FOUNDATION DESIGN 811
A practical perspective

14: Applicable Codes & Standards

SAICE Geotechnical Division
Site Investigation Short Course
Codes and Standards
Outline

• Purpose of Codes & Standards
• Applicable Codes, Standards and Legal Requirements
• Status of Codes & Standards
• Requirements of Various Codes & Acts
• Other documents with “code-like” status.

Purpose of Codes

1st African YGE Conference, Swakopmund
Purpose of Codes

• Lay down minimum requirements
• Ensure compatibility of products / outputs

Courtesy Bernd Schuppener
Purpose of Codes

- Lay down minimum requirements
- Ensure compatibility of products / output
- Provide a uniform basis for pricing
- Protection of the public / consumer
- Statement of acceptable practice

Applicable Codes & Standards
Applicable Codes & Standards

- Safety standards & legal requirements
- Building standards
- Design standards
- Site investigation standards

SAFETY STANDARDS / LEGISLATION:

- OHSA & Construction Regulations 2014
- Mine Safety Act
- SAICE Safety in Trial Holes: 2007
Applicable Codes & Standards

BUILDING STANDARDS:

- National Building Regulations (NBR)
- SANS 10400: Application of NBR
  - 10400-A: General principles
  - 10400-B: Structural design
  - 10400-F: Site operations
  - 10400-H: Foundations
- NHBRC Home Building Manual

DESIGN STANDARDS:

- SANS 10160-5: Basis of Geotechnical Design
- EN 1997-1: Geotechnical Design – General Rules
- SAICE Lateral Support Code 1989
Applicable Codes & Standards

SITE INVESTIGATION STANDARDS:

- SANS 1936-2: Dolomite land – geotechnical investigations
- SANS 633: Soil profiling & chip logging on dolomite land
- SANS 634: Investigations for township development
- SAICE, 2010 Site Investigation Code

Are standards compulsory?
Are standards compulsory?

All South African standards are “voluntary” standards or statements of acceptable practice UNLESS...

referred in legislation

OR:

a contractual requirement.

The two main Acts that refer to standards are:


Are standards compulsory?

• NBR applies to:
  – any structure within a given list of uses
  – walls, swimming pools, reservoirs, bridges
  – fuel tanks and fuel pumps
  – any facilities incidental to a building.

• SANS 10400 goes hand-in-hand with NBR
• SANS 10400 refers to SANS 1936.

Are standards compulsory?

• Housing Consumers Protection Act:
  – Applies to all residential structures (financed or not)
  – Requires NHBRC to produce a Home Building Manual
  – Makes Manual an integral part of the act (§1(xxxi))
  – Home builders must comply with the manual.
Outline

• Purpose of Codes & Standards
• Applicable Codes, Standards and Legal Requirements
• Status of Codes & Standards
  • Requirements of Various Codes and Acts
  • Other documents with code-status.

Safety standards
Safety Standards

APPLICABLE LEGISLATION:

- Compensation for Occupational Injuries and Diseases Act 130/1993

• Occupational Health and Safety Act 85/1993
  – Construction Regulations 2014

The Crux:

§8(1): Every Employer shall provide and maintain, as far as is reasonably practicable, a working environment that is safe and without risk to the health of his employees.

§16(1): CEO to ensure this duty is fulfilled.
Safety Standards

Reasonably practicable:  
OHSA §1(1)(xliii)

Practicable having regard to:

• Severity and scope
• State of knowledge
• Availability of safeguards
• Cost of mitigation
• Benefits vs. risk

Publications:

Safety Standards

- Site investigation practice
- Relevant legislation
- Personnel
- Risk Assessment
- Plant & Equipment
- Procedures
- Emergency Preparedness
- Appendices:
  - Typical Hazards
  - Risk Assessment flowchart
  - Safety Equipment
  - Shoring Systems
  - Gasses

Building Standards
Building Standards

- National Building Regulations (NBR)
- SANS 10400: Application of NBR
  - 10400-A: General principles
  - 10400-B: Structural design
  - 10400-F: Site operations
  - 10400-H: Foundations
- NHBRC Home Building Manual

These are standards referenced by legislation

SANS 10400-A: General principles

Definition: Geotechnical site investigation (AZ 2)
process of evaluating the geotechnical character of a site in the context of existing or proposed works or land usage, which may include one or more of the following –

a) evaluation of the geology and hydrogeology;
b) examination of existing geotechnical information;c) excavating or boring in soil or rock and description of the soil and rock profiles;d) determining the depth of any fill;e) in-situ assessment of geotechnical properties;f) recovery of samples;g) testing of soil or rock samples;h) evaluation of geotechnical properties; andi) reporting the results
Building Standards

SANS 10400-A: General principles (A19)

Where, in respect of any building:

a) a rational design is required; or

b) a geotechnical investigation is required by Regulation F3;

the owner of the building shall appoint and retain an approved competent person..

