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# DRAFT TANZANIA STANDARD

## Gabions and revet mattresses — Specification



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*National Development Corporation (NDC)
*Dar es salaam Institute of Technology (DIT)
Weights and Measures Agency (WMA)
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The organizations marked with an asterisk (*) in the above list, together with the following, were directly represented on the Technical Committee entrusted with the preparation of this Tanzania Standard:

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## 0 Foreword

This Tanzania Standard has been prepared by Metals and Structures Technical Committee (MEDC 02) under the supervision of Mechanical Engineering Standards Divisional Committee (MEDC).

The role of gabions and revet mattresses is to provide a highly versatile solution of earth retention and erosion protection hence, control land sliding on road sides, erosion and scouring on the rivers banks during flood and high velocity river streams and prevent the water logged areas from further damaging. Therefore, the main objective this Tanzania Standard is to protect the environment through soil retention (preventing soil erosion) by ensuring the quality requirements of gabion and revet mattresses are in place and adhered to.

In the preparation of this Tanzania Standard, assistance was drawn from the following publications:

SABS 1580:2010, *Hexagonal steel wire mesh gabions and revet mattresses*.

ASTM A975 – 20, *Standard Specification for Double-Twisted Hexagonal Mesh Gabions and Revet Mattresses (Metallic-Coated Steel Wire or Metallic-Coated Steel Wire With Poly(Vinyl Chloride) (PVC) Coating)*

For the purpose of deciding whether a particular requirement of this Tanzania Standard is complied with, the final value observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with TZS 4 (see clause 2).

# Gabions and revet mattresses — Specification

## 1 Scope

This Tanzania Standard specifies materials, dimensions, construction and testing of gabions and revet mattresses. It also specifies the characteristics of metallic-coated steel wire applied in producing gabions and revet mattresses.

This standard cover gabions and revet mattresses produced from double-twisted metallic-coated wire mesh, and metallic-coated wire for lacing wire, stiffeners, and fasteners used for manufacturing, assembling, and installation of the product. These specifications also cover gabions and revet mattresses in which the wire mesh, lacing wire, and stiffeners are poly (vinyl chloride) (PVC) coated after the metallic coating.

## 2 References

For the purpose of this Draft Tanzania Standard, the following references shall apply:

TZS 4, *Rounding off numerical values*
TZS 1795/EAS 135, Steel wire and steel wire products for fencing — Specification
ISO 37, Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties
ISO 868, Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)
ISO 974, Plastics — Determination of the brittleness temperature by impact
ISO 1183-1, Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pycnometer method and titration method
ISO 6892-1, Metallic materials — Tensile testing — Part 1: Method of test at room temperature
ISO 6931-1, Stainless steels for springs — Part 1: Wire
ISO 7989-1, Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 1: General principles
ISO 7989-2, Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 2: Zinc or zinc-alloy coating
ISO 9227, Corrosion tests in artificial atmospheres — Salt spray tests
ISO 22034-1, Steel wire and wire products — Part 1: General test methods
ISO 22034-2, Steel wire and wire products — Part 2: Tolerances on wire dimensions
ISO 22779, Metallic coatings — Physical vapour-deposited coatings of aluminium — Specification and test methods
ASTM A809, Standard specification for aluminum-coated (aluminized) carbon steel wire
ASTM D1499, Standard practice for filtered open-flame carbon-arc exposures of plastics
ASTM G152, Standard practice for operating open flame carbon arc light apparatus for exposure of nonmetallic materials
ASTM D7014, Standard Practice for installation of double-twisted wire mesh gabions and revet mattresses

## 3 Definitions

For the purpose of this Tanzania Standard the following definitions shall apply:

**3.1 gabion**

A double-twisted metallic-coated wire mesh container (with or without PVC coating) of variable sizes, uniformly partitioned into internal cells, interconnected with other similar units, and filled with stone at the project site to form flexible, permeable, monolithic structures such as retaining walls, sea wall, channel linings, revetments, and weirs for erosion control projects and material-retaining structures in civil engineering works.

**3.2 revet mattress**

a double twisted metallic-coated wire mesh container (with or without PVC coating) uniformly partitioned into internal cells relatively small height in relation to other dimensions, having smaller mesh openings than the mesh used for gabions generally used for river bank protection and channel linings in civil engineering works.

**3.3 double-twisted wire mesh**

a nonraveling mesh made by twisting continuous pairs of wires through three one-half turns (commonly called double-twisted) to form hexagonal-shaped openings which are then interconnected to adjacent wires to form hexagonal openings.

**3.4 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, to the lid of the cage.

**3.5 edge wire**

a terminal wire used to edge the wire mesh parallel to the double twist by continuously weaving it into the wire mesh.

**3.6 lacing wire**

a metallic-coated steel wire or metallic-coated steel wire (with or without PVC coating) used to assemble and interconnect empty units, to close and secure stone-filled units, and for internal stiffeners.

**3.7 selvedge wire**

a terminal wire used to edge the wire mesh perpendicular to the double twist by mechanically wrapping the mesh wires around it at least 2.5 times or by inserting it throughout the twists and folding one mesh length, intended to strengthen and facilitate connections between panels.

**3.8 fastener**

an alternate method to lacing wire used for binding operations for gabions and revet mattresses.

**3.9 stiffener**

a length of metallic-coated steel wire (with or without PVC coating) used for support of facing by connecting the front panel to the back panel of a gabion using wire having the same diameter as for the lacing wire or across the corners of a gabion cell

## 4 Classifications

Double-twisted wire gabions and revet mattresses are classified according to coating, as follows:

**4.1 Style 1**

It consists of double-twisted wire mesh made from wire which is zinc coated before being double-twisted into mesh. Fasteners, lacing wire, and stiffeners are produced from zinc-coated wire.

