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**Roads and Bridges
Agrément Certificate
No 04/R138**

Designated by Government
to issue
European Technical
Approvals

LANDMARK WALL SYSTEM FOR REINFORCED SOIL RETAINING WALLS AND BRIDGE ABUTMENTS

Système de renforcement des sols
Bodenverfestigung



• THIS CERTIFICATE RELATES TO THE USE OF THE LANDMARK WALL SYSTEM FOR REINFORCED SOIL RETAINING WALLS AND BRIDGE ABUTMENTS, REFERRED TO IN THE ACCOMPANYING DETAIL SHEETS.

• The system is based on the use of proprietary dry-jointed concrete block facing units in combination with proprietary reinforcement identified in the accompanying Detail Sheet.

• The design and construction of the reinforced soil structure must be in accordance with the requirements of the Highways Agency; acting on behalf of the Department for Transport, the Scottish Executive Development Department, the Welsh Assembly Government, and the Department for Regional Development, Northern Ireland; and the conditions set out in the Design Data and Installation parts of this Certificate.

• The concrete block facing units are manufactured under licence by Acheson and Glover Limited, Fivemiletown, Co Tyrone BT75 OSY.

This Front Sheet must be read in conjunction with the accompanying Detail Sheet, which provides information specific to the system.

Highways Agency Requirements — Detail Sheet 1

1 Requirements

1.1 All proposals for adopting the system shall comply with current HA design and certification procedures and relevant design data shall be submitted in accordance with the requirements of section 3 of the accompanying Detail Sheet.

1.2 The design, materials specification and construction methods adopted must be in accordance with the HA Technical Standard BD 70/03 (DMRB 2.1.5), and Manual of Contract Documents for Highway Works (MCHW) Volumes 1 and 2.

Regulations

2 Construction (Design and Management) Regulations 1994 (as amended) Construction (Design and Management) Regulations (Northern Ireland) 1995 (as amended)

Information in this Certificate may assist the client, planning supervisor, designer and contractors to address their obligations under these Regulations.

See sections: 2 Delivery to site, handling and storage (2.1) and 4 Practicability of installation (4.1 and 4.2) of Detail Sheet 2.

Bibliography

BD 70/03 *Strengthened/Reinforced Soils and other Fills for Retaining Walls and Bridge Abutments*

Manual of Contract Documents for Highway Works, Volume 1 *Specification for Highway Works*, August 1998 (as amended)

Manual of Contract Documents for Highway Works, Volume 2 *Notes for Guidance on the Specification for Highway Works*, August 1998 (as amended)

Conditions of Certification

3 Conditions

3.1 This Certificate:

- (a) relates only to the product that is described, installed, used and maintained as set out in this Certificate;
- (b) is granted only to the company, firm or person identified on the front cover — no other company, firm or person may hold or claim any entitlement to this Certificate;
- (c) is valid only within the UK;
- (d) has to be read, considered and used as a whole document — it may be misleading and will be incomplete to be selective;
- (e) is copyright of the BBA;
- (f) is subject to English law.

3.2 References in this Certificate to any Act of Parliament, Regulation made thereunder, Directive or Regulation of the European Union, Statutory Instrument, Code of Practice, British Standard, manufacturers' instructions or similar publication, are references to such publication in the form in which it was current at the date of this Certificate.

3.3 This Certificate will remain valid for an unlimited period provided that the product and the

manufacture and/or fabrication including all related and relevant processes thereof:

- (a) are maintained at or above the levels which have been assessed and found to be satisfactory by the BBA;
- (b) continue to be checked as and when deemed appropriate by the BBA under arrangements that it will determine;
- (c) are reviewed by the BBA as and when it considers appropriate; and
- (d) remain in accordance with the requirements of the Highways Agency.

3.4 In granting this Certificate, the BBA is not responsible for:

- (a) the presence or absence of any patent or similar rights subsisting in the product or any other product;
- (b) the right of the Certificate holder to market, supply, install or maintain the product; and
- (c) the nature or standard of individual installations of the product or any maintenance thereto, including methods and workmanship.

