HAPAS

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HAPAS Certificate
18/H278
Product Sheet 1

VSL RETAINED EARTH SYSTEM

VSOL RETAINED EARTH WALL SYSTEM FOR RETAINING WALL AND BRIDGE ABUTMENTS

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

This Certificate relates to the VSoL Retained Earth Wall System(1) for use in reinforced-soil retaining walls and bridge abutments, and comprising reinforced concrete facing panels, geosynthetic soil reinforcement strips, polymer bearing pads and dowels and compacted fill material.

(1) Hereinafter referred to as 'Certificate'.

CERTIFICATION INCLUDES:

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

Design — interaction between the soil and the system has been considered, and coefficients relating to the long term performance of the system have been developed (see section 6).

Mechanical properties — the short- and long-term strength of the strips and the concrete facing panels, the loss of strength due to installation damage, and the strength of the VSoL connections have been assessed (see section 7).

Durability — the resistance of the system to environmental effects normally encountered in reinforced-soil retaining walls and bridge abutments has been assessed, and reduction factors established for use in design (see section 9).

The BBA has awarded this 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: 30 April 2018

Paul Valentine
Technical Excellence Director

Claire Curtis-Thomas
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
Readers are advised to check the validity and latest issue number of this Agrément Certificate by either referring to the BBA website or contacting the BBA direct.

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Requirements

In the opinion of the BBA, the VSoL Retained Earth Wall System for retaining walls and bridge abutments, when used in accordance with the provisions of this Certificate, will meet or contribute to meeting the following requirements of the *Manual of Contract Documents for Highways Works* (MCHW)(1), Volume 1 *Specification for Highways Works* (SHW).

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

Regulations

Construction (Design and Management) Regulations 2015
Construction (Design and Management) Regulations (Northern Ireland) 2016

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

See section: 3 *Delivery and site handling* (3.2) of this Certificate.

Additional Information

CE marking

The Certificate holder has taken the responsibility of CE marking the system components in accordance with harmonised European Standard BS EN 15258 : 2008.

