Roads and Bridges

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BBA APPROVAL INSPECTION TESTING CERTIFICATION
TECHNICAL APPROVALS FOR CONSTRUCTION

Agrément Certificate
09/R147
Product Sheet 1

ALLAN BLOCK RETAINING WALL SYSTEM

AB MODULAR STACKABLE CONCRETE BLOCK WALL SYSTEM FOR REINFORCED SOIL

The Highways Agency requirements to which this Certificate is subject are detailed on page 2

PRODUCT SCOPE AND SUMMARY OF CERTIFICATE

This Certificate relates to the AB Modular Stackable Concrete Block Wall System for Reinforced Soil Retaining Walls and Bridge Abutments.

AGRÉMENT CERTIFICATION INCLUDES:

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

KEY FACTORS ASSESSED

Mechanical properties — key areas evaluated include:

- design strength of the wall system including safety factors (see sections 5.2 to 5.5 and section 7).
- long-term connection strength (see section 6.5).

Durability — the wall system with concrete blocks classified as XF2 to BS 8500-1 : 2006 can achieve a design life greater than 100 years (see section 8).

The BBA has awarded this Agrément Certificate to the company named above for the system described herein. This system has been assessed by the BBA as being fit for its intended use provided it is installed, used and maintained as set out in this Certificate.

On behalf of the British Board of Agrément

Date of First issue: 9 July 2009

Brian Chamberlain
Head of Approvals — Engineering

Greg Cooper
Chief Executive

The BBA is a UKAS accredited certification body — Number 113. The schedule of the current scope of accreditation for product certification is available in pdf format via the UKAS link on the BBA website at www.bbacerts.co.uk

Highways Agency Requirements

All proposals for adopting the systems shall comply with current HA design and certification procedures and relevant Design Data shall be submitted in accordance with the requirements of section 5 of this Certificate.

The design, materials specification and construction methods adopted must be in accordance with HA Technical Standard BD 70/03 (DMRB 2.1.5) and Manual of Contract Documents for Highway Works (MCHW)[1], Volumes 1 and 2, August 1998 (as amended).

(1) The MCHW is operated by the Overseeing Organisations: the Highways Agency (HA), Transport Scotland, the Welsh Assembly Government and The Department for Regional Development (Northern Ireland).

Regulations

Construction (Design and Management) Regulations 2007

Construction (Design and Management) Regulations (Northern Ireland) 2007

Information in this Certificate may assist the client, CDM co-ordinator, designer and contractors to address their obligations under these Regulations.

See sections: 1 *Description* (1.2), 2 *Delivery and site handling* (2.1) and 4 *Practicability of installation*.

General

This Certificate relates to the AB Modular Stackable Concrete Block Wall System for Reinforced Soil Retaining Walls and Bridge Abutments.

The system is based on the use of proprietary dry jointed, hollow concrete block facing units in combination with Fortrac MP geogrids covered by Certificate 01/R125, Product Sheet 2. The geogrids are captured between layers of aggregate-filled blocks.

The design and construction of the reinforced soil structure must be in accordance with the requirements of the Highways Agency (HA); 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 Considerations* and *Installation* parts of this Certificate.

Technical Specification

1 Description

1.1 The AB Modular Stackable Concrete Block Wall System for Reinforced Soil Retaining Walls and Bridge Abutments comprises:

- AB Classic or AB Stones modular concrete block facing units
- AB Capstone
- Fortrac MP geogrids
- fill material.

Concrete units

1.2 The dimensions, setback, weight and shapes of AB Classic and AB Stones facing units and AB Capstone are shown in Table 1 and Figure 1. The minimum concrete strength is 40 Nmm^{-2} at 28 days. The concrete mix specification comprises a minimum cement content of 340 kgm^{-3} and a maximum water/cement ratio of 0.55 and satisfies the requirements of BS 8500-1 : 2006, exposure class XF2.