3.5 Any recommendations relating to the use or installation of this product which are contained or referred to in this Certificate are the minimum standards required to be met when the product is used. They do not purport in any way to restate the requirements of the Health & Safety at Work etc Act 1974, or of any other statutory, common law or other duty which may exist at the date of this Certificate or in the future; nor is conformity with such recommendations to be taken as satisfying the requirements of the 1974 Act or of any present or future statutory, common law or other duty of care. In granting this Certificate, the BBA does not accept responsibility to any person or body for any loss or damage, including personal injury, arising as a direct or indirect result of the installation and use of this product.



In the opinion of the British Board of Agrément, the Landmark Wall System for Reinforced Soil Retaining Walls and Bridge Abutments is fit for its intended use provided it is installed, used and maintained as set out in this Certificate. Certificate No 04/R138 is accordingly awarded to Anchor Retaining Wall Systems Incorporated.

On behalf of the British Board of Agrément

Date of issue: 25th May 2004

Chief Executive



Anchor Retaining Wall
Systems Incorporated

LANDMARK WALL SYSTEM FOR
REINFORCED SOIL RETAINING
WALLS AND BRIDGE ABUTMENTS

Roads and Bridges
Certificate No 04/R138
DETAIL SHEET 2

Product



- THIS DETAIL SHEET RELATES TO THE LANDMARK WALL SYSTEM FOR REINFORCED SOIL RETAINING WALLS AND BRIDGE ABUTMENTS, COMPRISING CONCRETE BLOCK FACING UNITS IN COMBINATION WITH POLYMERIC GEOGRIDS AND A PVC LOCK BAR.

- The concrete facing blocks are connected to the polymeric geogrids by a polyvinyl chloride (PVC) lock bar.
- The concrete block facing units, polymeric geogrids and PVC lock bar are bought-in to the Certificate holder's specifications.

This Detail Sheet must be read in conjunction with the Front Sheet, which gives, HA requirements and the Conditions of Certification.

Technical Specification

1 Description

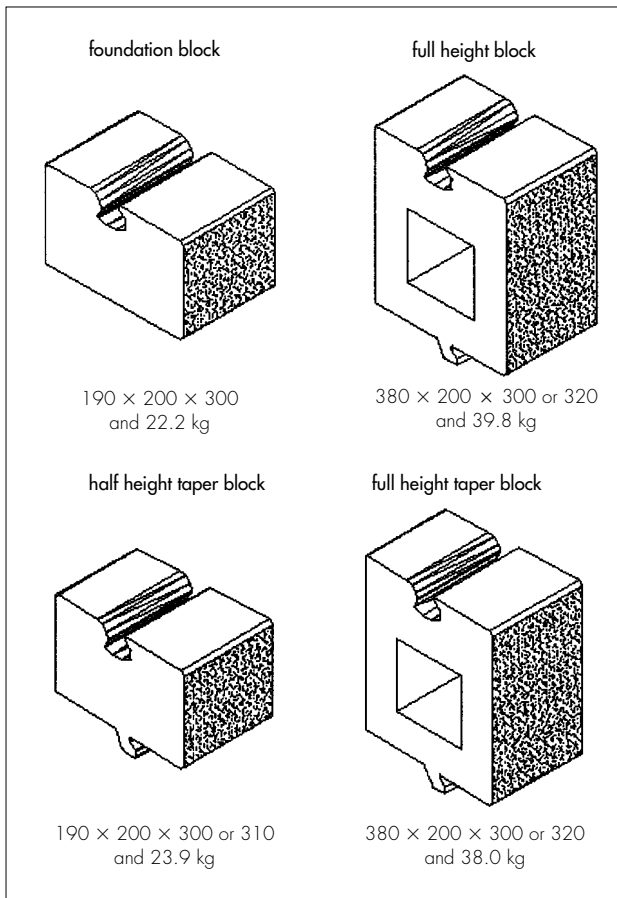
1.1 The Landmark Wall System for Reinforced Soil Retaining Walls and Bridge Abutments comprises:

- Landmark concrete block facing units
- Enkagrid PRO Geogrids
- PVC lock bar.

