

MACCAFERRI CIVIL ENGINEERING PRODUCTS

MACCAFERRI GABIONS

This HAPAS Certificate Product Sheet⁽¹⁾ is issued by the British Board of Agrément (BBA), supported by Highways England (HE) (acting on behalf of the Overseeing Organisations of the Department for Transport; Transport Scotland; the Welsh Government and the Department for Infrastructure, Northern Ireland), the Association of Directors of Environment, Economy, Planning and Transport (ADEPT), the Local Government Technical Advisers Group and industry bodies. HAPAS Certificates are normally each subject to a review every three years.

(1) Hereinafter referred to as 'Certificate'.

This Certificate relates to Maccaferri Gabions, cages formed from hexagonal double-twisted mesh of polymer coated galvanized wire, used with selected fill material for retaining wall structures, river training works and erosion control, in both temporary and long-term applications.

CERTIFICATION INCLUDES:

- factors relating to compliance with HAPAS requirements
- factors relating to compliance with Regulations where applicable
- independently verified technical specification
- assessment criteria and technical investigations
- design considerations
- installation guidance
- regular surveillance of production
- formal three-yearly review.

KEY FACTORS ASSESSED

Structural performance — the products, when used correctly in a fully designed application, will have adequate strength to resist the anticipated loads and the designed long-term performance (see section 6).

Resistance to weathering — the products will have adequate resistance to weathering (see section 7).

Durability — when used in accordance with the requirements of this Certificate, the polymer-coated gabions may be considered to have a life expectancy in excess of 120⁽¹⁾ years (see section 9).

(1) Excludes the effects of adverse abrasion.

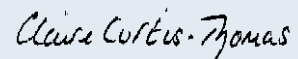


The BBA has awarded this Certificate to the company named above for the products described herein. These products have been assessed by the BBA as being fit for their intended use provided they are installed, used and maintained as set out in this Certificate.

On behalf of the British Board of Agrément



Paul Valentine
Technical Excellence Director



Claire Curtis-Thomas
Chief Executive

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Originally certificated on 22 June 2017

The BBA is a UKAS accredited certification body – Number 113.

The schedule of the current scope of accreditation for product certification is available in pdf format via the UKAS link on the BBA website at www.bbacerts.co.uk. Readers are advised to check the validity and latest issue number of this Agrément Certificate by either referring to the BBA website or contacting the BBA direct. Any photographs are for illustrative purposes only, do not constitute advice and should not be relied upon.

British Board of Agrément

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Requirements

The Highways Technical Advisory Committee has agreed with the BBA the aspects of performance to be used by the BBA in assessing Maccaferri Gabions.

In the opinion of the BBA, Maccaferri Gabions, when manufactured and installed in accordance with the provisions of this Certificate and the Department of the Environment, Transport and the Regions, Highways England (DETR, HE) Standard HD22 *Ground Investigations and Earthworks Procedure for Geotechnical Certification*, are suitable for use in short- and long-term applications including retaining wall structures, river training and erosion control.

The design, materials specification and construction methods adopted must be in accordance with the *Manual of Contract Documents for Highway Works* (MCHW)⁽¹⁾ Volume 1 *Specification for Highway Works* (SHW), BS 8002 : 2015, and BS EN 1997-1 : 2004 and its UK National Annex.

Additional site requirements may be included on particular projects.

(1) The MCHW is operated by the Overseeing Organisations: Highways England (HE), Transport Scotland, the Welsh Government and the Department for Infrastructure (Northern Ireland).

Regulations

Construction (Design and Management) Regulations 2015

Construction (Design and Management) Regulations (Northern Ireland) 2016

Information in this Certificate may assist the client, designer (including Principal Designer) and contractor (including Principal Contractor) to address their obligations under these Regulations.

See section: 3 *Delivery and site handling* (3.1, 3.3 and 3.4) of this Certificate.

Additional Information

CE marking

The Certificate holder has taken the responsibility of CE marking the products and their applications in accordance with ETA 15/0219. An asterisk (*) appearing in this Certificate indicates that data shown are given in the manufacturer's Declaration of Performance.

Technical Specification

1 Description

General

1.1 Maccaferri Gabions are cages formed from hexagonal double-twisted wire mesh panels made of galvanized (zinc-aluminium alloy) steel wire protected with PVC⁽¹⁾, PA6⁽²⁾ or PoliMac⁽³⁾⁽⁴⁾ polymer coating, fabricated into cage structures to be filled with selected granular material (gabion fill).

(1) PVC coating in accordance with BS EN 10245-2 : 2011.

