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First revision

SOUTH AFRICAN BUREAU OF STANDARDS

STANDARDIZED SPECIFICATION

for

CIVIL ENGINEERING CONSTRUCTION

DK : GABIONS AND PITCHING

Approved by the

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Civil Engineering Construction - DK: Gabions and pitching

1 Scope

This specification covers the construction of gabions and stone pitching for the protection of earthworks against erosion. It covers gabion walls and aprons used as retaining walls, channel linings, and the like and it covers light to heavy pitching, with and without mortar.

NOTE — The standards referred to in the specification are listed in appendix A.

2 Interpretations

2.1 Supporting specifications

2.1.1 Where this specification is required for a project, the following specifications shall, *inter alia*, form part of the contract document (NOTE — Items (b) and (c) below may or need not be bound in the document):

a) Project specification;

b) SABS 1200 A or SABS 1200 AA or SABS 1200 AD, as applicable; and

c) SABS 1200 D or SABS 1200 DA, as applicable.

2.1.2 In addition to the specifications referred to in 2.1.1, one or more of the following specifications might be required for the project:

a) SABS 1200 C;

b) SABS 1200 DE;

c) SABS 1200 DM;

d) SABS 1200 DN; and

e) SABS 1200 G or SABS 1200 GA, as applicable.

2.2 Application

This specification contains clauses that are generally applicable to the construction of gabions and pitching. Interpretations and variations of the specification are set out in portion 2 of the project specification (see 2.1).

2.3 Definitions

For the purposes of this specification the definitions and abbreviations given in the applicable of the specifications listed in 2.1 and the following definitions shall apply:

2.3.1 **Box**: A gabion generally of depth 0,3 m to 1,0 m, of width 1,0 m, and of length 2 m to 4 m.

2.3.2 **Diaphragm**: An internal division of a gabion cage that is attached to the bottom, the sides, and, after the gabion cage is packed with stones, the lid of the cage.

2.3.3 **Gabion**: A cage of galvanized steel wire mesh (with or without PVC coating) that is packed with stones and is used in material retaining structures and in various situations to counter erosion. (A gabion can be in the form of a box or a mattress, depending on its dimensions.)

2.3.4 **Gabion cage**: An unfilled gabion.

2.3.5 **Geomembrane**: A sheet material that is highly impermeable to water and typically has an hydraulic conductivity of 1×10^{-14} m/s to 1×10^{-13} m/s.

2.3.6 **Geotextile**: A material in the form of a sheet, a blanket or a net that is permeable to water and typically has an hydraulic conductivity of 1×10^{-5} m/s to 1 m/s.

2.3.7 **Mattress**: A gabion generally of depth up to 0,5 m, of width 1,0 m or 2,0 m, and of length up to 6,0 m.

2.3.8 **Pitching**: Large stones placed systematically on a trimmed earth surface, to counter erosion.

2.3.9 **Selvedge/selvage**: A boundary or edge for the panels of a gabion cage that is intended to strengthen and facilitate connections between panels.

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3 Materials

3.1 Gabions

3.1.1 Stone

3.1.1.1 Quality

Stone shall be clean, hard, unweathered, and free from fissures and flaking. It shall have a relative density of at least 2,65, and

a) when the stone is subjected to the weathering test given in 7.3, the loss of mass shall not exceed 5 %, and,

b) in the case of dolerites, when the stone is subjected to the durability test given in 7.4, the number of stones broken near their middle shall not exceed 5 %.

3.1.1.2 Size

No stone shall be of such a size that it will pass through a ring of diameter 10 % greater than the cross-dimension of the mesh being used for the gabion (dimension *b* in table 1).

No stone shall be of a size exceeding the maximum size given in column 5 of table 1, and at least 85 % of the stones shall be of a size equal to or exceeding the minimum size given in column 4, appropriate (in each case) to the nominal depth of the gabion and, when relevant, to the nominal mesh size.