Landmark concrete block facing units

1.2 The concrete facing units covered by this Detail Sheet are available in four different types and have the nominal dimensions and weights shown in Figure 1. All except the foundation blocks have a lower locating lock flange and they all have a receiving channel in the top. They are available in three standard colours. If special colours are required, the Certificate holder should be contacted. All units are manufactured to the same specification.

Figure 1 Facing units (all dimensions in mm)



1.3 All pigments used for the coloration of the concrete blocks comply with BS EN 12878 : 1999.

1.4 Facing units are manufactured in block machines where mechanical vibratory compaction and sizing is used with semi-dry concrete to achieve the specified minimum compressive strength, water absorption and block shape.

1.5 Minimum concrete strength is 30 Nmm^{-2} at 28 days. The concrete mix specification comprises a minimum cement content of 365 kgm^{-3} and a maximum water/cement ratio of 0.5.

1.6 The blocks are cured in a temperature- and humidity-controlled internal environment.

1.7 Factory production control is undertaken throughout all stages of manufacture. Checks include:

- formalised recording of use of correct concrete mix specification
- visual checks on appearance of demoulded units
- dimensional checks
- compressive strength recording at 7 days and 28 days on eight samples taken from each production run.

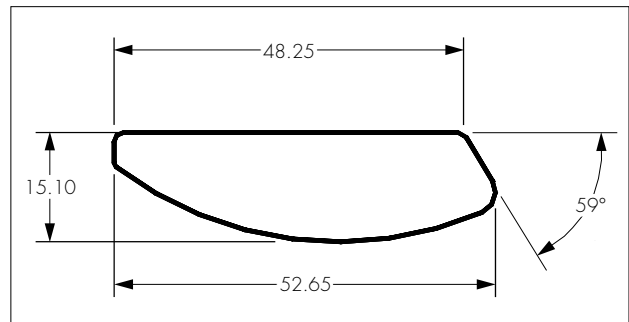
Enkagrid PRO Geogrids

1.8 The geogrids approved for use with the wall system are types 40, 60 and 90, which are covered by BBA Certificate No 03/R133.

PVC lock bar

1.9 The PVC lock bars are manufactured by extrusion to one specification (see Figure 2), and are supplied in either 1.625 m or 1 m lengths.

Figure 2 Lock bar (all dimensions in mm)



Fill

1.10 The fill material used in the structure should comply with the requirements of Class 6I, 6J, 7B, 7C or 7D of the HA Specification (MCHW1 and 2) and with BD 70/03.

2 Delivery to site, handling and storage

Facing units

2.1 The facing units are delivered to site on shrink-wrapped pallets. The shrink wrap is hand-marked with the date of production and labelled to show the product name, manufacturer's logo and the BBA logo. Pallets should not be stacked more than two high.

2.2 To prevent damage, care should be taken in transit and handling. Should the lock flange of the block get damaged in transit, the blocks should be discarded if there is damage in excess of a length of 25 mm. During prolonged periods of storage on site the units should remain covered on pallets.

Enkagrid PRO Geogrids

2.3 Enkagrid PRO Geogrids should be delivered, handled and stored in line with the requirements of BBA Certificate No 03/R133.

PVC lock bar

2.4 The PVC lock bars are delivered to site in cardboard boxes, which are labelled with the date of production and product code.

