GEOFABRICS®
Smarter Infrastructure

THE GABION GUIDE

INSTALLATION

REV: OCTOBER 2019

MACCAFERRI

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NOTICE AND ASSUMPTIONS

Geofabrics (also the “Company”) supplies all components and accessories which shall be used for construction of the Gabions structures described in detail in the Construction Designs approved and accepted by the Contractor.

This manual (hereinafter also the “Manual”) represents a guide to the construction and gives practical guidance for the organization and control of the related operations. The Contractor’s personnel (site agent, foreman in charge of the works, etc..) and the Engineer’s staff shall be aware of the contents of the manual before the delivery of the materials to site.

The Manual is addressed to the Contractor only. The content is confidential and, save as provided below, is for discussion with, and use by, the Contractor (and no one else) and the latter shall not be entitled to assign, transfer or charge any information and/or interest it may have in the Manual. No other person/entity is entitled to rely on the Manual for any purpose whatsoever and Geofabrics accept no responsibility, duty or liability to any other person in respect of the contents of the Manual.

Neither this Manual nor the data contained herein shall be reproduced, used or disclosed to anyone without the written authorization of Geofabrics; in this regard the Manual should not be provided, without our prior written specific consent, to anyone other than the Contractor and only on the basis that it is strictly confidential; it being understood that Geofabrics accept no liability to them, they should not rely on it and they should not provide copies of it to any other person.

The instructions given in the Manual are of a general nature, and do not, therefore, exempt the Contractor from the obligations and responsibilities for the definition and correct execution of all the specific operations required for implementation of the project (construction sequence, loading and unloading procedures, safety plans, etc.). In such respect, Geofabrics will not be liable for any inaccuracies or omissions in the execution results and will not bear the consequences of any connected liability. The details given in this manual do not exempt the Contractor from compliance with the Construction Designs, Technical Specifications, Conditions of Contract provided by third parties and safety requirements related to the site. In any case, the Manual does not replace the Construction Designs realized by the appointed project designer.

At regards, when the structure to be installed has some special details, these will be defined in the Construction Design drawings. In the case of ambiguities or discrepancies between the Construction Design documents and this manual, the former documents will take priority.

If requested, Geofabrics, will send a technician to site at the start of construction to assist the Contractor in setting up the correct execution procedures, being understood that such activity shall not entail any obligation of result for Geofabrics.

This installation Manual is not intended to provide to the Contractor an exhaustive summary of guidance for the organization and control of the related operations regarding GABIONS. All possible issues which may arise in connection with this Manual shall not be attributed to Geofabrics

Where the installation Manual reproduces or summarizes any information and/or description concerning GABIONS, Geofabrics does not accept any responsibility, duty or liability for the truth, accuracy or completeness of such information or opinion in any way whatsoever (including whether or not such information or opinion is misleading, by omission or otherwise).

INTRODUCTION

Gabions are baskets manufactured from double twisted hexagonal woven steel wire mesh 6x8 or 8x10 type, produced in compliance with CPR - Construction Product Regulation 305/2011, and UNI EN 10223-3:2013, having EC marking in compliance with ETA-15/0219.

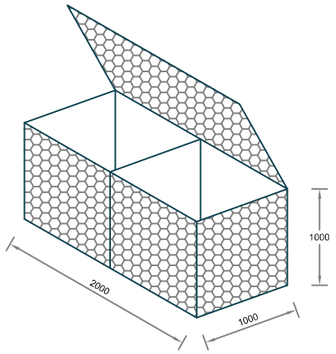
The management and production system is certified in compliance with standards ISO 9001 and ISO 14001.

Gabions are used for the following purposes:

- Retaining structures
- River works
- Erosion control
- Noise barriers
- Architectural works

Gabions are filled with stones at the project site to form flexible, permeable, monolithic structures such as retaining walls, channel linings and weirs for erosion control projects.

In order to reinforce the structure, all mesh panel edges are selvedged with a wire having a greater diameter.



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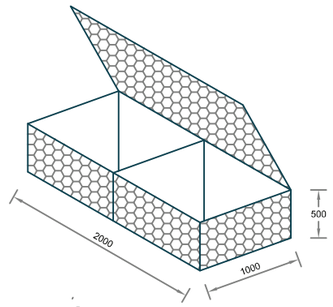

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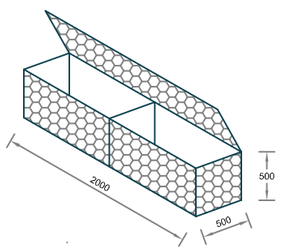

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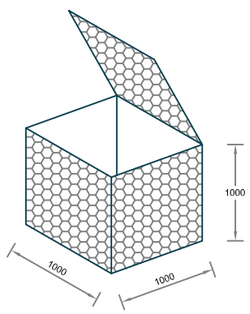

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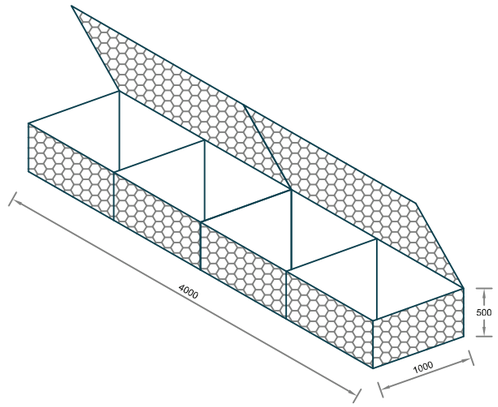

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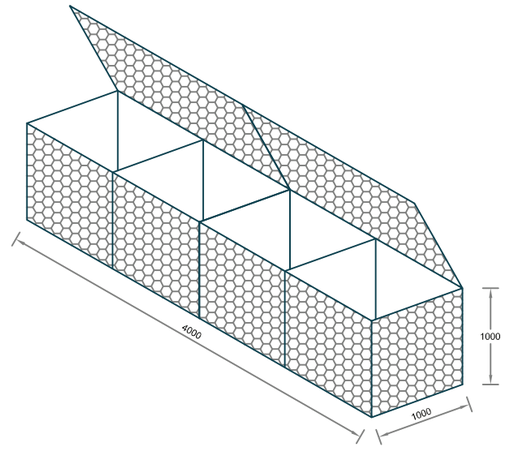
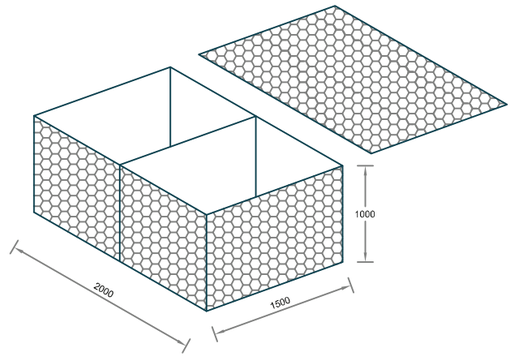


