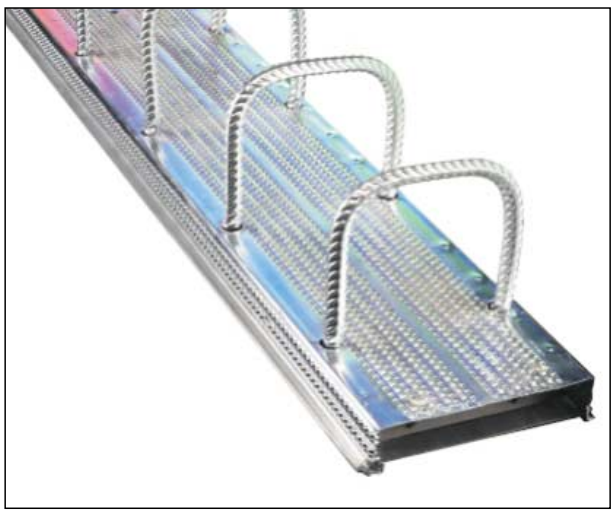
CARES Technical Approval Report TA2 5007

Assessment of the RFA Startabox Continuity System Product and Quality Management System for Production



STARTABOX®

TECHNICAL APPROVAL

UKAS PRODUCT CERTIFICATION 5007

Product

RFA Startabox Reinforcement Continuity System

Produced by:

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1 Product Summary

RFA Startabox is a reinforcement product designed to maintain reinforcement continuity across construction joints in concrete structures in a time saving and cost effective manner.

Startabox consists of selected reinforcement, pre-bent and housed in a purpose-designed carrier casing manufactured from perforated and indented galvanised steel.

The entire unit is fixed on site to the shutter and cast into the front face of the wall. After the formwork is struck, the carrier case lid is removed to reveal the starter bars lying inside the casing. These starter bars are bent out by the contractor, using the prescribed straightening tool and are ready for lapping with the main reinforcement of the subsequent concrete pour.

The rear part of the casing remains embedded in the wall, providing a rebate and key for the subsequent concrete pour of the adjoining member. This eliminates the need for traditional preparation such as scabbling at the joint.

1.1 Scope of Application

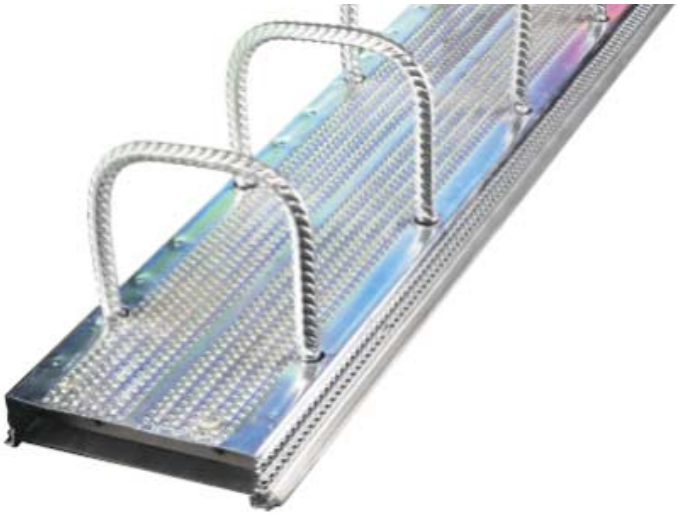
RFA Startabox reinforcement continuity system, in the size range 8mm-20mm, have been evaluated for use as follows:

a) In reinforced concrete structures designed in accordance with "BS8110: Part 1: 1997: Structural use of concrete, Code of practice for design and construction", which are subject to static loading in non-cryogenic environments, in accordance with CARES Appendix TA2.

1.2 Design Considerations

In the UK, the use of Startabox product types and construction jointing methods, which require the site bending of in-situ reinforcement, requires the engineer's approval. The most fundamental considerations are the rebending of high yield reinforcement, end anchorages and the bearing stress at bends:

BS8110 Paragraph 7.2 states "It is permissible to bend grade 250 reinforcement projecting from concrete provided that care is taken to ensure that the radius of bend is not less than that specified in BS8666. Grade 460 bars should not be bent, rebent or straightened without the engineer's approval."