**4.2 Style 2**
It consists of double-twisted wire mesh made from wire which is coated with Zn95Al5 before being double-twisted into mesh. Fasteners, lacing wire, and stiffeners are also produced from Zn95Al5 coated wire.

**4.3 Style 3**
It consists of double-twisted mesh, lacing wire, and stiffeners as Style 1 or Style 2 and over coated with PVC. Fasteners shall be of stainless steel wire.

**4.4 Style 4**
It consists of double-twisted mesh made from wire which is aluminum-coated before being double-twisted into mesh. Fasteners, lacing wire, and stiffeners are also produced from aluminum-coated wire.

## 5 Materials and Manufacture

**5.1** The wire used in the manufacture of double-twisted mesh for use in gabions and revet mattresses shall conform to the coating specifications shown in 5.1.1, 5.1.2, 5.1.3, or 5.1.4 as appropriate for the style ordered, except that the wire strength shall conform to 6.1.

**5.1.1** Style 1 double-twisted mesh shall be manufactured from zinc-coated steel wire conforming to ISO 7989-2, Class A as shown in Table 1.

**Table 1: Coating mass per unit area for zinc-coated steel wire**

| Nominal diameter of wire, *d* (mm) | Minimum mass of zinc coating per unit area (g/m) |
|---|---|
| 1,85 ≤ *d* < 2,15 | 215 |
| 2,15 ≤ *d* < 2,50 | 230 |
| 2,50 ≤ *d* < 2,80 | 245 |
| 2,80 ≤ *d* < 3,20 | 255 |
| 3,20 ≤ *d* < 3,80 | 265 |
| 3,80 ≤ *d* < 4,40 | 275 |
| 4,40 ≤ *d* < 5,20 | 280 |
| 5,20 ≤ *d* < 8,20 | 290 |
| 8,20 ≤ *d* ≤ 10,00 | 300 |

**5.1.2** Style 2 double-twisted mesh shall be manufactured from zinc-aluminium coatings of type Zn95Al5 steel wire conforming to ISO 7989-2, Class A as shown in Table 2.

**Table 2: Coating mass per unit area for zinc-aluminium coated steel wire of type Zn95Al5**

| Nominal diameter of wire, *d* (mm) | Minimum mass of zinc-aluminium coating per unit area (g/m) |
|---|---|
| 1,85 ≤ *d* < 2,15 | 215 |
| 2,15 ≤ *d* < 2,50 | 230 |
| 2,50 ≤ *d* < 2,80 | 245 |
| 2,80 ≤ *d* < 3,20 | 255 |
| 3,20 ≤ *d* < 3,80 | 265 |
| 3,80 ≤ *d* < 4,40 | 275 |
| 4,40 ≤ *d* < 5,20 | 280 |
| 5,20 ≤ *d* < 8,20 | 290 |
| 8,20 ≤ *d* ≤ 10,00 | 300 |

**5.1.3** Style 3 double-twisted mesh shall be manufactured from the same type of metallic-coated steel wire as Style 1 or Style 2 with an additional PVC coating extruded onto the metallic-coated steel wire. The PVC coating shall conform to the properties in 7.2.

5.1.3.1 Original or modified thermoplastic polymers along with their application methods can be permitted as a substitute for PVC coatings, as long as their performance is equivalent to the performance requirements of the PVC coating.

**5.1.4** Style 4 double-twisted mesh shall be manufactured from aluminum-coated steel wire conforming to ISO 22779 or ASTM A809.

**5.2** Lacing wire and stiffeners shall be made of wire having the same coating material as the double-twisted wire mesh furnished on the order and conforming to either ISO 7989-2 (as shown in Table 1 or Table 2), ISO 22779 or ASTM A809, with a tensile strength in accordance with 6.1

**5.3** Fasteners made from zinc-coated steel wire, zinc-aluminium coatings of type Zn95AI5 steel wire, and aluminum coated steel wire shall conform to either ISO 7989-2 (as shown in Table 1 or Table 2), ISO 22779 or ASTM A809, with a tensile strength in accordance with 6.1. Fasteners made from stainless steel wire shall conform to ISO 6931-1, with a tensile strength in accordance with 6.1.

**5.4** Gabions and revet mattresses shall be manufactured with all components mechanically connected at the production facility with the exception of the mattress lid which is produced separately from the base (see Fig. 1, Fig. 2, and Fig. 3). All gabions (Fig. 1 and Fig. 2) and revet mattresses (Fig. 3) shall be supplied in the collapsed form, either folded and bundled or rolled, for shipping.

