Erosion Control & Foreshore Protection

Road Building Model Specification

July 2022

Disclaimer

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Acknowledgments

Main Roads Western Australia (Main Roads WA) specifications and guidelines and the Institute of Public Works Engineering Australia, Western Australia Division (IPWEA-WA) **Local Government Guidelines for Subdivisional Development** have been heavily referenced in preparing this road building specification.

The work of Reg Leach, Senior Consultant, Golder Associates Pty Ltd, in assembling the previous (2012) version of the Specification upon which this document is based, is gratefully acknowledged.

Document Updates

The **Erosion Control and Foreshore Protection** road building model specification was originally published in July 2022. Subsequent document updates are shown in the table below:

Date	Updates	Contents and purpose	Edition No.	Amended Modules

Each update will be listed above with the model specification, as amended, available from the WALGA website.

GHD Pty Ltd | ABN 39 008 488 373
999 Hay Street, Level 10
Perth, WA 6000, Australia
T +61 8 6222 8222 | **F** +61 8 6222 8555 | **E** permail@ghd.com | **ghd.com**

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1. SCOPE

This road building specification details the requirements for the supply of materials, equipment and labour required for the installation of **Erosion Control and Foreshore Protection**. The provision of rock, geotextile lining, wire and wire mesh, in addition to cementitious grout are included in the scope. The Specification covers the supply of materials, construction requirements and minimum standards for quality assurance.

For the purpose of this specification, a revetment mattress is a double-sided mattress positioned over the surface and injected with a sand-cement grout. The finished product follows the contours over which it is laid and provides a neat appearance. The resultant product is a stable mat of suitable weight and configuration.

2. REFERENCES

Australian Standards are referred to in abbreviated form (e.g. AS 1234). For convenience, the full titles are given below:

Australian Standards

AS 1141	Methods for Sampling and Testing Aggregates
AS 1726	Geotechnical Site Investigations
AS 2758	Aggregates and Rock for Engineering Purposes
AS 3705	Geotextiles – Identification, Marking and General Data
AS 3706	Geotextiles – Methods of Test

Austroads Publications

AGPT04G	Guide to Pavement Technology Part 4G: Geotextiles and Geogrids

WALGA Road Building Specifications

Aggregate and Cementitious Binders
Earthworks and Pavement Construction
Erosion Control and Foreshore Protection
Granular Pavement Materials
Pavement Rehabilitation
Sprayed Bituminous Surfacing
Supply and Laying of Asphalt Road Surfacing (IPWEA / AAPA)
Supply of Recycled Road Base (IPWEA / WALGA)

Acts and Regulations

Aboriginal Heritage Act 1972
Dangerous Goods Safety (Road and Rail Transport of Non-explosives) Regulations 2007
Environmental Protection Act 1986
Environmental Protection Regulations 1987
Environmental Protection (Clearing of Native Vegetation) Regulations 2004
Health (Pesticide) Regulations 2011
Main Roads Act 1930
Occupational Safety and Health Act 1984
Occupational Safety and Health Regulations 1996
Rail Safety National Law (WA) Act 2015
Road Traffic Code 2000
Wildlife Conservation Act 1950

3. PRODUCTS AND MATERIALS

3.1 Source Rock

Source rock for rock protection and rock pitching shall consist of clean, sound, durable, hard rock. Rock used shall be fresh to slightly weathered and of very high to extremely high strength, as defined in AS 1726. Rock that is laminated, fractured, porous or otherwise physically weak is unacceptable and shall not be used in the Works. Flat slab-like rock pieces, with the breadth or thickness less than one third its length, should be avoided, due to poor interlocking and easy dislodgement by flow where not grouted.

Limestone (calcarenite) used for rock pitching shall be well to very well cemented and of medium to high strength, as defined in AS 1726. The unconfined compressive strength (UCS) of limestone shall be greater than 12.5 MPa and the calcium carbonate content shall be greater the 80%.

Source rock for rock protection and rock pitching shall conform to the general requirements in Table 1.