BS 8110 clause 3.12.8.22 states "End anchorages in the form of hooks and bends should only be used to meet specific design requirements and should conform to BS8666."

BS8110 clause 3.12.8.24 states that "In no case should this be less than twice the radius of the test bend guaranteed by the manufacturer of the bar, nor less than the radius required to ensure that the bearing stress at the midpoint of the curve does not exceed the values given in 3.12.8.25."

Whilst end anchorages and bearing stresses are a matter of design, rebending of reinforcement is a matter of product suitability and workmanship. This technical approval demonstrates that the performance of construction joints is not adversely affected by use of the Startabox reinforcement continuity system.

1.3 Conclusion

It is the opinion of UK CARES that RFA Startabox reinforcement continuity system is satisfactory for use within the limits stated in paragraph 1.1 when applied and used in accordance with the manufacturer's instructions and the requirements of this certificate.

B. Bowsher
Executive Director

July 2004

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2 Technical Specification

2.1 General

Startabox consists of pre-bent reinforcement, housed in a purpose-designed carrier casing that is fabricated off-site in a CARES quality assured environment.

The carrier casing is fabricated from galvanised steel sheet, which is indented and perforated to improve bond and key with the concrete.

The types of reinforcement are specially selected by RFA and provide a suitable degree of ductility, ensuring that they comply with the tensile requirements of BS4449, Grade 460B reinforcement after prefabrication and rebending on site. The material is CARES approved, assuring consistent compliance with the product standard. Material processing is CARES approved to ensure full traceability from steel mill to construction site.

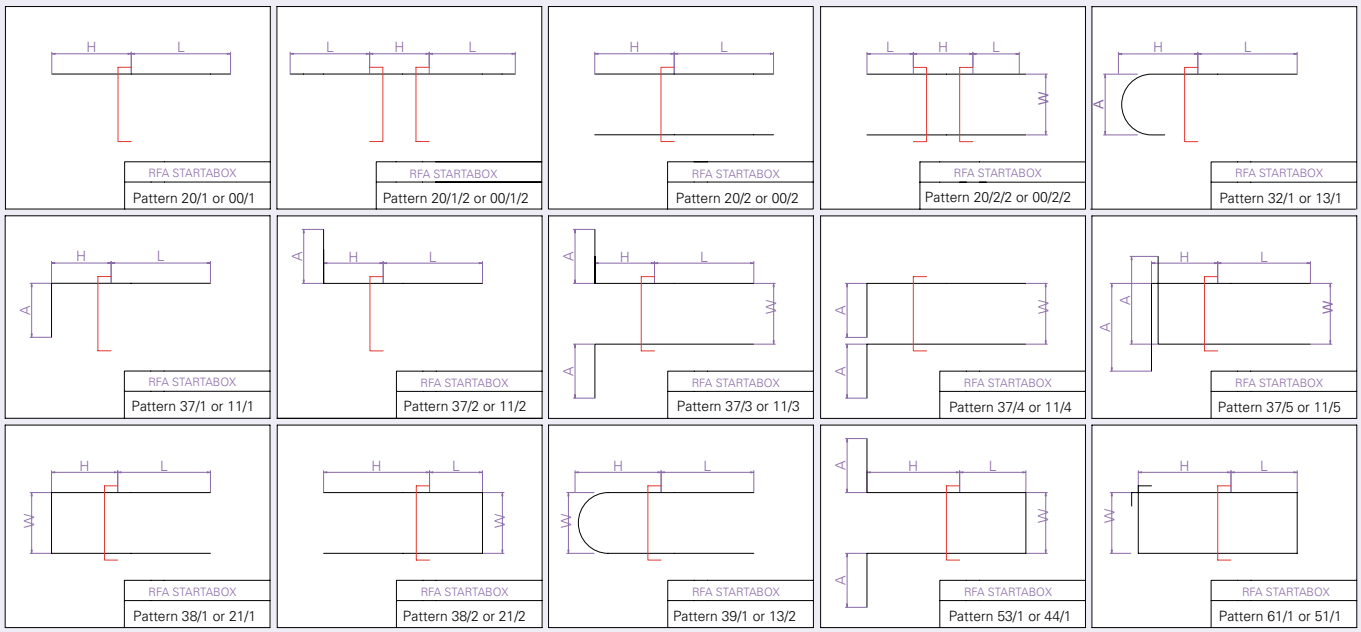
Startabox is available in bar sizes T8, T10, T12, T16 and T20, formed to a minimum bend radius of:

Bar Size	Bending Former Size	Ratio
T8	64mm	8
T10	64mm	6.4
T12	64mm	5.3
T16	80mm	5
T20	120mm	6

Startabox is available in a wide range of customer specified shape options.

The manufacturer's sales literature offers scheduling advice for the engineer and contractor.

All the manufacturing processes comply with ISO 9001:2000 and bars are cropped and bent according to BS8666.



STARTABOX Shape Variations

3 Product Performance and Characteristics

3.1 Reinforcement Tensile Properties

Mechanical tests on the reinforcement showed that the material, after bending and straightening, complied with the tensile requirements of BS4449 Grade 460B, exhibiting values for Total Elongation at Maximum Load (Agt) of greater than 5%.

3.2 Strength of Joints

Structural tests at Imperial College showed that the flexural strength and shear strength of construction joints formed with the Startabox reinforcement continuity system are no less than those of equivalent traditionally formed construction joints.

3.3 Serviceability Limit States

3.3.1 Deflection

The deflection of elements is not a function of this product insofar as joints formed using Startabox were able to ensure full structural continuity during testing and did not exhibit any significant additional rotation relative to the joint.

3.3.2 Cracking

In the tests conducted, the widths of flexural cracks in the joint regions at reinforcement stresses of 300 N/mm^2 were slightly over the 0.3mm required for areas of constant bending moment according to BS8110. Although BS8110 does not cover cracking at joints, e.g. corners at slab/wall interface, the value found is no worse than that experienced in traditional construction joints.

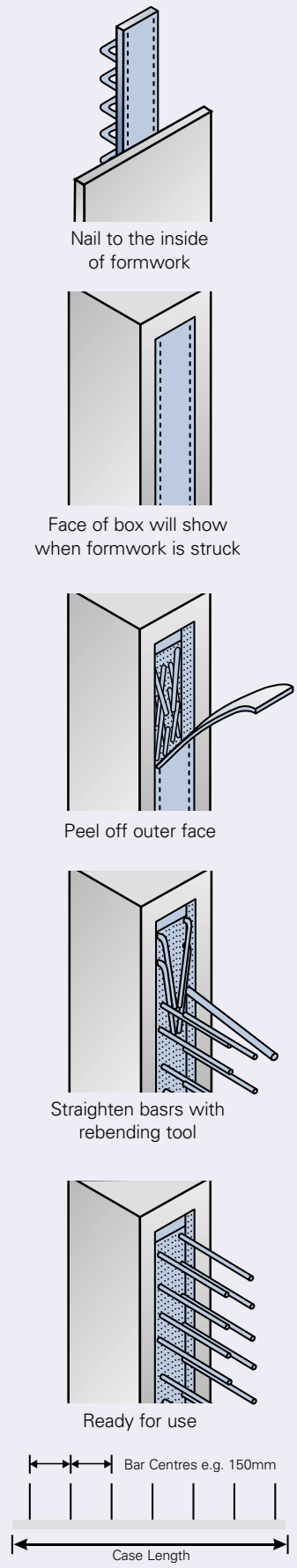
3.3.3 Calculation of Crack Widths

Crack widths at joints are not generally assessed in BS8110 designs but where a calculation is required, the following equation can be used:

$$w = \frac{\sigma_s^2 \phi_s}{4 E_s \tau}$$

Where
- σ_s is the steel stress in the crack,
- ϕ_s is the bar diameter,
- τ is the average bond stress,
- w is the crack width at the level of the centre of the steel,
- E_s is the elastic modulus of the steel.