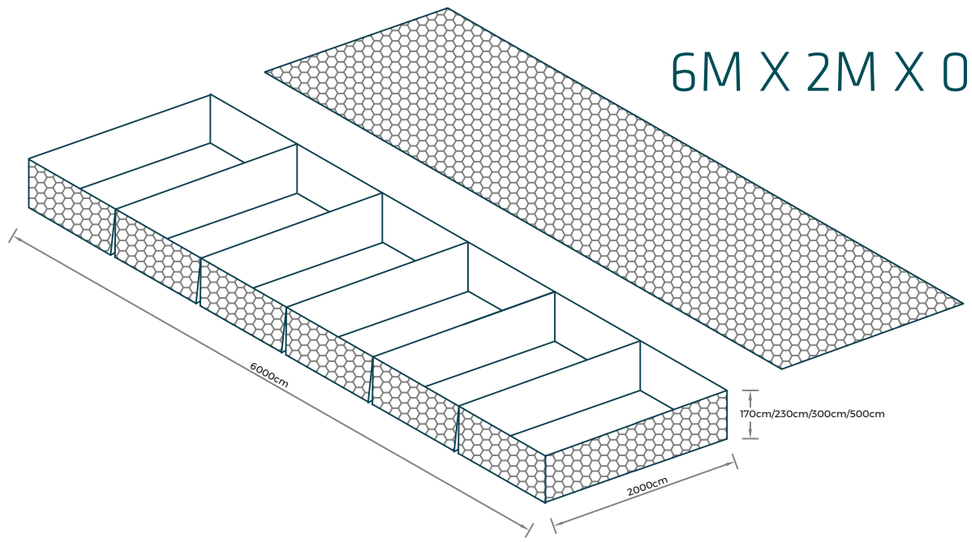
4M X 1M X 1M



2M X 1.5M X 1M

Reno Mattresses shall be “Castoro” type manufactured from double twisted, hexagonally woven wire mesh of nominal 60x80 mesh, with 2.4mm old frame wire and 2.0mm old mesh wire, complete with diaphragms at 1 m centres.

Diaphragms shall consist of two layers of mesh having the base of the Mattress and the diaphragms manufactured from one continious mesh panel.



6M X 2M X 0.5M

IMPORTANT INFORMATION

RESPONSIBILITIES

The Contractor is responsible for a correct execution of the works in compliance with the Construction Design documents, the Technical Specifications and the Contract Documents (not provided by Geofabrics). In order to assist the Contractor, Geofabrics provides the recommendations contained in this manual, but they in no case relieve the Contractor of the responsibility to comply with all the current safety regulations and procedures. Geofabrics will not be liable for any inaccuracies or omissions in the execution results and will not bear the consequences of any connected liability.

The Contractor and the Client must check that the site personnel appointed for performance of the works are in possession of a copy of this Manual and are aware of its contents.

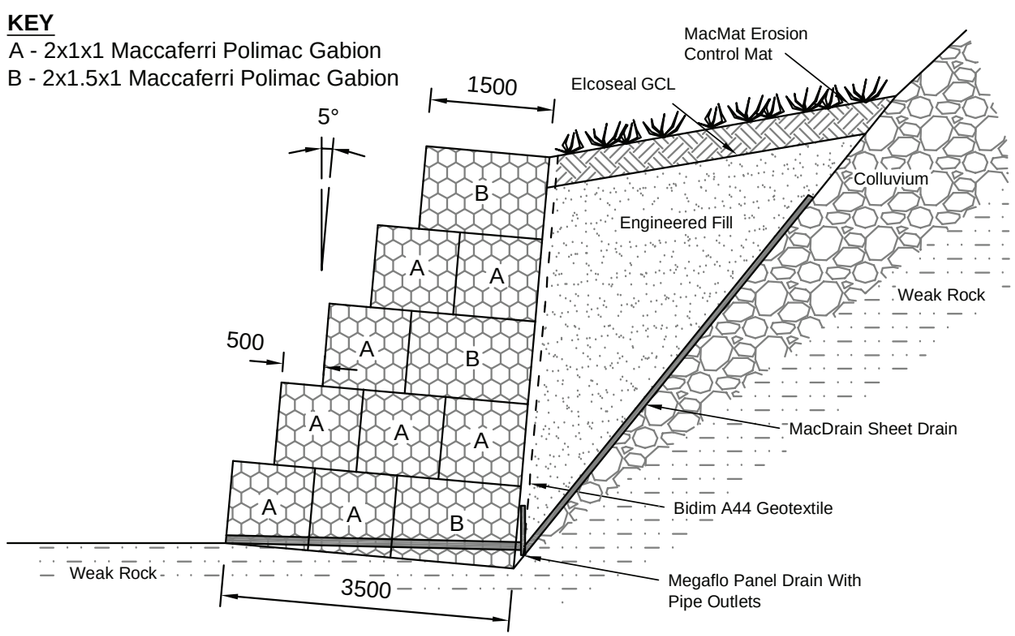
If previously agreed with the Contractor, the Technical Representative of Geofabrics will be present on site during the initial phases of the works. The Technical Representative will assist the Contractor in planning the deliveries and will provide advice on the installation procedures recommended for the gabions as described in this Manual, being understood that the Technical Representative's assistance shall be considered as mere support to the Contractor and it shall not be binding for the latter, which shall assume all responsibility connected to installation and execution procedures.

This Technical Representative will not be present on site for the entire duration of the works, and shall not be considered as a substitute of the supervision and quality control staff appointed by the Contractor and the Client.

CONSTRUCTION DESIGN

Before starting any operations on site, the Contractor shall ensure that the latest version of the related Construction Design, duly approved for Construction, is used in the construction of the structure.

The Contractor must also carry out topographical survey checks to ensure that the structure is constructed in the required position.



SPECIFICATION FOR GABION AND RENO MATTRESS ROCK

TYPE OF ROCK

The filling rock to be used in gabion baskets and mattresses shall be produced from dense, hard, durable and clean rock. The

rock shall resist weathering actions of air and water, it shall not be cracked or have visible defects which may reduce its structural capabilities (Ref. 1 Clause 8.1)

Materials with a density of 2400 kg/m3 or higher are preferable.