Table 1 Rock Protection and Rock Pitching (General Requirements)

Rock Class	Rock Size (m)	Approximate Rock Mass (kg)	Proportion Larger than Rock Size (%)	Typical Application
Type A	0.20 [1]		0	Catchpit Surrounds
	0.10 [1]		50	
	0.075 [1]		90	
Type B1	0.30 [1]		0	Culvert Outlets
	0.20 [1]		50	
	0.10 [1]		90	
Type B (Facing)	0.40 [1]	100	0	Culvert Outlets
	0.30 [1]	35	50	
	0.15 [1]	2.5	90	
Light	0.55 [1]	250	0	Floodway Batters
	0.40 [1]	100	50	
	0.20 [1]	10	90	
Quarter Tonne	0.75 [1]	500	0	Floodway Batters
	0.55 [1]	250	50	
	0.30 [1]	35	90	
One Tonne	1.15 [1]	2000	0	Floodway Batters
	0.90 [1]	1000	50	
	0.55 [1]	250	90	
Two Tonne	1.45 [1]	4000	0	Floodway Batters
	1.15 [1]	2000	50	
	0.75 [1]	500	90	
Rock Pitching	0.40 x 0.40 x 0.20	-	60	Landscaped Slopes (Typically Limestone)
	0.15 x 0.15 x 0.15	-	100	

Notes:

1) Assuming a specific gravity of 2.65 t/m^3 and a spherical shape.

3.2 Rock Fill

Rock fill for gabions and mattresses shall be produced or derived from dense, hard, durable and clean rock in accordance with AS 2758.4. It shall be resistant to weathering actions of air and water and shall be free from cracks and other structural defects.

Rock used for rock fill shall be fresh to slightly weathered and of very high to extremely high strength, as defined in AS 1726. The rock fill shall be clean, angular, durable and of uniform quality, free from dust, clay, dirt and other deleterious material and free from an excess of flat or laminated pieces.

For gabions, the minimum rock size shall be 100 mm and the maximum rock size shall be 250 mm.

For mattresses, the minimum rock size shall be 75 mm and the maximum rock size shall be two-thirds the thickness of the mattress, or 250 mm, whichever is the lesser.

Rock fill shall have a range of sizes and a degree of angularity to ensure mechanical interlocking between particles.

The wet strength of rock fill shall not be less than 100 kN and the wet/dry strength variation shall not exceed 35%. The rock may be crushed, so as to produce aggregate suitable to test by AS 1141.22.

3.3 Geotextile Lining

3.3.1 General

Geotextiles used for erosion control and/or foreshore protection shall be a non-woven fabric consisting of long chain synthetic polymer fibres, composed of at least 95% by mass of polyester or polyolefins (polypropylene, polyethylene), bonded by needle punching, heat or chemical bonding processes or combinations thereof. Bonded fibres must be capable of retaining their relative position in the geotextile. The geotextile shall be free of any flaws or defects that may adversely affect the mechanical or physical properties of the fabric.

The polymer fibres shall be rot proof, chemically stable and have low water absorbency. The geotextile shall have a high ultraviolet resistance such that when tested in accordance with AS 3706.11 shall have retained strength of at least 50% after 672 hours of test exposure.

Each roll of geotextile shall be provided with a suitable covering to protect the fabric against moisture and ultraviolet radiation and marked in conformance with AS 3705. Prior to installation, the geotextile rolls shall be stored on site under a protective cover and supported off the ground. The Contractor shall take appropriate measures to protect the geotextile from damage. This includes adhering to any other recommendations on method of storage set by the supplier/manufacturer.

The Contractor shall certify that all geotextile lining delivered to site meets the requirements in Table 2. Sampling, conditioning and statistical analysis of results for each batch of geotextile shall be carried out in accordance with AS 3706.1. Sampling frequency shall be in accordance with Appendix A of AS 3706.1. The conformance testing shall include determining the mean weight (mass per unit area) of the geotextile, in accordance with AS 3706.1.

