SABS

DRAFT SOUTH AFRICAN STANDARD (DSS): PUBLIC ENQUIRY STAGE			
Document number	SANS 2001-BE3		
Reference	7135/2001-BE3/SP		
Date of circulation	2011-12-20	**Closing date**	2012-02-29

Number and title:

SANS 2001-BE3: CONSTRUCTION WORKS — PART BE3: REPAIR OF SINKHOLES AND SUBSIDENCES IN DOLOMITE LAND

Remarks:

PLEASE NOTE:

- **The technical committee, SABS SC 59P:** *Construction standards – Geotechnical standards* **responsible for the preparation of this standard has reached consensus that the attached document should become a South African standard. It is now made available by way of public enquiry to all interested and affected parties for public comment, and to the technical committee members for record purposes. Any comments should be sent by the indicated closing date, either by mail, or by fax, or by e-mail to**

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ISBN 978-0-626-

SANS 2001-BE3:2012

Edition 1

SOUTH AFRICAN NATIONAL STANDARD

Construction works

Part BE3: Repair of sinkholes and subsidences in dolomite land

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SANS 2001-BE3:2012
Edition 1

Table of changes

Change No.	Date	Scope

Acknowledgement

The SABS Standards Division wishes to acknowledge the work of the National Department of Public Works, and the South African Civil, Geological and Geotechnical Engineering Fraternity in the development of this document.

Foreword

This South African standard was approved by National Committee SABS SC 59P, *Construction standards – Geotechnical standards*, in accordance with procedures of the SABS Standards Division, in compliance with annex 3 of the WTO/TBT agreement.

This document was published in xxxxx 2012.

SANS 2001 consists of a number of parts in various stages of preparation, under the general title *Construction works.*

Annex A forms an integral part of this document. Annex B is for information only.

Introduction

The different parts of SANS 2001 each address a specific component of construction works. The prime purpose of these standards is to create a set of standards that are generally applicable to construction works, and which can be readily modified to make them applicable to particular works.

The SANS 2001 family of standards provides technical descriptions of the standard of materials and workmanship that will be used in the works that are executed or in the performance of the works when completed (or both). These standards do not make reference to the actions of those responsible for executing the works or the parties to a contract, i.e. to the constraints relating to the manner in which contract work is to be performed. Neither do they deal with the commercial arrangements of such contracts. These standards are suitable for use in any “in-house” construction work or in all types of engineering and construction works contracts, for example, design by employer, design and build, develop and construct, construction management or management contracts.

Standard requirements pertaining to the manner in which works are constructed can be found in the SANS 1921 family of standards.

Contents

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Construction works

Part BE1:
Repair of sinkholes and subsidences in dolomite land

1 Scope

This part of SANS 2001 describes standard requirements for the repair of sinkholes and subsidences in dolomite land.

NOTE 1 These requirements may be varied to suit the needs of a particular project or alternative methods of repair may be determined by a competent geo-professional in accordance with the requirements of SANS 1936-1 and SANS 1936-4.

NOTE 2 Annex A provides guidance to those responsible for compiling procurement documents which make reference to this part of SANS 2001.

NOTE 3 Annex B identifies items that might need to be considered when preparing the scope of work for a particular project

NOTE 4 The repair of sinkholes and subsidences might impact negatively on the stability of the in-situ soils and might jeopardise the safety of personnel and nearby buildings and infrastructure, and water-bearing services in particular. Therefore, available service drawings should be inspected and site-specific geotechnical investigations should be undertaken around the sinkhole or subsidence. These investigations may involve a drilling programme and may also include a gravity survey or other appropriate remote-sensing techniques, before determining the best method of rehabilitation. The nature and extent of the investigation should be determined by the competent person, depending on the particular circumstances.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Information on currently valid national and international standards can be obtained from the SABS Standards Division.

SANS 10403:2003, *Formatting and compilation of construction procurement documents.*

TMH1-A7, *Standard methods of testing road construction materials – Method A7: The determination of the maximum dry density and optimum moisture content of gravel, soil and sand.*

TMH1-A10(a), *Standard methods of testing road construction materials – Method A10(a): The determination of the in-place dry density of soil or gravel by the sand replacement method.*

TMH1-A10(b), *Standard methods of testing road construction materials – Method A10(b): The determination of the in-place density and moisture content of soils and gravels by nuclear methods.*

TRH14, *Guidelines for road construction materials.*

3 Definitions

For the purposes of this document, the definitions given in SANS 10403 and the following apply.

