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BBA APPROVAL INSPECTION TESTING CERTIFICATION
TECHNICAL APPROVALS FOR CONSTRUCTION

Agrément Certificate
04/4152
Product Sheet 1

DURAPILE PILING SYSTEM

DURAPILE 200 MM SQUARE SEGMENTAL PILES

PRODUCT SCOPE AND SUMMARY OF CERTIFICATE

This Certificate relates to Durapile 200 mm Square Segmental Piles, for providing a piled foundation. The formed piles are designed for compressive loading only.

AGRÉMENT CERTIFICATION INCLUDES:

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

KEY FACTORS ASSESSED

Strength — the products have adequate strength to resist foundation loads when designed and installed in accordance with the provisions of this Certificate (see sections 3, 5 and 10).

Durability — when designed and installed in accordance with the provisions of this Certificate, the products will withstand the long-term effects of compressive loading (see section 7).

The BBA has awarded this Agrément Certificate to the company named above for the products described herein. These products have been assessed by the BBA as being fit for their intended use provided they are installed, used and maintained as set out in this Certificate.

On behalf of the British Board of Agrément

Date of First issue: 6 September 2011

Originally certificated on 24 September 2004

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

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Regulations

In the opinion of the BBA, Durapile 200 mm Square Segmental Piles, if used in accordance with the provisions of this Certificate, will meet or contribute to meeting the relevant requirements of the following Building Regulations:

The Building Regulations 2010 (England and Wales)

Requirement:	A1	Loading
Requirement:	A2	Ground movement
Requirement:	A3	Disproportionate collapse
Comment:		The products can contribute to providing foundations of adequate strength. See sections 3.1 and 5.3 of this Certificate.
Requirement:	Regulation 7	Materials and workmanship
Comment:		The piles are acceptable. See section 7.1 and the *Installation* part of this Certificate.

The Building (Scotland) Regulations 2004 (as amended)

Regulation:	8(1)(2)	Fitness and durability of materials and workmanship
Comment:		The piles can contribute to a structure satisfying this Regulation. See sections 6 and 7.1 and the *Installation* part of this Certificate.
Regulation:	9	Building standards — construction
Standard:	1.1(a)(b)(c)	Structure
Standard:	1.2	Disproportionate collapse
Comment:		The products can contribute to a structure satisfying this Standard, with reference to clauses 1.1.1[(1)(2)] and 1.2.1[(1)(2)]. See sections 3.1 and 5.3 of this Certificate. (1) Technical Handbook (Domestic). (2) Technical Handbook (Non-Domestic).

The Building Regulations (Northern Ireland) 2000 (as amended)

Regulation:	B2	Fitness of materials and workmanship]
Comment:		The products are acceptable. See section 6 and the *Installation* part of this Certificate.
Regulation:	B3(2)	Suitability of certain materials
Comment:		The products are acceptable. See section 7.1 of this Certificate.
Regulation:	D1	Stability
Regulation:	D2	Disproportionate collapse
Comment:		The products when incorporated into a structure can contribute to a structure satisfying these Regulations. See sections 3.1 and 5.3 of this Certificate.

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: 2 *Delivery and site handling* (2.1) and 8 *General* (8.1) of this Certificate.

Non-regulatory Information

NHBC Standards 2011

NHBC accepts the use of Durapile 200 mm Square Segmental Piles, when installed and used in accordance with this Certificate, in relation to *NHBC Standards*, Chapters 2.1 *Concrete and its reinforcement*, 4.2 (D5 and D8) *Building near trees* and 4.5 *Raft, pile, pier and beam foundations*.

General

This Certificate relates to Durapile 200 mm Square Segmental Piles.

The products are for use in providing a piled foundation by driving segmental, precast concrete piles to the desired depth. The piles are designed for compressive loading; any tensile capacity is nominal.

The products are for use as part of a foundation system incorporating pile caps or ground beams, the design of which is outside the scope of this Certificate.

The pile segments, when installed in accordance with sections 8 and 9 of this Certificate and correctly designed, are capable of transmitting structural loading safely to the loadbearing soil.

The pile segments are driven to the required depth or an agreed set using pile-driving equipment.

Assessment of the suitability of the product for use in any particular ground conditions should be based on the results of an adequate site investigation, following the recommendations of BS 5930 : 1999. Full consideration must be given to various factors which can affect the assumed performance. The limitations for use of the piles are set out within the Certificate. The user should be aware of these limitations.