Table 2 Requirements for Geotextile Lining

Fabric Property	Test Method	Rock Protection	Gabions & Mattresses	Revetment Mattresses
Fabric weight (g/m^2)	AS 3706.1	Report [1]	Report [1]	400 - 470
Grab tensile strength [min] (N) Machine direction Cross-machine direction	 AS 3706.2 AS 3706.2	 - -	 - -	 2,500 2,400
Grab elongation @ break [max] (%)	AS 3706.2	-	-	25
Tear strength [min] (N) Machine direction Cross-machine direction	 AS 3706.3 AS 3706.3	 - -	 - -	 1,100 1,100
Burst strength [min] (N)	AS 3706.4	Report [1]	Report [1]	2,200

Fabric Property	Test Method	Rock Protection	Gabions & Mattresses	Revetment Mattresses
Puncture resistance [min] (mm)	AS 3706.5	Report [1]	Report [1]	1,100
Equivalent opening size [max] (µm)	AS 3706.7	200	200	-
Flow rate ($cm^3/min/cm^2$)	AS 3706.9	-	-	85 - 125
Retained strength - UV stabilisation [min] (%)	AS 3706.11	50	50	-
Geotextile strength rating [min] (N*mm)	AGPT04G	4,500	2,000	-

Notes:

1) To be included with conformance certification.

3.3.2 Geotextile for Rock Protection

Unless otherwise specified by the Local Government, geotextiles for rock protection shall conform to the requirements in Table 2.

The equivalent opening size (EOS) of the geotextile shall be less than 200 µm, mean value determined in accordance with AS 3706.7. The geotextile strength rating (G) shall be greater than 4,500, as defined in AGPT04G. The characteristic values of L and h_{50} shall be calculated as the mean value less 0.83 x standard deviation. Where approved in advance by the Local Government, the minimum G value may be reduced to 2,000 when the nominal maximum particle size of the rock is less than 200 mm.

3.3.3 Geotextiles for Gabions and Mattresses

Unless otherwise specified by the Local Government, geotextiles for gabions and rock mattresses shall conform to the requirements in Table 2. All gabions and mattresses shall be laid on geotextile filter lining as per the Contract Drawings.

The EOS of the geotextile shall be less than 200 µm, mean value determined in accordance with AS 3706.7. The G value shall be greater than 2,000, as defined in AGPT04G. The characteristic values of L and h_{50} shall be calculated as the mean value less 0.83 x standard deviation.

3.3.4 Geotextiles for Revetment Mattresses

Unless otherwise specified by the Local Government, geotextiles for revetment mattresses shall conform to the requirements in Table 2.

Uniform cross section fabric shall consist of double layer fabric joined together by restraining ties of uniform strength. Hydrostatic uplift, where required, shall be provided by inserting plastic weep-hole assemblies through the mat at specified centres. The minimum thickness of the pumped mat shall be 750 mm.

3.4 Gabions

Details of gabions shall be as shown on the Contract Drawings.

The gabions supplied by the Contractor shall be flexible, woven, galvanised PVC coated steel wire mesh boxes to the overall dimensions as specified on the Contract Drawings. Alternative equivalent or improved methods of corrosion protection such as Zinc-Aluminium alloy and polyethylene coatings are acceptable.

Gabions shall have a hexagonal mesh with nominal size of 80 mm x 100 mm. The minimum steel core wire diameter for the mesh shall be 2.7 mm.

Each gabion shall be divided by diaphragms into cells whose length shall not be greater than the width of the gabion plus 100 mm.

3.5 Rock Mattresses

Details of rock mattresses shall be as shown on the Contract Drawings.

The mattresses supplied by the Contractor shall be flexible, woven, galvanised PVC coated steel wire mesh boxes to the overall dimensions as specified on the Contract Drawings. Alternative equivalent or improved methods of corrosion protection such as Zinc-Aluminium alloy and polyethylene coatings are acceptable.

Mattresses shall have a hexagonal mesh with nominal size of 60 mm x 80 mm. The minimum steel core wire diameter for the mesh shall be 2.0 mm for mattresses with less than 350 mm depth and 2.4 mm for 350 to 550 mm depth.