3.1
backfill
material that is placed in an excavation in a controlled manner

3.2
competent person
person who is qualified by virtue of his experience, qualifications, training and in-depth contextual knowledge of development on dolomite land to

a) plan and conduct geotechnical site investigations for the development of dolomite land, evaluate factual data, develop a geological model, derive interpretative data and formulate an opinion relating to the outcomes of such investigations;

b) develop and inspect for compliance the necessary precautionary measures required on dolomite land to enable safe developments to take place;

c) develop dolomite risk management strategies; or

d) investigate the cause of an event and participate in the development of the remedial measures required

3.3
deviation
difference between the actual (i.e. measured) dimension or position and the specified dimension or position

3.4
dolomite
rock composed of the mineral dolomite, which is a carbonate of calcium and magnesium

3.5
dolomite land
land underlain by dolomite or limestone residuum or bedrock (or both), within the Malmani Subgroup and Campbell Rand Subgroup, typically at depths of no more than

a) 60 m in areas where no de-watering has taken place and the local authority has jurisdiction, is monitoring and has control over the groundwater levels in the areas under consideration; or

b) 100 m in areas where de-watering has taken place or where the local authority has no jurisdiction or control over groundwater levels

NOTE For more information on dolomite land in South Africa, see annex B of SANS 1936-1:2012.

3.6
modified AASHTO maximum dry density
maximum dry density of a soil obtained from the modified AASHTO compaction test performed in accordance with the requirements of TMH1-A7

3.7
OMC
optimum moisture content
moisture content at which the maximum dry density of a soil is obtained for a specific compaction effort

3.8
permissible deviation
pd
specified limit(s) of deviation within which a dimension or position lies

3.9
sinkhole
feature that occurs suddenly and manifests itself as a hole in the ground

3.10
specification data
data, provisions and variations that make this part of SANS 2001 applicable to a particular contract or works (see annex A)

3.11
specified density
ratio of the dry density of compacted backfill in the field to laboratory-determined maximum dry density of the backfill material used

3.12
subsidence
shallow, enclosed depression

NOTE Most South African literature previously used the term "doline" when referring to subsidence as defined above. The use of the term "subsidence" is in line with international literature and practice.

3.13
suitable
capable of fulfilling or having fulfilled the intended function, or fit for its intended purpose

4 Requirements

4.1 Materials

4.1.1 Bulk fill

4.1.1.1 Unless otherwise specified in the specification data (see annex A), bulk fill shall comprise

a) G8 or better material in accordance with TRH14 that, once compacted, has a permeability lower than that of the surrounding ground; or

b) crushed or blasted rock (e.g. mine waste rock) or builders' rubble with a grading that ensures that the voids between larger particles are well filled with finer particles effectively preventing migration of finer material from above or from the sidewalls of the excavation into or through the fill under the action of percolating water.

NOTE The suitability of the grading of the material can be assessed using the filter criteria and internal stability criteria applicable to filters in dams.

4.1.1.2 Material that complies with 4.1.1.1(b) shall only be used at depths of more than 2 m below the reinstated ground surface.

4.1.1.3 Material that complies with 4.1.1.1(b) shall comprise material that is not subject to decomposition, slaking or other degradation. The maximum particle size is determined by the method of placement and compaction.

4.1.2 Capping fill

Unless otherwise specified in the specification data (see annex A), capping fill shall comprise G8 or better material in accordance with TRH14 that, once compacted, has a lower permeability than that of the surrounding ground.

4.1.3 Grout

Unless otherwise specified in the specification data (see annex A), grout shall comprise a pumpable mix of sand, cementitious binder, bentonite (optional) and water, with a slump of between 125 mm and 200 mm. Cementitious binder shall be cement with up to 50 % (mass fraction) of fly ash (FA). Minimum binder content shall be 150 kg/m^3 of grout. Plasticizing, accelerating or retarding agents may be added.

4.1.4 Self-compacting concrete

Unless otherwise specified in the specification data (see annex A), self-compacting concrete shall comprise a pumpable concrete mix that requires no external vibration to achieve consolidation, with a cube strength greater than 5 MPa.

4.1.5 Soil-cement mix

Unless otherwise specified in the specification data (see annex A), the soil-cement mix shall comprise a pumpable, high slump mix of soil and cementitious binder with a cube strength greater than 2 MPa.

4.2 Repair of sinkholes

4.2.1 Safety

4.2.1.1 The sidewalls of sinkholes are typically steep and unstable. The stability of the sidewalls shall be assessed by a competent person before any work around or inside the sinkhole is permitted. Specific safety requirements shall be as specified in the specification data (see annex A). All personnel working within a sinkhole shall be equipped with harnesses that are equipped with fail-safe attachments to a safety rope. A suitable means of escape shall be provided for use in the event of further collapse or slumping.

4.2.1.2 Where the sidewalls are unstable, they shall either be cut back to a safe angle, or a method of sinkhole repair, which does not require persons to enter the hole, should be selected.