Building Standards

SANS 10400-B: Structural Design

2 Normative References:

The following are indispensible for the application of this Standard:

- SANS 1936-1, Development of dolomite land – Part 1: General principles and requirements.
- SANS 1936-2, Development of dolomite land – Part 2: Geotechnical investigations and determinations.
Building Standards

SANS 10400-B: Structural Design

4.4 Buildings on Dolomite Land:

Buildings shall not be constructed on dolomite land unless such sites are developed in accordance with the requirements of SANS 1936-1 and

a) competent persons (dolomite land) plan and conduct geotechnical site investigations .... in accordance with the relevant requirements of SANS 1936-2;

b) competent persons (structures) design buildings in accordance with the relevant requirements of SANS 1936-3;

c) competent persons (civil engineering) design and inspect precautionary measures required on dolomite land ....; and

d) competent persons (dolomite land), develop dolomite risk management strategies in accordance with the requirements of SANS 1936-4.

Invokes SANS 1936 as compulsory standards

SAICE Geotechnical Division        Peter Day        Site Investigation Codes & Standards

Building Standards

SANS 10400-F: Site operations

F3 Geotechnical Site and Environmental Conditions:

(1) Local authority must inform owner of:

- Contaminated land,
- Unstable land
- Land that may cause foundation movements (heave of settlement)

(2) Owner must appoint a competent person to undertake a geotechnical investigation.
Building Standards

SANS 10400-F: Site operations

F3 Geotechnical Site and Environmental Conditions:

(3) Competent Person shall determine:
   - whether building should be permitted and under what conditions,
   - the magnitude of total and differential foundation movements.

(4) Investigations conducted in terms of 10400-B (for dolomite land) and 10400-H for building foundations are “deemed to satisfy” this regulation.

Building Standards

SANS 10400-G: Excavations

- References SAICE1989 Lateral Support Code
- No investigation requirements
Building Standards

SANS 10400-H: Foundations

2 Normative References
Also references SANS 1936 as indispensible to application of requirements.

3.10 Defines a competent person (geotechnical) as:
• PrSci Nat or PrEng, PrTechEng or PrTechniEng
• with suitable experience in geotechnical investigations and foundation design

3.23 Defines a geotechnical site investigation as in 10400-A

Building Standards

SANS 10400-H: Foundations

4.2 Geotechnical site investigations shall:
• be carried out by a competent person (geotechnical)
• shall classify sites for single and double storey masonry according to site class designations
### Building Standards

#### SANS 10400-H: Foundations

<table>
<thead>
<tr>
<th>Typical founding material</th>
<th>Nature of founding material</th>
<th>Expected range of total soil movements (mm)</th>
<th>Assumed differential movement (% of total)</th>
<th>Site class designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock (excluding mud rocks which might exhibit swelling to some depth)</td>
<td>Stable</td>
<td>Negligible</td>
<td>-</td>
<td>R</td>
</tr>
<tr>
<td>Fine-grained soils with moderate to very high plasticity (clays, silty clays, clayey silts and sandy clays)</td>
<td>Expansive soils</td>
<td>&lt; 7.5</td>
<td>50</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.5 to 15</td>
<td>60</td>
<td>H1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 to 30</td>
<td>50</td>
<td>H2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 30</td>
<td>50</td>
<td>H3</td>
</tr>
<tr>
<td>Silty sands, clayey sands, sands, sandy and gravelly soils</td>
<td>Compressible and potentially collapsible soils</td>
<td>&lt; 5</td>
<td>75</td>
<td>C0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 to 10</td>
<td>75</td>
<td>C1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 10</td>
<td>75</td>
<td>C2</td>
</tr>
<tr>
<td>Fine-grained soils (clayey silts and clayey sands of low plasticity), sands, sandy and gravelly soils</td>
<td>Compressible soils</td>
<td>&lt; 10</td>
<td>50</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 to 20</td>
<td>50</td>
<td>S1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 20</td>
<td>50</td>
<td>S2</td>
</tr>
<tr>
<td>Contaminated soils, controlled fill, dolomite land, landslip, landfill, marshy areas, mine waste fill, mining subsidence reclaimed areas, uncontrolled fill, very soft siltsilts clays</td>
<td>Variable</td>
<td>Variable</td>
<td>-</td>
<td>p³</td>
</tr>
</tbody>
</table>