Table 1 AB facing units and AB Capstone

Unit type	Height (mm)	Depth (mm)	Width (mm)	Setback	Weight (kg)
AB Stones	200	300	450	12°	35
AB Classic	200	300	450	6°	35
AB Capstone	100	300	450	–	27

Figure 1 AB facing units and AB Capstone

1.3 The AB facing units and the AB Capstone are available in a range of colours, including: Limestone Blend, Cinder Blend, Slate Blend, Abbey Blend, Pewter and Cotswold. All pigments used for the coloration of the concrete units comply with BS EN 12878 : 2005.

1.4 Ingredients for the concrete are weighed by a computer-controlled weigh-batcher system. After mixing the concrete, units are cast in block machines.

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

- visual checks on appearance of demoulded units
- compressive strength
- dimensional checks
- density.

Fortrac MP geogrids

1.6 The range of geogrids approved for use with the wall system are those covered by BBA Roads and Bridges Agrément Certificate 01/R125, Product Sheet 2.

Fill

1.7 The fill material used in the structure shall comply with the requirements set out in BS 8006 : 1995 as amended by HA Technical Standard BD 70/03 (DMRB 2.1.5).

1.8 Crushed coarse aggregate is used to infill the hollow core of the AB facing units. The aggregate is well-graded granular fill ranging in diameter from 6 mm to 38 mm and containing less than 10% passing the 0.075 mm sieve size.

2 Delivery and site handling

AB facing units and AB Capstone

2.1 The facing units and capstones are tied together with steel straps and delivered to site on shrink-wrapped pallets. They carry a manufacturer's label bearing the product type and batch code. Pallets should not be stacked more than two high.

2.2 To avoid damage, care should be taken in transit and handling. Damaged materials shall not be incorporated into the project. During prolonged periods of storage on site, the blocks should remain covered on pallets.

Geogrids

2.3 Fortrac MP geogrids should be delivered, handled and stored in line with the requirements of BBA Certificate 01/R125, Product Sheet 2.

Assessment and Technical Investigations

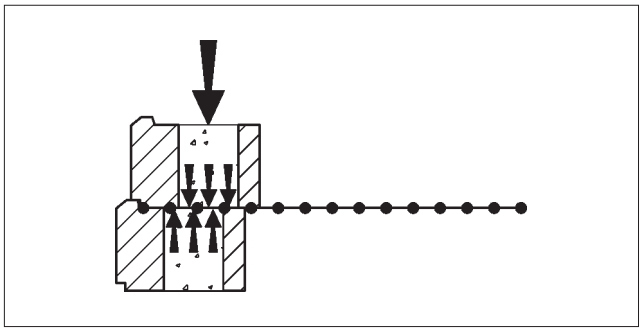
The following is a summary of the assessment and technical investigations carried out on AB Modular Stackable Concrete Block Wall System for Reinforced Retaining Walls and Bridge Abutments.

Design Considerations

3 General

3.1 The AB Modular Stackable Concrete Block Wall System for Reinforced Retaining Walls and Bridge Abutments is satisfactory for use in providing reinforced soil retaining walls and bridge abutments. Walls up to a maximum height of 10 m are covered by this Certificate. Walls above this height require special consideration as described in BD 70/03, clause 1.5. Structural stability is achieved by frictional interaction and interlock of the soil particles with the geogrid. Connection strength of the geogrids to the facing units is achieved by the friction between the blocks and the geogrid and the interlock between the geogrid and the crushed course aggregate used to fill the hollow core of the blocks (see Figure 2).

Figure 2 Connection of geogrids to facing units



3.2 The BBA has not assessed this system for supporting parapet loading caused by vehicle collision at the top of the wall. When applicable, this aspect of a design would require separate consideration and approval by the HA.

3.3 Where appropriate, the reinforced soil structure should be protected against horizontal impact loads caused by possible vehicle collision with the lower part of the wall.