From CEB-FIP Model Code: $\tau = 0.465\ f_{cu}^{2/3}$ for short-term instantaneous loading and $\tau = 0.35\ f_{cu}^{2/3}$ for long-term repeated loading.



STARTABOX Fixing in Formwork

4.1 Fixing in Formwork

The STARTABOX cases are simply nailed to the formwork where possible. In the case of excessively heavy cases or with steel shuttering the cases are tied securely to the wall reinforcing steel. In either situation the STARTABOX is contained within the wall pour.

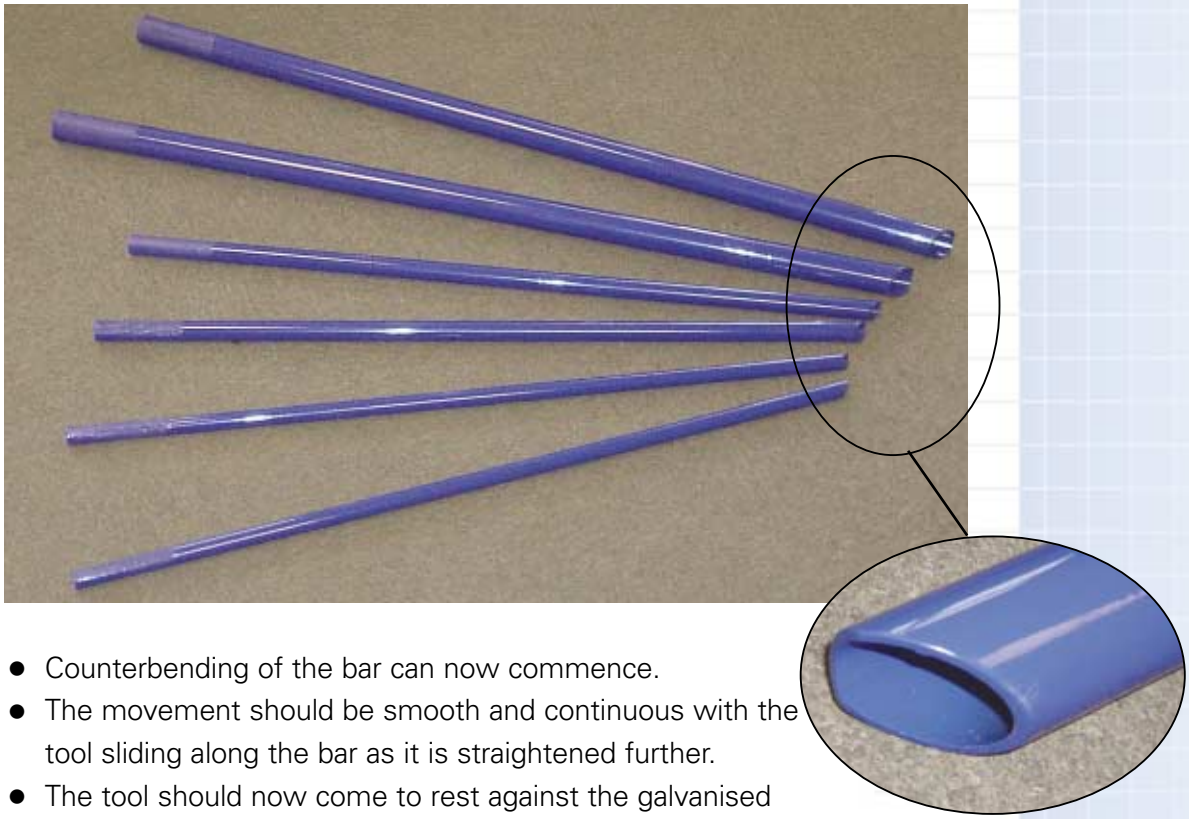
Once the concrete has been poured and has cured sufficiently the formwork is removed exposing the removable lids of the STARTABOX. After these lids are removed, the lap bars are visible and can be pulled into position utilising the RFA straightening tool (consult RFA Straightening procedure). In order to alleviate damage to surrounding concrete, RFA advise allowing at least seven days curing before any attempt is made to straighten bars.