Australian Standard 2758.4

TYPE OF ROCK	DENSITY (KG/M^3)	DENSITY (KN/M^3)
Basalt	2900	29
Granite	2600	26
Hard Limestone	2600	26
Hard Sandstone	2400	24
Soft Sandstone	2300	23

TABLE 1—Typical Density Of Different Types of Rock (Ref 2. Clause 2.2.2)

GABION ROCK SIZE

8x10 Mesh Size As Per Figure 1

The minimum rock size shall be 100mm
The maximum rock size shall be 250mm

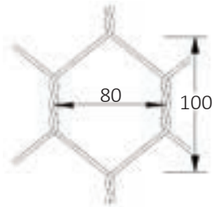


Figure 1. Gabion 8x10 Mesh

RENO MATTRESS ROCK SIZE

6x8 Mesh Size As Per Figure 2

The minimum rock size shall be 75mm
The maximum rock size shall be two-thirds the thickness of the mattress or 250mm, whichever is the lesser.
(Ref. 1 Clause 7)

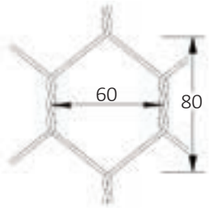


Figure 2. Mattress 6x8 Mesh Dimensions in mm

MATERIALS AND REQUIREMENTS BEFORE STARTING

This work shall consist of furnishing, assembling and filling woven wire mesh gabions with rock as specified in the contract to the dimensions, lines and grades shown on the plans, or determined by the engineer.

1. GABIONS

Gabions are manufactured with all components mechanically connected at the production facility. Units are delivered to site folded and compressed in bundles weighting approximately 800 kg, and measuring approximately 2x1 m in plan and 0.5 m in height; type and size determine the number of units per bundle.

2. RING FASTENERS

To increase the installation productivity, steel ring fasteners are used to connect units and to close and secure filled gabions (Fig 2).

The rings shall comply with EN 10223-3 and are supplied in box (1600 rings/box); these rings are available Galmac coated for the use with the corresponding type of material, or stainless steel for use with polymer coated mesh in highly corrosive environments. The indicative amount of rings depends on the size of the gabion units (Table 1)

Lacing wire is also used to assemble and interconnect the units; sufficient lacing wire is supplied in coils with each unit to enable assembly (Fig. 4). For Galmac and polymer coated gabions, Galmac and polymer coated lacing wire is used. Ensure that the correct type of lacing wire is available for use with the required structure, see Table 2:

To support the facing and to connect the front panel of a gabion 3,4mm pre-formed bracing wires (MacTie) may alternatively be used to the lacing wire (Fig. 4).

Fig. 4 - Lacing wire (top), pre-formed brace MacTie (bottom)

GABIONS	RINGS
H = 1 m with diaphragms	30-40 /m3
H = 1 m without diaphragms	30-40 /m3
H = 0.5 m	40-60 /m3

Table 1 - Suggested number of rings

Fig. 2 - Fastening Rings

PRODUCT	MESH TYPE	MESH WIRE DIAMETER (MM)	LACING WIRE DIAMETER (MM)
Gabions	6x8	2.20	2.20
	8x10	2.70	2.20
		3.00	2.40

Table 2 - Lacing wire diameters

3. GEOTEXTILE

A bidim (nonwoven) geotextile must be placed at the soil-gabion interface for separation and filtration purposes. Ensure that the correct type, grade and quantity is delivered to the site. The bidim range is available in various grades for different applications.

4. GABION STONES

Ensure that the correct quality, grading and quality of rock is available for the completion of the works. Rocks for filling the gabions shall be obtained by any suitable quarrying method. Rocks shall be hard, angular to round, durable and of such quality that they do not lose their integrity on exposure to water or weathering during the life of the structure. Rocks shall range between 100 mm and 200mm for 8x10 wire mesh gabions and between 75mm and 150mm for 6x8 wire mesh gabions. The range in sizes may allow for a variation of 5% oversize and/or 5% undersize rock, provided it is not placed on the exposed surface. In all cases, the oversize rock shall not be larger than 250mm and the undersize rock shall not be smaller than 50mm.

5. TOOLS

To aid the lacing and bracing operations, the use of pliers tight joints is recommended. Care shall be taken to avoid damaging to the wire coating. The teeth of the pliers should be ground to a smooth finish. Do not use fencing pliers as they damage the polymer coating. Care shall be taken when using crowbars for closing the lids as this also damages the coating. Available tools suitable for fasteners rings are shown in Fig. 2 and the picture to the right: Pneumatic (to be connected to a 6-7 bar air compressor, air pipe Φ max 10mm and max length 30m)

Fig. 3 - Compressor mounted in the tray for mobile use

6. DELIVERY AND STORAGE OF MATERIALS ON JOB SITE

Gabion units are delivered to the warehouse storage or construction site. The staff of the contractor is responsible for checking that the materials are supplied carefully in order to:

1. Ease loading and unloading operations
2. Avoid risk of damage during transportation
3. Keep the area accessible for any inspection controls
4. Promptly report any anomaly for the acceptance of the goods.

The delivered material is labelled so that the characteristics can be read and the products can be properly identified and used by the staff responsible for installation.

SITE REQUIREMENTS

CONSTRUCTION SITE MANAGEMENT

Gabion installation shall be managed as earthworks. The installation productivity will depend directly on the optimal management of the construction site. Installation includes facing and earthworks.

Note: It is suggested carrying out the installation of the soil filling during the installation of the gabion wall. In some cases the gabion wall might not be installed on more layers without the laying of backfill.

The height of gabions is 50 cm or 1 m, the minimum number of soil compaction layers will two for 50 cm high units and three for 1 m high units.

REQUIRED MACHINERY FOR INSTALLATION

Gabions – The units can be transported by a minimum of two workers. Their unloading from trucks shall be carried out with the help of handling equipment (mechanical shovel, manuscopic…). The filling of the cages shall be carried out with the help of mechanical shovel whose weight and arm length shall be adapted to the construction site configuration.

Backfilling – The backfill soil shall be transported by trucks and unloaded with the help of mechanical shovels. The choice of the machinery is left to the contractor as it depends on the condition of access to the site and the volume of soil fill. It is strictly prohibited to use the heavyweight machinery close to the facing (within 1 m from the facing).

Compaction – Vibratory rollers of adequate dimensions shall be used in function of the filling material (A1-a, A1-b, A3, A2-4 or A2-5 as per ASTM D3282). For uniformly distributed fine sand, it is suggested using non vibrating rollers. For the compaction of the backfill soil close to the facing, within a minimum width of 1 m, lightweight compaction devices, such as vibratory compactors and small vibratory rollers shall be used.