Table 1 - Size of stones for gabions

1	2	3	4	5
Nominal depth of gabion cage m		**Nominal size of mesh (nominal cross-dimension *b* - as in SABS 1580)** mm	**Stone size (largest dimension)** mm	
Over	**Up to and including**		**Min.**	**Max.**
0,15	0,17	50	60	100
0,17	0,23	80	100	120
0,23	0,3	80	100	150
0,3	0,5	80	100	200
0,5	1,0	80	100	250

3.1.2 Gabion cages

Gabion boxes and mattresses shall comply the requirements of SABS 1530. They shall be to the dimensions shown on the drawings, specified in the project specification, or scheduled. The wire shall be polyvinyl-chloride (PVC) coated if so specified in the project specification or scheduled.

3.1.3 Geotextile

A geotextile blanket shall be made of fibres consisting of at least 85 % (by mass) of polypropylene, polyethylene, a polyester, a polyamide, or a co-polymer of vinyl chloride and vinylidene-chloride, or any combination of these polymers, and the polymer(s) shall contain such additives as are necessary to render the filaments resistant to the effects of ultraviolet radiation and heat.

The amount of water absorbed by a geotextile after it has been soaked in water at 20 °C for 24 h shall be less than 1 % (by mass) and its equivalent open size (EOS), strength and other properties shall be as specified in the project specification.

The Engineer's approval of the make and grade of the geotextile shall be obtained by the Contractor before the Contractor orders or uses any geotextile in the Works.

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3.1.4 Geomembrane (impermeable membrane)

A geomembrane shall be either

a) an orange waterproof sheet of polyethelene that, except that the nominal thickness shall be at least 1 000 µm, complies with the relevant requirements of SABS 952 for type C sheet and bears the SABS certification mark; or

b) a material made from a woven or non-woven fabric that has been heat bonded or impregnated with bitumen or with a plastics material. The Engineer's approval of the make and grade of the geomembrane shall be obtained by the Contractor before the Contractor orders or uses any geomembrane in the Works.

3.1.5 Concrete

Where required in terms of 5.2.1, concrete shall comply with the relevant requirements of SABS 1200 G or SABS 1200 GA, as applicable.

3.2 Pitching

3.2.1 Stone

Stone for pitching shall comply with the requirements given in 3.1.1.1.

The dimensions and mass of any individual stone for pitching shall conform to the values given in columns 3 and 4 of table 2, appropriate to the type of pitching scheduled.

Table 2 - Size and mass of individual stones for pitching

1	2	3	4
Size/mass of pitching	**Thickness of pitching** mm, min.	**Least dimension** mm, min.	**Mass** kg, min.
Extra heavy	300	300	180
Heavy	400	190	50
Medium	300	150	27
Light	200	110	11

3.2.2 Grout

The cement used for grout shall comply with the relevant requirements of SABS ENV 197 and the fine aggregate shall comply with the relevant requirements for sand for concrete given in SABS 1083. The grout shall consist of a mortar comprising one part portland cement and four parts fine aggregate (by volume) mixed with enough water to give a consistency that will allow it, when assisted by spading or rodding, to flow under gravity into the voids. Where the pitching has a relatively high percentage of large voids, a portion of the fine aggregate may be replaced with a graded coarse aggregate that complies with the requirements of SABS 1083 for stone for concrete, except that the maximum size shall be 19 mm.

3.2.3 Wire netting

Wire netting shall be in the form of a 150 mm square mesh and shall be manufactured from plain, class A zinc-coated, mild steel wire that complies with the relevant requirements of SABS 675 and is of nominal diameter 4 mm.

4 Plant

Except for the production of the rock and stone and the fabrication of wire mesh and wire netting, gabion and pitching operations are predominantly labour-based. The Contractor shall provide such vehicles, cranes and pumps as are necessary to prepare foundations and to place materials in the manner specified.

5 Construction

5.1 Gabion cages

5.1.1 Binding and connecting wire

Sufficient lacing (binding) and connecting wire shall be supplied with the gabion cages to complete all the wiring operations that are necessary for the construction of all gabion walls and aprons as specified in 5.2.

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5.1.2 Lacing of cages

Using adequate quantities of connecting and lacing (binding) wire, the Contractor shall complete the wiring in accordance with the manufacturer's instructions. The lacing together of the edges of adjoining boxes/mattresses and of diaphragms to side panels, and the lacing of lids shall be so carried out that, when the laced attachments are tested in accordance with 7.5, the force required to separate the edges, the diaphragms and the lids is at least 1,5 kN/m.