3.4 Prior to commencement of the work, the designer shall satisfy the HA technical approval requirements.

3.5 Where appropriate to specific projects, the designer should provide the main contractor with details of:

- working drawings
- calculations
- specification for fill material
- acceptable moisture content of fill material at time of placement
- method of tightening Fortrac MP geogrids prior to fill placing
- 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

The wall system is installed easily by trained ground engineering contractors provided all requirements of sections 9 and 10 of this Certificate and the relevant sections of Certificate 01/R125, Product Sheet 2, as appropriate, are complied with.

5 Design

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

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

5.3 The ultimate limit state design strength of the geogrid ($T_{Dgrid(ult)}$), should be taken as $T_{CR}/f_m \times f_n$, where T_{CR} is the characteristic tensile creep strength of the geogrid, at the appropriate times and design temperature (see section 6.1), f_m is the partial material factor (see section 7) and f_n is the value of the partial factor for ramification of failure in accordance with BD 70/03.

5.4 The serviceability limit state design strength of the geogrid ($T_{Dgrid(serv)}$), should be taken as T_{CS}/f_m, where T_{CS} is the tensile load in the reinforcement which induces the prescribed limit value of post-construction strain in the geogrid (see section 6.4) and f_m is the partial material factor (see section 7).

5.5 For the ultimate limit state, the connection design strength should be calculated by using $T_{Dconn} = T_{conn}/f_m \times f_n$, where T_{conn} is the ultimate long-term connection strength (see section 6.5), f_m is the partial material factor (see section 7) and f_n is the value of the partial factor for ramification of failure, which should be a value of 1.1.

5.6 For the ultimate limit state, the design load (T_i) that the geogrid and the connection must resist is to be calculated using prescribed load factors in accordance with BD 70/03. In all cases, T_i must be $\leq T_{Dgrid(ult)}$ and T_{Dconn}.

5.7 Post-construction strain can be related to the average load in the reinforcement. The average serviceability limit state design loads (T_{avj}) that the geogrid must resist is to be calculated in accordance with BD 70/03. The average load in the jth level (T_{avj}), is related to the maximum load in the reinforcement (T_j) by a factor k such that $T_{avj} = T_j/k$. The factor k has a minimum value of unity and generally falls in the range of 1.0 to 2.0. Where the distribution of tensile load along the loaded length of the reinforcement is not proven by field measurements, the factor k should be taken as unity. In all cases, $T_{avj} \leq T_{Dgrid(serv)}$.

5.8 Interface shear capacity between the units is provided by the upper concrete lip of the blocks, the friction between the concrete surfaces and the interlock between the particles of fill material. From test data it is confirmed that the interface shear capacity of non-reinforced joints is satisfactory.

5.9 Guidance on soil/geogrid interaction coefficients applied to calculate direct sliding and pull-out resistance can be found in Certificate 01/R125, Product Sheet 2, section 8.

5.10 Adequate consideration shall be given to the provision of drainage to the wall in accordance with Highways Agency requirements.

5.11 It is considered that with correct design and workmanship and by following the recommendations of this Certificate, normally accepted tolerances of line and level for the construction of retaining walls, as defined in BS 8006 : 1995, Table 23, 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 wall units.

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

5.13 Particular attention should be paid to changes in direction of walls where overlapping of the geogrids may occur.

5.14 Working drawings should show the correct orientation of the geogrids.

5.15 The designer should specify the relevant properties of the fill material for the reinforced soil structure deemed acceptable for the purposes of the design. Acceptable materials should meet the requirements of the MCHW, Volume 1, Series 600.

6 Mechanical properties

Long-term tensile strength of the geogrids (T_{CR})

6.1 For the ultimate limit state, the method of establishing the characteristic tensile strength of the geogrids (T_{CR}) is given in Certificate 01/R125, Product Sheet 2, section 6.4 (T_{CR} is synonymous with P_C in Certificate 01/R125).