REQUIRED EQUIPMENT FOR INSTALLATION

- Equipment for topographic location
- Pliers, pincers, scissors
- Ring fasteners and lacing guns
- Safety devices

ESTIMATED WORKING TEAM

- 1 foreman (responsible for installation)
- 3 workers

WORK TO BE DONE BY THE CONTRACTOR

- Preparation of the construction site, including the foundation level, if necessary replacement of foundation soil and installation of drainage systems, impermeable membranes, geotextiles if they are included in the construction drawings.
- Preparation of the laying surface for soil fill and Gabions
- Safety devices installation
- Unloading and stock of materials
- Installation of Gabion and backfill soil
- Preparation of the systems required for the access and the maintenance of the construction site (access roads, banks, lateral draining channels, protections against bad weather)

OPTIONAL SERVICES PROVIDED BY MACCAFERRI

If requested, Geofabrics can provide the following services:

- Drawings used to obtain the BOQ of the elements required to build gabion structures
- Delivery to the site of the material provided (F.O.B.), considering an unloading time, from the arrival at site is relative to each branch.

MATERIALS PROVIDED BY GEOFABRICS

Geofabrics will provide the following materials:

- Gabion units
- Ring fasteners and tools
- Bidim Geotextile

The Certificate of conformity for the above-mentioned materials are supplied by Geofabrics It is, however, the Contractor’s responsibility to check that all the materials received comply with the Delivery Documentation and the Construction design requirements.

Any discrepancy must be recorded on the Delivery Documentation (or proof of delivery) at the time of unloading and immediately notified to Geofabrics

INSTALLATION

1. FOUNDATION PREPARATION

The foundation on which gabions are to be placed shall be levelled, and graded to the elevations as shown on the project construction drawings (Fig. 7).

The foundation for gabions shall be smooth, and free from surface irregularities, loose material and vegetation, in accordance with the project specifications.

To ease the construction of battered walls the foundation should be sloped at a maximum of 6 degrees.

The foundation should be compacted to the engineer's specification to ensure uniform bearing capacity and minimize differential settlements. When founding on a rock, a concrete levelling pad and dowel anchors are recommended.

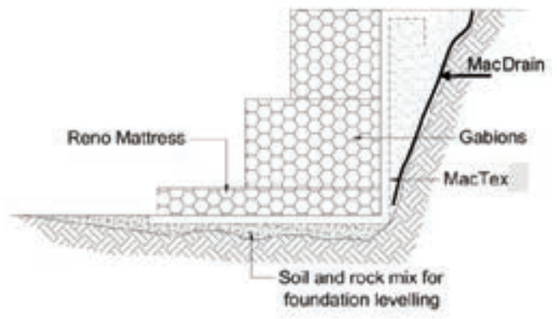


Fig. 7

2. SETTING OUT

Points marked should be start of the wall, end of wall and any internal/external angle changes or steps. Points required to be marked out must be at the front of the toe wall i.e. front base of wall at top of foundation level.

3. FLATTENING THE UNITS

Workers shall ensure to have a safe open level area adequate for opening the units.Each individual basket will be removed from the bundle; unfold the gabion flat on the ground and stretch the unit making sure all creases are in the correct position for forming the box (fig. 9).

Fig. 8

4. PLACING GEOTEXTILES

Geotextiles prevent the loss of fines from the soil behind the gabion structure though the rock fill and simultaneously negate the build-up of any water pressure behind the wall. The omission of the geotextile is detrimental to the integrity of the structures as a whole. Cut sufficient geotextile to line the structure along the soil-gabion interface. Place the geotextile on the prepared foundation, with the remaining geotextile temporarily draped along the backfill.

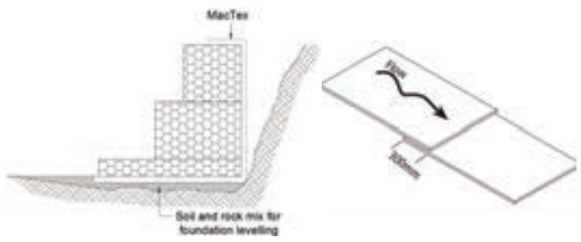


Fig. 11

5. ASSEMBLY AND LACING THE INDIVIDUAL UNITS

Front, back and end panels shall be lifted to a vertical position to form an open box shape, making sure tops of all four sides are at the same level. Panels shall be fastened together with the projecting heavier wire by firmly wrapping the selvedge wire around the selvedge or edge of the intersecting panel, or back panel. Inner diaphragms shall be lifted into vertical position and secured in the same manner.

Note: it is essential that the top corners meet (Fig. 9)

Secure the lacing at the top corners of the panels to be joined and laced from the top down. After that, in order to achieve the highest installation productivity rates fastening with rings is recommended instead of fastening with lacing wire.

When steel ring fasteners are used, the use of either a mechanical or a pneumatic fastening tool is required. Rings shall be installed at the top and the bottom connections of the end and centre diaphragms and then a maximum spacing of 200 mm along all edges shall be used (Fig. 10).

Fig. 9

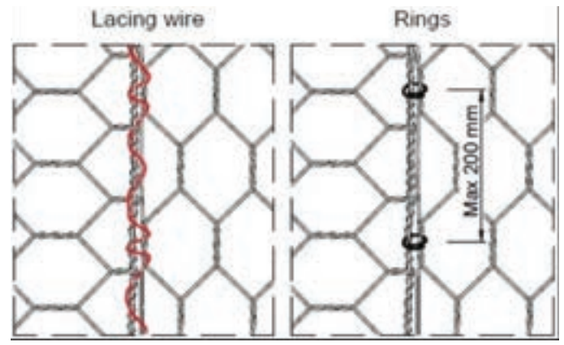


Fig. 10

6. PLACING THE UNITS

Place a number of individually laced units side by side in the required position. Care must be taken not to damage the geotextile.

Lace adjacent together at every adjacent edge to form a monolithic cage structures.

All gabion structures should be aligned and constructed accurately using standard engineering methods and procedures e.g. fish lines, dumpy levels or formwork; alignment should be done before the units are filled, as the units are almost impossible to move afterwards.