5.2 Gabion walls and aprons

5.2.1 Preparation of the foundation and surface for bedding

The bed on which gabion cages are to be laid before they are filled with rock shall be so levelled as to present an even surface at the depth shown on the drawings or as directed. If necessary, cavities between rock protrusions shall be filled with suitably sized material of a type similar to that specified in 3.1.1 and well compacted or, if so scheduled and ordered, such cavities shall be filled with well-punned grade 15 concrete. A foundation trench that runs along the toe of a revetment and in which gabions are to be laid, shall be excavated to the dimensions shown on the drawings or as directed.

5.2.2 Geotextile or geomembrane

Where and as scheduled, geotextile or geomembrane that complies with 3.1.3 or 3.1.4, as applicable, shall be placed in the positions shown on the drawings, on the top of the prepared bottom or on the sides, or on both, of each excavation before the gabion cages are placed. A geotextile shall be placed either

a) with an overlap of at least 300 mm that is securely fastened to prevent any movement or slipping during the placing of gabion cages and rock fill, or

b) provided that it is sewn or bonded in an approved manner, with an overlap of at least 75 mm. A geomembrane shall be joined by means of a welding process or an adhesive that has been approved and is used in accordance with the manufacturer's instructions.

5.2.3 Assembly

During erection and before the start of rock placing, each gabion cage shall be stretched, aligned, and wired to the adjacent cage. Wire braces in sufficient number to prevent the deformation of a cage as it is being filled with rock shall be connected between the vertical sides of each of the outer cells of each gabion cage. The lower braces shall be tensioned when the gabion cage is not more than one-third full and the upper braces when it is not more than two-thirds full. Where gabions of depth 0,5 m or more are to be used immediately downstream of weirs or where water could fall direct onto the gabions or where a neat upper face is required, similar vertical braces shall be used at spacings ordered by the Engineer.

The corners of adjacent gabion cages shall be securely wired together to provide a uniform surface. Where practicable, consecutive courses of gabion cages shall be staggered to avoid the coincidence of vertical joints.

Subject to prior approval, certain cages may be filled with rock before they are placed in situations of difficult access, such as under water.

5.2.4 Rockfilling

5.2.4.1 Gabion boxes in retaining walls

Particular care shall be exercised in filling against the faces of gabion boxes that will be exposed to view in the finished structure. Selected rock particles of adequate size shall be so packed as to obtain a fair-faced finish. Successive gabion boxes shall be filled in stages, to prevent deformation and bulging. They shall be filled to just below the level of the wire braces (see 5.2.3) and the braces shall then be twisted, windlass-style, to provide tension, after which the filling shall be completed, the boxes being slightly overfilled to provide for settlement. Care shall be taken to ensure that the lids of each course of gabion boxes are closed and laced before the next successive course of gabion boxes is placed, and that each box is filled evenly to a level surface ready to receive the next course of boxes.

5.2.4.2 Mattresses used in revetments and aprons

Gabion mattresses used to form aprons and revetments shall be filled by spreading random rock particles in at least two layers and, where so required in terms of the project specification, by so using selected rock particles for the top layer as to present the appearance of a dry stone pitched surface.

5.2.5 Final wiring

The closing and wiring-down of lids shall proceed as soon as is practicable after the filling operations. Lids shall be stretched tightly over the filling and wired down securely through each mesh along all edges, ends and diaphragms. The ends of all tying and bracing wires shall be turned into the gabion box or mattress on completion of the lacing operations.

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5.2.6 *Cutting and folding mesh*

Only where shown on the drawings or where directed for the purpose of forming mitre joints, angles, curves or slopes that are not possible to obtain in structures with standard rectangular gabions, shall a gabion mesh be cut, folded and wired together. Such mesh shall be neatly cut, and the surplus mesh shall be completely removed, or folded back, or folded and tightly wired to an adjacent gabion face. The cut edges of the mesh shall be securely laced together with binding wire in the manner specified in 5.1.2. The assembly, filling and final wiring of re-shaped gabions shall otherwise be carried out as specified in 5.2.3 to 5.2.5.