Each mattress shall be divided by diaphragms into cells across the width of the unit and at not more than 1 m centres or as shown on the Contract Drawings.

3.6 Selvedges

All edges of the gabions, mattresses, diaphragms and end panels shall be selvedged with a continuous wire, thicker than the corresponding wire of the gabion, mattress or diaphragm, to give the mesh rigidity when subjected to tension.

The selvedging must be such that the mesh will not unravel. In addition, the strength of the connection between the galvanised selvedge wire and the mesh shall be equal to or greater than the breaking strength of the mesh.

The minimum steel core wire diameter shall be 3.4 mm for gabions, 2.4 mm for mattresses less than 350 mm depth and 3.0 mm for mattresses between 350 to 550 mm depth.

3.7 Lacing and Connecting Wire

Lacing (tying) and connecting wire must be supplied with the gabions and mattresses to perform all the wiring operations required for the construction of the gabions or mattresses on site.

The minimum steel core wire diameter, for lacing/tying and connecting either gabions or mattresses, shall be 2.2 mm.

Where the selvedge has to be fastened to the cut ends of the mesh, its diameter shall be 3.4 mm and it shall be attached by binding the cut ends of the mesh about it so that a force of not less than 8,330 N applied in the same plane as the mesh, at a point on the selvedge of a mesh sample of length 1,000 mm, is required to separate it from the mesh.

3.8 Cementitious Grout

Unless otherwise specified by the Local Government, grout for revetment mattresses shall consist of a mixture of General Purpose (GP) cement, fine aggregate and water so proportioned and mixed as to provide a readily pumpable slurry. The cured grout shall exhibit a minimum 28-day unconfined compressive strength of 20 MPa.

4. CONSTRUCTION

4.1 Geotextile Lining

The correct geotextile filter lining shall be supplied to suit unconfined rock protection, or for use with gabions and mattresses.

The period between initial laying out and complete cover of the geotextile with rock embankment protection, gabions or mattresses shall not exceed 14 days. Where possible and practical, geotextile shall be placed just ahead of associated advancing construction work and covered by relevant construction materials or suitable protective sheeting within 48 hours of being placed.

Any geotextile allowed to remain exposed to sunlight for a period greater than 14 days shall be removed and replaced at no cost to the Local Government.

The geotextile shall be laid in full roll widths as supplied with the length of the fabric laid in the direction of stream flow. Adjacent strips shall be overlapped a minimum of 500 mm.

The Contractor shall take every reasonable care to ensure that the geotextile is not damaged during installation and cover placement operations. The laid geotextile shall be subjected only to pedestrian traffic.

Any geotextile torn shall be replaced or patched by the laying over of an additional piece of geotextile extending a minimum of 1 m from the extremities of the tear. The fabric shall be held down by rocks or other suitable means to prevent movements before placement of the rock protection, gabions or mattresses.

4.2 Rock Protection

Rock protection shall be supplied to the specified classes of rock, and shall comprise hard, clean rock spalls or cobbles obtained from the excavation of a uniform type and colour and grading as specified in Table 1, placed to the dimensions, shape and extent shown on the Contract Drawings.

Excavation or any required trenching for the placement of rock protection shall be constructed to the line, level and dimensions shown on the Contract Drawings. Surplus, oversize and unsuitable material from excavations shall be disposed of in accordance with the WALGA **Earthworks and Pavement Construction** road building model specification.

The rock spalls shall be firmly placed into position to the required lines and levels with a minimum of voids and shaped to suit the drain grades or batter slopes to the following tolerances and compacted with at least 4 passes of a crawler tractor of mass not less than 11 tonnes:

1. Batter slopes shall be smoothly shaped to a uniform plane.
2. The dimensions of the rock layer shall not be less than that shown in the Contract Drawings. Local surface irregularities of the finished surface shall not vary from the prevailing batter slope by more than +100 mm or -50 mm measured at right angles to the slope, except for culvert outlet protection which shall not vary by more than +0 mm or -100 mm.
3. On floodways, no rock shall project above the shoulder and pavement level.