Technical Specification

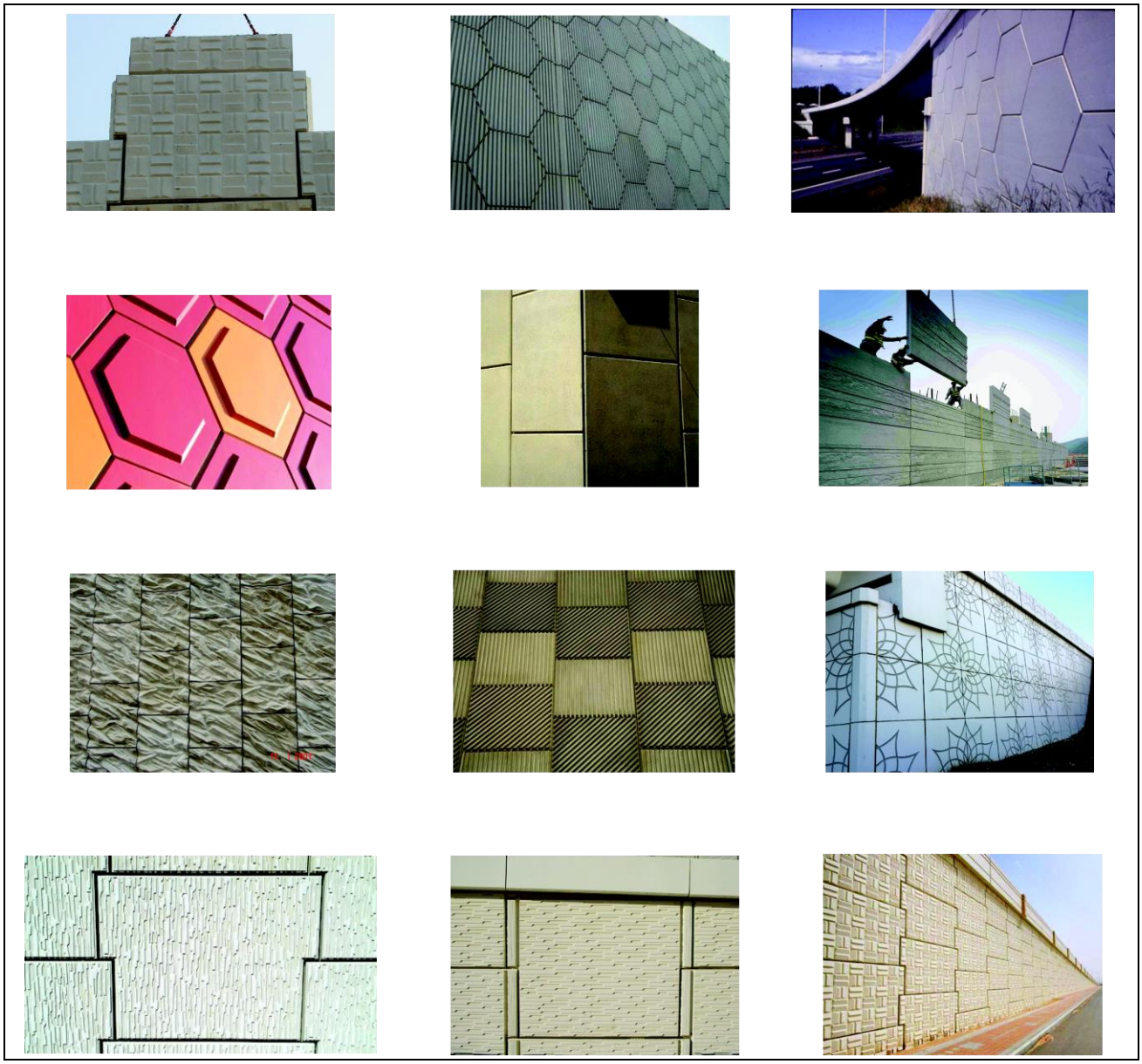
1 Description

1.1 The VSoL Retained Earth Wall System for retaining walls and bridge abutments comprises concrete facing panels with a proprietary connection detail, Paraweb strips(1) (see section 2.2 of this Certificate), HDPE bearing pads and uPVC dowels, and structural backfill material to the Certificate holder's specification.

(1) Used for soil reinforcement. The specifications are detailed in BBA HAPAS Certificate 12/H191.

1.2 The BBA has assessed the system for use with concrete facing panels designed and manufactured in accordance with BS 8006-1 : 2010, BS EN 14475 : 2006, BS EN 1990 : 2002 and BS EN 1992-1-2 : 2004 and their UK National Annexes, and the requirements of section 6 of this Certificate. The panels may have various shapes according to architectural requirements, but typical forms are shown in Figure 1. The shape of the panel must be agreed with the relevant local highways authority. Typical panel dimensions are < 2410 x 2230 mm x 150 mm and the minimum concrete grade is C25/30, reinforced with steel to BS EN 10080 : 2005. The design and detailing of the panel must satisfy the minimum requirements for exposure class XF2, XC4 and XD3 of BS EN 206 : 2013, or a more severe exposure class if the site-specific assessment indicates that this is necessary.