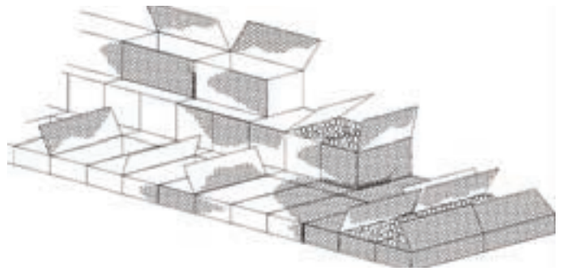


Fig. 12 - Gabion layout to allow for an easier installation

Note 1: All gabion units to be laced to each other on all contact surfaces. Each layer gabion must be securely laced to the gabion layer below.

Note 2: During the installation procedure, it is of fundamental importance to assure that the gabion's layout and the orientation/positioning of their lids allows an easy access to the worker or the frontal loader for the filling procedure to improve the installation productivity (Figs. 12, 13).

Note 3: The installation of steel bars/pipes placed at the top edge of vertical panels assure a protection of the wire mesh panels during the mechanical filling (Figs. 13, 14)

GABION CONSTRUCTION FRAME

For ease of alignment of the structures, both horizontally and vertically, and to obtain the correct lines and levels, the use of a gabion construction frame is recommended. The frame further assists in minimizing bulging during filling and ensures that the finished structure is aesthetically pleasing.

Alternatively you can use wood panelling cable tied to front face to create a similar effect.

FILLING AND BRACING THE GABIONS

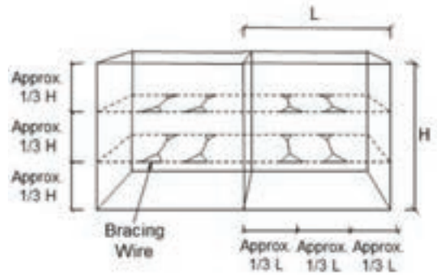
Only stone as specified in Section 1.4 of this document can be used for filling of gabions unless otherwise stipulated by the project engineer. Fill each gabion cell in 1/3 layers between which bracing wires are installed. A minimum of four bracing wires per square metre of gabion front face are recommended. These should be fixed at one third and two thirds the total depth of a 1m deep gabion as shown in the sketch. For 0.5m high gabions, bracing wires should be fixed at a height of 0.25m.

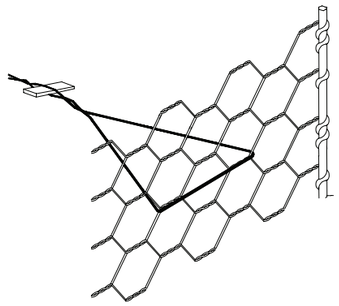
Two complete turns from the coil of binding wire supplied (approximately 2.3 - 2.7m), is sufficient for each brace for a 1m wide gabion unit and approximately 3.3 - 3.7m for a 1.5m gabion unit. Else preformed braces can be used. Thread the wire around two mesh openings on the front and rear faces of the basket and twist the ends together at the middle.

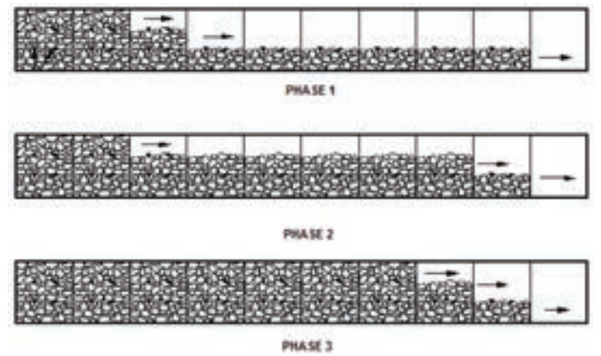
Tension the brace by windlassing with the plier handle or a rock until the front face is in line. This procedure may be repeated across the side panel and the diaphragm if the side panel is visible.

Fill each row of gabions in stages when placing a number of gabion units next to each other. Fill the entire row, except the last cell to a third. Thereafter brace the entire row and proceed with filling the row up to the two third mark. Again brace the entire row at the two third mark and then fill the remainder of the cells to the top. At no time should the difference in height of gabion rock between adjacent cells be more than a third of a metre. This is done so as to prevent bulging of the diaphragms. If more gabions are to be added to a row, the last cell in each row should be left empty to facilitate wiring. To ensure a good finished appearance, all visible faces should be hand-packed carefully.

Alternatively prefabricated wires are available to expedite construction. Gabions should be overfilled by 25-50mm to allow for natural settlement of the rock fill whilst keeping the top edge of the diaphragm visible so as to lace it to the lid.

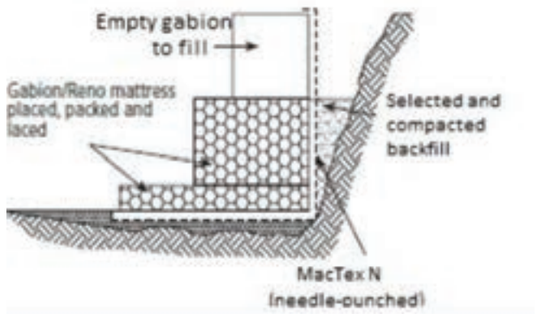






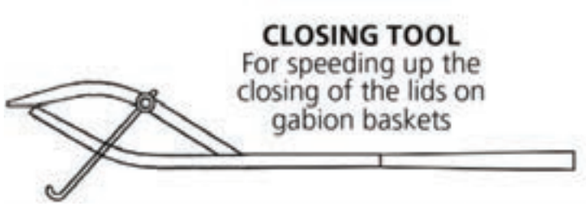
BACKFILLING

Compaction of the backfill must be done simultaneously with every row of gabions laid. Care must be taken not to damage the geotextile when placing and compacting the backfill. Heavy compaction equipment (>1500 kg) must not come within 1.0 m of the gabion basket: small hand held compaction equipment may be used adjacent to the gabion basket (Fig. 22).



CLOSING

Fold the lid down, stretch into position with the aid of a suitable tool (Fig. 23), lace the lid to the front, the ends and the top of the diaphragm.