Rock protection shall present a generally uniform finish with flat surfaces of larger individual spalls, facing uppermost, comprising the finished surface and thoroughly keyed to the adjoining rocks.

Care shall be taken during placement to prevent sand filling voids between the rocks.

Where grouted rock protection is specified, individual rock spalls shall be placed on a mortar bed and voids between spalls filled with mortar, as detailed in the Contract Drawings. The size of the voids shall not exceed 50 mm in any direction.

Mortar for grouting shall comprise a 3:1 mix of builder's sand and GP cement, with all sand being from a single source.

4.3 Rock Pitching

4.3.1 Sample Panels

Prior to the commencement of rock pitching, the Contractor shall prepare a sample panel of each type of rock pitching required in the Works, each at least 1.5 m high x 2 m long, for approval by the Local Government.

The samples shall display rock colour, texture, grain, surface treatment, rock size and jointing detail. The sample shall remain until the completion of stonework in the Works.

The standard of construction approved for the samples shall be maintained throughout the Works.

4.3.2 Construction

The finished rockwork on sloping rock pitching shall present a uniform surface matching adjacent slopes. The finished surface shall be thoroughly cleaned of all excess mortar and other debris.

Transitions from pitched batter slopes to pitched level surface shall be in the form of a smooth vertical curve to both top and toe conforming to the dimensions and form as indicated on the Contract Drawings.

Unless otherwise shown on the Drawings, the rocks shall be set level and flush for a lateral distance of 1.0 m when located adjacent to other paving materials such as kerbs, paths and manholes.

Rocks at the top and toe of batter slopes shall be securely underpinned with mortar to prevent any vertical movement. No mortar shall be visible after adjacent finished levels have been restored. Voids shall be filled with mortar from the bottom to within 10 mm of the exposed face of the rock.

Mortar shall comprise a 3:1 mix of builder's sand and GP cement, with all sand being from a single source. Where limestone is used for rock pitching, mortar shall comprise a 3:1:1 mix of builder's sand, builders lime and GP cement, with all sand being from a single source.

4.4 Installation of Gabions and Rock Mattresses

The assembly and erection of the gabions and mattresses shall conform to the Specification and the manufacturer's recommendations. Prior to assembly, the wire mesh of the gabion or mattress shall be opened out flat on the ground and stretched as much as possible to remove all kinks and bends and checked to make sure that all creases are in the correct positions for forming the box.

The gabion or mattress shall be assembled individually by lifting the side and end panels into vertical position to form a rectangular box, ensuring that the tops of all four sides are level.

The four corners of the gabion or mattress box shall be wired together with lengths of lacing wire supplied. Starting at the top, the end of the wire shall be secured by twisting it around the selvedges and through each mesh in turn using alternate single and double loops. The wire at the bottom shall be secured with the lacing wire turned to the inside of the box on completion. The diaphragm panels shall also be secured in a similar fashion.

The assembled empty gabion or mattress boxes shall be positioned in the structure. The end or side from which work is expected to proceed shall be secured either to completed work or by stakes driven into the ground at the corners. These stakes must be secure and reach at least to the top of the gabion or mattress.

For gabions, the opposite end or side of the box shall be stretched using crowbars or a small winch and secured top and bottom by stakes placed at the corners, fixed at the bottom and tied back at the top. Lacing to adjacent boxes and filling shall be carried out whilst gabion boxes are under tension.

For mattresses, movement of the rockfill inside the cells, either due to gravity or flowing current, should be kept to a minimum. Mattresses on slopes shall be placed such that the long dimension lies up and down the slope (i.e. internal diaphragms at right angles to the direction of the slope). In watercourses, the long dimension of the mattress should be aligned with the direction of flow (i.e. internal diaphragms at right angles to the direction of flow). The boxes shall be wired together along all adjoining edges and at diaphragm points.