Technical Specification

1 Description

1.1 Durapile 200 mm Square Segmental Piles (see Figure 1) are available in the sizes detailed in Table 1.

Figure 1 Typical details

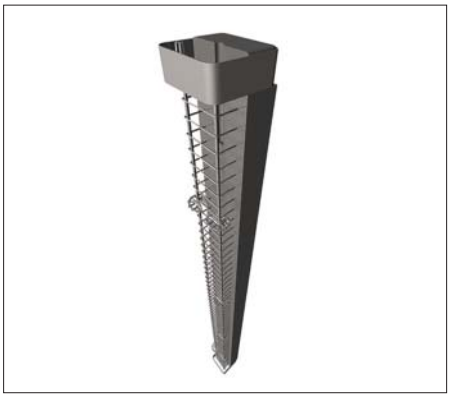


Table 1 Typical dimensions for pile segments

Nominal pile size (mm)	Segment length (mm)	Actual pile dimension (mm)	Safe working load (kN)
200 x 200	3000	196 x 200	400
200 x 200	4000	196 x 200	400
200 x 200	5000	196 x 200	400
200 x 200	6000	196 x 200	400

1.2 Pile segments are manufactured from:

- Grade C50 concrete to BS 8500-1 : 2006 incorporating:
  - — Portland cement to BS EN 197-1 : 2000
  - — blast furnace slag to BS EN 15167-1 : 2006 and BS EN 15167-2 : 2006
  - — sand/aggregate to BS EN 12620 : 2002
- reinforcing bar to BS 4449 : 2005
- helical reinforcement to BS 4483 : 2005
- steel headband — steel strip to BS EN 10025 : 2004
- spacers for reinforcement — plastic.

1.3 Pile segments are joined in accordance with the installation instructions (see sections 9.5 to 9.7) using:

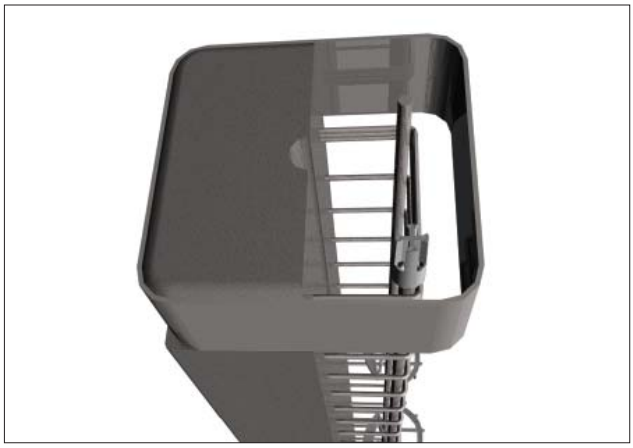
- steel dowel pins — mild steel bar to BS EN 10025 : 2004, 25 mm diameter
- felt gasket to BS 4060 : 2006.

Manufacture

Headbands

1.4 Mild steel headbands (see Figure 2) are manufactured by the Certificate holder or supplied ready fabricated from an approved supplier. The steel strip is cold formed and welded together at the joint.

Figure 2 Details of headbands



Joint socket

1.5 At the top and bottom of the pile segment, a threaded socket is formed within the concrete which provides an adequate bond for the dowel bar pin introduced during the driving process. When inserted to its design depth, the dowel provides resistance against the joint opening during the driving operation.

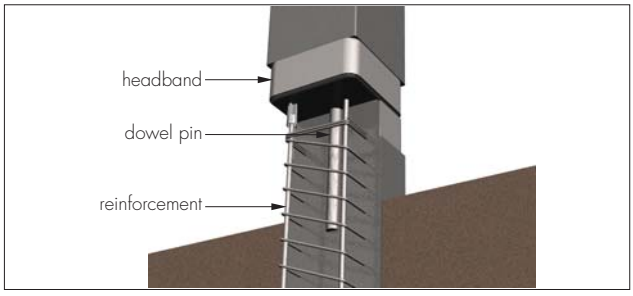
Reinforcing bars and socket joints

1.6 The sizes of reinforcing bar for the pile segments are given in Table 2. A typical joint detail is shown in Figure 3.