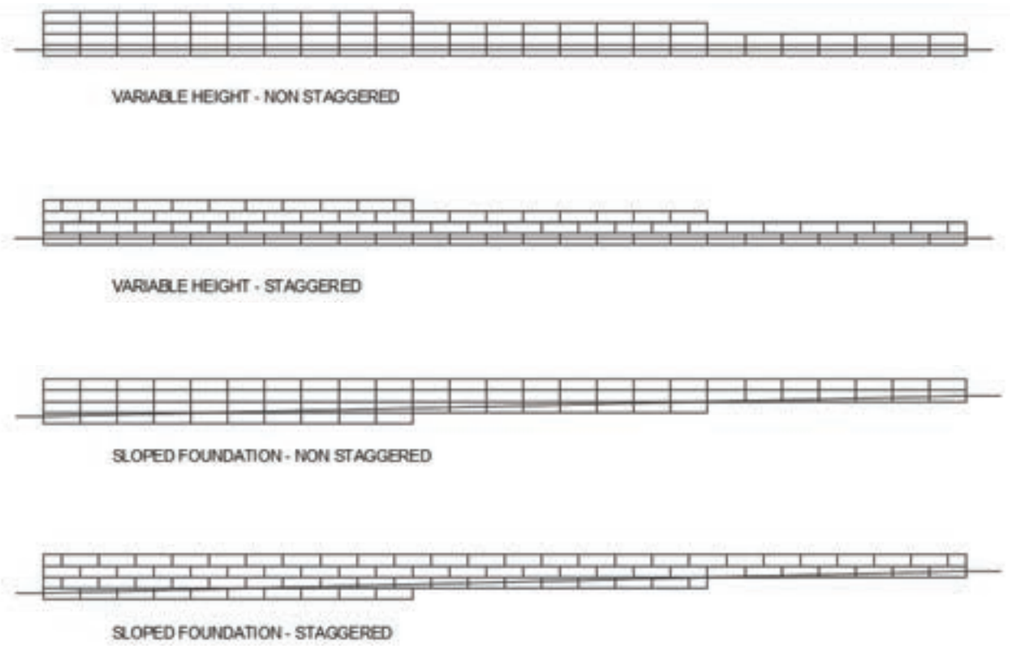
This can be purchased from your local Geofabrics branch

VERTICAL ALIGNMENT OF GABIONS UNITS (STAGGERING)

If the lacings and the Gabions units filling are made in accordance with the requirements, non-staggered Gabions units have the same performance of staggered ones, from a structural point of view. It can be stated that staggering, when realized, can only improve the monolithic behaviour of the Gabions units.

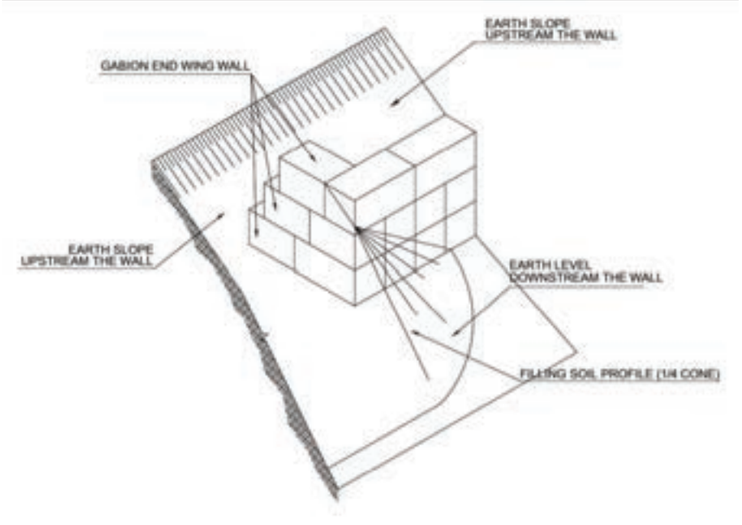
Stacked Bond

Staggered Bond



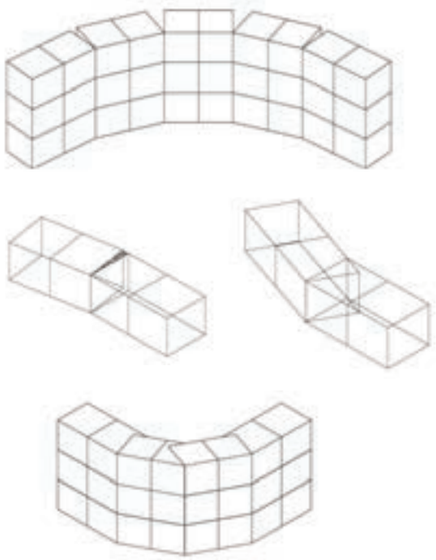
ENDING OF STRUCTURES

In order to ensure the tie-in of the structure to the earth slope, ending gabions wings should be provided. Furthermore, the earth slope should be shaped using a cone profile as indicated in Fig. 26.



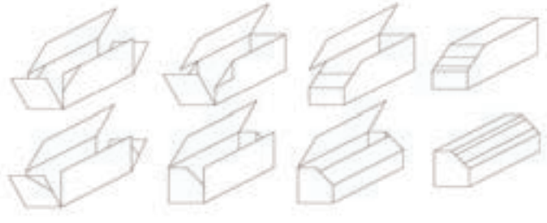
INSTALLATION IN CORNERS AND CURVES

Curved structures create special considerations with Gabions details and different placement procedures are generally required for convex and concave curves (Fig. 27). Gabion can conform to bends up to a radius of 18 m to 21m without alterations.



GABION SHAPING

Gabions can be shaped in order to meet specific geometric and aesthetic requirements; this can be easily done on-site by cutting and folding the DT mesh as shown below. Where a complete gabion cannot be installed because of space limitations, the basket unit shall be cut, folded or overlapped, and securely connected to suit existing site conditions.



INTERFERENCES, OBSTRUCTIONS AND FACING PENETRATIONS

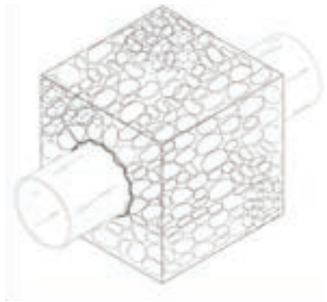
Interferences and obstructions can be vertical or horizontal.

Vertical obstructions are structures that are embedded in the gabion unit (e.g. safety barriers and poles). Such applications might require additional reinforcement and facing support to resist the local increase in lateral stress. Likewise, the wall may exert lateral earth pressure or vertical downdrag stress on the obstruction due to movement of the wall, the consequences of which to the obstruction design and performance must also be evaluated

Horizontal obstructions are structures which extend horizontally through the gabion unit. The horizontal obstructions are commonly due to utilities such as storm drain pipes. In some cases, pipes must penetrate the gabion unit and pass through the backfill. The gabion elements should be designed to fit around the pipe such that these are stable and the wall backfill is not spilt through the wall face where it joins the obstruction.