NOTE Cutting back of the sidewalls is normally only practical where the depth to the floor of the hole is within the reach of an excavator (typically 6 m maximum). Care should be taken to minimize the amount of loose spoil spilling into the hole during trimming of the sidewalls.

4.2.1.3 Where dynamic compaction is carried out at the bottom of a sinkhole with unstable sidewalls, all the operations in 4.2 that require access to the bottom of the sinkhole and that cannot be safely undertaken by other means, may be omitted.

4.2.1.4 The repair work shall be carried out under the supervision of a competent person, who shall assess the safety of all the work procedures involved.

4.2.2 Choking of the sinkhole throat

4.2.2.1 Where the throat of the sinkhole is visible and the surrounding material is stable, the throat of the sinkhole may be choked by constructing an inverted filter in accordance with 4.2.3, or by filling the throat with self-compacting concrete in accordance with 4.6, unless otherwise specified in the specification data (see annex A).

4.2.2.2 Where the throat is not visible or is flanked by unstable material, the throat shall be choked by

a) dynamic compaction of the rubble on the sinkhole floor with or without prior placement of coarse rockfill or clean builders' rubble to assist in forming a stable plug; or

b) grouting of the loose rubble at the base of the sinkhole as described in 4.5, after backfilling of the sinkhole to the surface as described in 4.2.4.

NOTE The use of geotextiles or of mesh reinforcement (geogrids or weldmesh) may be considered to temporarily retain the material above the throat of the sinkhole.

4.2.3 Construction of an inverted filter

4.2.3.1 An inverted filter shall be designed to prevent the continued migration of material down the throat of the sinkhole.

4.2.3.2 The filter shall be constructed by placing rockfill or boulders that are coarse enough to block the throat, followed by layers of progressively finer material.

4.2.3.3 Where the material being placed is within the reach of an excavator, each layer of material shall be compacted by tamping with the back of the excavator bucket, taking care to compact the material adjacent to the sidewalls of the hole.

4.2.3.4 The grading of each successive layer shall satisfy the filter criteria required to ensure stability across the interface with the layer below under the passage of percolating water.

4.2.3.5 The grading and thickness of the layers shall be as specified in the scope of work.

4.2.4 Backfilling of sinkholes

NOTE The backfilling method, material requirements, and the extent of the various materials/layers should be shown in a drawing that should be included in the specification data (see annex A).

4.2.4.1 Where the sidewalls of the sinkhole are unstable, the hole shall be backfilled by any of the following methods:

a) uncontrolled bulk fill that is placed in layers that do not exceed 8 m in thickness, followed by dynamic compaction of each layer in accordance with 4.4;

b) a soil-cement mix; or

c) a self-compacting concrete.

Methods (b) and (c) shall be combined with grouting of the unconsolidated material below the soil-cement/concrete plug where there is a likelihood of further settlement of this material destabilizing the plug.

4.2.4.2 Unless otherwise specified in the specification data (see annex A), where the sidewalls of the sinkhole are stable, the sinkhole shall be backfilled using any of the methods in 4.2.4.1, or using bulk fill material in accordance with 4.1.1.1(a) placed in layers and compacted to 93 % modified AASHTO maximum dry density at OMC. The thickness of the layers shall be consistent with the size of compaction equipment used to ensure the specified compaction is achieved throughout the full thickness of the layer. Irrespective of the size of the compaction equipment, the thickness of the layer shall not exceed 300 mm. The maximum particle size in the backfill shall be limited to two-thirds of the thickness of the compacted layer.

Any work carried out inside the sinkhole shall comply with the safety requirements of 4.2.1 and such additional requirements as might be given in the specification data.

4.2.4.3 Unless otherwise specified in the specification data (see annex A), fill material within 2 m of the reinstated ground surface shall comprise capping fill material placed and compacted as described in 4.2.4.2 but, in this instance, in layers that are a maximum of 200 mm thick, compacted to 95 % modified AASHTO maximum dry density at OMC.

4.2.5 Finishing of the reinstated ground surface

4.2.5.1 The reinstated ground surface shall be elevated at least 300 mm above the level of the surrounding ground if site conditions allow.

4.2.5.2 The finished surface shall slope at a minimum gradient of 1:60 and shall be free of hollows or depressions to prevent ponding of surface water.

4.2.5.3 Low-lying areas within 15 m of the repaired area shall be filled to prevent the ponding of water by

a) removing the surface material to a depth of 200 mm over an area extending at least 500 mm beyond the extremity of the depression;

b) backfilling the depression as described in 4.2.4.2 and 4.2.4.3; and

c) finishing of the surface in such a manner that water drains away and does not accumulate on the finished surface.