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#### National Home Builders Manual

2.5 Requirements for Geotechnical Investigations and Terracing:

- Home Builder must appoint a competent person to classify site
- same classification system as given in SANS 10400-H.

A word of warning:

NHBRC is now rejecting investigations that do not comply with accepted standards, in particular, the SAICE 2010 code.
Design Standards

- SANS 10160-5: Basis of Geotechnical Design
- SANS 207: Reinforced soils and fills
- EN 1997-1: Geotechnical Design
- SAICE: Lateral Support Code 1989

These are voluntary standards
Design Standards
SANS 10160-5: Basis of Geotechnical Design

6.1 Geotechnical Investigations
• Investigations shall be carried out, and shall:
  – provide sufficient data on ground and groundwater
  – proper description of the soil profile
  – assessment of likely behaviour of ground
  – assessment of reliability of parameters to be used in design
  – provide quantitative data except for category 1 structures
  – give sufficient information for deviations form expected conditions to be recognised during construction
  – be commensurate with geotechnical category of structure

6.2 Ground properties selected for design shall:
• Be obtained from lab or field tests, theory, empiricism, relevant data
• Take account of:
  – differences between test results and in situ conditions
  – level of stress and strain and mode of deformation
  – effect of soil or rock fabric
  – the rate of loading and pore water pressure dissipation.
Design Standards

EN 1997-1: Geotechnical Design – General Rules

3.2.1 General
• Much the same as SANS 10160-5.

3.2.2 & 3.2.3 Investigations
• Gives requirements for preliminary and design investigations

3.3 Evaluation of Parameters
• Provides requirements for assessing various parameters

3.4 Reporting
• Provides requirements for presentation and evaluation of data
Design Standards

Lateral Support Code 1989

• Chapter 2 – Site Investigation
  – Objectives and planning
  – Desk study & preliminary fieldwork
  – Detailed field and laboratory investigation
  – Existing structures and services
  – Reports

Design Standards

Chapter 2 – Site Investigation

– Quantification of parameters required
– Must extend beyond the plan area of works
– Investigate to 2x depth or stable stratum
– Gives guidance of lab and field tests (App B)
– Verification and further investigation / monitoring during construction
– Advice on reporting
## Design Standards

### Appendix B – Laboratory and Field Tests

**TABLE B.1 LABORATORY TESTS ON SOILS**

<table>
<thead>
<tr>
<th>TEST</th>
<th>MATERIAL</th>
<th>SAMPLE TYPE</th>
<th>REMARKS</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triaxial Compression</td>
<td>Saturated, normally consolidated clays</td>
<td>U</td>
<td>Unfractured shear strength ($\tau_{uf} = \sigma_{fl}$). Short term stability and anchor behaviour under rapid loading with flawed clays, sample size may have significant effect.</td>
<td>Ansold (1952), Bishop &amp; Henkel (1957), Mander (1975)</td>
</tr>
<tr>
<td></td>
<td>Saturated, overconsolidated sheared clays</td>
<td>U</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Saturated, normally consolidated clays</td>
<td>U</td>
<td>Effective strength parameters ($\phi'$; $\psi$)</td>
<td>Bishop &amp; Henkel (1957), Ansold (1952)</td>
</tr>
<tr>
<td></td>
<td>Partially saturated clays (unceded)</td>
<td>U</td>
<td>Long term stability.</td>
<td>Ansold (1952)</td>
</tr>
<tr>
<td></td>
<td>Clayey sand, sandy clays, silts</td>
<td>U</td>
<td>Effective strength parameters ($\phi'$; $\psi$) Long term stability.</td>
<td>Bishop &amp; Henkel (1957), Ansold (1952)</td>
</tr>
<tr>
<td></td>
<td>Partially saturated clays (ceded)</td>
<td>U</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Peter Day  
Site Investigation Codes & Standards  

