

**MOKOLO AND CROCODILE
WATER AUGMENTATION PROJECT
PHASE 2 (MCWAP-2)**

TENDER NO 054/2024/PMID/MCWAP2/RFB

**PART C3.1
SPECIFICATION**

SECTION 21

**GABIONS AND RENO MATTRESS
STRUCTURES**

PART C3.1

SPECIFICATION

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GABIONS AND RENO MATTRESS STRUCTURES

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SECTION 21

GABIONS AND RENO MATTRESS STRUCTURES

21.1 SCOPE

This Section covers the use of gabion cages and Reno mattresses for the construction of retaining walls, aprons, channel linings and other erosion protection measures. Generally gabions shall be flexible, galvanised steel wire mesh cages packed with stone.

21.2 DEFINITIONS

21.2.1 Definitions

The following terms shall have the meanings given:

- a) **“Gabion”** a steel wire mesh basket or cage, usually rectangular, packed with rocks.
- b) **“Reno mattress”** a steel wire mesh container in the shape of a mattress, filled with rocks.
- c) **“Stone”** rock fragments obtained through a mechanical crushing process or naturally occurring boulders.
- d) **“Rock fragments”** individual particles together constituting the stone.
- e) **“Steel wire mesh”** a woven or welded barrier manufactured from connected steel wires with a regular pattern.
- f) **“Geotextile”** a synthetic-fibre filter fabric used for separation, filtration and drainage.

21.2.2 References

When reference is made to a Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise in writing by the Engineer.

21.3 MATERIALS

21.3.1 General

The use of all materials and proposed proprietary systems shall be subject to the prior approval of the Engineer.

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21.3.2 Stone**21.3.2.1 Quality**

Stone used as filling for the gabions and Reno mattresses shall be clean, hard, durable, un-weathered boulders or rock fragments, free from fissures and flaking and shall be of such a shape that a stable protection structure of the required thickness is formed.

Rounded boulders or cobbles shall not be used. Stone shall have a relative density of at least 2.65 and:

- a) When the stone is subjected to the weathering test given in Clause 21.7.3, 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 Clause 21.7.4, the number of stones broken near their middle shall not exceed 5% of the total.

21.3.2.2 Size

No rock fragment 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 21/1).

No rock fragment shall be of a size exceeding the maximum size given in column 4 of Table 21/1, and at least 85% of the rock fragments shall be of a size equal to or exceeding the minimum size given in column 3, appropriate (in each case) to the nominal depth of the gabion and, when relevant, to the nominal mesh size.

**TABLE 21/1
SIZE OF STONE FRAGMENTS FOR GABIONS**

1	2	3	4
NOMINAL DEPTH OF GABION CAGE m	NOMINAL SIZE OF MESH (NOMINAL CROSS- DIMENSION <i>B</i>) mm	FRAGMENT SIZE (LARGEST DIMENSION) mm	
		Min.	Max.
0.2	60	100	120
0.3	60	100	150
0.5	80	100	200
1.0	80	100	250

21.3.3 Wire

All wire used to manufacture the cages (gabions and Reno mattresses) shall comply with the requirements of SANS 675 for mild steel wire and shall have a tensile strength of not less than 350 MPa. Wire shall be zinc coated as per SANS 675 for Class A heavy duty galvanised mild steel wire.

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**TABLE 21/2
STANDARD MESH-WIRE**

MESH TYPE		B*	TOLERANCE (MM)	OD WIRE Ø (MM)
60	Galvanised	60	-4 + 10	2,2
	Galvanised + PVC	60	-4 + 10	2,2 / 3,2
80	Galvanised	80	-4 + 10	2,7
	Galvanised + PVC	80	-4 + 10	2,7 / 3,7
* B is the mesh opening, the distance between the axis of two consecutive twists according to SANS 1580: 2005				

**TABLE 21/3
PROPERTIES OF WIRE**

MESH TYPE	USE	UNITS	LACING	MESH	SELVEDGE
60	Wire** Galvanised Galvanised + PVC	Ø mm	2.2 2.2 / 3.2	2.2 2.2 / 3.2	2.7 2.7 / 3.7
	Wire Tolerance*	Ø mm	± 0.08	± 0.08	± 0.08
	Quality of zinc*	g/m ²	245	245	275
	Tensile strength*	N/mm ²	350-575		
80	Wire** Galvanised Galvanised + PVC	Ø mm	2.2 2.2 / 3.2	2.7 2.7 / 3.7	3.4 3.4 / 4.4
	Wire Tolerance*	Ø mm	± 0.08	± 0.08	± 0.1
	Quality of zinc*	g/m ²	245	275	275
	Tensile strength*	N/mm ²	350-575		
* According to SANS 675:1997					
** According to SANS 1580:2005 and SANS 675:1997					

The adhesion of the zinc coating to the wire shall be such that when the wire is wrapped six turns round a mandrel of four times the diameter of the wire, it shall not flake or crack to such an extent that any zinc can be removed by rubbing with bare fingers.