5.2.7 Special finish

Where a special finish is ordered and scheduled, the outer face of the gabions shall be carefully packed by hand with selected stone of size 100 mm to 250 mm or as ordered.

5.3 Pitching

5.3.1 General

Pitching of the type scheduled shall be constructed on surfaces as and where shown on the drawings or as directed. No pitching shall be placed on any fill or surface that has not been trimmed, prepared, and compacted to at least 90 % of modified AASHTO maximum density. Where shown on the drawings or directed, backing of suitably sized free-draining stony material shall first be laid on the surface to be pitched, to the thickness specified.

Except where other forms of toe protection are shown on the drawings, a footing trench shall be excavated along each toe, and along all other edges of the area to be pitched, including edges that lie in stream beds, to enable the pitching to be extended for its own protection. Each trench shall be excavated to firm material but the vertical depth shall not exceed 1 m below ground, unless otherwise ordered.

The material excavated from the footing trench shall be subsequently backfilled against the toe pitching and compacted to at least 90 % of modified AASHTO maximum density, and the remainder shall be spread neatly.

5.3.2 Plain pitching

Starting at the toe, pitching shall be placed by firmly embedding each stone into the underlying material and against adjoining stones. Each stone shall be placed with the largest dimension at right angles to the slope and with its surfaces in close contact with stones previously placed.

Each stone shall be so placed that it breaks joint. Spaces between the larger stones shall be filled with spalls securely rammed into place in such a way that the larger stones do not bear on the spalls. The finished pitching shall present an even, tight surface.

Stones shall be placed individually. Dumping will not be permitted.

To minimize the effect of any differential settlement, the pitching shall be laid in horizontal lengths that are as long as is practicable. Vertical jointing in the direction of a slope shall be avoided.

5.3.3 Grouted pitching

Grouted pitching shall be laid as specified in 5.3.2. The surfaces of the stones to be grouted shall be cleaned of adhering dirt and soil and moistened with water before grout is applied.

Grout that has been mixed more than half an hour before the time of application shall not be used, and the manner of delivery of grout shall be subject to approval. Voids shall be filled by the grout's being laid over the pitching and being worked into the voids by spading, rodding and trowelling or other approved means.

The minimum depth of penetration of the grout below the top of the pitching surface shall be 150 mm, 190 mm, 230 mm and 300 mm for light, medium, heavy and extra heavy pitching, respectively (see table 4). No workman or any other load shall be allowed on the grouted surface within the period of 48 h after the grout has been placed in the voids.

The grouted surface shall be cured for at least 4 d by the use of an approved curing compound or other approved means.

5.3.4 Wired pitching

Wired pitching shall be completely enclosed in wire netting, and shall be constructed in the shape of rectangular blocks as shown on the drawings or as directed. The lower net shall have approved wire ties fastened at 0,6 m centres and it shall be of such a size that when the pitching is laid on it, there is sufficient netting at the sides and ends to fold up for about half the depth of the pitching.

The pitching shall be laid on the lower net as specified in 5.3.2. After the pitching has been laid, an upper net similar to the lower net but without ties shall be drawn tightly over the pitching and so fastened to the ties of the lower net that the edges of the upper and lower nets are in contact with each other and no stone is able to fall out of the netting. Where a footing trench is provided in terms of 5.3.1, both upper and lower nets shall extend to the full depth of the footing trench.

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5.3.5 Grouted wired pitching

Except that the grout shall cover the upper wire net, grouted wired pitching shall be constructed as specified in 5.3.3 and 5.3.4.

6 Tolerances

The materials and the finish of the work shall be to Degree of Accuracy II and the permissible deviations (PD) (see clause 6 of SABS 1200 A, SABS 1200 AA or SABS 1200 AD, as applicable) shall be within the limits given below for Degree of Accuracy II:

1	2	3	4
Item	**Permissible deviation**		
	Degree of accuracy		
	III	**II**	**I**
	mm	mm	mm
a) **Gabion walls and revetments**			
1) **Position of top edge of terrace**[1)] PD from designated position of any point, measured from nearest grid line	±450	±300	±150
2) **Alignment of top edge of terrace**[1)] PD from a line joining any two points 30 m apart on top exposed edge of each course of gabion boxes or mattresses	±200	±100	± 50
3) **Finished levels** PD from designated levels	±150	± 50	± 50
4) **Slopes to top surfaces** PD from direction of slope	nil	nil	nil
	%	%	%
PD from rate of fall:			
1 in 100 to 1 in 300	20	20	5
1 in 400 and flatter	10	5	2
	mm	mm	mm
b) **Surface of pitching** Local irregularities in the surface of pitching from designated lines			
1) Light pitching	*2)	75	*2)
2) Medium pitching	*2)	100	*2)
3) Heavy pitching	*2)	125	*2)
4) Extra heavy pitching	*2)	150	*2)

1) Subject to the breakline between intersecting slopes being acceptably straight or curved, as applicable.
2) As stated in the project specification, if required.

7 Tests

7.1 Taking and testing of samples

The Contractor shall carry out sufficient tests to satisfy himself as to the consistency of materials used for and placed in gabion cages and used for pitching.

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7.2 Material or standard of finish not to specification

The Engineer may carry out such check tests as he deems necessary, at any depth or on any layer, and the results of such tests will be made available to the Contractor. Where the Engineer's tests reveal that the material used does not comply with the applicable requirements of the specification, or that the specified standard of finish has not been attained, the Contractor shall so rectify the work that the material complies with the said requirements and the specified standard of finish is attained.

7.3 Weathering test

A crushed sample taken from the stone to be used shall be tested as follows:

a) At least 500 g of stone passing through a square mesh sieve of nominal aperture size 19 mm and retained on a square mesh sieve of nominal aperture size 13,2 mm shall be dried to constant mass *(M1)* in an oven that is maintained at 105 $\pm$ 2 °C.

b) The dried stone shall be immersed in a saturated Glauber salt solution in a porcelain dish for 8 h, after which it shall be carefully separated from the solution by decantation and placed in the oven (see (a) above) for 14 h.

c) The stone shall then be allowed to cool at room temperature for 2 h.

d) The procedure given in (b) and (c) above shall be repeated for a total of 10 cycles, after which the stone shall be thoroughly washed with hot water, dried to constant mass as in (a) above, screened on a square mesh sieve of nominal aperture size 1,70 mm, and the material retained on this sieve shall be weighed *(M2)*.

The percentage weathering loss calculated from the formula $(100(M1 - M2))/M1$ shall not exceed 5 %.

7.4 Durability test

In addition to being tested in accordance with 7.3, stones from doleritic source material shall be subjected to a durability test as follows:

a) From a crushed sample taken from the stones to be used, 100 stones passing through a sieve of nominal aperture size 53,0 mm and retained on a sieve of nominal aperture size 26,5 mm shall be taken at random.

b) The stones shall be washed to remove all adhering material.

c) The stones shall then be dried for 4 h in a well-ventilated oven maintained at 105 °C $\pm$ 5 °C and, after they have cooled to room temperature, they shall be weighed.

d) The procedure given in (c) above shall be repeated until the decrease in mass after each of two successive drying periods of 4 h does not exceed 0,1 % of the total mass.

e) The 100 dried stones shall then be placed in a suitable container and covered with ethylene glycol maintained at a temperature of 18 °C to 25 °C, for 20 d.

The number of stones that have broken near the middle shall be determined and this number shall not exceed 5.

7.5 Gabion cages after installation, filling and lacing

The lacing of the edges of adjoining cages, of diaphragms to side panels, and of lids (after filling) shall be tested by the application, in an approved manner, of a tensile force in the relevant plane and the force required to separate the edges, the diaphragms and the lids shall, in each case, be at least 1,5 kN/m.

8 Measurement and payment

8.1 Principles

The principles and computation of quantities set out in 8.1 and 8.2 of SABS 1200 D or SABS 1200 DA, as relevant, shall apply to excavations.

8.2 Scheduled items

8.2.1 Surface preparation for bedding of gabions

a) Cavities filled with approved excavated material or rock . . . . . Unit: m^2

b) Cavities filled with grade 15 concrete (provisional) . . . . . Unit: m^2

The area measured for payment will be calculated from the neat dimensions shown on the drawings of wall foundations, revetments or aprons, as applicable.

