Durapile Ltd
Eden Works
Colne Road
Kelbrook
Colne
Lancashire BB18 6SY
Tel: 01282 844213 Fax: 01282 843336
e-mail: info@wolfendenconcrete.co.uk
website: wolfendenconcreteltd.co.uk

CI/SfB
(28.9) Xt6

BBA BRITISH BOARD OF AGRÉMENT
TECHNICAL APPROVALS FOR CONSTRUCTION

Designated by Government to issue European Technical Approvals

Agrément Certificate No 04/4152

DURAPILE PILING SYSTEM

Raccords pour armatures
Verbindung für Armatur

Product

- *THIS CERTIFICATE RELATES TO THE DURAPILE PILING SYSTEM OF THE TYPE REFERRED TO IN THE ACCOMPANYING DETAIL SHEET.*
- *The piling system is for transmitting compressive loads to ground of suitable bearing capacity.*

These Front Sheets must be read in conjunction with the accompanying Detail Sheet, which gives information specific to each pile.

Regulations — Detail Sheet 1

1 The Building Regulations 2000 (as amended) (England and Wales)

The Secretary of State has agreed with the British Board of Agrément the requirements of the Building Regulations to which piling systems can contribute in achieving compliance. In the opinion of the BBA, the Durapile Piling System, if used in accordance with the provisions of this Certificate, will meet or contribute to meeting the relevant requirements.

Requirement:	A1(1)	Loading
Requirement:	A2	Ground movement
Requirement:	A3	Disproportionate collapse
Comment:		The product provides foundations of adequate strength. See the tinted areas of the *Design Data — General* and *Structural performance* sections of the accompanying Detail Sheet.
Requirement:	Regulation 7	Materials and workmanship
Comment:		The product is acceptable. See the tinted area of the *Durability* section of the accompanying Detail Sheet.

2 The Building Standards (Scotland) Regulations 1990 (as amended)

In the opinion of the BBA, the Durapile Piling System, if used in accordance with the provisions of this Certificate, will satisfy or contribute towards satisfying the various Regulations and related Technical Standards as listed below.

Regulation:	10	Fitness of materials and workmanship
Standard:	B2.1	Selection and use of materials, fittings, and components, and workmanship
Comment:		The product can contribute to a construction meeting this Standard. See the *Installation* part of the accompanying Detail Sheet.
Standard:	B2.2	Selection and use of materials, fittings, and components, and workmanship
Comment:		The product is acceptable. See the tinted area of the *Durability* section of the accompanying Detail Sheet.
Regulation:	11	Structure
Standard:	C2.1	Construction
Standard:	C3.1	Disproportionate collapse
Comment:		Reinforced concrete structures incorporating the product satisfy these Standards. See the tinted areas of the *Design Data — General, Structural performance* and *Durability* sections of the accompanying Detail Sheet.

3 The Building Regulations (Northern Ireland) 2000

In the opinion of the BBA, the Durapile Piling System, if used in accordance with the provisions of this Certificate, will satisfy or contribute to satisfying the various Building Regulations as listed below.

Regulation:	B2	Fitness of materials and workmanship
Comment:		The product is acceptable. See the tinted area of the *Durability* section of the accompanying Detail Sheet.
Regulation:	D1	Stability
Regulation:	D2	Disproportionate collapse
Comment:		Reinforced concrete structures incorporating the product satisfy the requirement. See the tinted areas of the *Design Data — General, Structural performance* and *Durability* sections of the accompanying Detail Sheet.

4 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 section:	11 *Health and safety* of the accompanying Detail Sheet.

Conditions of Certification

5 Conditions

5.1 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.

5.2 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.

5.3 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; and

(c) are reviewed by the BBA as and when it considers appropriate.

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

(a) the presence or absence of any patent, intellectual property 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 actual works in which the product is installed, used and maintained, including the nature, design, methods and workmanship of such works.

5.5 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.

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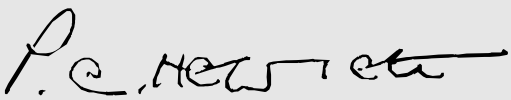
In the opinion of the British Board of Agrément, the Durapile Piling System is fit for its intended use provided it is installed, used and maintained as set out in this Certificate. Certificate No 04/4152 is accordingly awarded to Durapile Ltd.