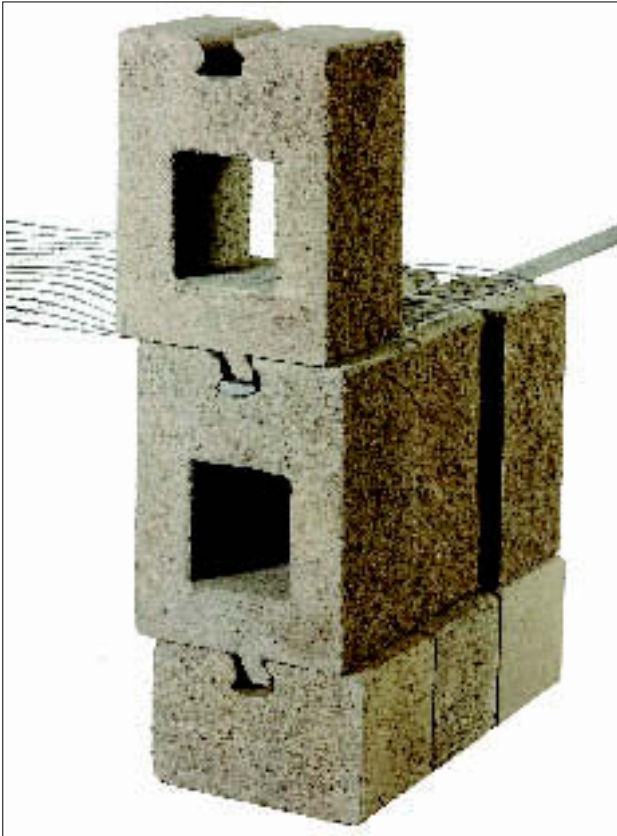
Design Data

3 General

3.1 The Landmark Wall System for Reinforced Soil Retaining Walls and Bridge Abutments is satisfactory for use in providing reinforced soil retaining walls. Walls up to a maximum height of 10 m are covered by this Detail Sheet. Walls above this height require special consideration as described in clause 1.5 of BD 70/03. Structural stability is achieved through the frictional interaction

and interlock of the soil particles with the geogrid and by the mechanical and frictional connection of the geogrid to the facing units (see Figure 3).

Figure 3 Typical section through wall



3.2 The BBA has not assessed this system for supporting parapet loading caused by vehicle collision at the top of the facing units. When applicable, this aspect of a design should be carried out in accordance with BD 70/03.

3.3 In common with all retaining walls of this type, supplementary details are required if there is a risk of dislodgement of the top courses.

3.4 The system should be protected against horizontal impact loads caused by possible vehicle collision with the lower facing units of the wall.

3.5 Design of the reinforced soil wall must be in accordance with HA requirements and carried out by a suitably qualified engineer.

3.6 Prior to the commencement of the work, the designer shall submit to the HA Nominee via the main contractor, relevant Technical Approval documents in accordance with current HA requirements and, as required, details of:

- working drawings
- calculations
- source of fill material
- acceptable moisture content of fill material at time of placement

- sequence of placing fill material
- estimated movements of facing units during filling and compaction operations
- tolerance on the position of finished line of the wall.

4 Practicability of installation

4.1 The system is installed easily, provided all requirements of section 8 are complied with.

4.2 It is important that the first course of concrete block units is laid accurately to the correct line and level to avoid compounding errors in alignment as the wall is built.

4.3 Where accurate cutting of facing units is required on site, disc cutting techniques should be employed.

5 Design considerations

General

5.1 Reinforced soil structures incorporating the wall system shall be designed in accordance with BD 70/03.

5.2 Adequate consideration shall be given to the provision of drainage to the wall in accordance with HA requirements.

5.3 It is considered that with correct design and workmanship and by following the recommendations of this Detail Sheet, normally accepted tolerances of line and level for the construction of retaining walls, as defined in Table 23 of BS 8006 : 1995, can be achieved. However, where the alignment of the vertical face is critical, consideration may be given to providing a brickwork skin, or similar, to the facing units.

5.4 The design of the retaining wall as a whole unit must ensure that the facing units can provide adequate anchorage to the geogrid and provide local support to the soil between the layers of geogrid.

5.5 Test data, available from the Certificate holder, confirms the interface shear capacity of non-reinforced joints is satisfactory where the reinforcement is at the maximum vertical spacing of 760 mm.