Figure 1 Shape typologies of the panels for VSoL partial height facing system

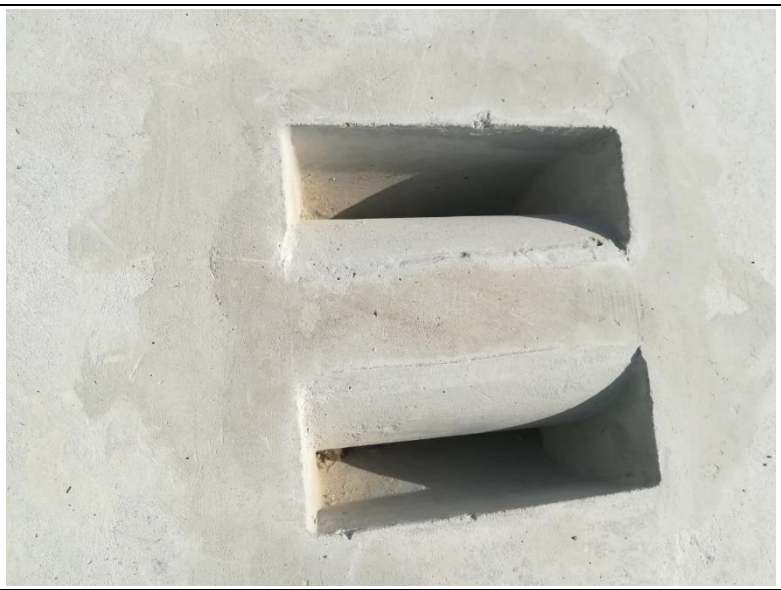


1.3 Each panel contains a number of void-formed connection points for the strips, according to the size and configuration of the panel. The connections are available in two grades: VF-70b and VF-100, with the specifications given in Table 1. The finished void is shown in Figure 2.

Table 1 VSoL connections — specification

Type	VF-70b	VF-100
Minimum panel thickness at the connection	150 mm	200 mm
Reinforcement diameter through the connection	10 mm	20 mm
Minimum aperture width	103 mm	153 mm
Maximum connection design force	72.5 kN	82 kN

Figure 2 Finished void

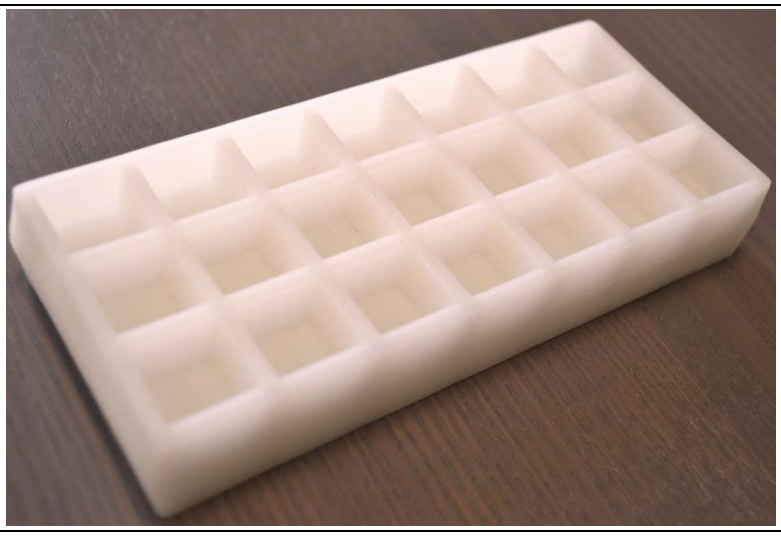


1.4 The appropriate combination and number of strips, panels and connections must be determined by a site-specific design. The connections between the strips and the panels must be arranged to ensure the stability of the panels, and to ensure that the resistance of the panel is adequate for the imposed loads. Particular care should be taken to avoid rotation of the panels due to eccentricity in the imposed loads. The following combinations of connections are permissible:

- panels with two connections are used in conjunction with 30, 50, 70 and 100 kN strips
- panels with four connections are used in conjunction with 30, 50, 70 and 100 kN strips
- panels with five connections are used in conjunction with 30 and 70 kN strips
- panels with six connections are used in conjunction with 30 kN strips.

1.5 The HDPE bearing pads, to one specification, are used between panels, providing an initial separating joint of 22 mm. The bearing pad dimensions are 136 to 288 mm long, 60 mm wide and 22 mm thick. The bearing pad has a waffle-type structure (see Figure 3) to achieve an appropriate stress-strain behaviour for the size of the bearing pad.