(2) Maccaferri PA6 is an environmentally safe, extruded polyamide coating applied to galvanized mild steel wire to provide increased resistance against mechanical damage, low friction coefficients, long term strength and elasticity, improved adhesion to wire, low liquid penetration for corrosion process, and improved performance in cold temperature.

(3) Maccaferri PoliMac is an environmentally safe an extruded polymer specifically developed with an additional masterbatch, to provide increased resistance to abrasion and to mechanical damage, an improved performance in cold and hot temperatures, and a better performance to UV radiation. The properties of the Polimac coating are in accordance with BS EN 10245-1 : 2011.

(4) Polimac is a registered trademark.

1.2 The products are available in a wide range of standard sizes, as defined in Table 1. Non-standard sizes can be manufactured for specific design requirements.

Table 1 Standard sizes of Maccaferri Gabions fabricated from mesh with a core diameter of 2.7 mm

Length ⁽¹⁾ (mm)	Width ⁽¹⁾ (mm)	Height ⁽¹⁾ (mm)
1	1	0.5 or 1
1.5	1	0.5 or 1
2	1	0.5 or 1
3	1 or 2 or 3	0.5 or 1
4	1 or 2 or 3	0.5 or 1
5	2 or 3	0.5
6	2 or 3	0.5

(1) Values are given in ETA 15/0219.

Note: Non-standard sizes are available for special order with specific design requirements to be checked with the Certificate holder.

Wire mesh

1.3 The hexagonal double-twisted wire mesh is manufactured from steel wire in compliance with BS EN 10218-1 : 2012 and BS EN 10218-2 : 2012. The steel wire has a minimum tensile strength in the range of 350 to 550 N·mm², with a minimum elongation at rupture of 8%, and is drawn from rods complying with BS EN ISO 16120-1 : 2017 and BS EN ISO 16120-2 : 2017.

1.4 The metallic coating is classified Class A⁽¹⁾ for PVC and PoliMac coated wire with nominal thickness of 0.5 mm, and Class E⁽²⁾ for PA6 coated wire with nominal thickness of 0.4 mm. Wire specifications are given in Table 2.

(1) Class A coating, as defined in BS EN 10244-2 : 2009, Table 2, relates to the highest coating thickness.

(2) Class E coating, as defined in BS EN 10244-2 : 2009, Table 2, for which corrosion resistance must be at least equivalent to that of zinc coating to Class B in BS EN 10244-2 : 2011, Table 1.

Table 2 Standard mesh wire specification

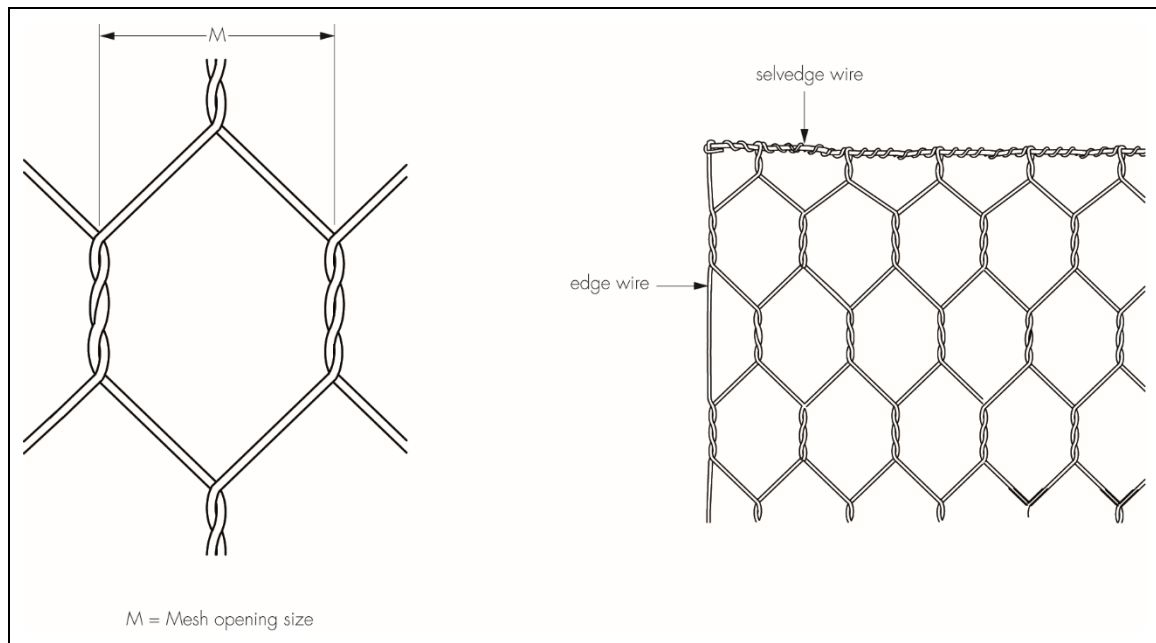
Galvanized wire without polymer coating ⁽¹⁾		Galvanized wire with PVC, PA6 or PoliMac coating ⁽²⁾	Minimum Zn or Zn-Al coating Class A	Minimum Zn-Al coating for PA6 coated wire Class E
Nominal diameter (mm)	Tolerance (mm)	Nominal diameter (external) (mm)	(g·m ²)	(g·m ²)
2.0	± 0.05	3.0	215	60
2.2*	± 0.06*	3.2*	230*	60
2.4*	± 0.06*	3.4	230*	60
2.7*	± 0.06*	3.7*	245*	60
3.0*	± 0.07*	4.0	255*	60
3.4*	± 0.07*	4.4*	265*	60
3.9*	± 0.07*	4.9	275*	60