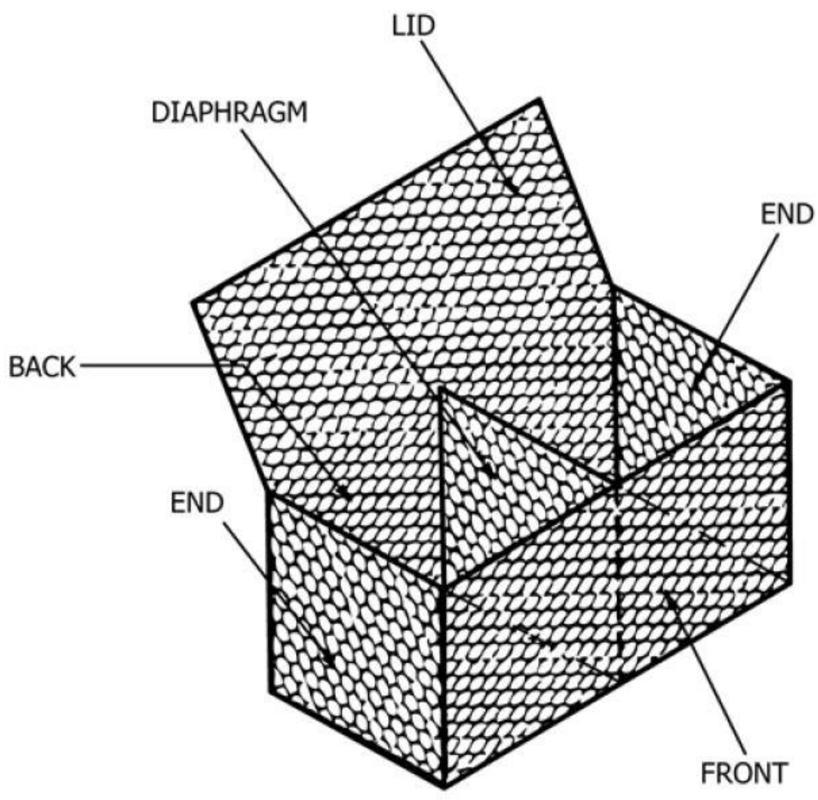


**Figure 1: Gabion**

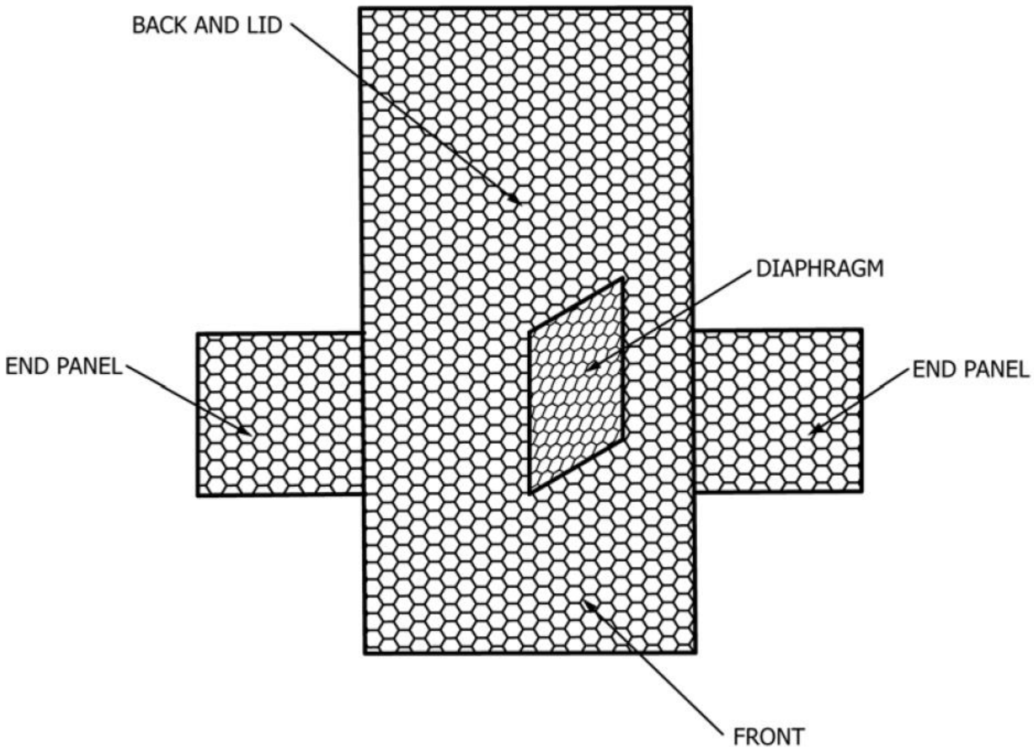


Figure 2: Mechanically Manufactured Gabion

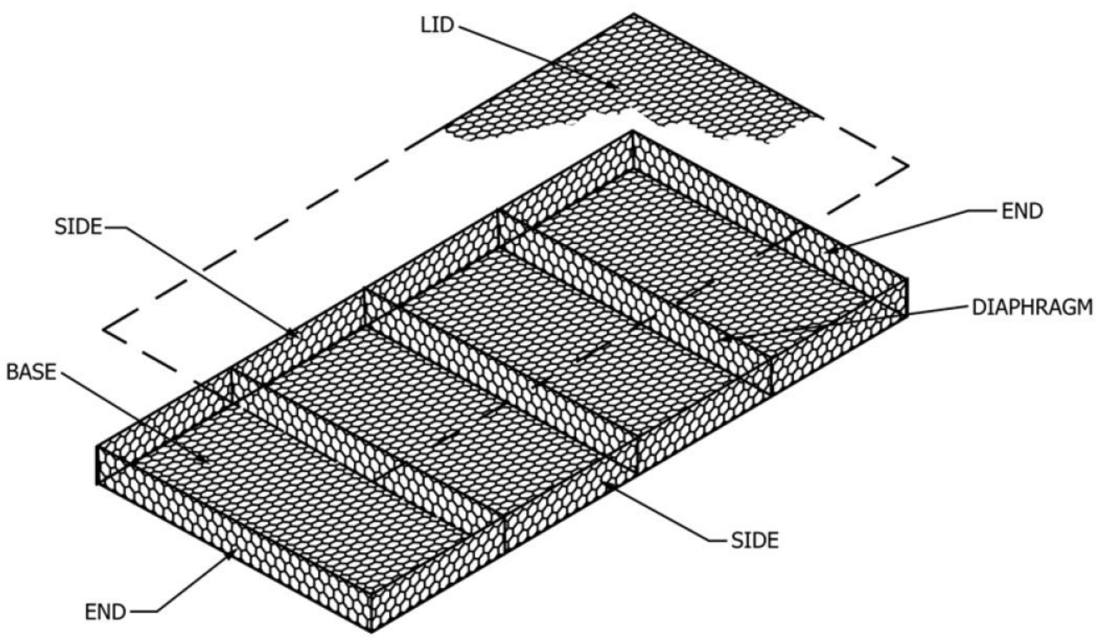


Figure 3: Revet Mattress

## 6 Mechanical Properties

### 6.1 Tensile Strength
The tensile strength of wire used for double-twisted mesh, selvedge wire, lacing wire, and stiffener, when tested in accordance with test methods specified in ISO 6892-1 or ISO 22034-1, shall be in accordance with the requirements of TZS 1795/EAS 135 or ISO 6931-1.