After the bars have been straightened and satisfactorily aligned, the corresponding reinforcement bars not supplied by RFA can be tied into position ensuring the correct lap criteria is met.

4.2 Straightening/Counterbending of Bars

Bars must only be straightened with the appropriate straightening tool which is obtained from RFA.

- No counterbending should be carried out in temperatures below 0˚ Celsius.
- Before counterbending commences all case covers in a working area should be removed to allow easy access.
- Where STARTABOX is used in a vertical application, RFA recommend that work is carried out on the highest bar first and then worked down to the lowest bar.
- The bar to be rebent should be pulled a minimal distance away from the case using the straightening tool; this will allow the tool to be slid on to the bar.
- The straightening tool should be slid onto the bar and should lay to rest at a point immediately before the curvature of the bend in the steel.



- Counterbending of the bar can now commence.
- The movement should be smooth and continuous with the tool sliding along the bar as it is straightened further.
- The tool should now come to rest against the galvanised STARTABOX case.
- A final check should be made and final adjustment should be carried out to ensure correct bar alignment for concrete cover and also lapping to main reinforcement.
- RFA rebar safety caps should now be fixed to all protruding bars not being lapped onto main steel immediately.

4.3 Storage

RFA advise that material is left on the pallets until required for use and that the pallets are stored away from moving plant on site to prevent damage of the casing material. The protective wrapping should be left on the pallets as long as is feasible to prevent excessive corrosion of the reinforcement bars.

5 Safety Considerations

Due consideration should be given to the manual handling procedures and regulations. If necessary a risk assessment should be carried out. The length and weight per metre of the STARTABOX is clearly defined on the detailing schedules supplied with the product. It is recommended that gloves and eye protection are worn when the bars are being straightened. Once the bars are straightened and are not being lapped onto immediately RFA Rebar Safety Caps should be fitted to the bars to protect operatives. Heat should not be applied to the Startabox casing as it is galvanised and may produce dangerous fumes.

6 Product Testing and Evaluation

6.1 General

The Startabox reinforcement continuity system was evaluated in two stages:

6.1.1 The reinforcement was subject to independent mechanical testing to establish its suitability for bending during the prefabrication process and rebending through 90 degrees during the straightening process on site and subsequent compliance with the tensile requirements of BS4449.

6.1.2 Startabox reinforcement continuity system samples were subject to a programme of full scale structural testing in concrete to evaluate the performance of construction joints under combinations of high shear and high flexural loading.

6.2 Mechanical Testing

Several types of reinforcement were tested to determine which combination of materials and bend radii were suitable.

Reinforcement was subject to the CARES bendability test, which consisted of bending the reinforcement through 90 degrees over a steel former, straightening and examination of the inside of the bend for signs of fracture. The test was conducted twice on each sample.

Reinforcement was also subject to a CARES tensile test regime, which consisted of bending the reinforcement through 90 degrees over a steel former and straightening with the Startabox tool prior to tensile testing to measure Ultimate Tensile Strength, Yield Strength and Elongation at Maximum Load (Agt). The selected reinforcing materials were found to comply with the tensile requirements of BS4449 Grade 460B (Clause 11.1, Table 7).

6.3 Full scale Structural Testing

Startabox reinforcement continuity system samples were subject to a programme of structural testing at Imperial College (Load Testing of Startabox continuity units by A. D. Pullen October 2003).

Several wall/floor joints and wall/wall constructions were formed in reinforced concrete, including construction joints formed using the Startabox reinforcement continuity system. The tests were full-scale in terms of bar sizes and member depths. In all wall/slab specimens the continuity reinforcement was 16mm diameter deformed bar, chosen as being the largest bar size normally used in the Startabox reinforcement continuity system and which imposes the greatest stresses on the surrounding concrete and the most severe demands on the reinforcement in relation to bending and straightening.