4.3 Repair of subsidences

4.3.1 Safety

Subsidence areas are generally shallower and more open depressions than sinkholes, and they do not exhibit the same potential for further rapid ground movement or sidewall instability. The subsidence feature shall, nevertheless, be inspected by a competent person to assess its stability and the safety of personnel and equipment involved in the repairs as specified in 4.2.1. Specific safety requirements shall be as specified in the specification data (see annex A).

4.3.2 Surface preparation

The following operations shall be carried out in preparation for the filling of the subsided area:

a) Unless otherwise specified in the specification data (see annex A), all existing services shall be rerouted around the subsided area. Water-bearing services that could act as conduits for water into the area shall be sealed by filling with grout or a soil-cement mix, or removed.

b) All vegetation shall be removed and topsoil shall be stripped to stockpile (for rehabilitation purposes).

c) Any steps within the shear zone around the perimeter of the subsided area shall be flattened by the removal of material on the upslope side.

4.3.3 Backfilling of subsidences

NOTE The backfilling method, material requirements, and the extent of the various materials/layers should be shown in a drawing that should be included in the specification data.

4.3.3.1 The exposed ground shall be scarified to 150 mm, and the moisture content shall be adjusted to OMC. Unless otherwise specified in the specification data (see annex A), the exposed ground shall be compacted to a minimum of 90 % modified AASHTO maximum dry density.

NOTE The degree of compaction should be specified by the competent person taking cognizance of the expected land use after rehabilitation.

4.3.3.2 The subsided area shall be backfilled as described in 4.2.4.2 and 4.2.4.3.

4.3.3.3 As an alternative to 4.3.3.2, the subsidence may be backfilled to 2 m below the reinstated ground surface using uncontrolled bulk fill, placed in layers that do not exceed 8 m in thickness. Each layer shall be compacted using dynamic compaction in accordance with 4.4. On completion of the dynamic compaction, the surface of the dynamically compacted fill shall be treated as described in 4.3.3.1 and the remainder of the fill shall be placed in accordance with 4.2.4.3.

4.3.4 Finishing of the reinstated ground surface

The reinstated ground surface shall be finished in accordance with 4.2.5.

4.4 Dynamic compaction

4.4.1 Dynamic compaction shall be undertaken using a mobile crane fitted with a free-fall winch and braking system and with a single-line pull adequate to handle the specified pounders. The crane shall remain stable when the pounder is accidentally dropped into a cavity with the depth specified in the specification data beyond the general level at which compaction is being carried out.

NOTE Due to the fact that compaction is carried out in areas of highly compressible material in which subsurface cavities might exist, there is always a possibility of the pounder penetrating deeper than expected or of the pounder being lost.

4.4.2 Compaction shall be undertaken by repeatedly dropping a flat-bottomed or ball-type pounder (tamper) at a particular location (or print position). The spacing of prints (typically on a grid layout), sequence of compaction, and the compaction energy (in terms of the number of drops, height of drop and weight of pounder) per print shall be as specified in the specification data.

4.4.3 The grid for dynamic compaction shall be set out before any compaction takes place and level readings shall be taken at each grid point (print position). A typical grid layout is shown in figure 1.

4.4.4 The crater formed during compaction at each print position shall be backfilled with bulk fill material as compaction progresses. The depth of the crater before filling shall not exceed 2,5 m. The bulk fill material used shall be similar in nature to the fill being compacted or shall be material that has a lower permeability than that of the fill being compacted. The volume of bulk fill material imported for backfilling craters shall be recorded.

4.4.5 On completion of the compaction, the area shall be levelled and the surface shall be compacted using overlapping prints of an ironing pounder in such a manner that the entire compacted area receives at least two blows of the ironing pounder.

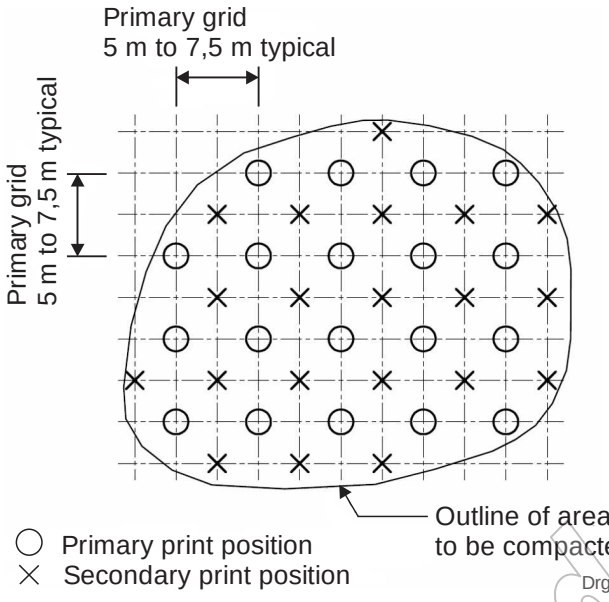

Figure 1 — Typical layout of a dynamic compaction grid

4.4.6 A further set of level readings shall be taken at each grid position on completion of compaction. This information may be used, together with the levels before compaction and the volume of fill material imported, to assess the degree of compaction achieved.