The gabion boxes shall be filled one third full and horizontal interval bracing inserted (approximately 0.30 m apart) to prevent excessive bulging and distortion of the completed structure. This procedure shall be repeated when the box is two thirds full. For both gabions and mattresses, final filling shall be to a level 25 to 50 mm above their tops to allow for subsequent settlement.

Closing and lacing down of lids for both gabions and mattresses shall proceed as soon as practicable after filling operations. The lids shall be stretched tight over the filling with suitably design closing tools and laced securely through each mesh along all edges, ends and diaphragms. The ends of all lacing wires shall be turned into the box on completion of all lacing operations.

4.5 Installation of Revetment Mattresses

Individual mill width panels shall be cut to suitable length and the two layers of fabric separately joined to create a continuous concrete mattress. The fabric shall be positioned in its desired location with allowance made for the fabric's contraction.

A cut shall be made in the top layer of the mattress, in which an injection hose shall be inserted, through which the cementitious grout is pumped.

The mattress shall be tied down into an anchor trench on all perimeters as detailed on the Contract Drawings. This trench is then earth backfilled or concrete backfilled to prevent any washouts behind the mat, as detailed on the Contract Drawings.

The finished product shall be fully inflated, free of wrinkles or flat spots and shall leave no gaps around any permanent structures that are to be protected.

5. MATERIAL QUALITY

The Contractor shall implement a quality management system to ensure material supplied under the Contract complies in all respects to the specified requirements for the Type of material purchased.

Testing shall be carried out in accordance with the relevant Main Roads or equivalent Australian Standard test method. Sampling methods shall be random and unbiased. Random site selection must be undertaken in accordance with WA 0.1.

The frequency of tests shall always be adequate to demonstrate that the material complies with the Specification. As a minimum, testing frequencies shall be as shown in Table 3. Prior to supply, the Contractor shall certify that the material complies in all respects with the specified requirements and shall provide National Association of Testing Authorities, Australia (NATA) endorsed test certificates to demonstrate compliance.

Unless otherwise specified, all testing shall be performed by a Laboratory holding current NATA accreditation for the methods undertaken. NATA accreditation shall be maintained until the completion of the Contract. All test reports shall be NATA endorsed by a current approved signatory for the Laboratory conducting the testing.

The Contractor shall allow, or cause to allow, the Local Government ready access to the quarry, pit, production and/or manufacturing site to inspect the works and/or to collect material samples.

Table 3 Minimum Testing Frequency for Erosion Control & Foreshore Protection

Method		Minimum Frequency
-	Rock Dimensions	1 : 1,000 m^3
AS 3706.1	Fabric weight (g/m^2)	1 : 5,000 m^2
AS 3706.4	Burst strength [min] (N)	1 : 5,000 m^2
AS 3706.5	Puncture resistance [min] (mm)	1 : 5,000 m^2
AS 3706.7	Equivalent opening size [max] (µm)	1 : 5,000 m^2
AGPT04G	Geotextile strength rating [min] (N*mm)	1 : 5,000 m^2

6. SUPPLY OF MATERIALS

The Contractor shall nominate the source of all materials to be supplied with the quotation.

Unless otherwise specified, the Contractor shall deliver the materials to the nominated stockpile sites on the date and time specified. The Contractor shall confirm all necessary arrangements concerning load size, rate for supply, timing of the delivery and documentation prior to delivery. Different material Types shall be placed in separate, clearly identified stockpiles.

Where the Contract includes cartage, the Contractor shall remove and replace at no cost to the Local Government any material that becomes damaged or contaminated during transport, delivery or stockpiling.

Where the Contract excludes cartage, the Contractor shall allow, or cause to allow, the Local Government or nominated third-party ready access to the quarry, pit, production and/or manufacturing site and shall provide any assistance necessary to ensure satisfactory load-out of the specified material.

7. REGULATORY REQUIREMENTS

The Contractor shall conform to all relevant statutory and regulatory requirements concerning the environment, aboriginal heritage, wildlife conservation, dangerous goods, occupational safety and health, rail safety, and road safety.