### 6.2 Fasteners
The tensile strength of zinc-coated steel wire, zinc-aluminium coatings of type Zn95AI5 steel wire, and aluminum-coated steel wire used for fasteners shall be in accordance with the requirements of TZS 1795/EAS 135. The tensile strength of stainless steel wire used for fasteners shall be in accordance with the requirements of ISO 6931-1. Any fastener system shall give the number of fasteners required to comply with Table 2 in accordance with the pull-part resistance test (see 12.1.2). The manufacturer or supplier shall state the number of fasteners required for all vertical and horizontal connections for single- and multiple basket joinings and shall include a description of a properly installed fastener including drawings or photographs.

### 6.3 Mesh and Panel to Panel Joint Strength
The minimum strength requirements of the mesh, selvedge wire to mesh connection, panel to panel connection, and punch test, when tested in accordance with 12.1, shall be as shown in Table 3.

**Table 3: Minimum strength requirements of mesh and connections**

| Test description | Gabions, metallic Coated (kN/m) | Gabion, PVC coated (kN/m) | Revet mattress metallic coated and PVC coated (kN/m) |
|---|---|---|---|
| Parallel to twist | 51.1 | 42.3 | 33.6 |
| Perpendicular to twist | 26.3 | 20.4 | 13.1 |
| Connection to selvedges | 20.4 | 17.5 | 10.2 |
| Panel to panel connection using lacing wire or fasteners | 20.4 | 17.5 | 10.2 |
| | **(kN)** | **(kN)** | **(kN)** |
| Punch Test | 26.7 | 23.6 | 17.8 |

## 7. Physical Properties

### 7.1 Metallic Coating
The coating weights shall conform to the requirements of ISO 7989-2 (see Table 1) for zinc coating or ISO 7989-2 (see Table 2) for zinc-aluminium coatings of type Zn95AI5, or ISO 22779/ASTM A809 for aluminum coating.

### 7.2 PVC for Coating
Where poly vinyl chloride (PVC) coated wire is required the wire shall have a zinc coating as specified in Table 1, and shall in addition be coated with PVC by means of an acceptable extrusion process. The initial properties of PVC coating material shall have a demonstrated ability to conform to the following requirements:

#### 7.2.1 Specific Gravity
It shall range from 1.30 to 1.35 when tested in accordance with Test Method ISO 1183-1.

#### 7.2.2 Tensile Strength
Not less than 20.6 MPa when tested in accordance with Test Methods ISO 37.

**7.2.3 Modulus of Elasticity**
Not less than 18.6 MPa when tested in accordance with Test Methods ISO 37.

**7.2.4 Hardness**
Shore "D" between 50 and 60, when tested in accordance with Test Method ISO 868.

**7.2.5 Brittleness Temperature**
Not higher than −9°C, or lower temperature when specified by the purchaser, when tested in accordance with Test Method ISO 974 (see Note 2).

NOTE 2: The maximum brittleness temperature should be at least −9°C (15°F) below the minimum temperature at which the gabions will be filled.

**7.2.6 Salt Spray Exposure and Ultraviolet Light Exposure:**
7.2.6.1 The PVC shall show no effect after 3000 h of salt spray exposure in accordance with Test Method ISO 9227.
7.2.6.2 The PVC shall show no effect of exposure to ultraviolet light with test exposure of 3000 h, using apparatus Type E and 63 °C, when tested in accordance with Practices ASTM D1499 and ASTM G152.

**7.2.6.3 Evaluation of Coating After Salt Spray and Ultraviolet Exposure Test**
After the salt spray test and exposure to ultraviolet light as specified in 7.2.6.1 and 7.2.6.2, the PVC coating shall not show cracks nor noticeable change of color, or blisters or splits. In addition, the specific gravity, tensile strength and hardness shall not change more than 6%, 25% and 10%, respectively, from their initial values.

**7.2.7** The PVC coating shall not show cracks or breaks after the wires are twisted in the fabrication of the mesh.

**7.2.8 Salt Spray Resistance for Fastener**
After testing in accordance with 12.1.3, the fasteners, the selvedge, or mesh wire confined by the fasteners shall show no rusty spots on any part of the surface excluding the cut ends.

## 8. Dimensions and Tolerances

**8.1** The minimum diameter of metallic coated wire shall conform to Table 3 with tolerances according to ISO 22034-2.

**8.2** The diameter of metallic-coated wire and stainless steel wire used in the fabrication of fasteners shall conform to Table 1 with tolerances according to ISO 22034-2. The minimum and nominal thickness of PVC coating uniformly applied in a quality workmanlike manner shall be as shown in Table 4.

**8.3** Gabions shall be manufactured with an 8 by 10 mesh type having a nominal mesh opening of 83 by 114 mm. Dimensions are measured at right angles to the center axis of the opening (D = 83 mm, see Fig. 4) and parallel to the twist along the same axis. The mesh tolerances are given in Table 7 of clause 8.8.