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## Design Standards

### Appendix B – Laboratory and Field Tests

**TABLE B.2 FIELD TESTS**

<table>
<thead>
<tr>
<th>TEST</th>
<th>APPLICABILITY</th>
<th>REMARKS</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permeability Test</td>
<td>Generally applied to rocks and clayey soils</td>
<td>Test measures the acceptance of the in situ rock of water under pressure between packers inserted in the hole. Used to assess the permeability or in situ material.</td>
<td>SAICE &amp; NITTR (1978), Lugen (1990), Enro (1990)</td>
</tr>
<tr>
<td>Seepage Test</td>
<td>Soils or rocks below W.T.</td>
<td>Flowing or steady state flow observed and measured in observation wells at various distances from the pumped well. Provides permeability of in situ material.</td>
<td>SAICE &amp; NITTR (1978), Lugen (1990), Enro (1990)</td>
</tr>
<tr>
<td>Picometer</td>
<td>All soils and rock</td>
<td>Used to determine ground water pressures at various depths in the ground. In permeable ground, piezometric piezometers are used but in impermeable conditions or where rapid response is required, hydraulic piezometers or other high frequency are used.</td>
<td>SAICE &amp; NITTR (1978), BS 5930 (1981), Fenner (1990)</td>
</tr>
<tr>
<td>Vane Shear Test</td>
<td>Saturated cohesive soils</td>
<td>Normally restricted to saturated clays with an undrained shear strength of less than 100 kPa. This method can give peak and residual undrained shear strengths.</td>
<td>SAICE &amp; NITTR (1978), BS 5930 (1981), Enro (1990)</td>
</tr>
<tr>
<td>Plate Bearing Test</td>
<td>Most soils and soft rocks. Generally above W.T.</td>
<td>Test performed in moist or wet hole by placing circular plates against the soft rock. May be carried out horizontally (by pushing against a header) or vertically (poking against a header). Size of plate depends on hole size and stiffness of material - generally 75-300mm for horizontal tests and 200-300mm for vertical tests.</td>
<td>Enro (1989), Varath (1984)</td>
</tr>
<tr>
<td>Test Anchors (Proving load anchors)</td>
<td>All soils and rocks</td>
<td>Where the size of the project permits, test anchors may be installed during the investigation stage. The purpose of these tests is to assess the suitability, and test capacity of the selected anchor (method). See 6.7.2</td>
<td>BS 8088: (1988), Lithgow (1971)</td>
</tr>
</tbody>
</table>

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## Design Standards

### Appendix B – Laboratory and Field Tests

<table>
<thead>
<tr>
<th>TABLE B.3 LABORATORY TESTS ON ROCKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Moisture Content</td>
</tr>
<tr>
<td>Bulk Density</td>
</tr>
<tr>
<td>Swelling Test</td>
</tr>
<tr>
<td>Point Load Test</td>
</tr>
<tr>
<td>Uniaxial Compress</td>
</tr>
</tbody>
</table>

**Reference**

- Williams et al (1954)
- Parnell & Underberg (1979)
- North (1967)
- Duncan et al (1966)
- Brooks & Feck (1970)
- North (1973)
- Nemes & Maier (1972)
- Chen (1980)
Site Investigation Standards

- SANS 1936-2: Dolomite land – geotechnical investigations
- SANS 633: Soil profiling and chip logging on dolomite land
- SANS 634: Investigations for township development
- SAICE Site Investigation Code: 2010

SAICE Site Investigation Code: 2010
Site Investigation Standards

SAICE Site Investigation Code: 2010

• Purpose
  – Set down standards of good practice
  – Give guidance to geotechnical practitioners
  – Assist Clients in specifying and procuring investigation services.
Site Investigation Standards

SAICE Site Investigation Code: 2010

- Contents
  - Planning
  - Procurement
  - Execution
  - Reporting
  - Verification during Construction
  - Bibliography
**Table 1: Typical guidelines for various stages of site investigation**

