling

Minimum of four boreholes per hectare (or as directed by ESKOM scope and spec) percussion boreholes should be drilled to:

- A depth of 60m.
- Where shallow bedrock is encountered, the borehole should be drilled a minimum of 6m into the rock.

On gravity high anomalies, the borehole should be drilled into bedrock to determine depth of the shallowest bedrock

- Where area has been de-watered, a sample of boreholes shall be drilled a minimum depth of a 100m or 6m where bedrock depth is shallow
- Where competent non-dolomitic bedrock overlies the dolomite, the borehole shall be drilled such that
- If depth of rock is more than 15m, then it should be drilled a minimum of 15m into the rock
- If depth more than 15m, then I should be drilled a minimum of 6m into the dolomite bedrock.

The drilling contractor should allow for a concrete plug to fill up the boreholes after drilling.

3.6.1.3 Geohydrological data

Gathering of geo-hydrological data shall be undertaken for the proposed development and shall be reported as per SANS:1936:2 section 4.2.5.

3.7 Deliverables

3.7.1 Factual Report

A factual report should be compiled within two weeks upon completion of the field work. The report should contain:

- A revision section, which shows all the revisions done to the documents and reasons why the document was revised
- Names of all authors
- Professional registration body of all authors listed
- Professional registration number of all authors listed
- Signatures of all authors listed,
- and dates on which they signed the document

The above sections should also be included in the interpretive reports.

The factual report should be structured in the following manner:

a. Physical Site Data

Physical site data based on information required in the desktop study such as location, current land use (incl. known services), accessibility, trafficability, regional geology and local geology, topography, drainage aspects and vegetation, climate conditions and seismic zoning.

b. Field Work

Details of field work carried out on site with Coordinates of all test pits (clear pictures of each test pit), boreholes and other in-situ tests done, number of tests done, date of execution, laboratory testing procedures followed, type of equipment used during execution, any limitations and relevant observations noted during the site investigation.

c. Site Map Layout Drawing With Cross-Sections

Coordinated site maps indicating test pits and other in-situ testing of the subsurface conditions shall be prepared together with representative cross sections and longitudinal sections showing positioning all test pits and variation in geology down the profile at each position.

d. Geological Plan Layout

A coordinated plan showing geological contacts, faults etc. for each site.

e. Excavation Test Pits

Complete test pits profiles showing all samples taken and in-situ tests done. All test pits should be accompanied with clear colour pictures of the test pits.

Test pits should be excavated to the maximum reach or refusal of the excavator. The in-situ test profiles should be recorded as per the latest standard of South African practice (after Jennings et. al.1973).

3.7.2 Interpretive Report

Three full interpretive reports shall be compiled within three weeks after receiving of laboratory results and delivered in the following manner:

- 3 x Hard copies of a full interpretive report together with all the associated drawings, laboratory tests and all other in-situ tests done (report should also include **ALL** information and drawings contained in the factual report)
- 2 x CD's (soft copies) of the report in a pdf format and drawings in dwf, dwg and pdf format.

On sites underlain by dolomitic bedrock the the investigation and compiling of the report shall be in accordance to SANS 1936 and SANS 633. The report should include a dolomite risk management plan (consultant to work together with geo-professional from ESKOM), dolomite risk management strategy and a CGS (Council of Geoscience) review

In addition to the information contained in the factual report, the following information should be in the interpretive report:

3.7.2.1 Laboratory Tests

Discussion and evaluation of all laboratory tests results together with all in-situ tests done. Copies of the results as received from the laboratory shall accompany the report. Calculation sheets of analysis done should be included in the report.

3.7.2.2 Design of Platforms with Typical Design Sections

The substation terrace will consist of the following main civil structures:

- Access roads (outside and within station both category D)
- Column foundations (loading up to 150kPa, incl. self-weight of foundation)
- Medium sized foundation (maximum loading up to 100kPa, incl. self-weight of foundation)
- Transformer plinth drawing and transformer outline drawing (max load is usually 150 kPa. Drawings have been provided to enable the author to make accurate calculations of the load exerted by the transformer and the plinth), and a
- Control and GIS building (bearing loads will be between 200-300kPa).

The substation will carry, in high density both the column foundations as well as the medium sized foundation, to depths as shown in drawing provided.

Specific earthworks recommendations should be made for the access road, transformer, control and GIS buildings.

Design of the platform with reference to the suitability of materials from cut for the construction of the fill – design options should be evaluated with respect to typical construction of the fill, incorporating rock fill if required, with cost estimates.