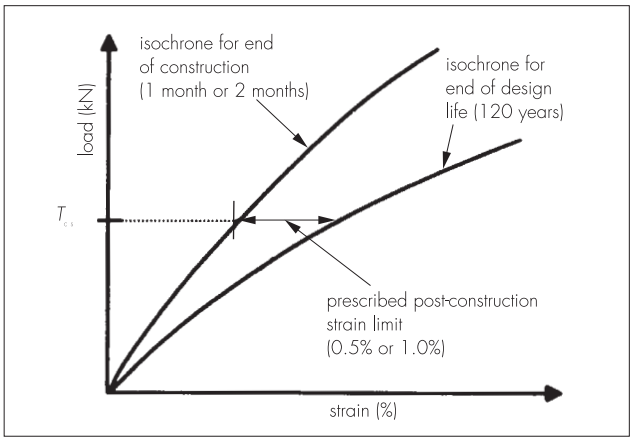
Creep performance of the geogrids (T_{CS})

6.2 For the serviceability limit state, the prescribed allowable post-construction strains are:

- bridge abutments — 0.5% (2 months to 120 years)
- retaining walls — 1.0% (1 month to 120 years).

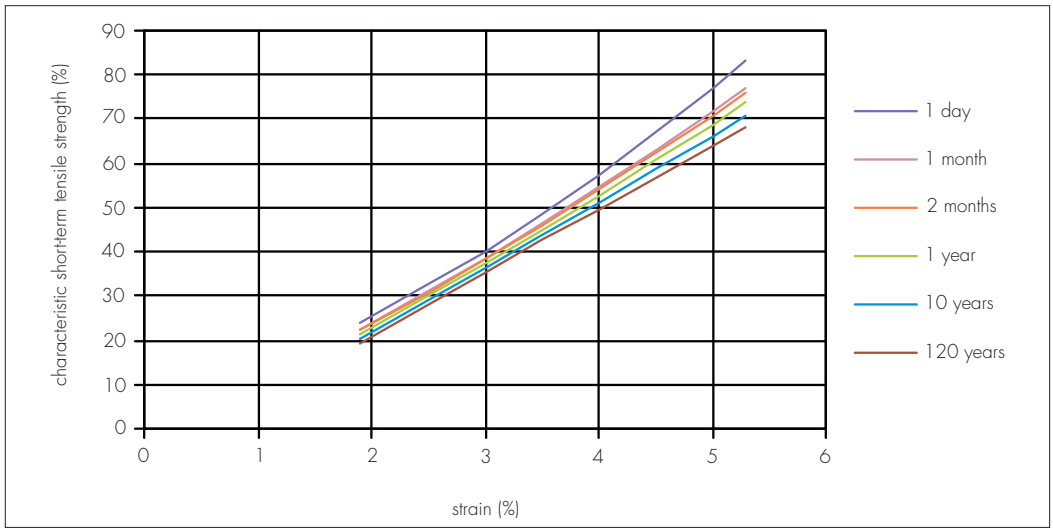
6.3 The definitions of prescribed post-construction strain limit and T_{CS}, the tensile load that would create the prescribed post-construction strain, are explained in Figure 3.

Figure 3 Definition of T_{CS}



6.4 Isochronous curves based on long-term creep strain tests have been derived (see Figure 4). From these curves values for T_{CS} have been calculated and it has been found that creep rupture, as opposed to creep strain, governs the long-term performance of the geogrid. T_{CS} values, therefore, can be taken as the corresponding T_{CR} value.

Figure 4 Isochronous curves



Long-term connection strength (T_{conn})

6.5 A value for the long-term connection strength of the wall system (see Table 2) has been derived by performing a series of short-term tests in line with the National Concrete Masonry Association's *Design Manual for Segmental Retaining Walls* (Second Edition, 2002). From the results of these tests, a connection efficiency, expressed as a percentage, has been applied to the values of tensile creep rupture strength (T_{CR}) of the geogrid, as given in section 6.1. Values of T_{conn} are applicable for both AB Classic and AB Stones units.