(1) Manufacturing reference: 8 x 10 mesh type.

(2) Values are given in ETA 15/0219.

1.5 The wire is woven into a hexagonal pattern mesh (see Figure 1) with double-twist joints. Larger diameter wire is introduced along the edges to create the selvedge at cut ends.

Figure 1 Details of hexagonal mesh



1.6 A gabion unit is fabricated from a base panel, two end panels and diaphragm panels (as appropriate, see Figure 2). To form these panels, the mesh is cut, during manufacture, to the required dimensions and selvedge wire positioned and mechanically fixed to the base panel. The gabion end panels are fixed to the base panel. Diaphragm panels, where provided, are connected to the base panel. The fabricated unit is conveniently folded, then packed into bundles for delivery.

1.7 Items used with the products, but outside the scope of this Certificate, include:

- gabion filling material
- backfill material.

1.8 An ancillary item for use with the products is lacing wire.

1.9 The Maccaferri Pneumatic Fixing Tool is a mechanical device for crimping stainless steel or galvanized steel Flex-C rings to the polymer-coated mesh or the galvanized steel mesh, respectively. Stainless steel rings are manufactured from 3 mm diameter stainless steel wire with a minimum tensile strength of 1550 MPa. Galvanized steel rings are manufactured from 3 mm diameter stainless steel wire with a minimum tensile strength of 1720 MPa, and coated with 255 g·m⁻² of Zn or Zn/5%Al. The pull-apart strength of the lacing rings is minimum of 2.0 kN.

2 Manufacture

2.1 The products are manufactured from galvanized steel wire, with or without polymer-coating, which is either manufactured by the Certificate holder or bought in to the Certificate holder's specification. Certificates of conformity and/or mill certificates are supplied with each batch of bought-in wire.

2.2 Maccaferri Gabion end panels and diaphragms have a selvedge wire along their upper edges. The cut ends are mechanically selvedged with a wire of greater diameter than that used for the mesh (see Table 2 and Figure 1).

2.3 As part of the assessment and ongoing surveillance of product quality, the BBA has:

- agreed with the manufacturer the quality control procedures and product testing to be undertaken
- assessed and agreed the quality control operated over batches of incoming materials
- monitored the production process and verified that it is in accordance with the documented process
- evaluated the process for management of nonconformities
- checked that equipment has been properly tested and calibrated
- undertaken to carry out the above measures on a regular basis through a surveillance process, to verify that the specifications and quality control being operated by the manufacturer are being maintained.

2.4 The management system of Maccaferri Ltd has been assessed and registered as meeting the requirements of BS EN ISO 9001 : 2015 by CERTICOM/Slovak Republic (Certificate CM5620718/1). The management system of Maccaferri Ltd has also been certified by SGS UK for geotechnical design and supplying of retaining structures, erosion protection works, highway and bio-engineering systems (Certificate GB01/52789).

3 Delivery and site handling

3.1 The gabions are delivered to site in bundles weighing from 600 to 900 kg, depending on unit size and mesh specification. A label bearing the Certificate holder's name, the batch and product code numbers, and the BBA logo incorporating the number of this Certificate, is attached to each bundle.

3.2 The products may be stored in the open, but away from site traffic to avoid the risk of accidental damage, and should remain packaged until required.

3.3 All bundles must be handled with due care to avoid damage to the polymer coating. Individual units can be manhandled. Individual units vary in weight between approximately 10 and 75 kg, and the appropriate number of people required to lift the units must therefore be assessed to satisfy manual lifting limits.

3.4 Lacing wire is supplied in 25 kg coils.

Assessment and Technical Investigations

The following is a summary of the assessment and technical investigations carried out on Maccaferri Gabions.