On behalf of the British Board of Agrément



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Chief Executive

British Board of Agrément
P O Box No 195, Bucknalls Lane
Garston, Watford, Herts WD25 9BA
Fax: 01923 665301

e-mail: mail@bba.star.co.uk
website: www.bbacerts.co.uk

CI/SfB
(28.9) Xt6

BBA BRITISH BOARD OF AGRÉMENT
TECHNICAL APPROVALS FOR CONSTRUCTION

Durapile Ltd

DURAPILE PILING SYSTEM FOR 200 MM SQUARE SEGMENTAL PILES

Certificate No 04/4152

DETAIL SHEET 2

Product

- *THIS DETAIL SHEET RELATES TO THE DURAPILE PILING SYSTEM FOR 200 MM SQUARE SEGMENTAL PILES.*
- *The product is 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 product is 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, 9 and 10 of this Detail Sheet 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 Durapile precast piles are set out within the Certificate. The user should be aware of these limitations.*

This Detail Sheet must be read in conjunction with the Front Sheets, which give the product's position regarding the Building Regulations and the Conditions of Certification.

Technical Specification

1 Description

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

Table 1 Typical dimensions for pile segments

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

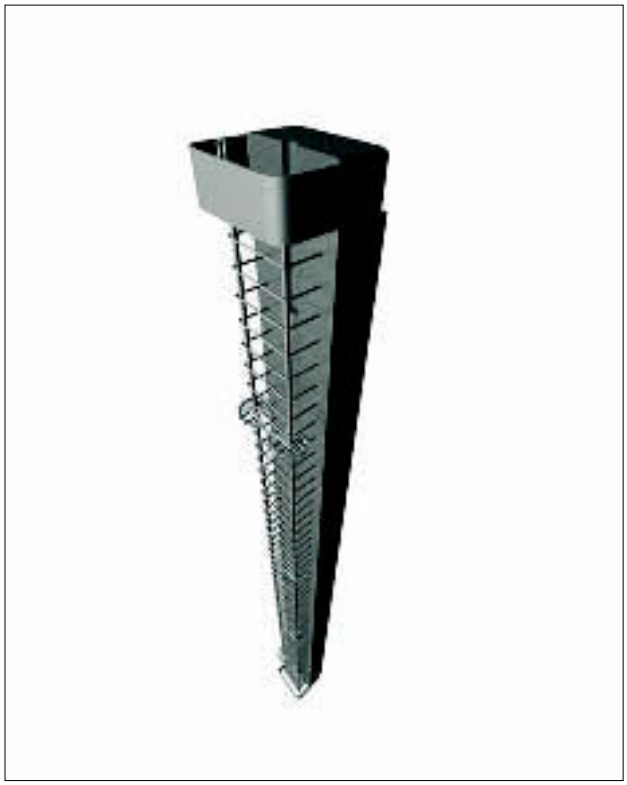
1.2 Pile segments are manufactured from:

- Grade C50 concrete to BS 5328-1 : 1997 incorporating:
  - Portland cement to BS EN 197-1 : 2000
  - blast furnace slag to BS 6699 : 1992
  - sand/aggregate to BS EN 12620 : 2002
- reinforcing bar to BS 4449 : 1997
- helical reinforcement to BS 4482 : 1985
- steel headband — steel strip to BS EN 10025 : 1993
- plastic spacers for reinforcement.

1.3 Pile segments are joined in accordance with the installation instructions (see sections 10.5 to 10.7) using:

- steel dowel — mild steel bar to BS EN 10025 : 1993, 25 mm diameter
- felt gasket to BS 4060 : 1989.

Figure 1 Typical details for 200 mm square segmental piles



2 Manufacture

Headbands

2.1 Mild steel headbands are (see Figure 2) supplied ready fabricated from an approved supplier. The steel strip is cold formed in two sections and welded together at the joints.

Figure 2 Details of headbands

Joint socket

2.2 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 introduced during the driving process. When inserted to its design depth, the dowel provides resistance against the joint opening during the driving operation.

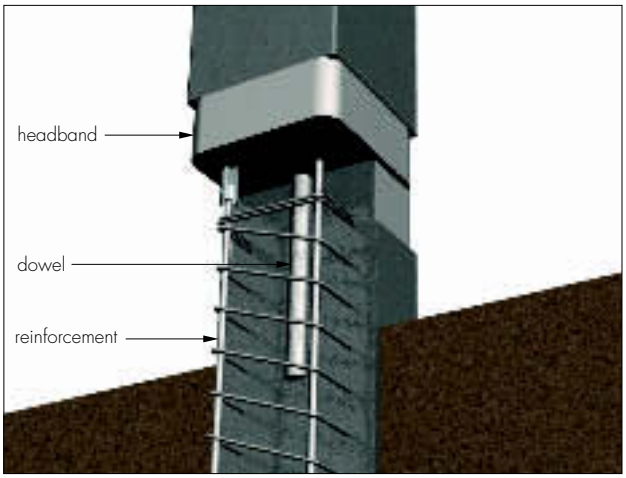
Reinforcing bars and socket joints

2.3 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

2.4 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.

2.5 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 Nmm^{-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.

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

Procurement of raw materials

2.7 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

2.8 Formalised quality control checks include:

During manufacture

- visual inspection of mould, for damage or irregularities
- visual inspection of headband shape
- visual inspection of the formed socket
- correct positioning of lifting hooks
- concrete cube tests for compressive strength to BS EN 12390-3 : 2002(1).