<table>
<thead>
<tr>
<th>Category</th>
<th>Development Phase</th>
<th>Data Points</th>
<th>Special Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building (Block or Frame)</td>
<td>Feasibility</td>
<td>1 per structure</td>
<td>Settlement sensitivity of trenches</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>3 per structure</td>
<td></td>
</tr>
<tr>
<td>Factory (Steel Frame)</td>
<td>Feasibility</td>
<td>2 per ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>4 per ha or 4 per structure</td>
<td>Crane &amp; floor requirements</td>
</tr>
<tr>
<td>Tunnel or Mined (Excav.)</td>
<td>Feasibility</td>
<td>2 per ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>1 per structure</td>
<td></td>
</tr>
<tr>
<td>Substation</td>
<td>Feasibility</td>
<td>2 per ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>1 per pm</td>
<td></td>
</tr>
<tr>
<td>Pipeline</td>
<td>Feasibility</td>
<td>1 per km</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>4 per km</td>
<td></td>
</tr>
<tr>
<td>Road/Rail/Conveyor</td>
<td>Feasibility</td>
<td>2 per km</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>4 per km</td>
<td></td>
</tr>
<tr>
<td>Canal</td>
<td>Feasibility</td>
<td>2 per km</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>5 per km</td>
<td></td>
</tr>
<tr>
<td>Power Transmission</td>
<td>Feasibility</td>
<td>2 per km</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>4 per km</td>
<td></td>
</tr>
<tr>
<td>Tunnels</td>
<td>Feasibility</td>
<td>2 per km</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>5 per km</td>
<td></td>
</tr>
<tr>
<td>Housing Complex</td>
<td>Feasibility</td>
<td>1 per ha or 1 per structure</td>
<td>SFH &amp; NMEBC requirements</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>1 per structure</td>
<td>ASABE standard</td>
</tr>
<tr>
<td>Port</td>
<td>Feasibility</td>
<td>1 per km</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>4 per km</td>
<td></td>
</tr>
<tr>
<td>Harbour</td>
<td>Design</td>
<td>1 per km</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 per structure</td>
<td>4 per km</td>
<td></td>
</tr>
</tbody>
</table>

**Typical parameters from a geotechnical investigation will include the following:**

**Classification: Soil**
- Grading properties (75 mm to 2 μm)
- Atterberg limits
- Maximum compacted density and optimum moisture content
- California bearing ratio
- Corrosivity
- Erosibility

**Classification: Rock**
- Unconfined compressive strength
- Joint characteristics
- Rock mass classification

**Characterisation - State**
- Specific gravity
- In-situ density & moisture content (void ratio)
- Permeability
- Collapsibility, heave and swell potential

**Characterisation - Strength and Compressibility**
- Shear strength
- Compressibility
- Consolidation and creep properties
Cost of Investigation

Figure 2: Cost overruns as a function of expenditure on site investigations for United Kingdom highway projects (Mott MacDonald and Soil Mechanics Ltd, 1994)

Table 2: Site investigation costs as a percentage of project costs

<table>
<thead>
<tr>
<th>Type of Work</th>
<th>% of capital cost of works</th>
<th>% of earthworks and foundation costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth dams</td>
<td>0.9 - 3.3</td>
<td>1.1 - 5.2</td>
</tr>
<tr>
<td>Embankments</td>
<td>0.1 - 0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Docks</td>
<td>0.2 - 0.5</td>
<td>0.4 - 1.7</td>
</tr>
<tr>
<td>Bridges</td>
<td>0.1 - 0.5</td>
<td>0.3 - 1.3</td>
</tr>
<tr>
<td>Buildings</td>
<td>0.1 - 0.2</td>
<td>0.50 - 2.0</td>
</tr>
<tr>
<td>Roads</td>
<td>0.2 - 1.6</td>
<td>1.6 - 5.7</td>
</tr>
<tr>
<td>Railways</td>
<td>0.6 - 2.0</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Overall mean</strong></td>
<td><strong>0.7</strong></td>
<td><strong>1.5</strong></td>
</tr>
</tbody>
</table>
Site Investigation Standards

SAICE Site Investigation Code: 2010

• Procurement of a Geotechnical Investigation
  – Sole source
  – Solicited proposals
  – Competitive tender

Site Investigation Standards

SAICE Site Investigation Code: 2010

• Selection Criteria for Consultants
  – Professional competence
  – Knowledge and experience
  – Adequacy of scope of investigation
  – Cost
  – Disclaimers
  – PI Cover
  – Programme & resources
  – BBBEE
Site Investigation Standards