Design Considerations

4 Use

4.1 Maccaferri Gabions, used with selected fill materials, are satisfactory for use as retaining wall structures, river training and erosion control, in both short- and long-term applications. Where required by the overseeing authority, the gabions must be protected by the use of environmental barriers, as recommended in HE 85/01.

4.2 The design of structures using Maccaferri Gabions should be carried out by a suitably qualified engineer in accordance with BS EN 1997-1 : 2004, BS 8002 : 2015 and BS 6031 : 2009.

4.3 The design of the gabion structures must be based on the principle of mass gravity earth-retaining walls. Additional allowances may be made to account for the effect of the wire mesh.

4.4 The magnitude and distribution of the earth pressures and earth resistance should be calculated in accordance with current design practices and available guidelines.

4.5 As with other earth-retaining structures, it is necessary to ensure by design that a suitable factor of safety is achieved against the following potential modes of failure:

- overall stability
- overturning
- shearing pressure
- sliding
- internal stability.

4.6 The designer should specify the relevant properties of both the gabion stone fill and backfill material (placed behind the cages) as deemed 'acceptable' for the purpose of the design. 'Acceptable' materials must meet the requirements of the MCHW, Volume 1 SHW.

4.7 The density of filled gabions depends on both the granulometric curve of the filling stones and the installation procedures: generally it should be taken as 60 to 70% of the density of the solid material. A higher value may be

appropriate in certain circumstances, but this will be the responsibility of the consulting engineer who must ensure that the design value is achieved on site.

4.8 The stone infill of the gabions is normally sized between 100 and 200 mm and will depend on the mesh size, the lower limiting size being controlled by the dimensions of the mesh. The fill should satisfy the requirements of the MCHW, Volume 1 SHW, Class 6G⁽¹⁾. The fill must be a hard, durable material, eg stone as quarried or naturally occurring rounded stone (in accordance with BS EN 13383-1 : 2002).

(1) The MCHW, Volume 1, Series NG 600 *Earthworks*.

4.9 Gabion walls can be constructed with a minimum radius of curvature of 25 m on plan without modification of the gabion structure.

4.10 Watercourse linings, weirs and/or other hydraulic or erosion protection structures may require special consideration in regard to scour, uplift, wave action, seepage, etc.

4.11 The specification of the mesh for the gabions should be chosen to achieve the required design life (see section 9).

5 Practicability of installation

The products are designed to be installed by a competent general builder, or contractor, experienced with these types of products, and are easily installed under normal site conditions.

6 Structural performance

6.1 When installed in accordance with the Certificate holder's installation guidelines and this Certificate, the gabions have adequate strength to resist all loads associated with handling, positioning and filling.

6.2 Gabion walls are permeable and, in general, will not allow hydrostatic pressure to build up behind the wall. Gabion earth-retaining structures are not normally designed to withstand hydrostatic pressure.

6.3 Where cohesive material, such as clay, is retained, water movement may cause it to exude into the gabion structure and block the passage of water. To reduce the risk of a build-up of hydrostatic pressure in these conditions, it may be necessary to provide additional granular layers behind the gabion structure to allow water to drain away.

6.4 Maccaferri Gabion cages have adequate strength to permit pre-filling and placing by crane, carried out in accordance with the Certificate holder's instructions.

7 Resistance to weathering

7.1 Some localised damage may occur to the polymer coating during installation and in exposed areas this may lead to local corrosion of the mesh. Site evidence and test data indicate that such damage will not spread and will not cause sequential corrosion underneath the intact adjacent area of mesh. The design of the wire mesh, and the fact that the strength of the external facing mesh is not used in the design of the structure as a whole, indicate that this local damage will not affect the integrity of the structure.

7.2 A gabion wall is a mass earth-retaining structure and settlement may occur under the action of its self-weight. The movement associated with this will gradually increase the density of the structure and reduce the volume of voids. Additional settlement may occur when gabions are founded on weak soils.

7.3 A gabion wall will permit the growth of vegetation, which will contribute to the integrity of the structure and to maintaining a natural appearance.

8 Maintenance and repair

Routine maintenance is not normally required; however, should the exposed gabion be damaged, additional or replacement panels can readily be fixed to the structure.

9 Durability

9.1 For a particular installation environment, the most appropriate Maccaferri mesh wire coating specification may be selected in accordance with BS EN 10223-3 : 2013, Annex A, to satisfy the required project design life.

9.2 Evidence from tests show that the polymer-coated, Zn-Al alloy galvanized wire, has good resistance to chemical corrosion, bio-degradation, temperature effects and ultraviolet exposure and will not be affected by the chemicals normally encountered in earth-retaining structures.