Table 2 Reinforcement for pile segments

Nominal pile size (mm)	Segment length (mm)	Longitudinal reinforcement (mm)	Helical links (mm)
200 x 200	3000	4T10	R6 at 80 pitch
200 x 200	4000	4T10	R6 at 80 pitch
200 x 200	5000	4T10	R6 at 80 pitch
200 x 200	6000	4T12	R6 at 80 pitch

Figure 3 Typical joint detail



Pile segment

1.7 The components are assembled in oiled, steel moulds. Stopends, held in place by jacks, are positioned within the mould and headbands and socket secured in place. The pre-assembled reinforcing cage is positioned with the specified cover maintained by plastic spacers. The batched concrete is poured into the mould and vibrated using poker vibrators to ensure full compaction.

1.8 Initially, the castings are cured inside the factory with additional heat being provided to a minimum ambient temperature of 5°C. When a minimum strength of 18 $N{\cdot}mm^{-2}$ has been achieved, the segments are lifted from the mould by overhead crane, using the cast-in lifting eyes. The segments are stacked on timber chocks for further curing. Chocks are located at quarter distance from each end of individual segments; the segments being stacked up to a maximum height of 3 m. Segments are not dispatched until the full design compressive strength is attained.

1.9 The concrete batching plant is computer controlled and programmed to produce uniform concrete to fine tolerances.

Procurement of raw materials

1.10 All raw materials used in the manufacture of the products are obtained from the Certificate holder's approved suppliers, to an agreed specification and in accordance with the company's documented quality procedures.

Quality control

1.11 Formalised quality control checks include:

During manufacture

- visual inspection of:
  - mould, for damage or irregularities
  - headband shape
  - the formed socket
- correct positioning of lifting hooks.

After manufacture

- visual and dimensional check of position of headband
- dimensional tolerance check of the cross-section and length of each segment
- concrete to the head of the pile being fully compacted
- integrity of formed socket at head and base of segment head
- position and integrity of the lifting eyes
- concrete cube tests for compressive strength to BS EN 12390-3 : 2009
- Schmidt hammer tests to confirm compressive strength.

2 Delivery and site handling

2.1 The pile segments are delivered to site both by the Certificate holder's operatives and/or by fully-trained transport sub-contractors. On site they are supported on timbers at one-quarter distance from each end and in accordance with the Certificate holder's instructions. They should be free of surface cracks exceeding 0.3 mm width, honeycombed or spalled concrete, exposed reinforcement, and out-of-position headbands or lifting eyes.

2.2 If segments are to be exposed for an extended period of time, they should be protected against damage. Any dirt, debris or water within the socket should be removed prior to driving.

2.3 The dowel bars are delivered in containers and the felt gasket material in rolls. Each component should be stored under cover and off the ground.

Assessment and Technical Investigations

The following is a summary of the assessment and technical investigations carried out on Durapile 200 mm Square Segmental Piles.

Design Considerations

3 General

3.1 Durapile 200 mm Square Segmental Piles, when selected for use, are satisfactory for transferring compressive loads to a suitable ground-bearing strata.

3.2 When a single length pile is driven, some bending moment can be resisted, however, the use of single-pile segments to resist working-load-induced bending moment is outside the scope of this Certificate. Further information on allowable bending moments can be obtained from the Certificate holder.

3.3 Piles are capable of resisting Class 3 sulfate attack (as defined in BRE Special Digest 1 : 2001 *Concrete in aggressive ground*).

3.4 The overall length of pile is dependent on soil conditions, design working load, working conditions, design factor of safety and limiting criteria specified by the overall design. Pile lengths range from 3 m to 18 m.

3.5 The pile layout and design should be in accordance with the requirements of BS EN 1997-1 : 2004 using the safe working loads provided by the Certificate holder. The Certificate holder's installation manual gives further guidance on the extent of site investigation carried out and pile-testing regime adopted. Site investigations should follow the recommendations given in BS 5930 : 1999.