Wire mesh shall be double twisted hexagonally woven, of the types specified, complying with the requirements of SANS 1580: 2005.

21.3.4 Synthetic-fibre Filter Fabric (Geotextile)

Geotextile shall be Grade 2 as specified in Section 27 - Drainage and Erosion Protection.

21.3.5 Concrete

Concrete shall comply with Section 20 - Concrete Works (Structural).

21.4 CONSTRUCTION

21.4.1 General

Cages shall be fabricated of galvanised wire mesh, double twisted hexagonally woven to the mesh types and selvedge as specified above and in Tables 21/2 and 21/3. The cages shall be subdivided into cells by wire mesh diaphragms, manufactured from double twisted galvanised wire, hexagonally woven to the mesh types specified overleaf:

Gabions

Length:	1, 2, 3 and 4 m
Width:	0.5 m, 1 m and 1.5 m
Depth:	0.5 m and 1.0 m
Mesh Type:	80
Diaphragm spacing:	1 m
Diaphragm Mesh Type:	80

Reno Mattresses

Length:	2.3 and 6 m
Width:	1 m and 2.0 m
Depth:	0.3 m
Mesh Type:	60
Diaphragm spacing:	600 mm
Diaphragm Mesh Type:	60

21.4.2 Selvedges

The cut edges of all mesh used in the construction of gabions, except the bottom edge of diaphragms and end panels, shall be selvedged with wire, as specified in Tables 21/2 and 21/3, complying with SANS 675. Where the selvedge is not woven integrally with the mesh but has to be fastened to the cut ends of the mesh, it must be attached by binding the cut ends of the mesh about it so that a force of not less than 8.5 kN applied in the same plane as the mesh, at a point on the selvedge of a mesh sample 1 m long, is required to separate it from the mesh.

21.4.3 Diaphragms and E-panels

The diaphragms and end panels shall be selvedged on the top and vertical sides only. The end panels shall be attached by twisting the cut ends of the mesh wires at the bottom of the panel about the selvedge on the base of the gabions. Similarly, the diaphragms shall be attached by twisting the cut ends of the mesh to the twisted joints of the mesh at the base of the gabion. In each case the force required to separate the panels from the base should not be less than that required to break the mesh over the same length.

21.4.4 Binding and Connecting Wire

Sufficient binding and connecting wire shall be supplied with the gabions to perform all the tying and lacing operations to be carried out in the construction of the gabion work. The diameter of the wire shall be as specified in Table 21/3.

21.4.5 Tolerances

The tolerance on the specified diameter of all wire and on the mesh openings shall be as specified in Tables 21/2 and 21/3. The length of the cages shall be subject to a tolerance of $\pm 5\%$, the width of the cages shall be subject to a tolerance of $\pm 3\%$ and the depth of the cages shall be subject to a tolerance of $\pm 5\%$.

21.4.6 Preparation of the Foundation and Surface for Bedding

The surface on which the gabion or Reno mattress cages are to be laid prior to them being filled with rock shall be levelled to the depth shown on the Drawings or as directed by the Engineer to present an even surface. Where required, a foundation trench along the toe of the revetment or wall shall be excavated to the dimensions shown on the Drawings or indicated by the Engineer.

21.4.7 Synthetic-fibre Filter Fabric (Geotextile)

One layer of an approved geotextile as specified in Clause 21.3.4 shall be placed where indicated on the Drawings or ordered by the Engineer. The fabric shall be placed and secured flush against the base and the sides of the excavation prior to the placement of the gabions or Reno mattresses, in accordance with the instructions, in strips with a minimum overlap of 300 mm at the joints and properly secured to prevent any movement or slipping during installation of the rock fragments.

21.4.8 Construction of Cages**21.4.8.1 Assembly, Erection and Stretching****(a) Assembly**

Prior to assembly, the gabion material shall be opened out flat on the ground and stretched to remove any kinks and bends. The gabion cages shall then be assembled individually by raising the sides, ends and diaphragms ensuring that all creases are in the correct position and that the tops of all four sides are even. The four corners of the gabion cages shall be laced first followed by the edges of internal diaphragms to the sides. In all cases lacing shall commence at the top of the box by twisting the end of the lacing wire around the selvages. It shall then be passed round two edges being joined, through each mesh in turn and securely tied off at the bottom. The ends of all lacing wire shall be turned to the inside of the box on completion of each lacing operation.