Figure 3 HDPE bearing pad



1.6 PVC dowels, to one specification, are used as a construction aid to align T-, cruciform- and hexagonal-shaped panels. Each panel incorporates a socket into which the dowel is inserted. The dowels have a 28 mm diameter and 5 mm wall thickness. The dowels do not contribute to the structural strength of the finished retaining wall.

1.7 The fill material must comply with the requirements set out in BS EN 8006-1 : 2010 and the MCHW, Volume 1.

1.8 Ancilliary items(1) for use with the system, but outside the scope of this Certificate, are:

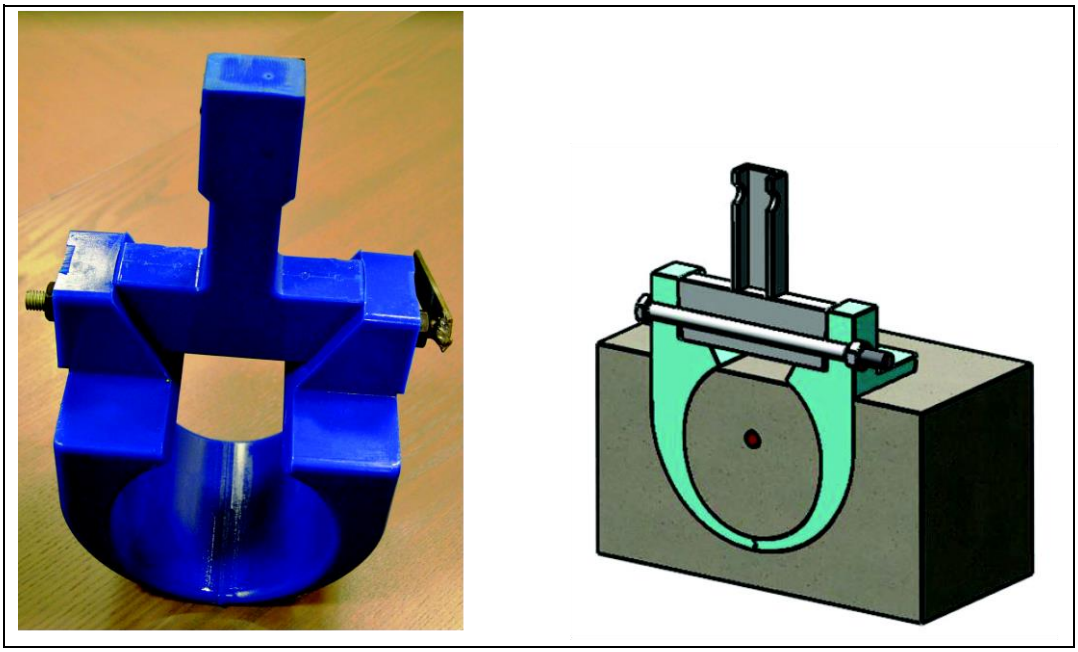
- a levelling pad or foundation — for the retaining wall, to the design engineer's specification
- a geotextile fabric to BS EN 13251 : 2016 — to prevent loss of fines through the joints in the panels. The fabric must be CE marked, with a durability in excess of 100 years
- bituminous paint, sealant or adhesive — to adhere the geotextile fabric to the panels
- granular fill material and pipe — for drainage
- lifting eyes or anchor screws — for securing, transporting and lifting panels into position.

(1) The exact specifications for the ancilliary items must be determined on a project-specific basis by an suitability competent and qualified engineer.

2 Manufacture

2.1 The panels are manufactured to the Certificate holder's specification, and under the supervision of a competent person appointed by the Certificate holder. The proprietary tooling, illustrated in Figure 4, required to produce the voids is supplied by the Certificate holder.

Figure 4 Void formers



2.2 Paraweb strips are manufactured by Linear Composites Ltd.

2.3 The bearing pads and dowels are bought-in items to one specification.

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

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

2.5 The management system of VSL International AG has been assessed and registered as meeting the requirements of BS EN ISO 9001 : 2008 and BS EN ISO 14001 : 2004 by SGS (Certificates CH12/2155 and CH12/2156 respectively).