9.3 The life of a gabion structure is dependent on the quality of the mesh, the durability of the stone fill and, in the longer term, the stability of the consolidated mass of the infill material and the conditions of exposure encountered during the structure's design life.

9.4 In the opinion of the BBA, when used and installed in accordance with this Certificate, the polymer coated gabions may be considered to have a design life in excess of 120 years.

9.5 The Certificate holder can advise on the life expectancy of products used in river erosion and coastal protection schemes and the design of such installation if required to optimise the performance of the system.

10 Reuse and recyclability

The products are made from polymer-coated (PVC, PA6 or PoliMac), galvanized (zinc-aluminium alloy) steel wire, which can be recycled.

Installation

11 General

11.1 Installation of Maccaferri Gabions must be in accordance with this Certificate and the Certificate holder's installation instructions.

11.2 Prior to and during installation, particular care must be taken to ensure that:

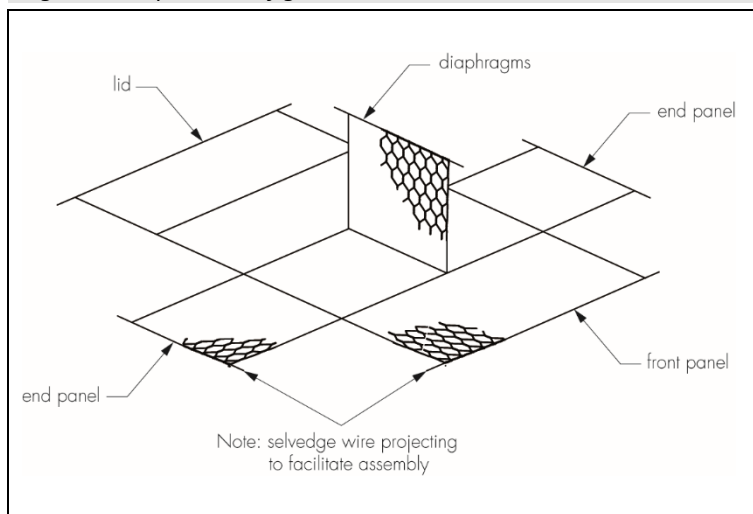
- site preparation and gabion foundation are in accordance with the contract drawings
- gabion construction is as detailed in section 12
- fill properties (gabion stone and backfill) satisfy the design specification
- drainage is adequate at all stages of construction, as required by the contract documents
- the system is protected against damage from site traffic and installation equipment
- the stability of existing structures is not affected.

12 Procedure

In-situ filled gabions units

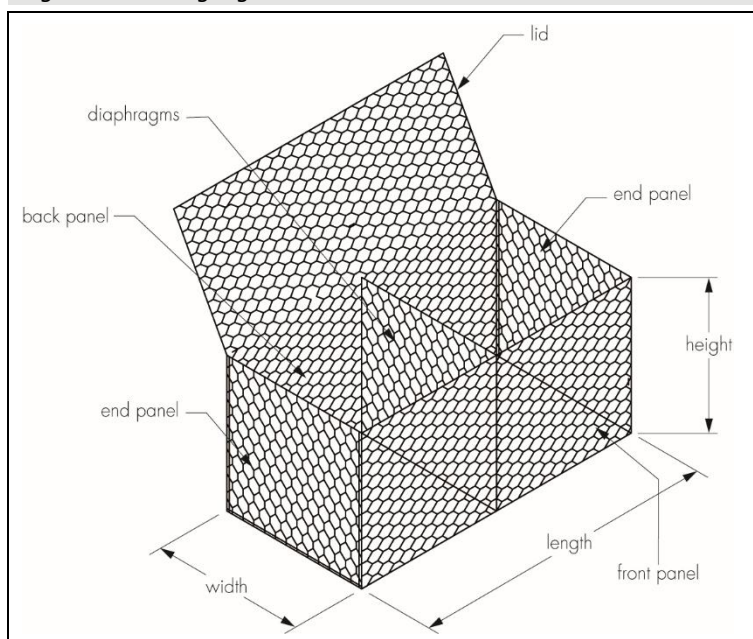
12.1 The flat-packed gabion cages are opened and folded on a hard surface, pressing out any unwanted creases (see Figure 2).