Table 2 Long-term connection strength (T_{conn})

Geogrid grade	T_{CR}[1] (kNm^{-1})	Wall height – H[2] (m)	T_{conn}[3] (kNm^{-1})
Fortrac 20 MP	13.94	$0.8 \leqslant H \leqslant 10.0$	2.7
Fortrac 35 MP	24.39	$0.9 \leqslant H \leqslant 10.0$	8.0
Fortrac 55 MP	38.33	$2.5 \leqslant H < 4.9$	9.6
		$4.9 \leqslant H < 5.8$	10.8
		$5.8 \leqslant H < 7.4$	12.1
		$7.4 \leqslant H \leqslant 10.0$	13.0
Fortrac 80 MP	55.76	$2.5 \leqslant H < 5.8$	13.2
		$5.8 \leqslant H < 7.4$	14.2
		$7.4 \leqslant H < 8.2$	14.8
		$8.2 \leqslant H \leqslant 10.0$	15.9

(1) Assumes a design life of 120 years and a design temperature of 20°C.

(2) Assumes a density of 1900 kgm^{-3} of the fill in the hollow core of AB units and the weight of the whole wall height above the connection

(3) In situations where fire can occur adjacent to a structure, connection strength values should be reduced by a factor of 1.25 for Fortrac 20 MP, 35 MP and 55 MP grades and by a factor of 1.11 for Fortrac 80 MP grade.

7 Partial material factors

7.1 In establishing the design strength of the geogrids and the connection (T_{Dgrid} and T_{Dconn}), and ensuring that during the life of the reinforced soil structure the geogrid will not fail in tension, the BBA recommends that in line with BS 8006 : 1995, a set of partial material factors should be applied to T_{CR}, T_{CS} and T_{conn}. Conditions of use outside the scope for which partial material factors are defined (see also sections 7.3 to 7.6) are not covered by this Certificate and the advice of the manufacturer should be sought.

7.2 The total material factor (f_m) is given by $f_m = f_{m11} \times f_{m12} \times f_{m21} \times f_{m22}$, where f_{m11} is a material factor relating to manufacture, f_{m12} is a material factor relating to extrapolation of test data, f_{m21} is a material factor relating to susceptibility of installation damage and f_{m22} is a material factor relating to environmental effects.

Manufacture — partial material factor (f_{m11})

7.3 For Fortrac MP geogrids, a characteristic base strength is specified and partial material factor f_{m11} can be taken as 1.00.

Extrapolation of test data — partial material factor (f_{m12})

7.4 To account for extrapolation of data for a design life of 120 years, the values for the partial material factor (f_{m12}) for Fortrac MP geogrids are given in Certificate 01/R125, Product Sheet 2, section 7.2 (f_{m12} is synonymous with f_m in Certificate 01/R125).

Installation damage — partial material factor (f_{m21})

7.5 When calculating T_{Dgrid}, to account for installation damage the values for the partial material factor (f_{m21}) for Fortrac MP geogrids are given in Certificate 01/R125, Product Sheet 2, section 7.3 (f_{m21} is synonymous with f_d in Certificate 01/R125).

7.6 When calculating T_{Dconn}, to account for installation damage the value for the partial material factor (f_{m21}) can be taken as 1.0 since installation damage effects are deemed to have been taken into account when deriving the value, T_{conn}.

Environmental effects — partial material factor (f_{m22})

7.7 To account for environmental conditions, the appropriate value for f_{m22} for Fortrac MP geogrids for a 120-design life is given in Certificate 01/R125, Product Sheet 2, section 7.4 (f_{m22} is synonymous with f_e in Certificate 01/R125).

8 Durability

8.1 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 greater than 100 years. This is based on the assumption that the exposure environment for the concrete is classified as XF2 in accordance with BS 8500-1 : 2006.

8.2 Where concrete wall units are to be embedded in potentially aggressive soils, the guidance given in BRE Special Digest 1 : 2005 *Concrete in aggressive ground* should be followed.