4.4.7 The tests that shall be carried out during compaction shall be as specified in the specification data.

4.4.8 The following information shall be recorded at each print position during the compaction process:

a) date and time;

b) grid position;

c) mass, footprint size and shape of pounder;

d) drop height;

e) number of drops at grid position;

f) volume of crater on completion of compaction (from measurements of crater depth and average diameter);

g) volume of backfill used to fill crater; and

h) results of any tests undertaken.

4.4.9 Any tests required to verify the degree of compaction achieved shall be specified in the specification data.

4.4.10 Where surrounding development could be affected by ground vibrations caused by dynamic compaction, a crack survey shall be carried out before and after the dynamic compaction operation.

4.5 Pressure grouting of subsurface cavities

4.5.1 Pressure grouting of subsurface cavities shall be undertaken using grout that complies with the requirements specified in the specification data.

4.5.2 The grouting equipment used shall

a) be capable of pumping 20 cubic metres of grout per hour at a pressure of up to 1,5 MPa (at discharge point) to a depth of at least 60 m;

b) be fitted with a calibrated pressure gauge and flow meter; and

c) require less than 4 h down time for minor repairs in every 40 h of grouting.

4.5.3 The grout mix shall remain workable for a minimum period of 3 h after mixing. The consistency of the grout shall be checked for every 6 m^3 of grout supplied, shortly before injection. Where necessary, the consistency of the grout may be corrected by adding no more than 20 % of water to the mix. Any grout that requires the addition of more water or has begun to set shall be removed from the site.

4.5.4 Grouting shall be undertaken in accordance with the sequence and the depth ranges specified by the competent person in the specification data.

4.5.5 After completion of grouting at a particular borehole, all grout spilled on the surface shall be removed.

4.5.6 A field report shall be made available to the competent person. This report shall contain particulars of the method of grouting, grout mix, consistency measurements, volume of any water added, depth of grouting stages, volume of grout pumped per stage, standing pressure achieved on each stage, and equipment-related friction losses.

4.5.7 During injection of grout, the level of the ground surface and any surrounding infrastructure shall be monitored to ensure that heave does not occur.

4.6 Filling with self-compacting concrete or soil-cement mix

4.6.1 Self-compacting concrete or soil-cement mix placed under gravity may be used for choking the throat of a sinkhole, for forming a stable working platform at the base of a sinkhole, or for mass filling of cavities or runnels.

NOTE Gravity placement of grout is often combined with pressure grouting. In such cases, gravity grouting is used for mass filling of voids, choking of the sinkhole throat or blocking of runnels, followed by the pressure injection of grout to consolidate any loose material and to fill smaller interstices.

4.6.2 Unless otherwise specified in the specification data (see annex A), the properties of the concrete or soil-cement mix should be specified by the competent person and shall ensure that the mix properties are suitable for the specified method of placement.

4.6.3 Unless otherwise specified in the specification data (see annex A), the material shall be placed using a concrete pump or a suitable chute extending to within 3 m of the surface of the pour. Free-fall placement shall only be permitted if sanctioned by the competent person and if segregation does not occur.

4.6.4 The consistency of the concrete or soil-cement mix shall be checked for every 6 m^3 of material supplied, shortly before placement. Where necessary, the consistency may be corrected by adding no more than 20 % of water to the mix. Any material that requires the addition of more water or has begun to set shall be removed from the site.

4.6.5 A field report shall be made available to the competent person. This report shall contain particulars of the mix, consistency measurements, volume of any water added, volume of material placed, location of placement, and method of placement.

5 Compliance with the requirements

5.1 Material properties of backfill

Determine the material properties of capping fill and backfill, where relevant, in accordance with the requirements of relevant part of TMH1.

5.2 In-place dry density and moisture content

5.2.1 Determine the in-place dry density of the backfill in accordance with the requirements of TMH1-A10(a) by means of the sand replacement method, or where appropriate, by nuclear methods in accordance with the requirements of TMH1-A10(b).

5.2.2 Determine the moisture content in accordance with the requirements of TMH1-A7 where the sand replacement method is used, and TMH1-A10(b) where nuclear methods are used.

5.2.3 Ensure that the moisture content and density during compaction are within the limits of table 1, appropriate to the degree of accuracy required in terms of the specification data.