(b) Erection

Only assembled boxes or groups of boxes shall be positioned in the structure. The side, or end, from which work is to proceed, shall be secured to either completed work or by rods or stakes driven into the ground at the corners. These must be secured and reach at least to the top of the gabion box. Further gabions shall then be positioned in the structure as required, each being securely laced to the preceding one at all corners and diaphragm joints.

(c) Stretching

On completion of erection of a suitable length of gabion, the gabion cages shall be stretched using a wire strainer or winch of at least one ton capacity firmly secured to the free end of the assembled gabion cages.

Whilst under tension, the gabion cages shall be securely laced along edges (top, bottom and sides) and at a diaphragm point, to all adjacent boxes and shall thereafter be filled.

21.4.8.2 Rock Filling**(a) Cages in Retaining Walls**

Particular care shall be taken in packing the visible faces of gabion cages, where only selected rock fragments of the specified size shall be used so as to obtain an even faced finish. The cages shall be filled in layers to prevent deformation and bulging. Cages shall be filled to just below the level of the wire braces, after which the braces shall be twisted to provide tension. Care must be taken to ensure that the consecutive layers in cages are filled evenly to a level surface ready to receive the next layer.

(b) Mattresses used in Revetments and Aprons

The 0.3 m deep Reno mattresses forming aprons and revetments shall be filled by random rock fragments being packed in the first layer and by selected rock fragments being used for the top layer so as to resemble normal stone pitching.

(c) General

Filling shall be carried out only whilst gabion cages and Reno mattresses are under tension. Filling material shall consist of rock fragments of sizes as specified in Clause 21.3.2.2 so placed to produce a neat face and line with a minimum of voids.

Internal horizontal bracing wire shall be provided at 500 mm vertical centres or such spacing as to ensure a ratio of four wires to every 1 m² of filling. These bracing wires shall be wrapped around two mesh wires and extended from front to back and so positioned to ensure a neat face and line free of excessive bulges and depressions. Gabion cages shall be filled in layers and horizontal bracing wires inserted as filling is brought up.

Similar bracing wires used vertically shall be provided in 0.5 m deep gabions at 330 mm horizontal centres where waterfalls directly onto gabions or where a neat face is required.

Tension on the gabion cages shall be released only when sufficiently full to prevent the mesh from slackening. Gabion cages shall be overfilled by 20 to 50 mm above their tops to allow for subsequent settlement of the rock fragments.

21.4.8.3 Grouted Rock Fill

Grouted rock fill, if required shall be done in accordance with Clause 27.8.3.1 (c).

21.4.8.4 Final Wiring

Closing and wiring down of lids shall proceed as soon as possible after filling operations and certainly in the likelihood of storms or floods occurring during construction. The wiring down shall consist of wrapping around wire at such intervals as required or specified.

Lids shall be stretched tight over the filling with bars 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 on completion of all lacing operations. Tightness of mesh, well packed filling and secure lacing is essential in all structures.

21.4.8.5 Removal, Dismantling and Stacking of Gabions

Existing gabions, either damaged or not, that require to be removed or moved to a new location shall be dismantled. Material not required for re-assembly or unsuitable for re-use shall be neatly stacked at locations approved by the Engineer. Payment will be made only for gabions removed in accordance with the written instruction of the Engineer.

Where gabions require moving or, as declared suitable by the Engineer, are re-usable, the Contractor shall re-use all the material, plus supply such new materials as may be required to re-assemble the gabion again to the standard specification for new gabions.

21.5 TRIMMING AND CLEARING UP ON COMPLETION

After completion of construction, all areas affected by the Contractor's operations shall be cleaned up and finished off and all rock larger than 75 mm maximum dimension, shall be removed and disposed of in approved spoil areas.

All intersecting earthwork slopes shall be neatly rounded. Drains shall be cleared of debris and obstructions, and any excess earth, debris or other waste material shall be removed to spoil or shaped and trimmed as directed by the Engineer.

All loose stones, dead vegetation or other waste matter exposed on fill or excavation slopes which are liable to become loosened and fall into drains shall be removed.

All parts of the work and adjacent ground shall be left in a neat and presentable condition to the satisfaction of the Engineer.

The rehabilitation of all disturbed areas shall be in accordance with Section 47 – Landscaping and Rehabilitation.

21.6 EQUIPMENT**21.6.1 General**

All equipment used in the installation of the gabion and Reno mattress structures shall be in good working order and properly maintained.

21.7 TESTS

21.7.1 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.

21.7.2 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.