SAICE Site Investigation Code: 2010

• Forms of Contract


Site Investigation Standards

SAICE Site Investigation Code: 2010

• Remuneration methods
  – Time and Cost
  – Lump sum
  – Percentage fee
Site Investigation Standards

SAICE Site Investigation Code: 2010

• Execution
  – Investigation stages
  – Field investigation methods
  – Field trials
  – Laboratory testing
  – Supervision & Quality control
  – Specialised investigations

Site Investigation Standards

SAICE Site Investigation Code: 2010

• Reporting
  – Factual information
  – Interpreted information
  – Additional work
  – Investigation during construction
  – QA and Document Control
The Geotechnical Division of SAICE

Site Investigation
Code of Practice

SAICE Geotechnical Division
Peter Day
Site Investigation Codes & Standards

- Reporting
  - Factual information
  - Interpretative information
  - Additional work
  - Investigation during construction
  - QA and Document Control

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Site Investigation Codes & Standards

- SANS 1936-2: Dolomite land – geotechnical investigations
- SANS 633: Soil profiling and chip logging on dolomite land
- SANS 634: Investigations for township development

- SANS 1936-2: Dolomite land – geotechnical investigations

Standard referenced by legislation
Site Investigation Standards

SANS 1936-2: Site Investigation on Dolomite

- Objective (4.1.1)
  - Identification and quantification of hazard
  - Determination of inherent hazard class
  - Dolomite area designation
  - Selection of appropriate design methods
  - Determination of precautionary measures
  - Determine risk management procedures

Site Investigation Standards

SANS 1936-2: Site Investigation on Dolomite

- Feasibility-level investigation (4.2)
  - Basic assessment of geology and site history
  - Gravity survey and borehole drilling
  - Geotechnical model (bedrock, overburden, groundwater)
  - Determination of Inherent Hazard Class
  - Reporting
Site Investigation Standards

SANS 1936-2: Site Investigation on Dolomite

- **Design-level investigation** (4.3)
  - Includes footprint investigation
  - Additional work indicated by Feasibility-level Investigation
  - Additional work for a particular development
  - Additional work for design purposes.

Site Investigation Standards

SANS 1936-2: Site Investigation on Dolomite

- **Investigation during installation of services** (4.4)
  - Establish formal inspection procedure
  - Inspect service trenches to verify zoning
  - Investigate paleo-structures
  - Undertake additional investigation where necessary
  - Confirm or refine inherent hazard class.
Site Investigation Standards

SANS 1936-2: Site Investigation on Dolomite

- **Geophysical Surveys** (4.2.2)
  - Gravity survey required
  - Grid not specified
  - 0,01 mGal resolution, 0,1 m Gal contours
  - Other methods can also be used:
    - electromagnetic
    - resistivite
    - seismic, etc.

Site Investigation Standards

SANS 1936-2: Site Investigation on Dolomite

- **Borehole drilling** (4.2.3)
  - Down-the-hole rotary percussion methods
  - Positioned according to gravity map
  - At least 6m into solid dolomite.
  - 15m into non-dolomite rock with selection of holes 6m in dolomite
  - In deep dolomite, drill to rock on gravity highs with shallower holes in-between
  - Backfill all holes to prevent preferential water ingress.
Site Investigation Standards

SANS 1936-2: Site Investigation on Dolomite

• Borehole drilling (4.2.3)

\[
\text{Table 1 — Minimum frequency of boreholes in dolomite areas for a feasibility-level investigation}
\]

<table>
<thead>
<tr>
<th>Study area (ha)</th>
<th>Minimum number of holes per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt; 1.0)</td>
<td>3</td>
</tr>
<tr>
<td>(&gt; 1.0 \text{ but } \leq 2.5)</td>
<td>2</td>
</tr>
<tr>
<td>(&gt; 2)</td>
<td>1</td>
</tr>
<tr>
<td>(&gt; 5)</td>
<td>0.5</td>
</tr>
<tr>
<td>(&gt; 10)</td>
<td>0.3</td>
</tr>
<tr>
<td>(&gt; 15)</td>
<td>0.2</td>
</tr>
</tbody>
</table>

\[
n = \frac{3 \cdot \text{Area (ha)}}{\sqrt{\text{area (ha)}}}
\]

NOTE: The frequency of boreholes required is determined by the minimum number of boreholes required for adopting a frequency higher than the minimum required.