6 Mechanical properties

Long-term connection strength (T_{conn})

6.1 A value for the long-term connection strength of the wall system (see Table 1) has been derived by performing a series of short-term tests in line with the National Concrete Masonry Association *Design Manual for Segmental Retaining Walls* (Second Edition, 1997). From the results of these tests, a connection efficiency, expressed as a percentage, has been applied to values of characteristic long-term strength (P_c) for a

120-year life. The values of the P_c have been derived from long-term creep rupture testing at 20°C. For ultimate limit state, for a 120-year design life, P_c is 60% of the ultimate tensile strength (P_{ult}).

Design strength of Landmark wall system

6.2 To evaluate the overall design strength of the wall system, it is necessary to consider both the design strength of the grid (T_{Dgrid}) and the design strength of the connection (T_{Dconn}).

| Geogrid grade | P_c (kNm ⁻¹) | Wall height (m) | T_{conn} (kNm ⁻¹) |
|---------------|----------------------------|-----------------|---------------------------------|
| PRO 40 | 24 | 0.0–6.0 | 15.3 |
| | | 6.1–10.0 | 14.7 |
| PRO 60 | 36 | 0.0–3.0 | 23.2 |
| | | 3.1–10.0 | 30.3 |
| PRO 90 | 54 | 0.0–10.0 | 35.9 |
| | | 3.1–10.0 | 37.3 |

Design strength T_{Dgrid}

6.3 T_{Dgrid} should be calculated for both the ultimate and serviceability limit states. For ultimate limit state, for a 120-year design life, P_c is 60% of P_{ult} . Further information can be found in BBA Certificate No 03/R133.

Design strength T_{Dconn}

6.4 For the ultimate limit state, the connection design strength should be calculated by using:

$$T_{Dconn} = \frac{T_{conn}}{f_m f_n}$$

6.5 For all designs involving the use of the wall system the value of the partial factor for ramification of failure, f_n , should be in accordance with BD 70/03.

6.6 The values of the partial material factor, f_m , sub-components should be taken from Table 2.

| Partial Material Factor component | Value |
|-----------------------------------|---------------------|
| f_m 11 | 1.00 |
| f_m 121 | 1.10 |
| f_m 122 | 1.00 |
| f_m 212 | 1.00 ⁽¹⁾ |
| f_m 22 | |
| pH ⁽²⁾ 2.0–4.0 | 1.10 |
| pH 4.1–8.9 | 1.00 |
| pH 9.0–10.0 | 1.10 |
| pH 10.1–12.5 | 1.34 |

(1) Short-term installation damage effects are deemed to have been taken into account through the method of deriving the value, T_{conn} .

(2) These values refer to the soil's pH as in BBA Certificate No 03/R133.

6.7 The design load the connection must resist (T_i) is to be calculated using prescribed load factors recommended in BD 70/03. For all designs including the wall system the minimum value of load factor is to be 1.5. In all cases T_i must be $\leq T_{Dconn}$.

7 Durability

In the opinion of the BBA, when used and installed in accordance with this Certificate, the wall system results in a reinforced soil structure that can achieve a design life of 120 years.

Installation

8 Procedures

8.1 Detailed information on installation can be found in the Certificate holder's installation instructions.

8.2 Landmark blocks are laid on a levelling pad which may be composed of either good compactable material (MCHW1, type 1) or a suitable concrete foundation (C25/20 or as specified) laid to the correct level for the first course of facing units. Where a concrete foundation is used, a base course of Landmark blocks can be laid by placing on a mortar bed to achieve the required accuracy in line and level. The tops of each unit should be brushed clean prior to the placement of the next course.

8.3 The maximum vertical spacing between geogrid layers should be 760 mm.

8.4 Backfilling should be placed up to the top level of the layer that requires reinforcement and compacted back to the extent of the geogrid reinforcement or as shown on the construction drawings. Heavy plant exceeding one tonne should not be allowed within two metres of the face of the wall (MCHW1, clause 622.7). A vibrating plate compactor of less than one tonne must carry out compaction within this zone. Frequent checks must be made to the alignment of the face to ensure that any disturbance from the compaction process is promptly corrected.

8.5 A suitable length of geogrid is cut from the roll. The geogrid should be placed with the machine direction perpendicular to the wall face and within 25 mm of the face of the lower concrete facing units.