**8.4** Revet mattresses shall be manufactured with a 6 by 8 mesh type having a nominal mesh opening of 64 by 83 mm. Dimensions are measured at right angles to the center axis of the opening (D = 64 mm, see Fig. 4) and parallel to the twist along the same axis. The mesh tolerances are given in Table 7 of clause 8.8.


**Figure 4: Wire mesh opening nominal dimension *D***

**8.5** The width, height, and length of the gabion as manufactured shall not differ more than ±5 % from the ordered size prior to filling. (Typical gabion sizes are shown in Tables 5).

**8.6** The width and length of the revet mattress as manufactured shall not differ more than ±5 %, and the height shall not differ more than ±10 % from the ordered size prior to filling. (Typical revet mattress sizes are shown in Tables 6).

**Table 4: Mesh Characteristics [a]**

| **Characteristics** | **Gabion** | | **Revet Mattresses** | |
|---|---|---|---|---|
| | **Metallic Coated** | **PVC Coated** | **Metallic Coated** | **PVC Coated** |
| Mesh Type | 8 by 10 | | 6 by 8 | |
| Mesh Opening (mm) | 83 by 114 | 83 by 114 | 64 by 83 | 64 by 83 |
| Mesh wire (mm) | 3.05 | 2.7 | 2.2 | 2.2 |
| Selvedge wire (mm) | 3.8 | 3.4 | 2.7 | 2.7 |
| Lacing wire (mm) | 2.2 | 2.2 | 2.2 | 2.2 |
| Fasteners (mm) | 3.0 | 3.0 | 3.0 | 3.0 |
| Stiffeners: | | | | |
| - Using lacing Wire (mm) | 2.2 | 2.2 | 2.2 | 2.2 |
| - Preformed (mm) | 3.8 | 3.4 | N/A | N/A |
| PVC coating thickness: | | | | |
| - Nominal (mm) | N/A | 0.50 | N/A | 0.50 |
| - Minimum | N/A | 0.45 | N/A | 0.45 |
| [a] All dimensions and wire diameters are minimum nominal values. | | | | |

**Table 5: Typical Gabion Sizes**

| Length (m) | Width (m) | Height (m) | Number of cells, Each | Volume, $m^3$ |
|---|---|---|---|---|
| 2.0 | 1.0 | 1.0 | 2.0 | 2.0 |
| 3.0 | 1.0 | 1.0 | 3.0 | 3.0 |
| 4.0 | 1.0 | 1.0 | 4.0 | 4.0 |
| 2.0 | 1.0 | 0.5 | 2.0 | 1.0 |
| 3.0 | 1.0 | 0.5 | 3.0 | 1.5 |
| 4.0 | 1.0 | 0.5 | 4.0 | 2.0 |
| 2.0 | 1.0 | 0.3 | 2.0 | 0.6 |
| 3.0 | 1.0 | 0.3 | 3.0 | 0.9 |
| 4.0 | 1.0 | 0.3 | 4.0 | 1.2 |
| 6.0 | 2.0 | 0.5 | 6.0 | 6.0 |
| N.B: Other dimensions of gabions may be produced as per agreement between purchaser and manufacturer. | | | | |

**Table 6: Typical Revet Mattress Sizes**

| Length (m) | Width (m) | Height (m) | Number of cells, Each | Area, $m^2$ |
|---|---|---|---|---|
| 3.0 | 2.0 | 0.17 | 3.0 | 6.0 |
| 4.0 | 2.0 | 0.17 | 4.0 | 8.0 |
| 3.0 | 2.0 | 0.23 | 3.0 | 6.0 |
| 4.0 | 2.0 | 0.23 | 4.0 | 8.0 |
| 3.0 | 2.0 | 0.30 | 3.0 | 6.0 |
| 4.0 | 2.0 | 0.30 | 4.0 | 8.0 |
| 6.0 | 2.0 | 0.17 | 6.0 | 12.0 |
| 6.0 | 2.0 | 0.23 | 6.0 | 12.0 |
| 6.0 | 2.0 | 0.30 | 6.0 | 12.0 |
| N.B: Other dimensions of revet mattresses may be produced as per agreement between purchaser and manufacturer. | | | | |

**8.8 Mesh Opening Tolerances**

Tolerances on the hexagonal, double-twisted wire mesh opening shall not exceed ±10 % on the nominal dimension *D* values, as follows (see Fig. 4):

**Table 7: Mesh Opening Tolerances**

| S/No. | Mesh Type | Nominal Dimension *D* Values | Tolerances |
|---|---|---|---|
| 1 | 6 by 8 | 64 mm | ±10 % |
| 2 | 8 by 10 | 83 mm | ±10 % |

## 9. Workmanship

**9.1** Wire of proper grade and quality, when fabricated in the manner herein required, shall result in a strong, serviceable mesh-type product having substantially uniform openings. It shall be fabricated and finished in a workmanlike manner, as determined by visual inspection, and shall conform to this specification.

**9.2** Installation of double-twisted wire mesh gabions and revet mattresses for various applications such as erosion control, soil retention or freestanding structures should be done according to ASTM D7014.

## 10. Sampling

**10.1** Samples for determining the mechanical and physical properties of double-twisted wire mesh shall be in accordance with the samples, dimensions, and requirements described in clause 12.

**10.2** Samples for determining the mechanical and physical properties of coated steel wire used for mesh, lacing wire, and stiffeners shall be selected at random from wire coils used for manufacturing.