Figure 2 Preparation of gabion boxes



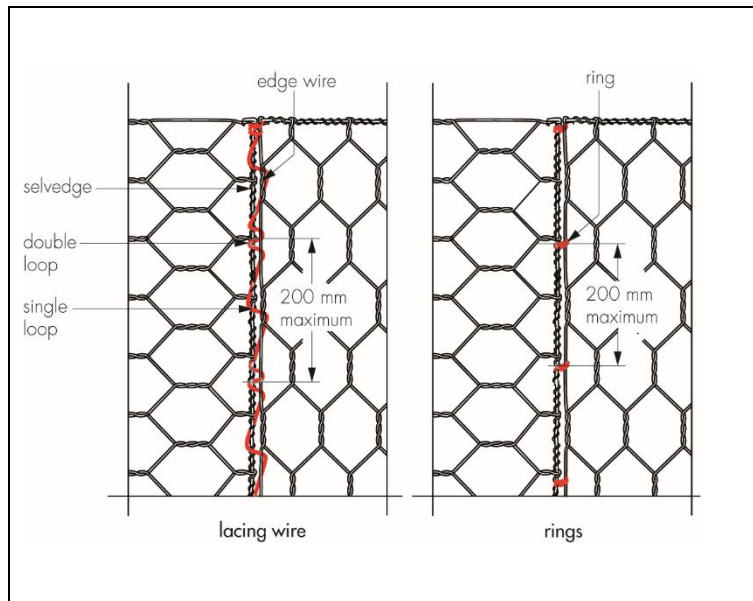
12.2 The front and rear sides, ends and diaphragm are lifted into position to form a box shape (see Figure 3).

Figure 3 Forming a gabion box



12.3 Top corners are secured with the projecting lengths of thick selvedge wire. Vertical edges are then joined together, starting from the top, using either the appropriate lacing wire, in a continuous operation with alternate single and double twists, or with rings applied using the Maccaferri Pneumatic Fixing Tool (see Figure 4).

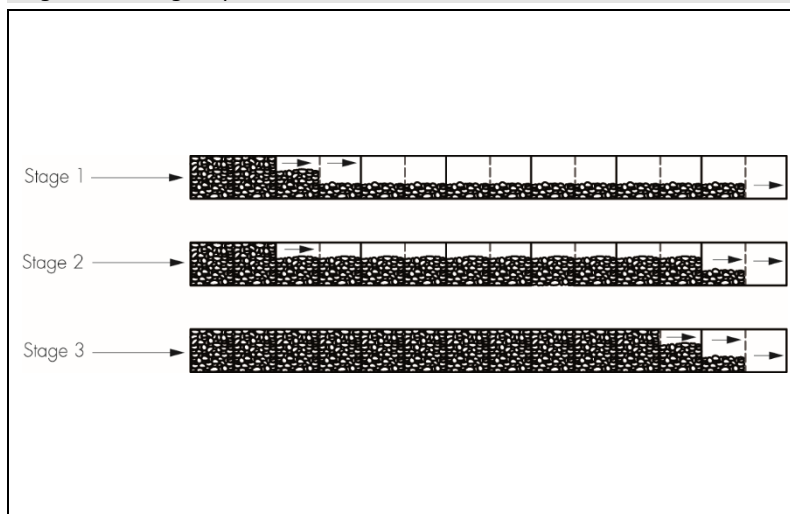
Figure 4 Typical Wiring pattern



12.4 A number of empty gabions are placed in position on a flat surface and secured together as described in section 12.3.

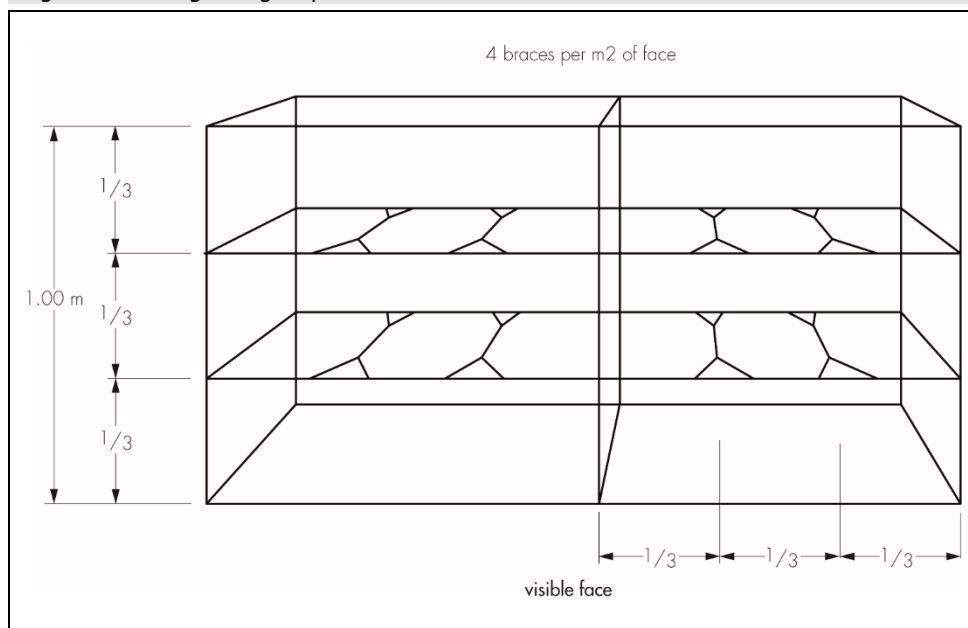
12.5 The gabions are filled progressively, in one third height layers, with suitable stone. To ensure a good finished appearance, all visible faces should be carefully hand-packed. Gabions should be overfilled to allow for natural settlement of the rock fill, see Figure 5.