8.6 The reinforcement is placed on top of the units formed in the top of the units. The lock bar should be installed flat side up, with the angled side to the back of the units, shown by an arrow printed on the lock bar. Plant should not be allowed to run directly over geogrids and at least

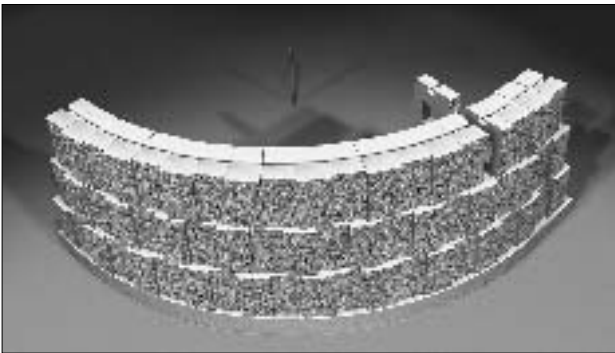
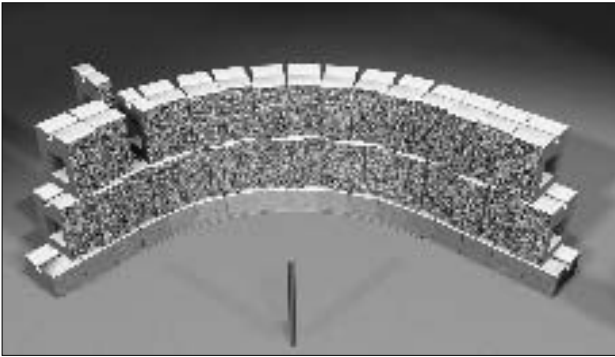
150 mm of fill should be placed over them to avoid damage from traffic.

8.7 Backfilling should be placed as described in section 8.4 and further courses of blocks and geogrids added in an identical manner until the required level for a coping unit is reached.

Corners and curves

8.8 External curves with a minimum radius of 2.75 m can be formed using tapered blocks. Internal curves with a minimum radius of 1.8 m can be formed using tapered blocks (see Figure 4). It should be noted that the setback of the block will cause the radius of each course to gradually increase/decrease and affect the running bond of the wall. To maintain proper running bond, partial units should be used, as necessary. It should also be noted, that with decreasing radii, the lockbar may require cutting into smaller lengths.

Figure 4 Internal and external curves



8.9 External corners of 90° can be formed using special corner units available from the Certificate holder (not covered by this assessment). Further guidance can be found in the Certificate holder's Installation Instructions.

Technical Investigations

The following is a summary of the technical investigations carried out on the Landmark Wall System for Reinforced Soil Retaining Walls and Bridge Abutments.

9 Investigations

9.1 The manufacturing process for the concrete facing units was examined, including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

9.2 An examination was made of test data relating to:

- compressive strength of concrete block facing units
- durability
- performance of the retaining wall system under fire test conditions
- the connection strength between the geogrids and facing units
- interface shear between non-reinforced concrete joints.

9.3 Visits were made to installations in progress to assess the practicability and ease of construction of the system.

9.4 Proposed design methods were assessed in relation to the requirements of BD 70/03 and the National Concrete Masonry Association *Design Manual for Segmental Retaining Walls* (Second Edition — 1997) National Concrete Masonry Association, Herndon, Virginia, USA.

Bibliography

BS 8006 : 1995 *Code of practice for strengthened/reinforced soils and other fills*

BS EN 12878 : 1999 *Pigments for the colouring of building materials based on cement and/or lime — Specifications and methods of test*

BD 70/03 *Strengthened/Reinforced Soils and other Fills for Retaining Walls and Bridge Abutments*

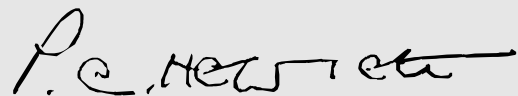
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On behalf of the British Board of Agrément

Date of issue: 25th May 2004



Chief Executive

Electronic Copy

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or check the BBA website.