## 11. Number of Tests

**11.1** A minimum of three tests each for conformance to strength of metallic-coated steel wire mesh parallel to twist, perpendicular to twists, connection of metallic-coated steel wire mesh to selvedge, and punch test shall be performed. A minimum of five tests for the conformance of the fastener test shall be performed. A retest for conformance with the aforementioned strength and connection tests shall be required when changes of the physical characteristics of the mesh products occur. For metallic-coated steel wire with PVC coating, follow the same requirements as for the metallic-coated steel wire mesh. The results of all three tests must meet the requirements of Table 2.

**11.2** The tensile strength, metallic coating weight, and PVC coating thickness of the metallic steel wire used in the fabrication of mesh, lacing wire, stiffeners, and fasteners must be certified by the steel wire producers for conformance to the requirements of Sections 6, 7 and 8, and Table 1 or Table 2 for each lot shipment to the manufacturer's facility.

## 12. Test Methods

### 12.1 Mechanical Property Tests:

### 12.1.1 Tensile Strength Test

The wire mesh specimens shall be representative of proper field construction and be taken randomly from a production lot or material delivered to the jobsite, and shall be as large as practical to minimize the effect of variations. The wire mesh specimen shall be rectangular in shape with minimum 25 cm in load direction (L) and 80 cm in the cross direction (W).Wire mesh specimens shall be selvedged on both cross ends by either manually or mechanically inserting a selvedge wire with a diameter shown in Table 1 and securely twisting the wire mesh around it with minimum 2.5 turns before testing. The tests shall be run with the load applied parallel to the axis of twist and repeated on a separate test specimen with the load applied perpendicular to the axis of twist.

**12.1.1.1** The apparatus shall grip the wire in such a manner as to allow the wire failures to occur at least one mesh pattern away from the gripping points. If a failure occurs in a wire leading directly to a gripping point, that specimen shall be rejected and not included among the tests reported.

**12.1.1.2** To pretension and remove the wire mesh slack, a preload of approximately 4000 N shall be applied.

Once the preloading is reached, the load is then applied at a uniform strain rate of 6 mm/min until first fracture of an individual wire in the mesh occurs. Tensile strength of the mesh is a ratio of breaking load to effective width of the specimen. Failure is defined when no further increment in the tensile strength is observed. The machine head travel at each load increment or sequential incident of wire failure may be stopped for recording pertinent information such as load, fracture type, resulting mesh geometry and elongation, and resulting reduction in wire gauge. The distortion of the mesh or changes in gauge length shall be measured to accuracy consistent with reporting the percent elongation to the nearest 0.5 %. The results of the tests shall be in accordance with the requirements shown in Table 2.

**12.1.2 Pull-Apart Resistance Test**
A set of the jointed panels, which are prepared by the same method as specified in the salt spray test but without being subject to the 48 h salt spray test, shall be mounted on a loading machine with grips or clamps such that the panels are uniformly secured along the full width. The grips or clamps shall be designed to only transmit tension forces. The load will then be applied at a uniform rate not to exceed 220 N/s until failure occurs. The failure is defined as when the maximum load is reached and a drop of strength is observed with subsequent loading or alternatively the opening between any two closest selvedge wires, applicable to a fastener confining two selvedge wires, becomes greater than the wire mesh opening (D) at any place along the panel width. The strength requirements of the jointed panels at failure shall be as shown in Table 2.

**12.1.2.1 Fastener Test**
The pull-apart test on the fastener shall be done in conjunction with the pull-apart test on panel to panel connection. The test consists of measuring the maximum opening resistance of single fastener used to connect the wire mesh panels together for the pull-apart resistance test. The fasteners used for this test shall be obtained from the same manufacturer production batch as the fasteners used during the panel to panel connection test. The testing tension machine used for the test shall be able to register the maximum tensile strength achieved during the test. The clamping system used shall not interfere with the radius of the fastener when closed. The loads applied to the specimen shall be done perpendicular to the closing axe (see Fig. 5). The load shall be applied without interruption at a speed of 5 mm per minute. The test shall be done on five specimens to determine the average maximum resistance of each type of fastener tested.

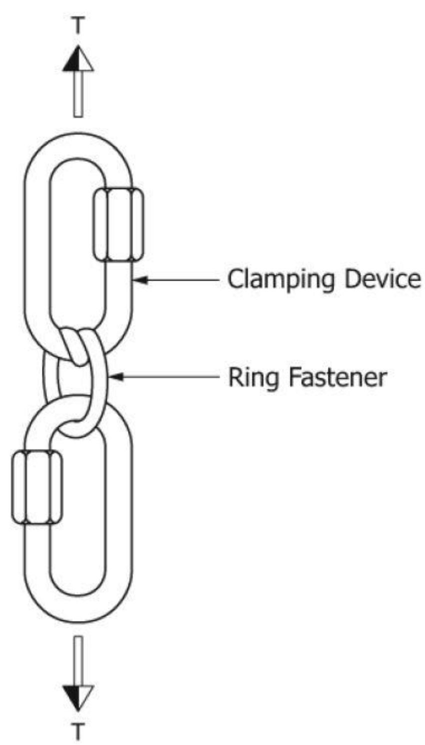


**Figure 5: Single fastener test with load applied perpendicular to the closing axe**

**12.1.2.2 Report**
The report shall include the pull-apart resistance test and the fastener test, and have the following information:

(1) Type of fastener tested (manufacturer, material composition, coating, and dimension).
(2) Description of the testing apparatus used for both tests, if different.
(3) Table showing the results obtained for the panel to panel connection and the single fastener tests.
(4) Name of the laboratory where the test was done, date of test, and name of the test supervisor.