The series of reinforced concrete samples, some of which were cast in a manner to simulate poor concrete compaction, were subject to various loading conditions representing high shear or high bending moment loading. The displacements and crack widths were measured in relation to applied load. The ultimate loads were measured.

In all cases the samples exceeded the ultimate loads calculated from BS8110. The maximum crack width at the joint was over 0.3mm. Although BS8110 does not cover cracking at joints, this exceeded the code requirement of 0.3mm for areas of constant bending, which is no worse than that experienced in monolithic construction.

The structural tests were evaluated by Professor P. E. Regan (Evaluation of the RFA Startabox Continuity System from tests of Reinforced Concrete Specimens, by Professor P.E. Regan October 2003).

7 Quality Assurance

The Startabox reinforcement continuity system is produced by RFA under an ISO 9001 quality system that is certified by UK CARES: Quality System Certificate No 1113.

The quality system monitors the production of the Startabox reinforcement continuity system and ensures that materials and product remain within the limits of this technical approval.

8 Building Regulations

8.1 The Building Regulations 1991 (England and Wales)

Structure, Approved Document A

RFA Startabox reinforcement continuity systems, when used in BS8110 based designs using the data contained within this technical approval, satisfy the relevant requirements of The Building Regulations 1991 (England and Wales), Approved Document A.

Materials and Workmanship, Approved Document, to support regulation 7

This technical approval gives assurance that the RFA Startabox reinforcement continuity systems comply with the material requirements of BS8110.

8.2 The Building Regulations (Northern Ireland) 1994

Part B, Materials and Workmanship

This technical approval gives assurance that RFA Startabox reinforcement continuity systems comply with the material requirements of BS8110 by virtue of regulation *B3, Deemed to satisfy provisions regarding the fitness of materials and workmanship.*

8.3 The Building Standards (Scotland) Regulations 1990

Part B, Fitness of Materials

This technical approval gives assurance that RFA Startabox reinforcement continuity systems comply with the material requirements of BS8110 by virtue of *Clause B2.1*

Part C, Structure

RFA Startabox reinforcement continuity systems, when used in BS8110 based designs using the data contained within this technical approval, satisfy the requirements of *The Building Standards (Scotland) Regulations 1990, Part C, C2.1 clause b. construction,ii.*

9 References

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

BS 8110:Part 1:1997 Structural use of concrete, Code of practice for design and construction.

BS8666: 2000 Specification for scheduling, dimensioning, bendingand cutting of steel reinforcement for concrete.

BS EN ISO 9001: 2000 Quality Management Systems - Requirements.

CEB-FIP Model Code 90.

CARES Appendix TA2 Quality and Operations Schedule for the Technical Approval of Reinforcement Continuity Systems.

Imperial College Test report: Load Testing of Startabox continuity units by A. D. Pullen October 2003.

Professor Regan evaluation report: Evaluation of the RFA Startabox Continuity System from tests of Reinforced Concrete Specimens, by Professor P.E. Regan October 2003.

10 Conditions

1. The quality of the materials and method of manufacture have been examined by CARES and found to be satisfactory. This technical approval will remain valid provided that:

   a The product design and specification is unchanged.
   b The materials and method of manufacture are unchanged.
   c The manufacturer complies with CARES regulations for technical approvals.
   d The manufacturer holds a valid CARES Certificate of Product Assessment.
   e The product is installed and used as described in this report.

2 CARES make no representation as to the presence or absence of patent rights subsisting in the product and/or the legal right of RFA to market the product.

3 Any references to standards, codes or legislation are those which are in force at the date of this certificate.

4 Any recommendations relating to the safe use of this product are the minimum standards required when the product is used. These requirements do not purport to satisfy the requirements of the Health and Safety at Work act 1974 or any other relevant safety legislation.

5 CARES does not accept any responsibility for any loss or injury arising as a direct or indirect result of the use of this product.

6 This Technical Approval Report should be read in conjunction with CARES Certificate of Product Assessment No 5007. Confirmation that this technical approval is current can be obtained from UK CARES.

UK CARES

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