8.3 The durability of Fortrac MP geogrids is described in BBA Certificate 01/R125, Product Sheet 2, section 10.

8.4 Fill materials classified as 6I, 6J, 7B, 7C and 7D should comply with the limits of the MCHW1 (600 series), Table 6/3, regarding maximum water soluble sulfate content and maximum oxidisable sulfides content.

Installation

9 General

9.1 In general, the execution of reinforced soil structures should be carried out in accordance with BD 70/03 and BS EN 14475 : 2006.

9.2 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.

9.3 Where accurate cutting of facing units is required on site, disc-cutting techniques should be used.

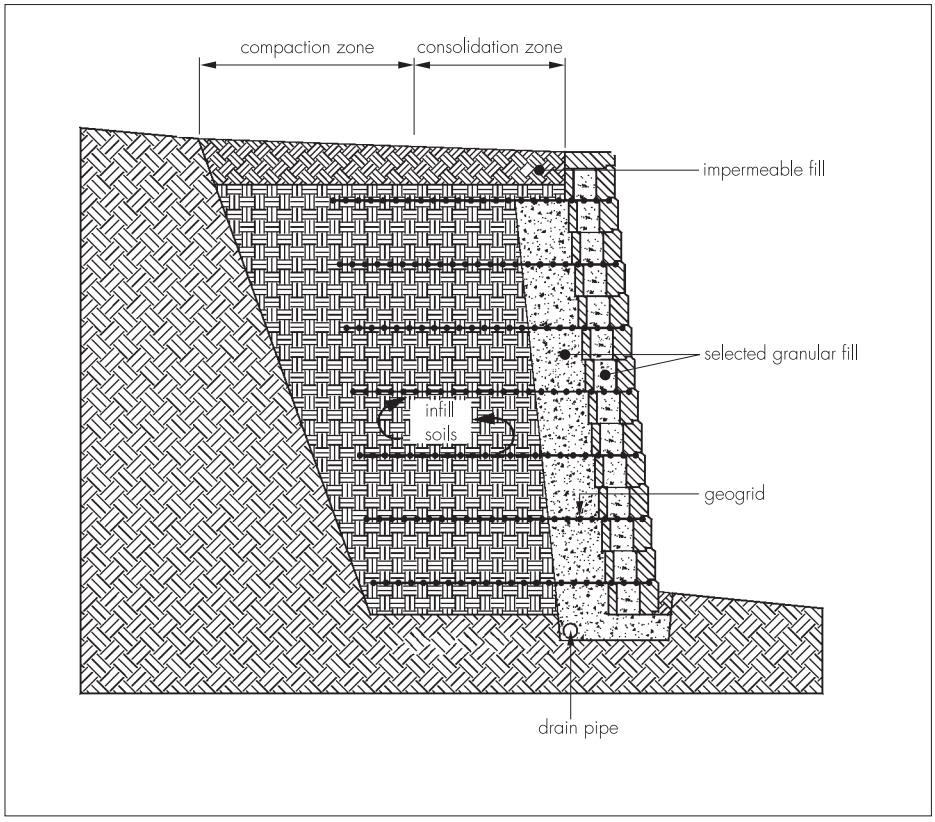
9.4 During construction it is particularly important to ensure that:

- fill is properly compacted, especially close to facing units
- at each construction stage, the level of the compacted fill coincides with the level of the facing unit connection to prevent the risk of voids occurring below the geogrid
- the geogrid is tensioned at right angles to the plane of the facing, within a tolerance of ± 50 mm in a five-metre length, and the geogrid is pulled tight to ensure that all slack is removed.

10 Procedure

10.1 Detailed information on installation of the AB Modular Stackable Concrete Block Wall System for Reinforced Soil Retaining Walls and Bridge Abutments can be found in the Certificate holder's Installation Guide. A typical cross-section of a reinforced wall is shown in Figure 5.