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 : 2002(1).

(1) Piles produced from a batch where the results of a cube test fall outside the specified tolerance, will be rejected.

3 Delivery and site handling

Piles

3.1 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 fifth points 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.

3.2 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.

3.3 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.

Design Data

4 General

4.1 The Durapile Piling System for 200 mm Square Segmental Piles, when selected for use, is satisfactory for transferring compressive loads to a suitable ground-bearing strata.

4.2 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.

4.3 Piles are capable of resisting Class 3 sulphate attack (as defined in BRE Special Digest 1 *Concrete in aggressive ground*).

4.4 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.

4.5 The pile layout and design should be carried out 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.

4.6 Pile spacing should be in accordance with design considerations and the requirements of BS 8004 : 1986.

4.7 Full consideration must be given to the particular ground conditions when assessing the suitability of the Durapile Piling System for 200 mm Square Segmental 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
- soil cohesive soils — a minimum cu-value of 35 kNm^{-2} is required
- highly-compressible soils — an mv-value less than 0.6 $m^2(MN)^{-1}$ is required
- heave-susceptible soils — the Durapile Piling System is not suitable and an alternative piling system should be adopted
- 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 12) — 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 then the designer should consult the Certificate holder or specify a suitable alternative piling system.

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 10.3).

5.3 The pile itself is capable, when driven to the required depth and agreed set, 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 have been assessed based on 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 Practicability of installation

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

6.2 Before insertion of the dowel bar, the formed socket must be checked for cleanliness.

7 Durability

7.1 Precast concrete piles installed correctly will sustain 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 8110-1 : 1997.

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 8110-1 : 1997, Table 3.3.

Installation

8 On site quality control

Following delivery, and prior to driving of the Durapile Piling System for 200 mm Square Segmental Piles, checks should be carried out 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
- damage or misplacement of headbands
- cracking in excess of 0.3 mm width
- condition of felt gasket.

9 General

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 8004 : 1986 and this Detail Sheet.

10 Procedure

Pitching

10.1 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.

10.2 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

10.3 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.

10.4 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

10.5 Pile segments are jointed using a single, mild steel dowel bar hammered into the full depth of the formed socket. A copper hammer or chock of wood should be used to avoid damage to dowel bar.

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

10.7 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 bar. The pile segment is gently winched down, the weight of the pile being sufficient to ensure full penetration of the dowel bar into the socket. Driving recommences and procedure repeated until correct set is achieved.

11 Health and safety

All stages in the piling operation should meet the statutory requirements as laid down in the Health & Safety at Work etc Act 1974 and the Factories Act 1961. General guidance is also given in BS 8004 : 1986.

Technical Investigations

The following is a summary of the technical investigations carried out on the Durapile Piling System for 200 mm Square Segmental Piles.

12 Tests

Concentric and eccentric axial load tests

12.1 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.

12.2 Transverse loading was applied horizontally 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 4.7 will provide adequate restraint.

13 Investigations

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

13.2 An examination was made of technical data relating to:

- effect of corrosion of steel dowel bar at joints
- durability.

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

13.4 An examination was made of Durapile Ltd's installation manual.

13.5 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.

13.6 An assessment was made of the product in relation to BS 8004 : 1986 and BS 8110-1 : 1997.

Bibliography

BS 4060 : 1989 *Specification for pressed wool felts*

BS 4449 : 1997 *Specification for carbon steel bars for the reinforcement of concrete*

BS 4482 : 1985 *Specification for cold reduced steel wire for the reinforcement of concrete*

BS 5328-1 : 1997 *Concrete — Guide to specifying concrete*

BS 5930 : 1999 *Code of practice for site investigations*

BS 6699 : 1992 *Specification for ground granulated blast furnace slag for use with Portland cement*

BS 8004 : 1986 *Code of practice for foundations*

BS 8110-1 : 1997 *Structural use of concrete — Code of practice for design and construction*

BS EN 197-1 : 2000 *Cement — Composition, specifications and conformity criteria for common cements*

BS EN 10025 : 1993 *Hot rolled products of non-alloy structural steels — Technical delivery conditions*

BS EN 12390-3 : 2002 *Testing hardened concrete — Compressive strength of test specimens*

BS EN 12620 : 2002 *Aggregates for concrete*

BBA BRITISH BOARD OF AGRÉMENT
TECHNICAL APPROVALS FOR CONSTRUCTION

On behalf of the British Board of Agrément

Date of issue: 24th September 2004

Chief Executive

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British Board of Agrément
P O Box No 195, Bucknalls Lane
Garston, Watford, Herts WD25 9BA
Fax: 01923 665301

e-mail: mail@bba.star.co.uk
website: www.bbacerts.co.uk