Table 1 — Permissible deviations in respect of moisture content and density

1	2	3	4
Item	**Permissible deviation pd**		
	Degree of accuracy		
	III	**II**	**I**
Moisture content pd in moisture content in field during compaction from OMC	± 2 %	+2 % −1 %	+2 % 0
Maximum dry density a) pd of minimum recorded value from specified density	no top limit −2 %	no top limit −1 %	no top limit 0
b) pd of average of recorded values from specified density	no top limit 0	no top limit 0	no top limit 0

5.3 Setting out and level readings

Ensure that the accuracy of setting out and of level readings is within the limits of table 2, appropriate to the degree of accuracy required in terms of the specification data.

Table 2 — Permissible deviations in respect of setting out and level readings

1	2	3	4
Item	**Permissible deviation, pd** mm		
	Degree of accuracy		
	III	**II**	**I**
Setting out pd in plan position	± 300	± 100	± 30
Level readings a) pd of levels of ground surface before and after compaction	± 50	± 20	± 10
b) pd of levels taken during surface heave tests	± 10	± 5	± 2
c) pd for levels taken during pounder penetration test	± 20	± 10	± 5

Annex A
(normative)

Preparation of specification data associated with this part of SANS 2001 for inclusion in the scope of work

Specification data form an essential part of this part of SANS 2001; without such data, the requirements are incomplete.

The format for the specification data has been developed to be compatible with the requirements in table D.1 of SANS 10403:2003. The specification data shall be incorporated in the scope of work as shown in table A.1.

NOTE In the development of a scope of work, it might be necessary to address the items discussed in annex B as these are not covered in this part of SANS 2001.

Table A.1 — Incorporating this part of SANS 2001 in the scope of work

<table>
<tr><td>1</td><td>2</td><td>3</td></tr>
<tr><td>TOPIC</td><td>ASPECT</td><td>COMMENTARY</td></tr>
<tr><td colspan="3">DESCRIPTION OF THE WORKS</td></tr>
<tr><td colspan="3">CONSTRUCTION</td></tr>
<tr><td rowspan="4">Works specifications</td><td>Applicable part(s) of SANS 2001</td><td>The following parts of SANS 2001 and associated specification data are applicable:
1) SANS 2001 .....
2) SANS 2001 .....

The associated specification data are as follows:<table><tr><td>Specification data pertaining to SANS 2001…</td><td>Essential data:
The requirements for …….. are ……..
The requirements for …….. are ……..</td></tr><tr><td></td><td>Variations:
1) .....
2) .....</td></tr><tr><td></td><td>Additional clauses:
1) .....</td></tr></table></td></tr>
<tr><td>Applicable national and international standards</td><td></td></tr>
<tr><td>Applicable health and safety legislation</td><td></td></tr>
<tr><td>Particular/generic specifications</td><td></td></tr>
</table>

Develop the specification data based on the contents of table A.2.

Table A.2 — Specification data associated with this part of SANS 2001

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
Bulk fill shall comprise …..	4.1.1	State requirements if standard requirements are not suitable
Capping fill shall comprise ……	4.1.2	State requirements if standard requirements are not suitable
Grout shall comprise	4.1.3	State slump (or flow characteristics), minimum binder content and type, permissible additives, 28 d cube strength, etc.
Self-compacting concrete shall comprise	4.1.4	State any additional requirements such as slump, binder content and type, 28 d cube strength, etc.
Soil-cement mix shall comprise	4.1.5	State any additional requirements.
The following safety precautions shall be taken during the repair of sinkholes:.....	4.2.1.1	State any specific safety precautions required following the stability assessment by the competent person.
The sinkhole throat shall be choked by	4.2.2	State method of choking the sinkhole throat and give any additional requirements.
The inverted filter shall be constructed of the following layers:	4.2.3.5	State thickness and grading requirements for various layers of filter (if used).
The method of backfilling shall be as shown in Drawing No.	4.2.4 and 4.3.3	Include a drawing defining the method of backfilling, the materials to be used in the various layers, and the extent of the various materials/layers.
Maximum layer thickness for bulk fill and capping fill shall be ..... The bulk fill and capping fill shall be compacted using ..... The degree of accuracy required is	4.2.4.2 4.2.4.3	State requirements if standard requirements are not suitable. State type and size of compaction equipment to be used. State required degree of accuracy (I, II or III) – see 5.2.3.
The following safety precautions shall be taken during the repair of subsidences:	4.3.1	State any specific safety precautions required following the stability assessment by the competent person.
Existing services shall be	4.3.2(a)	Identify and describe services affected and state required actions.
The exposed ground should be compacted to a density of …..	4.3.3.1	State compaction effort required in terms of a percentage of the maximum dry density.
The crane cable shall allow for accidental dropping to a depth of …. m below ground level.	4.4.1	State depth of cavity into which tamper may be accidentally dropped. NOTE Typically, this depth is 20 m.