3.6 Full consideration must be given to the particular ground conditions when assessing the suitability of the piles. The following factors apply:

- made ground containing obstructions — the product should not be used where made ground containing large or hard obstructions greater than 50 mm square are present
- positioning and number of pile segment joints — the selection of pile segments must ensure that the first pile segment joint is at a minimum depth of three metres below ground level and that the minimum number of pile segments are used for the final pile depth
- loose frictional soils — a minimum angle of friction of 25° and N-value greater than 4 is required
- cohesive soils — a minimum cu-value of 35 $kN \cdot m^{-2}$ is required
- highly-compressible soils — an mv-value less than 0.6 $m^2 \cdot MN^{-1}$ is required

- shrinkable soils and other situations where uplift forces may develop in the piles — the jointing arrangement used in the piling system is not designed to transfer tensile forces, therefore, an alternative piling system should be adopted unless the engineer responsible for the project is satisfied that tensile forces will not need to be carried by the joints
- sloping hard strata — as with all end-bearing piling systems, steeply sloping hard strata can lead to lateral displacement resulting in pile failure
- ground containing voids — where voids are encountered, the pile should be relocated if possible, or an alternative piling system adopted
- foundations where significant horizontal forces and bending moments act on the pile — apart from bending moment induced by nominal eccentric loading (derived from test results — see section 10) — the Durapile Piling System, in segmental form, will resist compressive loads only. Where the design calls for horizontal loads or bending moments to be resisted, the designer should consult the Certificate holder or specify a suitable alternative piling system.

4 Practicability of installation

4.1 The piles are designed to be installed by competent piling contractors experienced with this type of product using suitable mechanical equipment (see section 8).

4.2 Provided the ground conditions are suitable and as predicted from the site investigation and that the method of installation is as detailed in this Certificate, pile segments are driven and jointed without undue difficulty to form a precast concrete pile.

5 Structural performance

General

5.1 The precast concrete pile segments have adequate strength and stiffness to sustain the loads to which they are subjected during normal handling, transport and installation.

5.2 The segments can withstand the dynamic loadings likely to occur during installation (see section 9.3).

5.3 When driven to the required depth and agreed set, the pile itself is capable of carrying the working loads specified in Table 1 of this Certificate. In the event that the agreed set is achieved before the design depth, the design must be reviewed by the pile design engineer to establish acceptability of the driven depth.

5.4 The working loads given in Table 1 were assessed from test results and the requirements of BS 8110-1 : 1997.

5.5 If the pile is driven to a set, temporary compression should be checked on site during driving. In addition, a sample of piles should be restruck and tested 24 hours after installation to verify that dynamic resistance is not decreasing with time.

5.6 Generally, the method of testing should be by the dynamic pile testing technique using the Case Pile Wave Analysis Programme (CAPWAP). As an alternative, static load testing using kentledge or tension piles can be used and should be undertaken over a 48-hour period. The responsibility for testing and deciding on the number of piles to be tested remains with the project engineer. The Certificate holder recommends that at least 10% of the piles are tested. Guidance is given in the Certificate holder's Installation Manual on the factors of safety to be applied depending on the test method adopted.

6 Maintenance

Once the piles are installed, maintenance is not required. However, it is important that the pile segments are checked for suitability before accepted for installation (see section 8.2).

7 Durability

7.1 Precast concrete piles installed correctly will withstand the long-term effects of design compressive loading without undue deterioration in strength or stiffness for the life of a structure when designed in accordance with BS EN 1992-1 : 2004.

7.2 The grade of concrete and the nominal cover provided to the face of the reinforcing cage in the pile segment is in accordance with the durability requirements given in BS EN 1992-1 : 2004.

Installation

8 General

8.1 The pile segments and ancillary items are generally delivered on a supply-only basis for installation by others. Competent piling installers using suitable mechanical equipment should always be employed with installation in strict accordance with the Certificate holder's Installation Manual, BS EN 1997-1 : 2004 and this Certificate.

Quality control on site

8.2 Following delivery, and prior to driving, the piles should be checked by the pile installers for damage and cracking, in accordance with the Certificate holder's instructions. These checks include:

- visual evidence of spalling or chipping of concrete
- cracking in excess of 0.3 mm width
- damage or misplacement of headbands
- condition of felt gasket.

9 Procedure

Pitching

9.1 Using one of the lifting eyes, a pile segment selected from the stack is winched to the vertical by steel cable and moved to the front of the piling rig. During this part of the operation the toe of the pile segment should remain in contact with the ground.

9.2 The pile segment toe is guided into the pile rig platform and the pile head into the driving head of the hammer. The tension in the cable (minimum one tonne capacity) is gradually released and at the same time load is introduced to the pile head via the pile hammer box. Final checks are made for verticality of pile and rig mast and adjustments made as necessary.