**12.1.3 Salt Spray Test**
A set of two identical rectangular gabion panels, each with a width about 10.5 mesh openings along a selvedge wire, shall be jointed by properly installed wire fasteners along the two selvedge wires so that each fastener confines two selvedge and two mesh wires. If the fasteners are also to be used to join two individual empty gabion baskets, two additional selvedge wires that are each mechanically wrapped with mesh wires shall be included so that each fastener confines four selvedge and four mesh wires. A properly installed fastener shall meet the following requirements:

**12.1.3.1** Each fastener type shall be in a closed position. Each fastener type shall be closed and the free ends of the fastener shall overlap a minimum of 25.4mm. The set of the jointed panels shall be subject to Salt Spray Test according to ISO 9227 for a period not less than 48 ± 1 h cycle length.

**12.1.4 Punch Test**
The wire mesh specimens shall be representative of proper field construction and be taken randomly from a production lot or from materials delivered to the jobsite. The punch test could be done using two different apparatus.

**12.1.4.1 Pre-Tensioned Punch Test**
An uncut section of 1.82 m in length (unselvedged) and not less than 0.91 m in width shall have the ends securely clamped for 0.91 m along the width of the sample. When the width of the section under test exceeds 0.91 m, the clamps shall be centered along the width and the excess width will be allowed to fall free on each side of the clamped section. The sample shall then be subjected to tension sufficient to cause 10 % elongation of the sample section between the clamps. After elongation and while clamped as described above (and otherwise unsupported), the section shall be subjected to a load of 960 $cm^2$ applied to the approximate center of the sample section between the clamps and in a direction perpendicular to the direction of the tension force.

**12.1.4.2 Secured Punch Test**
The specimen shall be rectangular in shape with 1.0 m side length (L). The tolerance on specimen size shall not exceed 620 %. The wire mesh specimen shall be securely connected to the perimeter of a rigid square test frame using constraining devices such as grips or links as schematically shown in Fig. 6. After being secured to the test frame, the specimen shall be subjected to a loading disc with a contact area of 960 $cm^2$ applied to the approximate center of the sample section between the clamps and in a direction perpendicular to the direction of the tension force. To remove the wire mesh slack, the specimen shall be preloaded until the maximum vertical deformation at the center is less than 20 % of the side length. Once the preloading is reached, the load is then applied at a uniform strain rate of 10 mm/min until the specimen no longer supports any increase in the applied load. During the test, the applied load and vertical deformation at the center of the wire mesh specimen shall be continuously measured and load versus deformation curve shall be plotted. Failure is determined when no further increment of punching load to the specimen is observed.

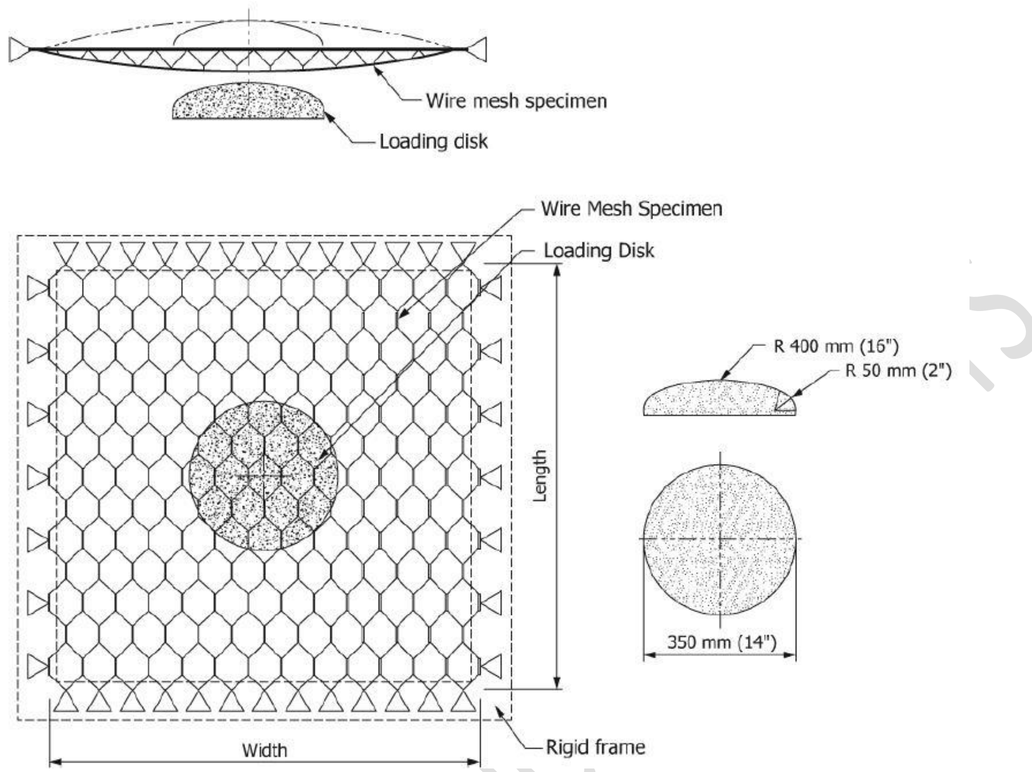


**Figure 6: Secured punch test with every mesh clamped**

**12.1.4.3** The sample shall withstand, without rupture of any strand or opening of any mesh fastening, an actual load applied by means of a circular ram at a rate as indicated in 12.1.2 equaling or exceeding the values shown in Table 2. The ram head used in the test shall be circular with a 350 mm diameter and have its edges beveled or rounded to prevent cutting of the wire strands.

**12.1.5 Abrasion Resistance Test**

This test method covers the determination of the resistance of polymer coated steel wire to abrasion caused by a linear rubbing action. An abrading wire reciprocates back and forth along a linear path, until it abrades through the polymer coating and the test is automatically stopped. Abrasion is prominent where there is scuffing, scratching, or wearing action caused by actions such as glaciation, movement of solid objects, or waves breaking on coastlines.