3 Delivery and site handling

3.1 The panels should be handled and stored in accordance with the manufacturer's instructions and the requirements of BS 8006-1 : 2010, BS EN 14475 : 2006 and the MCHW, Volume 1.

3.2 Each panel incorporates lifting eyes, hooks or similar to allow the panel to be safely lifted.

3.3 Care should be taken to prevent damage to the panel during transit, handling and storage.

3.4 The Paraweb strips should be handled and stored in accordance with the provisions of BBA HAPAS Certificate 12/H191 and the manufacturer's instructions.

3.5 The geotextile, bearing pads, dowels, drainage material and bituminous paint should be delivered, handled and stored in accordance with the manufacturer's instructions.

Assessment and Technical Investigations

The following is a summary of the assessment and technical investigations carried out on the VSoL Retained Earth Wall System for retaining walls and bridge abutments.

Design Considerations

4 Use

4.1 When designed and installed in accordance with this Certificate, the panels and strips are satisfactory for use in the construction of reinforced-soil retaining walls and bridge abutments, where the system is designed to resist the applied loads.

4.2 Structural stability is achieved through the strength of the strips, the connection strength between the strips and the panels, and by the frictional interaction between the soil particles and the strips.

4.3 Key design factors include:

- the specification for fill material and method of placement and compaction
- design strength of the strips and length of embedment within the compacted fill material
- design strength of the VSoL void-formed connections.

4.4 Prior to the commencement of work, the designer must satisfy the design approval and certification procedures of the relevant Highway Authority.

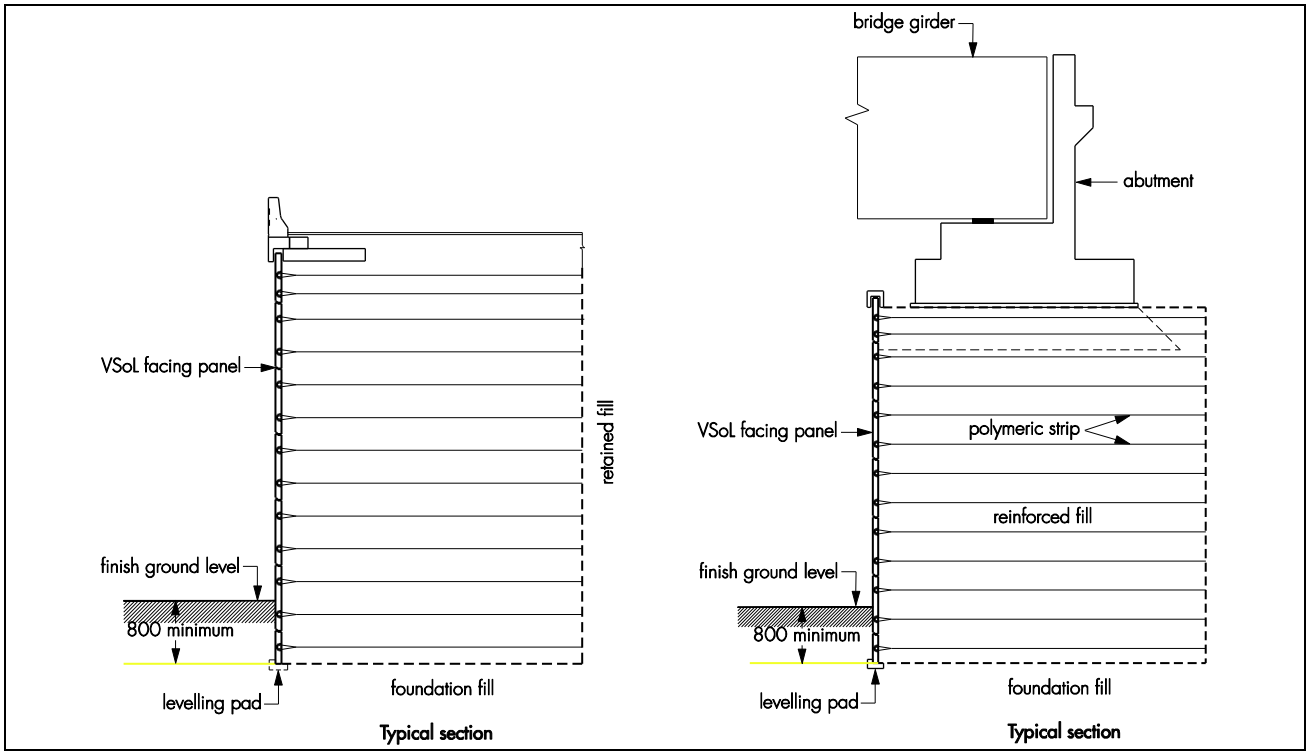
4.5 The BBA has not assessed the structures for supporting parapet loading caused by vehicle collision at the top of the panels.