Figure 5 Typical cross-section of reinforced wall



10.2 The blocks are laid on a levelling pad composed of either well-graded, good compactable material ranging in diameter from 6 mm to 38 mm or a suitable concrete foundation laid to the correct level for the first course of facing units. The first course of the wall units are laid and checked for level and alignment.

10.3 A drain pipe is placed at the back of the trench along the wall and should be vented to a daylight or a stormwater system.

10.4 Selected granular fill of crushed coarse aggregate, ranging in diameter from 6 mm to 38 mm and containing less than 10% fines, is placed and compacted 300 mm behind the block and in the hollow core up to the top of the facing unit. Suitable infill soil is placed and compacted behind the 300 mm deep granular fill.

10.5 The compaction requirements depend on the fill type selected, but can be found in the MCHW, Volume 1, Clause 612. Heavy plant exceeding one tonne should not be allowed within two metres of the face of the wall (MCHW, Volume 1, 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.

10.6 A suitable length of geogrid is cut from the roll and laid with the cut edge against the back edge of the raised front lip. The geogrid should be placed with the machine direction perpendicular to the wall face and pulled back over the compacted area. The next course of wall units can be laid on the first, ensuring that the vertical seams are offset by at least 75 mm.

10.7 The geogrid is pulled on the back to remove any slack by staking the corners and back edge in place.

10.8 The frequency of the geogrid layers depends on the design and should be indicated on the design drawings. Typically geogrids are placed in every two courses.

10.9 Fill should be placed by mechanical plant with an opening bucket, avoiding trafficking of unprotected grids, and should cover the grid reasonably uniformly.

10.10 The general construction procedure is repeated until the required level for the coping unit is reached.

10.11 Detailed guidance on forming curves and corners, including the placement of geogrids, can be found in the Certificate holder's Installation Guide.

Technical Investigations

11 Investigations

11.1 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.

11.2 An examination was made of test data relating to:

- 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.

11.3 An assessment was made of the method of installation to assess the practicability and ease of construction of the system.

11.4 Design methods including partial material factors were assessed in relation to the requirements of BD 70/03.

11.5 Dimensional check tests were carried out on facing units and capstone.

Additional Information

The management systems of the Allan Block Corporation have been assessed and registered as meeting the requirements of BS EN ISO 9001 : 2000 by BMTRADA (Certificate No 6593).

Bibliography

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

BS 8500-1 : 2006 Concrete — *Complementary British Standard to BS EN 206-1 — Method of specifying and guidance for the specifier*

BS EN 12878 : 2005 *Pigments for the colouring of building materials based on cement and/or lime — Specifications and methods of test*

BS EN 14475 : 2006 *Execution of special geotechnical works — Reinforced fill*

BS EN ISO 9001 : 2000 *Quality management systems — Requirements*

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)

12 Conditions

12.1 This Certificate:

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

12.2 Publications and documents referred to in this Certificate are those that the BBA deems to be relevant at the date of issue or re-issue of this Certificate and include any: Act of Parliament; Statutory Instrument; Directive; Regulation; British, European or International Standard; Code of Practice; manufacturers' instructions; or any other publication or document similar or related to the aforementioned.

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

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

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

- the presence or absence of any patent, intellectual property or similar rights subsisting in the product/system or any other product/system
- the right of the Certificate holder to manufacture, supply, install, maintain or market the product/system
- individual installations of the product/system, including the nature, design, methods and workmanship of or related to the installation
- the actual works in which the product/system is installed, used and maintained, including the nature, design, methods and workmanship of such works.

12.5 Any information relating to the manufacture, supply, installation, use and maintenance of this product/system which is contained or referred to in this Certificate is the minimum required to be met when the product/system is manufactured, supplied, installed, used and maintained. It does 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; nor is conformity with such information to be taken as satisfying the requirements of the 1974 Act or of any statutory, common law or other duty of care. 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 manufacture, supply, installation, use and maintenance of this product/system.

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