• Inherent Hazard Classification (4.5)
  – Code allows for Rational Assessment based on geotechnical model (Annex C)
  – Scenario supposition method given in Annex B
## Site Investigation Standards

### SANS 1936-2: Site Investigation on Dolomite

<table>
<thead>
<tr>
<th>Inherent hazard class</th>
<th>Statistical occurrences of sinkholes and subsidences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small sinkhole</td>
</tr>
<tr>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Medium</td>
</tr>
<tr>
<td>3</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>Medium</td>
</tr>
<tr>
<td>5</td>
<td>High</td>
</tr>
<tr>
<td>6</td>
<td>High</td>
</tr>
<tr>
<td>7</td>
<td>High</td>
</tr>
<tr>
<td>8</td>
<td>High</td>
</tr>
</tbody>
</table>

**NOTE:** The statistical occurrence of the event/hazard over a 20-year period is in the following ranges:

- Low: \( 0 \leq 0.1 \) (return period is greater than 200 years)
- Medium: \( 0.1 \leq 1.0 \) (return period is between 200 and 20 years)
- High: \( > 1.0 \) (return period is less than 20 years)

SANS 1936 is not perfect – it can be improved

Code due for revision in 5 years

Up to the profession to work with SABS to improve code

Need a dolomite seminar to thrash out issues.
Site Investigation Standards

- SANS 1936-2: Dolomite land – geotechnical investigations
- SANS 633: Soil profiling and chip logging on dolomite land
- SANS 634: Investigations for township development
- SAICE Site Investigation Code: 2010

Site Investigation Standards

SANS 633: Soil profiling and chip logging
- Originally written as a code on soil profiling and borehole logging
- Fell well short of this mark!
- Changed to chip logging and profiling **ON DOLOMITE LAND** as a compromise.
Site Investigation Standards

• SANS 1936-2: Dolomite land – geotechnical investigations
• SANS 633: Soil profiling and chip logging on dolomite land
• SANS 634: Investigations for township development
• SAICE Site Investigation Code: 2010

Site Investigation Standards

SANS 634: Investigations for Township Dev.

Sets out a 3-phase approach for investigation of undeveloped land for township development purposes
  – Preliminary investigation (4.2)
  – Phase 1 detailed investigation (4.3)
  – Phase 2 detailed investigation (4.4)
Site Investigation Standards

SANS 634: Investigations for Township Dev.

- Preliminary Investigation: (4.2)
  - Desk study
    - geology and geohydrology
    - mining
    - topography
    - terrain units (photo interpretation)
    - existing reports
    - seismicity
  - Identification of restraints
  - Reporting

<table>
<thead>
<tr>
<th>Constraint</th>
<th>1 (most favourable)</th>
<th>2 (intermediate)</th>
<th>3 (least favourable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Collapsible soil</td>
<td>Any collapsible horizon or consecutive horizons totalling a depth of less than 750 mm in thickness.</td>
<td>Any collapsible horizon or consecutive horizons with a depth of more than 750 mm in thickness.</td>
<td>A 'least favourable' situation for this constraint does not occur.</td>
</tr>
<tr>
<td>B Soilage</td>
<td>Permanent or perched water table more than 1.5 m below ground surface.</td>
<td>Permanent or perched water table less than 1.5 m below ground surface.</td>
<td>Dumps and marshes.</td>
</tr>
<tr>
<td>C Active soil</td>
<td>Low soil-heave potential anticipated.</td>
<td>Moderate soil-heave potential anticipated.</td>
<td>High soil-heave potential anticipated.</td>
</tr>
<tr>
<td>D Highly compressible soil</td>
<td>Low soil compressibility anticipated.</td>
<td>Moderate soil compressibility anticipated.</td>
<td>High soil compressibility anticipated.</td>
</tr>
<tr>
<td>E Embrittlement of soil</td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
</tr>
<tr>
<td>F Difficulty of excavation to 1.5 m depth</td>
<td>Scattered or occasional boulders less than 10 % of the total volume.</td>
<td>Rock or hardpan pedocores between 10 % and 40 % of the total volume.</td>
<td>Rock or hardpan pedocores more than 40 % of the total volume.</td>
</tr>
<tr>
<td>G Undermined ground</td>
<td>Old undermined areas to a depth of 200 m below surface where slope closure has ceased.</td>
<td>Mining within less than 200 m of hardpan or where total extraction mining has taken place.</td>
<td></td>
</tr>
</tbody>
</table>
Site Investigation Standards

SANS 634: Investigations for Township Dev.