4.6 Particular attention should be paid in design to :

- the global stability of the retained earth structure
- site preparation
- fill material properties
- specification for placing and compaction of the fill material
- drainage
- protection of the strips against damage during installation
- adequacy of the strength of VSoL void-formed connections
- the required construction tolerances for the completed structure.

4.7 Typical configurations of the system for retaining walls and bridge abutments are shown in Figure 5.

Figure 5 Section of typical retaining wall using the system



5 Practicability of installation

The panels and strips can be installed by competent contractors in accordance with the specifications, method statements and construction drawings, and under the direct supervision, of VSL International AG.

6 Design

Design methodology

6.1 Reinforced-soil retaining walls and bridge abutments constructed using the system should be designed in accordance with BS 8006-1 : 2010 and the MCHW, Volume 1.

6.2 In accordance with BS 8006-1 : 2010, Annex B, the required design life for permanent walls and bridge abutments is 120 years.

Paraweb strips

6.3 For detailed design methodology for the strips, refer to BBA HAPAS Certificate 12/H191.

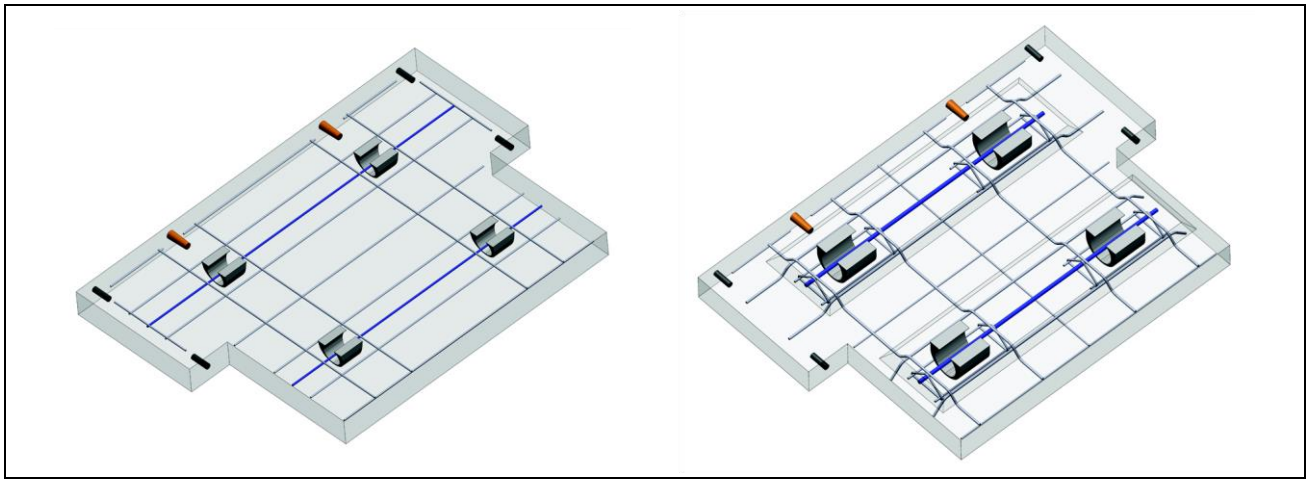
Concrete facing panels

6.4 The panels must be designed in accordance with the relevant provisions of BS 8006-1 : 2010, BS EN 14475 : 2006, BS EN 1990 : 2002 and BS EN 1992-2 : 2005 and their UK National Annexes.