Figure 5 Filling Sequence



12.6 Gabions forming the exposed face of a structure should be filled to one-third height, braced from front to rear with bracing wires (lacing wire) located as shown in Figure 6, then filled to two-thirds height and again braced (see Figure 6). Four bracing wires should be provided for each square metre of visible face. Filling may then be completed.

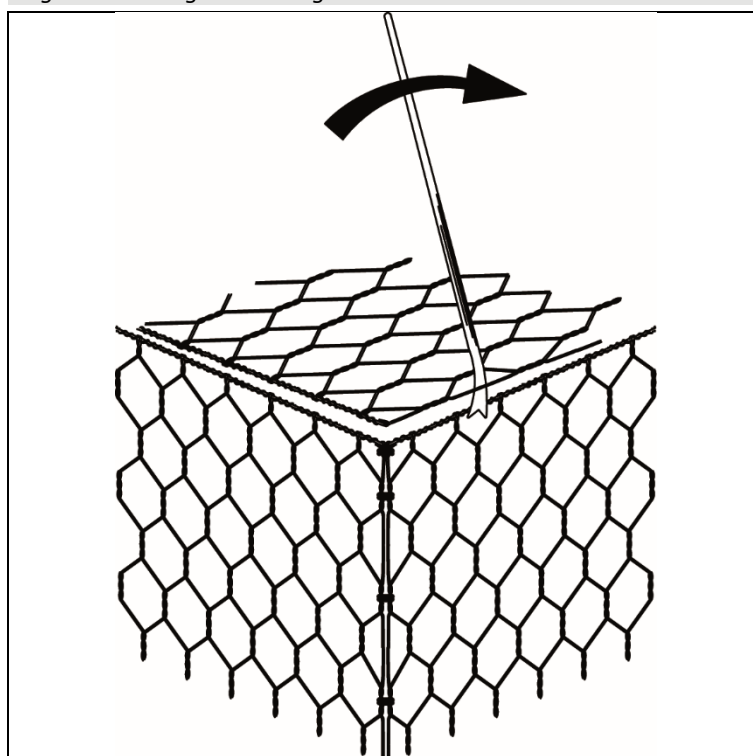
Figure 6 Bracing Filling Sequence



12.7 When considered necessary for aesthetic or other considerations, the gabion may be filled whilst under tension. Gabions are tensioned by applying a load, distributed over the full end panel of a row of gabions, to the first cell which has been anchored in position. An external frame may also be used.

12.8 On completion of the gabion cage filling, the mesh lid is folded down, stretched into position and laced to the top of the front and side panels/adjacent gabion, and the top of any diaphragms.

Figure 7 Closing the lid on gabions



12.9 The remaining row of gabions is then filled sequentially in the same manner.

12.10 It is essential that each gabion is properly secured to adjacent gabions above, below and on each side, using the lacing wire as described in section 12.3.

Pre-filled gabions units

12.11 The Certificate holder should be contacted for specific advice on the pre-filling procedure.

12.12 Prefilled Gabion units [traded under the name Readymac⁽¹⁾ or Cubiroc⁽¹⁾] are constructed as described in sections 12.1 to 12.9, but with double loop lacing throughout. It is advantageous to construct a slightly oversized frame within which the empty unit can be held, stretched taut during filling. For example, Cubiroc units are filled using a special frame combined with a shaking table to ensure that the stone are compacted by vibration.

(1) Readymac and Cubiroc are registered trademarks.

12.13 During the filling operations, reinforcing steel bars or lifting straps are included to maintain the shape of the gabion during lifting.

12.14 Purpose-made lifting frames and slings must be used for lifting the filled units, which weigh up to 1.8 tonnes per cubic metre.