- Phase 1 Detailed Investigation: (4.3)
  - Near surface investigations
  - Dolomite investigation (where appropriate)
  - Field and laboratory testing
  - Identification/quantification of geotechnical constraints
  - Classification of excavation characteristics
  - Reporting

---

Site Investigation Standards

SANS 634: Investigations for Township Dev.

Table 3 — Minimum frequency of exploratory holes in near surface soil horizons

<table>
<thead>
<tr>
<th>Study area (ha)</th>
<th>Minimum number of holes per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 1.0</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 1.0 ≤ 2.0</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 2.0 ≤ 4.0</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 4.0 ≤ 6.0</td>
<td>1.5</td>
</tr>
<tr>
<td>&gt; 6.0 ≤ 10.0</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 10.0 ≤ 100.0</td>
<td>0.5</td>
</tr>
<tr>
<td>&gt; 100 ≤ 500</td>
<td>0.35</td>
</tr>
<tr>
<td>&gt; 500</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Site Investigation Standards

SANS 634: Investigations for Township Dev.

Table 4 — Minimum test samples for different sizes of study areas

<table>
<thead>
<tr>
<th>Study area (ha)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum number of test samples</td>
<td>Foundation indicator</td>
<td>Considometer/swell</td>
<td>Chemistry (see 4.3.2.2)</td>
</tr>
<tr>
<td>&lt; 5</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt; 5 ≤ 10</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt; 11 ≤ 20</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>&gt; 21 ≤ 50</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>&gt; 51 ≤ 100</td>
<td>15</td>
<td>6</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>&gt; 101 ≤ 200</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>&gt; 201 to 500</td>
<td>50</td>
<td>20</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

*When physically feasible

Site Investigation Standards

SANS 634: Investigations for Township Dev.

Table 5 — Classification of material for machine excavation

<table>
<thead>
<tr>
<th>Excavation</th>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted</td>
<td>Soft</td>
<td>Material which can be efficiently removed by a back-acting excavator of flywheel power &gt; 0.16 kW for each millimetre of bucket width.</td>
</tr>
<tr>
<td></td>
<td>Intermediate</td>
<td>Material which can be removed by a back-acting excavator of flywheel power &gt; 0.16 kW for each millimetre of bucket width, or with the use of pneumatic tools, before removal by a machine capable of removing soft material.</td>
</tr>
<tr>
<td></td>
<td>Hard rock</td>
<td>Material that cannot be removed without blasting or wedging and splitting.</td>
</tr>
<tr>
<td>Non-restricted</td>
<td>Soft</td>
<td>Material which can be efficiently removed or loaded, without prior ripping, by any of the following: a) a bulldozer or a track-type front-end loader with an approximate mass of 22 tonnes and 145 kW flywheel power. b) a tractor-scraping unit with an approximate mass of 20 tonnes and 245 kW flywheel power, pushed during loading by a bulldozer equivalent to that described in (a) above.</td>
</tr>
<tr>
<td></td>
<td>Intermediate</td>
<td>Material that can be efficiently ripped by a bulldozer with an approximate mass of 35 tonnes and 226 kW flywheel power.</td>
</tr>
<tr>
<td></td>
<td>Crushed rock</td>
<td>Material that cannot be efficiently removed by a bulldozer with an approximate mass of 22 tonnes and 145 kW flywheel power.</td>
</tr>
</tbody>
</table>
Site Investigation Standards

SANS 634: Investigations for Township Dev.

- **Phase 2 Detailed Investigation**: (4.4)
  - Inspection during installation of services
  - Establish formal procedure
  - Observe and record soil profiles
  - Undertake additional investigation / sampling if required
  - Confirm / amend findings of Phase 1 detailed investigation

- Reporting

Site Investigation Standards

SANS 634: Investigations for Township Dev.

Contains most of the requirements of GFSH-2.
Other “code-status” documents

• Jennings, Brink and Williams

• Brink & Bruin

• SA AEG
Thank you