6.5 The appropriate combination of concrete exposure classes should be selected from Table A.1 of BS 8500-1 : 2015, and Table 1 of BS EN 206 : 2013, to suit the proposed location and level of exposure of the proposed structure. Design and detailing of the panels should provide adequate durability for an intended design life of at least 120 years.

6.6 The steel reinforcement in the panels is to be designed and detailed in accordance with BS EN 1992-1-1 : 2004 and its UK National Annex. Typical configurations for reinforcement are shown in Figure 6.

Figure 6 Typical reinforcement configuration for (a) VF70 and (b) VF-100 panels



6.7 Where panels are to be embedded in soils which could be potentially aggressive, the guidance in BRE Special Digest 1 : 2005, Part C should be followed.

6.8 The appropriate connection detail should be selected to ensure adequate strength to the connection between strips and the panels for the intended use.

7 Mechanical properties

7.1 The characteristic short- and long-term tensile strength of each grade of Paraweb strip for the appropriate installation conditions are given in BBA HAPAS Certificate 12/H191, along with the appropriate reduction factors for a 120 year design life.

7.2 Tests have shown that the void-formed connection in the panels is capable of resisting the connection forces as shown in Table 2, and no reduction in the strength of the Paraweb strip was observed. The design strength of the VF-70b and VF100 connections, established by testing in accordance with BS EN 1990 : 2002 and incorporating partial factors in accordance with BS EN 1992-1-1 : 2004 and BS 8006-1 : 2010, when used in conjunction with Paraweb strips, are detailed in Table 2.

Table 2 Design strength of connection

Type	Reinforcement bar diameter (mm)	Paraweb strips — grade	Design strength of VSoL connection T_{Dconn} (kN)
VF-70b	10	27 - 70	72.5
VF-100	20	70 - 100	82

8 Maintenance

As the system is confined within the soil and has suitable durability, maintenance is not required. Periodic cleaning of the panels to remove dirt and moss growth may be employed.

9 Durability

9.1 The panels will have adequate durability for the proposed life of the structure under exposure conditions normally encountered in reinforced-earth retaining walls and bridge abutments in the UK, when designed and installed in accordance with the provisions of BS 8006-1 : 2010 and BS EN 14475 : 2006 and the requirements of this Certificate.

9.2 Paraweb strips will have adequate durability for a design life of 120 years, when installed and used in accordance with the provisions of BBA HAPAS Certificate 12/H191.

10 Reuse and recyclability

10.1 The panels can be crushed and reused as aggregate.

10.2 The steel reinforcement can be readily recycled.

10.3 The compacted fill material can be reused.

Installation

11 General

Installation of the VSoL Retained Earth Wall System for reinforced-soil retaining walls and bridge abutments must be carried out in accordance with the Certificate holder's instructions, BS 8006-1 : 2010, BS EN 14475 : 2006 and the MCHW, Volume 1.

12 Approved installers

Installation of the system, within the context of this Certificate, is carried out by installers recommended or recognised by the Certificate holder. Such an installer is a company which:

- employs operatives who have been trained and approved by the Certificate holder to install the system
- has undertaken to comply with the Certificate holder's application procedure
- is subject to supervision by the Certificate holder, including site inspections.

13 Procedure

13.1 A concrete levelling pad is laid, to provide a suitably level base for the panels.

13.2 The first course of panels is laid. Depending on the shape, this may consist of alternate full and half units. Dowels, temporary clamps and props may be used to aid positioning and to maintain alignment during construction. To prevent loss of fine fill material through the joints in the panels, a geotextile adhered with bituminous paint may be applied to the rear of the panels.