PIPES OF SMALL DIMENSIONS (DIAMETER < 400MM)

The steel wire mesh of gabion basket faces should be cut and bended into the inner side of the gabion in order to make way for the pipe (Fig. 30). Fill the gabion basket with stones up to the elevation of the pipe base and at this point place the pipe through the gabion basket and cover it with a protective mean if requested by the pipe manufacturer. The circle edges of the steel mesh should be tied using lacing wire and finally continue filling with stones up to the top of the basket.

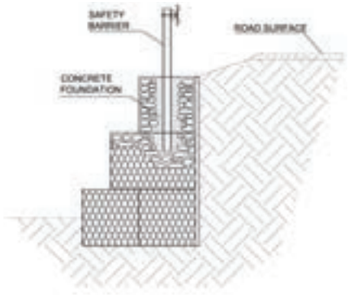


HYDRAULIC STRUCTURES OF GREATER DIMENSIONS

Gabion units should be shaped in such a way that the hydraulic structure fits best to the openings. Concrete hollow precast elements having a rectangular cross section and height which is multiple of gabion unit height are recommended.

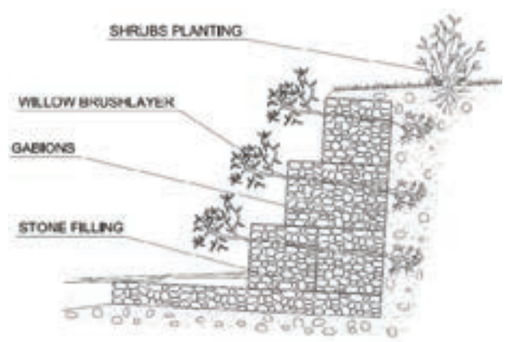
SAFETY AND NOISE BARRIERS

In some cases the top edge of gabion structures may require the construction of crash or noise barriers. Safety barriers shall be specifically designed. Construction details are provided by standards and national annexes. Before driving the posts, the Designer has to account for the damage on the reinforcement (depending on both the size of the posts and the installation method) in order to assure the stability of the structure.



GREEN GABIONS

Live cut branches can be placed in horizontal layers in between the rock-filled gabion baskets as shown in Fig. 32; branches should extend into the soil backfill behind the gabion, so the perforation of the MacTex geotextile is needed.



EXTERNAL DRAINAGE

Good drainage is essential to the proper performance of a gabions structure. There are two types of drainage considerations, internal and external.

Internal drainage considerations are related to control of surface or subgrade water that may infiltrate the backfill soil mass and depends on the characteristics of the backfill used in the reinforced soil mass.

External drainage considerations deal with water that may flow externally over and/or around the facing taxing the internal drainage and/or creating external erosion issues. The external drainage depends on the location of the gabions structure with respect to local hydrogeological. Regardless of the source of the water, the cardinal rule in the design is to remove water before it enters the zone of influence to prevent the following:

- Build-up of hydrostatic forces that increase lateral pressures,
- Piping, i.e., erosion of one soil into another, which creates paths for additional water flow or clogging of drainage aggregate, and
- External soil erosion from the toe, around the edges or at the top of the structure.

It is recommended that adequate drainage features be required unless the engineer determines that such features are not needed for a specific project. During a determination of the need for drainage features, the engineer must include consideration for both subsurface (e.g., ground water, perched water, flooding and tidal action) and surface infiltration water (e.g., rain, runoff, and snow melt). Surface drainage is an important aspect of ensuring the gabions structure performance and must be addressed during design. Appropriate measures to prevent surface water from infiltrating into the backfill should be included in the design. This typically requires coordination with designers of other project elements. When possible, finished grading at the top of the structure should provide positive drainage to prevent or minimize infiltration of surface water into the backfill.

Suitable outlet needs to be defined by others.

Drainage outside the scope of this guideline

DRAINAGE SWALE AT TOP

A drainage swale is a man-made depression in the ground surface used to intercept surface water and direct it in a controlled manner to an outlet. Drainage swale can also be used to reduce the potential for surface water from overtopping the gabions structure. When a drainage swale is used, the project civil engineer and the designer should address and detail the outlet(s) for the swale.

GRADE AT TOE AND ENDS

The final grade at the toe and ends of a gabions structure, both as designed and as constructed, is an important consideration for water flow conditions. Surface water flow along the toe may occur around the ends or along the face of the structure and has the potential to erode the soil. Erosion of soil at the toe eventually may undermine the facing units. Thus, design and construction details normally should direct flow away from the toe of structures.

This can be accomplished with site grading and with a soil berm or slope at the toe. Erosion control details are required where water will flow adjacent to the toe. The ends that terminate in or intercept embankment slopes should also be protected from erosion. Structures that terminate in slopes should be adequately keyed into the slope and a swale used to divert water away from the ends to mitigate erosion.

CAUSE-EFFECT RELATIONS

Gabions structures must be constructed in strict compliance with the structural requirements shown in the drawings and technical specification of the construction design and in the contract documents. The required result is obtained by the use of high-quality materials, adoption of the correct installation procedures and careful supervision of the works.

In case improper practices or inacceptable deformations are observed, the necessary corrective measures must be adopted right away to ensure that the structure is brought back to the acceptable level.

Some of the most common and probable cause-effect relations are given below.

CAUSES

- Foundation soil with insufficient bearing capacity
- Foundation soil with non-uniform bearing capacity
- Foundation soil with moisture content too high
- Foundation soil not well compacted
- Foundation scour
- Backfill material not well compacted
- Thickness of the backfill layers greater than 30 cm
- Backfill material with a moisture content higher than the optimal value
- Backfill material with too high fines content

- Construction frame not used
- Inadequate filling material
- Pre-formed braces not used
- Pre-formed braces not completely tensioned
- Compaction carried out not in parallel to the front face
- Excessive compaction energy
- Vehicles and construction equipments kept within 1 m from the front face
- Fill surface not left with a slight inclination (2% - 4%) away from the facing and not sealed at the end of each work's day

EFFECTS

Settlements and distortions of the structure

Bulging of the front face

TOLERANCES

Care should be taken to ensure that predicted construction and design life deformations will meet specified tolerances. For gabions structures reference can be made on the standard EN 14475 "Execution of special geotechnical works" (table C.9), taking into account the limits specified for reinforced soil structures having gabion baskets as facing elements.

The values reported in Table 3 are indicative of the construction tolerances which are commonly achieved, or the deformations which are normally withstood without any significant structural damage or any effect on the stability of the structure.