The rates for (a) and (b) above shall cover the cost of material, plant and labour for levelling, filling of cavities, if any, with rock or concrete, as applicable (see 5.2.1), and compacting the founding surface ready to receive gabion cages for retaining walls, aprons and revetments.

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8.2.2 Gabions . . . . . Unit: m^3

Separate items will be scheduled for gabions of galvanized wire and for gabions of PVC-coated galvanized wire and for each size of box or mattress, each mesh size, and each diaphragm spacing.

The volume will be calculated from the dimensions of the gabions as shown on the drawings or as ordered, irrespective of any deformation or bulging of gabions as constructed.

The rate shall cover the cost of the supply of stones, wire mesh cages, binders and connectors, and the cost of loading, transporting, offloading, assembly and filling of the cages, and completion of the construction of the gabions.

8.2.3 Extra-over 8.2.2 for packing selected stone for exposed face

(Degree of accuracy on finished faces and edges stated) . . . . . *Unit: m^2*

Where packing selected stone for an exposed face is scheduled or ordered, the area measured will be that specified as having the special appearance.

The rate shall cover the additional cost of selecting and placing selected stone in the manner specified in the project specification.

8.2.4 Geotextile (or geomembrane) . . . . . Unit: m^2

The area measured will be that of the gabion face scheduled or ordered to be backed with geotextile (or geomembrane).

The rate shall cover the cost of supplying geotextile (or geomembrane), cutting, waste, placing, joining, overlapping and fastening the geotextile (or geomembrane) in position.

8.2.5 Pitching . . . . . Unit: m^2

Separate items will be scheduled for each type of pitching and slope. The area measured will be that of the finished surface.

The rate shall cover the cost of trimming and preparing slopes and excavated surfaces, excavating footing trenches to a vertical depth not exceeding 1 m and backfilling and compacting, supplying, hauling and placing all stone, grout and wire netting, and the complete construction of the pitching as specified in 5.3.1 to 5.3.5, as applicable.

NOTES

1 Where the footing trench is ordered to be excavated to a depth exceeding 1 m vertically below natural ground, the extra excavation over that required for a 1 m vertical depth will be measured for payment in terms of 8.3.3 of SABS 1200 D or 8.3.2 of SABS 1200 DA, as applicable, which payment shall also cover the cost of excavating, backfilling and compacting the extra depth. In such a case, the extra pitching will be measured for payment in terms of 8.2.5 above.

2 Where the form of protection for pitching toes or edges is other than a footing trench, payment will be made separately at suitable schedule rates or at an agreed price or as daywork, as approved.

8.2.6 Backing for pitching (see 5.3.1) (provisional) . . . . . Unit: m^2

The area measured will be that ordered to be backed.

The unit rate shall cover the cost of supply, handling and placing of the backing.

8.2.7 Weepholes . . . . . Unit: No.

The rate shall cover the cost of supplying materials and constructing weepholes to specified details.

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Appendix A
Applicable standards

Reference is made to the applicable issues (see 2.2 of SABS 1200 A, SABS 1200 AA, or SABS 1200 AD, as applicable) of the following standards:

SABS 952	*Polyethylene sheet.*
SABS 1083	*Aggregates from natural sources.*
SABS 1580	*Steel wire gabion cages.*
SABS 1200 A	*Civil engineering construction : General.*
SABS 1200 AA	*Civil engineering construction : General (small works).*
SABS 1200 AD	*Civil engineering construction : General (dams).*
SABS 1200 C	*Civil engineering construction : Site clearance.*
SABS 1200 D	*Civil engineering construction : Earthworks.*
SABS 1200 DA	*Civil engineering construction : Earthworks (small works).*
SABS 1200 DE	*Civil engineering construction : Small earth dams.*
SABS 1200 DM	*Civil engineering construction : Earthworks (roads, subgrade).*
SABS 1200 DN	*Civil engineering construction : Earthworks (railway sidings).*
SABS 1200 G	*Civil engineering construction : Concrete (structural).*
SABS 1200 GA	*Civil engineering construction : Concrete (small works).*
SABS ENV 197	*Cement - composition, specifications and conformity criteria.*

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