Table A.2 (*continued*)

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
The boom configuration shall allow a drop height of …..m measured from normal ground level whilst the centre of the crane is a minimum of …..m away from point of impact. The furthest point of impact possible shall be a minimum of …..m from the centre of the crane.	4.4.1	State parameters for the equipment. NOTE Typically the boom configuration allows a drop height of 18 m at a minimum distance of 13 m from the crane. The furthest point of impact is typically 20 m.
The spacing and configuration of the primary and secondary prints shall be	4.4.2	Provide a diagram showing the spacing and configuration of the primary and secondary (and tertiary, if required) print positions.
The sequence of compaction shall be	4.4.2	Specify the sequence of compaction, if necessary, e.g. completion of all primary prints before secondary compaction (normally the case), completion of all work from one side of the sinkhole before moving the crane, etc.
The compaction energy shall be ...	4.4.2	Specify the number of drops, weight and shape of the pounder, and the drop height for each phase of compaction. Alternatively, specify the total compaction energy required. NOTE 1 Typical drop heights with crawler cranes range from 12 m to 20 m and the weight of the pounder is typically between 10 t and 18 t. NOTE 2 Primary prints are typically set out on a square grid with a print spacing of 5 m to 7,5 m. Secondary prints are normally located at the centre of the primary grid blocks. Tertiary prints may also be specified. NOTE 3 The compaction energy applied will depend on the depth of influence of the compaction and the type of material being compacted. Typical compaction energy ranges from 200 tm/m^2 to 400 tm/m^2 (weight of pounder times height of drop times total number of drops divided by total area treated, including both compaction and ironing phases).
The following tests shall be executed during compaction:	4.4.7	State the type, number (or frequency) of the various tests required. NOTE 1 Tests commonly conducted are pounder penetration tests and surface heave tests. NOTE 2 Pounder penetration tests are conducted by measuring the level of the top of the pounder placed on the ground surface before compaction and then after each drop. Level measurements are taken on studs positioned diametrically opposite one another on the perimeter of the pounder. The number of drops used during the test is typically 50 % more than the specified number of drops. The penetration of the pounder is plotted against the number of blows and the result is used to assess the optimal number of blows to be applied. Tests are typically carried out on about 1 % of the print positions or when the nature of the material being compacted changes.

Table A.2 (*continued*)

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
		NOTE 3 Surface heave tests measure the heave of the ground surface around the print position during compaction by determining the levels of two or more lines of pegs radiating outwards from the print position to a distance of at least three pounder diameters from the grid point. Level readings are taken after each blow or each alternate blow. On completion of the test, the volume of any surface heave is determined and compared to the volume of the crater. These tests are typically carried out in conjunction with some or all of the pounder penetration tests and assist in assessing the optimal number of blows to be applied.
The following tests shall be undertaken to verify the degree of compaction:	4.4.9	Specify tests required (if any). NOTE Typical tests include large diameter plate load tests (minimum 1,0 m diameter) or penetration testing (Dynamic Probe Super Heavy of Standard Penetration Tests).
The grout shall comprise ……	4.5.1	State any requirements not already given in 4.1.3. NOTE Parameters to be specified include the slump (or flow characteristics), minimum binder content, permitted additives and 28 d cube strength.
The method, sequence and depth ranges for grouting shall be ...	4.5.4	State all specific requirements, including extent of grouting, sequence (upstage or downstage), spacing of primary and secondary grout holes, maximum grouting pressure, length of stages, and limiting volume per stage. NOTE 1 Upstage grouting is undertaken from the bottom of a predrilled borehole. Grout is injected in 1,0 m to 2,0 m long stages up the length of the borehole, raising the grout tube to the top of the next stage on completion of each grout injection. NOTE 2 Downstage grouting is used in unstable ground where collapse of the hole and air loss during drilling have prevented drilling the hole to the required depth in a single operation. In such cases, the hole is advanced through the unstable area in 1,0 m to 2,0 m stages that are then grouted and the grout allowed to set for at least 24 h. The hole is then re-drilled and advanced to the depth of the next stage.

Table A.2 (*concluded*)

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
		NOTE 3 The intention of grouting is to fill cavities and voids, not to compact the ground or cause hydro-fracturing. Grout injection pressures (allowing for delivery hose losses) should typically be around 1 MPa (10 bar) below a depth of 10 m reducing linearly to surface above this depth. The upper few metres of the hole are generally gravity grouted (i.e. the hole is simply filled without injection pressure). The standing pressure required on completion of each stage (sustained pressure on grout measured over a minimum of 10 s) should be specified by the competent person. NOTE 4 Where large quantities of grout are injected in any one stage without achieving the specified standing pressure, the injection of grout may be suspended once a specified limiting quantity of grout has been pumped, the grout tube withdrawn and the stage re-injected after the grout in the hole has set for at least 24 h. Limiting volumes of grout per stage should be specified by the competent person.
The self-compacting concrete (or soil-cement mix) shall comprise ……	4.6.2	State any requirements not already given under 4.1.4 or 4.1.5. NOTE Parameters to be specified include the slump (or flow characteristics), minimum binder content, and 28 d cube strength.
The self-compacting concrete shall be placed....	4.6.3	State method of placement and permissibility of free-fall placement methods.
The permissible deviations and degree of accuracy shall be	5.2.3 5.3	State the permissible deviations for the various aspects of the work.
Variations		
		State variations, if any.
Additional clauses		
		State additional clauses, if any.