They should be understood as follows:

- Alignment: local variation in comparison with a 4 m long straightedge placed in the outer plane of the wall face;
- Longitudinal differential settlement: ratio ΔS / ΔL;
- Compressibility: ratio ΔH / H;

DEFORMATION	TOLERANCE
Alignment	± 100 mm
Longitudinal differential settlement	2 %
Compressibility	5 %

Table 3

MAINTENANCE

This section is intended to provide operational instructions in case the need arises for reparationworks to the facing surface of gabions used for walls or hydraulic works. Such interventions may be required due to local damage of the facing due to accidental events suchas impacts with earth moving machines, vehicles or falling boulders, cutting due to mowingmachines, vandalism, etc.

Reparation of denting and/or facing breakage due to impacts and abrasion due to water flow.

The intervention shall consist of:

- Cutting and removal of the damaged DT panels;
- Filling the voids, if any, with stones, taking care to use stones of the appropriate size;
- Filling of the soil empties;
- Installation of a double twist wire mesh panel (with the same coating as the existing mesh) ensuring at least 20 cm overlap with the surrounding undamaged mesh;
- The double twist wire mesh panels shall be connected to the adjacent undamaged panels by clips or lacing wire.

CONTROLS & MAINTENCE PERFORMED BY QUALIFIED PERSONNEL

Controls have to be performed after the completion of the work by qualified personnel (surveyors and/or engineers, geologists).

The staff should have a maintenance manual where to record the detected problems, their extents and the expected repair costs, each time there is a control.

The controls have to be made in order to ensure the stability of the structure and of the units which compose it. Typical controls are:

- Check of the Gabion structure footing; the bottom of the structure has to be intact e should not show irregularities such as settlements, distortions, deformations and bulging of the of the front face.

Analysis of the facing; the units composing the facing have to be intact.

WORKING AT HEIGHT

This chapter can be used as a basis for the editing of Risk Assessment document, whose final contents have to be adopted country by country depending on the local regulations.

In the following pages are explained the technical details and suggestions for the safety device used as a personnel protection in the gabions installation in order to assure a high installation productivity without affecting the safety of the workers.

This document is a support for the construction site manager that supervise the personnel, the work execution and control the using of protection device and equipment (individual and collective) on the working site.

Under no circumstances should anyone work from the front face of the wall. An appropriate edge protection system shall be installed; as the wall progresses in height this edge protection system will be lifted to ensure adequate protection.

DESCRIPTION OF THE SAFETY DEVICE (EXAMPLE)

The following paragraph describes a possible solution, to be verified on the basis of local regulations.

In the construction of TMS structures, each level must be provided of the protection deviceIn the construction of gabions structures each level must be provided of the protection device made by:

- Steel posts of suitable length and dimensions (0);
- Num. 2 supports to hook for reach the protection made by wooden plank or building site fencing (1);
- Num. 2 anchors to fasten the device to the element (DT mesh) or to the formwork (3).

The posts are put in place manually through anchors, without the need of an excavator or of mechanical equipment.

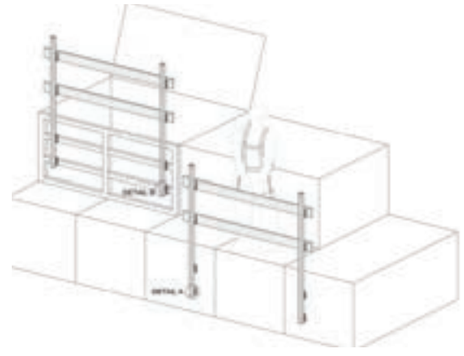
The distance to each other is ≥ 2 m.

This system must be installed when the reached height of the structure is ≥ 2 m and before laying the next upper level.

POSITIONING OF THE SAFETY DEVICE

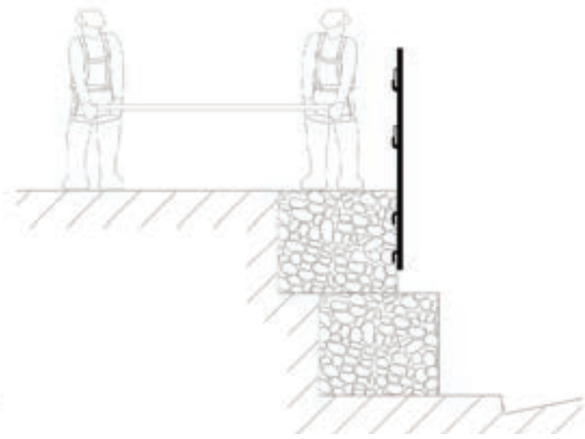
The operation of installing/removing the safety device must be also made in safety and the worker has to be fastened to an external weight support like concrete block or static excavator.

Depending upon the use or not of the external formwork, the safety device can be supported by formwork (Fig. 37 right) or positioned directly into DT mesh (Fig. 38 left).



CONSTRUCTION SAFELY

The operation of assembling and filling of gabions must be made safely.



INSTALLATION PRODUCTIVITY

The installation productivity is dependent on volume, geometry and access to working area.

By making reference to a typical 5 men working team (1 foreman, 1 backhoe loader operator, 3 workers) operating 8 hours a day, the following rates can be assumed for gabions with only 1 side facing (including the stone filling):

GABIONS HEIGHT (M)	UNITS	CREW	AVERAGE PRODUCTIVITY PER CREW	
			MINIMUM UNIT/ DAY / CREW	MAXIMUM UNIT/ DAY / CREW
1	m^3	5	40	50
0.5	m^3	5	30	40

LIMITS OF RESPONSIBILITY OF GEOFABRICS

The installation manual is realized in order to show how the various elements have to be assembled in order to realize gabions structures, it being understood that such installation manual is not intended to provide to the Contractor an exhaustive summary of guidance for the organization and control of the related operations relating to the construction of Gabions structures.

The Company reserves the faculty to bring modifications, integrations or improvements to the Manual, without that this can constitute reason to think inadequate the previous revision.

The Company declines every responsibility in case of:

- Accidents or incidents for improper use of the installation kit;
- Accidents or incidents that could happen during the installation of the elements;
- Wrong installation, lacked or wrong observance of the instructions supplied in the present Installation Manual;
- Any modifications not authorized from Geofabrics;
- Installation done by staff not adequately trained and equipped.

and more in general Geofabrics will not be liable for any inaccuracies or omissions in the execution results and will not bear the consequences of any connected liability.

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The quality of the installation depends also from the scrupulous observance of the Installation Manual, that it must be read before carrying out the installation of Gabions.

Geofabrics shall not be held responsible for damages of any kind, including – without limitation – bodily harm, injury or damage to property, in connection with handling system, installation, or compliance or non-compliance with the instructions set forth in this Manual.


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