21.7.3 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 $105\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.
- b) The dried stone shall be immersed in a saturated Glauber salt solution in a porcelain dish for 8 hours, after which it shall be carefully separated from the solution by decantation and placed in the oven (see (a) above) for 14 hours.
- c) The stone shall then be allowed to cool at room temperature for 2 hours.
- 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%.

21.7.4 Durability Test

In addition to being tested in accordance with Clause 21.7.3, 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 hours in a well-ventilated oven maintained at $105\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ 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 hours 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 $18\text{ }^{\circ}\text{C}$ to $25\text{ }^{\circ}\text{C}$, for 20 days.

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

21.7.5 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 of the gabion cage) 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.

21.8 MEASUREMENT AND PAYMENT

The rates tendered under this Section shall not include for the general obligations, Contractor's Equipment and work deemed to be covered by the items provided in Section 1 - General.

21.001 Foundation trench excavation and backfilling

- | | | |
|----|---|--|
| a) | In solid rock (material which requires blasting) | Unit: Cubic metre (m³) |
| b) | In all other classes of material | Unit: Cubic metre (m³) |

The unit of measurement shall be the cubic metre of each class of excavation made in accordance with the dimensions on the Drawings or indicated by the Engineer.

The tendered rate shall include for full compensation for excavation in each class of materials, including unavoidable over-break, the trimming of trenches and compacting the trench inverts, backfilling and compacting the backfill and the disposing of surplus excavated material within the free-haul distance of 1.0 km.

21.002 Surface preparation for bedding the gabions Unit: Square metre (m²)

The unit of measurement for levelling and preparing surfaces for bedding the gabions shall be the square metre measured to the net dimensions on the Drawings of revetments, aprons or wall foundations.

The tendered rate shall include full compensation for excavation, cavities, filling any cavities with rock, and levelling the surface so as to be ready for receiving the gabion cages.

21.003 Gabions, Rock fill

- | | | |
|----|--|--|
| a) | Galvanised gabion cages (dimensions of box, nominal diameter of mesh wire and mesh size indicated) | Unit: Cubic metre (m³) |
| b) | PVC-coated gabion cages (dimensions of box, nominal diameter of mesh wire and mesh size indicated) | Unit: Cubic metre (m³) |
| c) | Galvanised gabion mattresses (dimensions of mattress, mesh size, nominal diameter of mesh wire and diaphragm spacing indicated) | Unit: Cubic metre (m³) |
| d) | PVC-coated gabion mattresses (dimensions of mattress, nominal diameter of mesh wire and mesh size indicated) | Unit: Cubic metre (m³) |

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The unit of measurement shall be the cubic metre of the rock-filled cages and the quantity shall be calculated from the dimensions of the gabions or mattresses indicated on the Drawings or prescribed by the Engineer, irrespective of any deformation or bulging or settling of the completed gabions or mattresses.

The tendered rates shall include full compensation for supplying all the materials, including the rock fill, wire-mesh cages, galvanizing, PVC-coating, tying and connecting wires, loading, transporting and offloading, the assembling and filling of the cages and any other work necessary for constructing the gabions.

21.004 Gabions, Grouted Rock fill

- | | | |
|----|--|--|
| a) | Galvanised gabion cages (dimensions of box, nominal diameter of mesh wire and mesh size indicated) | Unit: Cubic metre (m³) |
| b) | PVC-coated gabion cages (dimensions of box, nominal diameter of mesh wire and mesh size indicated) | Unit: Cubic metre (m³) |
| c) | Galvanised gabion mattresses (dimensions of mattress, mesh size, nominal diameter of mesh wire and diaphragm spacing indicated) | Unit: Cubic metre (m³) |
| d) | PVC-coated gabion mattresses (dimensions of mattress, nominal diameter of mesh wire and mesh size indicated) | Unit: Cubic metre (m³) |

The unit of measurement shall be the cubic metre of the grouted rock-filled cages and the quantity shall be calculated from the dimensions of the gabions or mattresses indicated on the Drawings or prescribed by the Engineer, irrespective of any deformation or bulging or settling of the completed gabions or mattresses.

The tendered rates shall include full compensation for supplying all the materials, including the grouted rock fill, wire-mesh cages, galvanizing, PVC-coating, tying and connecting wires, loading, transporting and offloading, the assembling and filling of the cages and any other work necessary for constructing the gabions.

21.005 Geotextile fabric (type and grade indicated) Unit: Square metre (m²)

The unit of measurement shall be the net square metre of area covered with filter fabric placed in position, as indicated on the Drawing or as directed by the Engineer.

The tendered rate shall include full compensation for supplying the filter fabric, cutting, waste placing, jointing, overlapping and securing the material in position during the filling process.