Driving

9.3 Once the first pile segment is pitched, a short hammer drop (five-tonne hammer with a drop no greater than 600 mm) is made to ensure correct seating. Driving continues until the pile segment reaches an approximate depth of one metre when verticality and integrity of the pile should be checked and any adjustments made. The cable is removed from the lifting eye and driving continued.

9.4 When the pile head is approximately 300 mm above the pile rig platform, driving stops. If the pile has not reached the desired set(1), a further pile segment must be added.

(1) The pile is to be driven to a design set to achieve ultimate load resistance. Sets can be calculated using the Hiley formula or similar and advice sought from the contractor's engineer/person responsible.

Jointing

9.5 Pile segments are jointed using a single, mild steel dowel pin hammered into the full depth of the formed socket. Before insertion of the dowel pin, the formed socket must be checked for cleanliness. A copper hammer or chock of wood should be used to avoid damage to the dowel pin.

9.6 The felt gasket cut from the roll is slid over and down the dowel pin onto the top of the pile segment head.

9.7 The next pile segment is lifted into position above the first pile using the winch and cable, and carefully guided into position so that the formed socket at the toe of the piles over the dowel pin. The pile segment is gently winched down, the weight of the pile being sufficient to ensure full penetration of the dowel pin into the socket. Driving recommences and procedure repeated until the correct set is achieved.

Technical Investigations

10 Tests

Concentric and eccentric axial load tests

10.1 Test piles, 8 m long and jointed at 3 m from the loaded end, were tested in a horizontal test rig and subject to working loads applied concentrically and eccentrically at 30 mm, 50 mm and 70 mm. Deflections were measured at 1.25 m centres along the length of the pile and at the joint.

10.2 Transverse loading was applied at the joint using a hydraulic jack with loads measured by use of a load cell. The ends of the test piles were restrained and roller strip bearings placed between piles and laboratory floor to minimise frictional resistance. The pile was allowed to laterally deflect up to maximum working load then a transverse load applied via the hydraulic jack to reduce the deflection to 10 mm. The transverse load was recorded and used in calculations to determine the restraint offered by various soil types. The results of these calculations, based on immediate and long-term settlement prediction formulae, indicated that the range of soils identified in section 3.6 will provide adequate restraint.

11 Investigations

11.1 The manufacturing process was examined, including the methods adopted for quality control, and the quality and composition of the materials used were assessed.

11.2 An examination was made of technical data relating to:

- effect of corrosion of the steel dowel pin at joints
- durability.

11.3 A site visit was carried out to assess the practicability of installation.

11.4 An examination was made of the Certificate holder's installation manual.

11.5 An examination was made of pile penetration log data relating to sites where piles have been successfully driven and tested by static or dynamic pile testing techniques.

11.6 The original assessment of the product was made in relation to BS 8004 : 1986 and BS 8110-1 : 1997.

Bibliography

BS 4060 : 2006 *Pressed wool felts — Specification*

BS 4449 : 2005 *Steel for the reinforcement of concrete — Weldable reinforcing steel — Bar, coil and decoiled product — Specification*

BS 4483 : 2005 *Steel fabric for the reinforcement of concrete — Specification*
BS 5930 : 1999 *Code of practice for site investigations*
BS 8004 : 1986 *Code of practice for foundations*
BS 8110-1 : 1997 *Structural use of concrete — Code of practice for design and construction*
BS 8500-1 : 2006 *Concrete — Complementary British Standard to BS EN 206-1 — Method of specifying and guidance for the specifier*
BS EN 197-1 : 2000 *Cement — Composition, specifications and conformity criteria for common cements*
BS EN 1992-1-1 : 2004 *Eurocode 2 : Design of concrete structures — General rules and rules for buildings*
BS EN 1997-1 : 2004 *Eurocode 7 : Geotechnical design — General rules*
BS EN 10025 : 2004 *Hot rolled products of structural steels — Technical delivery conditions for non-alloy structural steels*
BS EN 12390-3 : 2009 *Testing hardened concrete — Compressive strength of test specimens*
BS EN 12620 : 2002 *Aggregates for concrete*
BS EN 15167-1 : 2006 *Ground granulated blast furnace slag for use in concrete mortar and grout. Definitions, specifications and conformity criteria*
BS EN 15167-2 : 2006 *Ground granulated blast furnace slag for use in concrete mortar and grout. Conformity evaluation*

Conditions of Certification

12 Conditions

12.1 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 or 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.

12.2 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.

12.3 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.

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

12.5 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
- individual 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.

12.6 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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