**12.1.5.1** The polymer coated wire specimens used in this test shall be taken randomly from production lot. A small segment of polymer coating shall be stripped from both ends of the wire specimen before securing in place. A total vertical load of 2400 g ± 50 g shall be applied to the abrading wire of 0.5 mm ± 0.05 mm diameter as shown in Figure 7. Subject the test specimen to abrasion at a speed of 55 ± 5 cycles per minute for a stroke length of 12.7 mm. The test shall stop automatically when the polymer coating is worn through to the metal wire.
Record the number of cycles. A total of four tests shall be performed on each specimen. For each subsequent test, move the specimen 25 mm and rotate 90°. Replace abradant wire before each test.

**12.1.5.2** The final result shall be calculated as the average of 4 tests performed.

**12.1.6 Corrosion Spread Test for Polymer Coatings**

The corrosion spread test is relevant for polymer coatings to assess, in the event of a local damage to an over-sheath, any consequential corrosion of the outer surface of the steel wire core and ensure that the corrosion effect will remain confined to the damaged area of the covering. The procedure consists of immersing wire samples of 250 mm long in a 5 % solution of HCl by weight. Samples are removed from the solution and analyzed after 100, 500, 1000, 1500, and 2500 hours of immersion. The polymer coating shall be removed, and the length of the corroded wire measured. The part of the wire with reduced diameter is considered as corroded. The average corrosion lengths measured versus time plot shall show the maximum length after which there is no more increase in length with time. This maximum length measured shall be always less than a mesh repetition.

**12.2 Metallic Coating Weight**
Perform coating weight tests as prescribed in Test Methods ISO 7989-1 or ISO 22779 as applicable.

**12.3 Polymer Coating Thickness:**
**12.3.1** The thickness of the polymer coating shall be determined on a randomly chosen individual piece of wire removed from the mesh.

**12.3.2** Measure with a micrometer the diameter of the metallic coated steel wire with polymer coating. Determine the thickness of the polymer coating by stripping the polymer coating from the wire and measure the reduced diameter with a micrometer. The thickness of the coating is the difference between the diameter of the metallic-coated steel wire with polymer coating and the measured diameter of the metallic coated wire divided by two. This value shall be in accordance with Table 1. When removing the polymer coating by stripping, take care not to remove any of the metallic surfaces.

## 13. Inspection

**13.1** Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements of this specification. The producer shall use his/her own or any other suitable facilities for the performance of the inspection and test requirements, at his option, unless disapproved by the purchaser at the time the order is placed. The purchaser at their own expense shall have the right to perform any of the inspections and tests set forth in this specification when such tests are deemed necessary to ensure that the material conforms to the prescribed requirements.

**13.2** When requested by owner or purchaser, fasteners used for assembly and installation of the units on the field shall be tested for compliance with the pull-apart resistance certification provided by the producer or supplier in accordance with 12.1.2.2. When tested in accordance with 12.1.2.1, the average maximum resistance of the fasteners from the field shall not be lower than 90 % of the resistance provided in the certification.

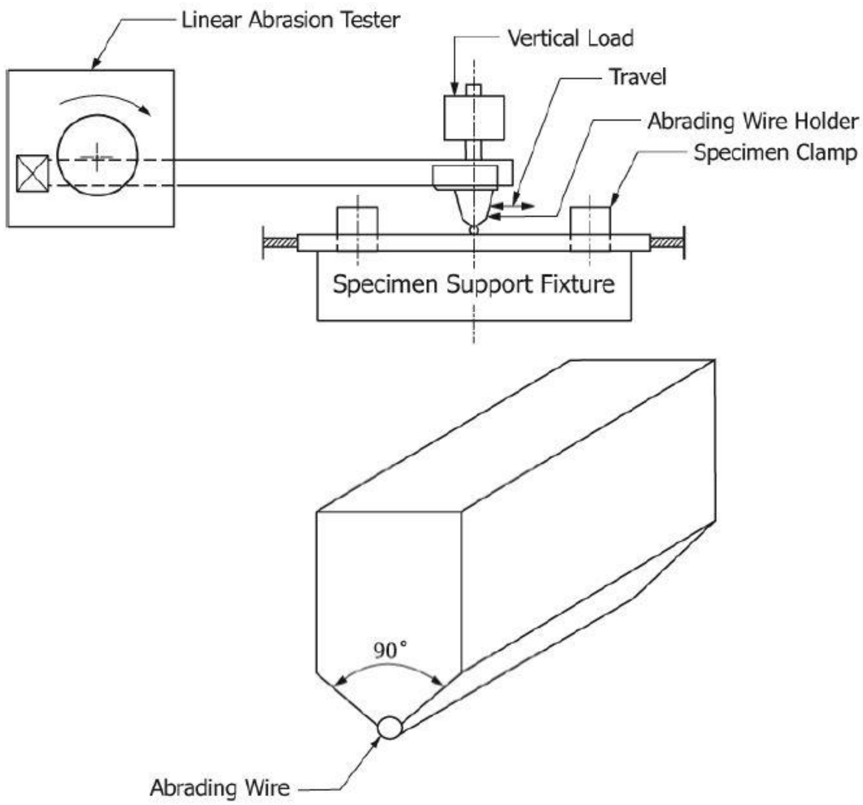


**Figure 7: Linear abrader**

**14. Marking**

The following information shall be legibly impressed on a corrosion-resistant metal tag that is securely attached to the longest side wall of a gabion or revet mattress:

a) The manufacturer's name or trade name or trade mark;

b) the date of manufacture; and

c) the size of the gabion or revet mattress.