Technical Investigations

13 Investigations

13.1 The manufacturing process was evaluated, including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

13.2 An assessment of data was made to determine:

- dimensional accuracy*
- tensile strength*
- quantity of galvanized coating*
- the effect of tolerances
- strength of wire, mesh and filled gabions
- quality of materials
- quality of plastic coating
- ease of assembly
- compliance with the MCHW, Volume 1, Clause 262
- specification (see sections 1.1 and 5.1)
- design procedures
- strength of the lifting frame
- durability effect of site damage
- equivalent performance of zinc-aluminium alloy steel and galvanized coated wire.

13.3 Site visits were carried out to assess the practicability, ease of handling and installation under various site conditions.

Bibliography

BS 6031 : 2009 *Code of practice for earthworks*

BS 8002 : 2015 *Code of practice for earth retaining structures*

BS EN 1997-1 : 2004 + A1 : 2013 *Eurocode 7 : Geotechnical design — General rules*

NA to BS EN 1997-1 : 2004 + A1 : 2013 UK National Annex to *Eurocode 7 : Geotechnical design — General rules*

BS EN 10218-1 : 2012 *Steel wire and wire products — General — Test methods*

BS EN 10218-2 : 2012 *Steel wire and wire products — General — Wire dimensions and tolerances*

BS EN 10223-3 : 2013 *Steel wire and wire products for fencing and netting — Hexagonal steel wire mesh products for civil engineering purposes*

BS EN 10244-2 : 2009 *Steel wire and wire products. Non-ferrous metallic coatings on steel wire. Zinc or zinc alloy coatings*

BS EN 10245-1 : 2011 *Steel wire and wire products — Organic coatings on steel wire — General rules*

BS EN 10245-2 : 2011 *Steel wire and wire products — Organic coatings on steel wire — PVC finished wire*

BS EN 13383-1 : 2002 *Armourstone — Specification*

BS EN ISO 9001 : 2015 *Quality management systems — Requirements*

BS EN ISO 16120-1 : 2017 *Non-alloy steel wire rod for conversion to wire — General requirements*

BS EN ISO 16120-2 : 2017 *Non-alloy steel wire rod for conversion to wire — Specific requirements for general-purpose wire rod*

Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works, Series 600 Earthworks
Manual of Contract Documents for Highways Works, Volume 2- Series NG 600 Earthworks

ETA 15/0219 *European Technical Assessment- Hexagona Woven Mesh Gabion Boxes and Mattresses, version 01 of 07/04/201*

ETA 16/0758 *Officine Maccaferri S.p.A. Hexagonal double twisted wire meshes, and hexagonal double twisted wire meshes with inserted wire ropes*

14 Conditions

14.1 This Certificate:

- relates only to the product/system that is named and described on the front page
- is issued only to the company, firm, organisation or person named on the front page – no other company, firm, organisation or person may hold claim that this Certificate has been issued to them
- is valid only within the UK
- has to be read, considered and used as a whole document – it may be misleading and will be incomplete to be selective
- is copyright of the BBA
- is subject to English Law.

14.2 Publications, documents, specifications, legislation, regulations, standards and the like referenced in this Certificate are those that were current and/or deemed relevant by the BBA at the date of issue or reissue of this Certificate.

14.3 This Certificate will remain valid for an unlimited period provided that the product/system and its manufacture and/or fabrication, including all related and relevant parts and processes thereof:

- are maintained at or above the levels which have been assessed and found to be satisfactory by the BBA
- continue to be checked as and when deemed appropriate by the BBA under arrangements that it will determine
- are reviewed by the BBA as and when it considers appropriate.

14.4 The BBA has used due skill, care and diligence in preparing this Certificate, but no warranty is provided.

14.5 In issuing this Certificate the BBA is not responsible and is excluded from any liability to any company, firm, organisation or person, for any matters arising directly or indirectly from:

- the presence or absence of any patent, intellectual property or similar rights subsisting in the product/system or any other product/system
- the right of the Certificate holder to manufacture, supply, install, maintain or market the product/system
- actual installations of the product/system, including their nature, design, methods, performance, workmanship and maintenance
- any works and constructions in which the product/system is installed, including their nature, design, methods, performance, workmanship and maintenance
- any loss or damage, including personal injury, howsoever caused by the product/system, including its manufacture, supply, installation, use, maintenance and removal
- any claims by the manufacturer relating to CE marking.

14.6 Any information relating to the manufacture, supply, installation, use, maintenance and removal of this product/system which is contained or referred to in this Certificate is the minimum required to be met when the product/system is manufactured, supplied, installed, used, maintained and removed. It does not purport in any way to restate the requirements of the Health and Safety at Work etc. Act 1974, or of any other statutory, common law or other duty which may exist at the date of issue or reissue of this Certificate; nor is conformity with such information to be taken as satisfying the requirements of the 1974 Act or of any statutory, common law or other duty of care.