The following specific items will also be dealt with in the report:

- Site geology and stratigraphy.
- Soil and rock classification.
- Identification of geotechnical problems.
- Earthworks and terrace construction recommendations

- Excavatability of material on site as per SANS1200 specifications
- Establish the sources available to obtain the G6/G7 material for fill
- Comment on cost estimates for the site
- Structural design requirements of the fill
- Recommended alternative foundation solutions (where necessary, should ESKOM designed foundations be deemed not fit for intended purpose)
- Foundation design parameters with allowable bearing capacities and
- expected settlement and prediction of heave
- Slope stability of cut and fill faces
- Corrosion protection recommendations for foundations and buried services
- Ground resistivity
- Seismic assessment and classification of the site needs to be part of the report
- Shear strength parameters of the in situ soils
- Bearing capacity of profiled layers on site

3.7.2.3 Construction Cost Evaluation

The consultant is required to prepare cost estimates for construction of the terrace final designs, scheduled in table format, indicating activities, quantities, rates and totals.

For the preliminary investigation, the Consultant is required to prepare a comparative cost estimate of the three sites for construction of the final design, scheduled in table format, indicating activities, quantities, rates and totals.

For detailed geotechnical/dolomitic analysis investigation the table should contain two cost comparison tables for a design which includes importing of competent materials to replace poor in situ materials (if necessary) and another table for stabilising of the in-situ materials (if necessary), scheduled in table format, indicating activities, quantities, rates and totals.

3.8 Health, Safety and Environment

All work shall be carried out in accordance with the requirements of the Occupational Health and Safety Act (Act 85 of 1993) and the regulations accompanying this act will be adhered to where applicable and comply with Eskom's SHE specification. All employees shall be provided with adequate training for the tasks that they are required to perform including an awareness of the risks involved in the execution of their duties and the methods available for the mitigation of these risks. Safety induction and security clearance will have to be done prior to establishment of site (min 2 hours). A safety file shall be prepared for the project and medicals might have to be carried out and therefore costs thereof should be included in the quote.

3.9 Site Accessibility

The following is excluded from the consultants' responsibility:

- Arranging access (ESKOM responsibility)
- Excavation permits (where necessary, ESKOM responsibility)
- Detection of buried services
- Breaking out & reinstatement of surface beds
- Compaction of backfill in test holes.

3.10 Terms and Conditions

3.10.1 Formal Agreement

Professional fees will be determined from the actual number of hours spent on the job, charged at current hourly rates. Internal disbursements will be charged at cost. The technical proposal should be submitted with the attached BOM. It should be filled in with all the necessary rates.

The below table should be used to guide the consultant in calculating the professional fees (excluding expenses that will be incurred and cost of compiling health and safety file).

Applicable Fee Bracket	Value of Works	Lower limit	Upper limit	Current Project Cost (A)	Supplier Rate (%)	Eskom Rate (%)	Negotiated Rate (%) (B)
1	(R 0 – R 150, 000.00)	(40%)	(35%)	R…. Eskom to complete			
2	(R 151, 000.00 – R 450, 000.00)	(35%)	(25%)	R…. Eskom to complete			
3	(R 451, 000.00– R 750, 000.00)	(25%)	(15%)	R…. Eskom to complete			

Example: Fee Calculations – From tables above.

Value of Works: R 600,000.00 (A)
Supplier Rate: 25%. (B)
Primary Fee: = R150 000.00 (A*B)

3.11 Programme

The project should be completed within 7-9 weeks of appointment

Activity	Duration in weeks
Mobilization and sub-contracts	1
Field geotechnical investigation	1
Factual report	1
Laboratory testing	3
Final report	4
Total	± 9

**** Factual Report and Laboratory testing could run concurrently.***

Due diligence should be exercised to ensure that the final interpretive report is delivered within the timelines proposed above.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Subhas Maharaj	Senior Manager: Substation Engineering
Andile Maneli	Middle Manager: Substation Engineering

5. Revisions

Date	Rev.	Compiler	Remarks

6. Development team

The following people were involved in the development of this document:

- Phenyo Mvuyana

7. Acknowledgements

None

APPENDIX A: BILL OF QUANTITIES

APPENDIX B: TYPICAL TRFR PLINTH AND TYPICAL TRFR OUTLINE

APPENDIX C: TYPICAL MEDIUM AND LARGE FOUNDATION LAYOUT

APPENDIX D: TEST PIT PLAN LAYOUT AND LONG SECTIONS

APPENDIX E: SOIL RESISTIVITY TESTING FOR SUBSTATION APPLICATION