Annex B
(informative)

Items that might need to be considered when preparing the scope of work for a particular project

B.1 The scope of work for a particular project, prepared in accordance with the requirements in annex D of SANS 10403:2003, should commence with a description of the works and thereafter describe items relating to general project management practice, namely Engineering, Procurement, Construction or Management. It might, in many instances, be necessary to include clauses in each of these sections to establish design responsibilities, management procedures, constraints to construction, etc. which are pertinent to works executed in accordance with this part of SANS 2001.

B.2 The health and safety aspects of work around sinkholes and subsidences should be addressed in the scope of work. The following issues should be considered:

a) requirements for personnel executing work in or around sinkholes to be strapped into harnesses and safety ropes secured away from the sinkhole or suspended from a crane or excavator parked at a safe position;

b) the safe parking distance for equipment and the zone where personnel are to be strapped into safety harnesses attached to safety ropes (see figure B.1);

c) all the precautionary measures that the contractor should take before and during the repair of the sinkhole;

d) the manner in which personnel are to be informed of the hazardous conditions pertaining to working in or around sinkholes;

e) the reporting requirements for the reporting of any

   1) surface cracks,

   2) cavities (irrespective of size),

   3) ground movement,

   4) sudden variation in soil profiles;

f) requirements, in the event of the items listed in (e) being observed, for the immediate stopping of the work and evacuation of all personnel from the area until the competent person has inspected the site and determined the course of action that is to take place;

g) the appointment of a suitable contractor's representative to oversee the safety of the works;

h) requirements for the locating and protection of existing services;

i) requirements for the reporting and repair of damage to existing services .e.g. damage reported to competent person within 1 of occurrence and full damage report submitted within 24 h; and

j) requirements for obtaining approval from the competent person before commencing operations.

NOTE Other issues, such as special risk insurance, should be considered in the contract data.

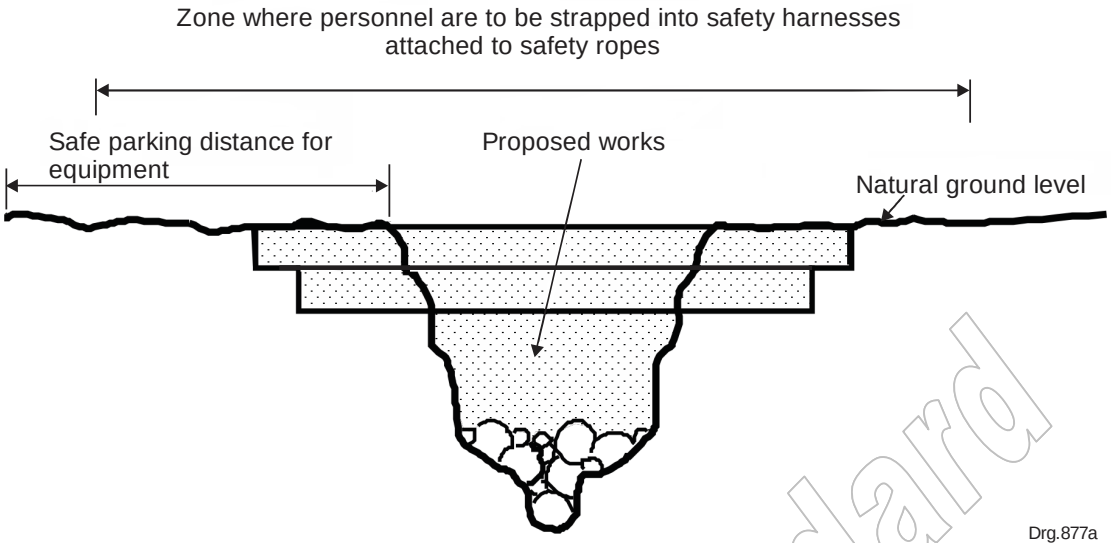

Figure B.1 — Safety distances

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SANS 1936-3, *Development of dolomite land – Part 3: Design and construction of buildings, structures and infrastructure.*

SANS 1936-4, *Development of dolomite land – Part 4: Risk management.*