13.3 If a drainage system is to be constructed at the rear of the wall, the pipes, geotextiles and granular material are laid in accordance with the designer's instructions.

13.4 Fill material is placed and compacted behind the facing panels to the level of the first layer of Paraweb strips. The compaction of the fill material, including formation levels, must be in accordance with the designer's specification and the MCHW, Volume 1.

13.5 The first layer of strips is installed, attached to the panels by threading through the voids. The strips are pulled taut and anchored at the rear of the reinforced area using a horizontal anchor bar and steel pins, prior to the next layer of fill material being placed above.

13.6 Further courses of panels are installed up to the next level of strips. The bearing pads are installed at the horizontal joints between the panels, to the designer's specification.

13.7 The fill material is placed and compacted, up to the next level of strips. Particular care should be taken to ensure the strips are adequately covered before compaction or trafficking. To avoid excessive movement of the panels, heavy compaction plant must not be used within two metres of the facing panels where the depth of fill material, before each pass, may be less than 150 mm to suit the lighter compaction plant used.

13.8 The process is completed up to the finished formation level.

13.9 Joints in the strip are made, if necessary, with a minimum overlap of 2 metres. The overlapping lengths are to be held together using clamps as a construction aid. Joints should be made adjacent to the horizontal anchor bar.

13.10 The ends of the strip are treated with a bitumastic-based sealant to reduce ingress of moisture.

Technical Investigations

14 Tests

A series of tests were carried out to establish the pull-out strength of the connection between the panel and strip.

15 Investigations

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

15.2 An examination was made of data relating to:

- evaluation of the connection details
- evaluation of short- and long-term tensile properties
- evaluation of short- and long-term load/strain characteristics
- durability of the panels.

Bibliography

BRE Special Digest 1 : 2005 *Concrete in aggressive ground,* Part C *Assessing the aggressive chemical environment*

BS 8006-1 : 2010 + A1 : 2016 *Code of practice for strengthened/reinforced soils and other fills*

BS 8500-1 : 2015 + A1 2016 *Concrete — Complementary British Standard to BS EN 206 — Method of specifying and guidance for the specifier*

BS EN 206 : 2013 + A1 : 2016 *Concrete — Specification, performance, production and conformity*

BS EN 1990 : 2002 + A1 2005 *Eurocode — Basis of structural design*
NA to BS EN 1990 : 2002 + A1 : 2005 *Eurocode. Basis of structural design*

BS EN 1992-1-1 : 2004 + A1 : 2014 *Eurocode 2 — Design of concrete structures — General rules and rules for buildings*
NA to BS EN 1992-1-1 : 2004 + A1 : 2014 UK National Annex to *Eurocode 2 — Design of concrete structures — General rules and rules for buildings*
BS EN 1992-1-2 : 2004 *Eurocode 2 — Design of concrete structures — General Rules*
NA to BS EN 1992-1-2 : 2004 UK National Annex *to Eurocode 2 — Design of concrete structures — General Rules*
BS EN 1992-2 : 2005 *Eurocode 2 — Design of concrete structures — Concrete bridges — Design and detailing rules*
NA to BS EN 1992-2 : 2005 UK National Annex to *Eurocode 2 — Design of concrete structures — Concrete bridges — Design and detailing rules*

BS EN 10080 : 2005 *Steel for the reinforcement of concrete — Weldable reinforcing steel — General*

BS EN 13252 : 2016 *Geotextiles and geotextile-related products — Characteristics required for use in drainage systems*

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

BS EN 15258 : 2008 *Precast concrete products — Retaining wall elements*

BS EN ISO 9001 : 2008 *Quality management systems — Requirements*

BS EN ISO 14001 : 2004 *Environmental management systems — Requirements with guidance for use*

Manual of Contract Documents for Highway Works, Volume 1 *Specification for Highways Works*

16 Conditions

16.1 This Certificate:

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

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

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

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

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

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

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

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

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