# CARES Technical Approval Report TA2 5007

Issue 3



RFA-TECH STARTABOX

## RFA-TECH
### Startabox Continuity System

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

TECHNICAL APPROVAL 5007

UKAS PRODUCT CERTIFICATION 0002

Validate with the CARES Cloud App

# Product

**RFA-TECH Startabox Reinforcement Continuity System**

**Product approval held by:**

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## 1 Product Summary

RFA-TECH 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 specifically 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-TECH 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 "BS EN 1992-1-1 Eurocode 2 Design of concrete structures – General rules for buildings" 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.

The design recommendations specified in BS EN 1992-1-1 Eurocode 2 can be applied paying particular attention to the sections relating to bearing stresses (8.3) and anchorage (8.4). Section 6.3 of this technical report addresses these requirements.



## 1.3 Conclusion

It is the opinion of CARES that RFA-TECH 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.

L. Brankley
Chief Executive Officer
December 2022

# 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-TECH and provide a suitable degree of ductility, ensuring that they comply with the tensile requirements of BS4449, Grade B500C 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 8mm, 10mm, 12mm, 16mm and 20mm the main bend is formed to a diameter of:

| Bar Size | Bending Former Size | Ratio |
|---|---|---|
| B8 | 64mm | 8.0 |
| B10 | 64mm | 6.4 |
| B12 | 64mm | 5.3 |
| B16 | 80mm | 5.0 |
| B20 | 120mm | 6.0 |

**Table 1**

The bending former sizes are in excess of the minimum sizes specified in table 8.1N of BS EN 1992-1-1 (also complies with BS8666). The design engineer should consider the bond and bearing stress of these bends in accordance with clauses 8.3 and 8.4 of BS EN 1992-1-1 to ensure that larger bending formers are not required.

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 BSEN ISO 9001 and bars are cropped and bent according to BS8666.

## STARTABOX Shape Variations

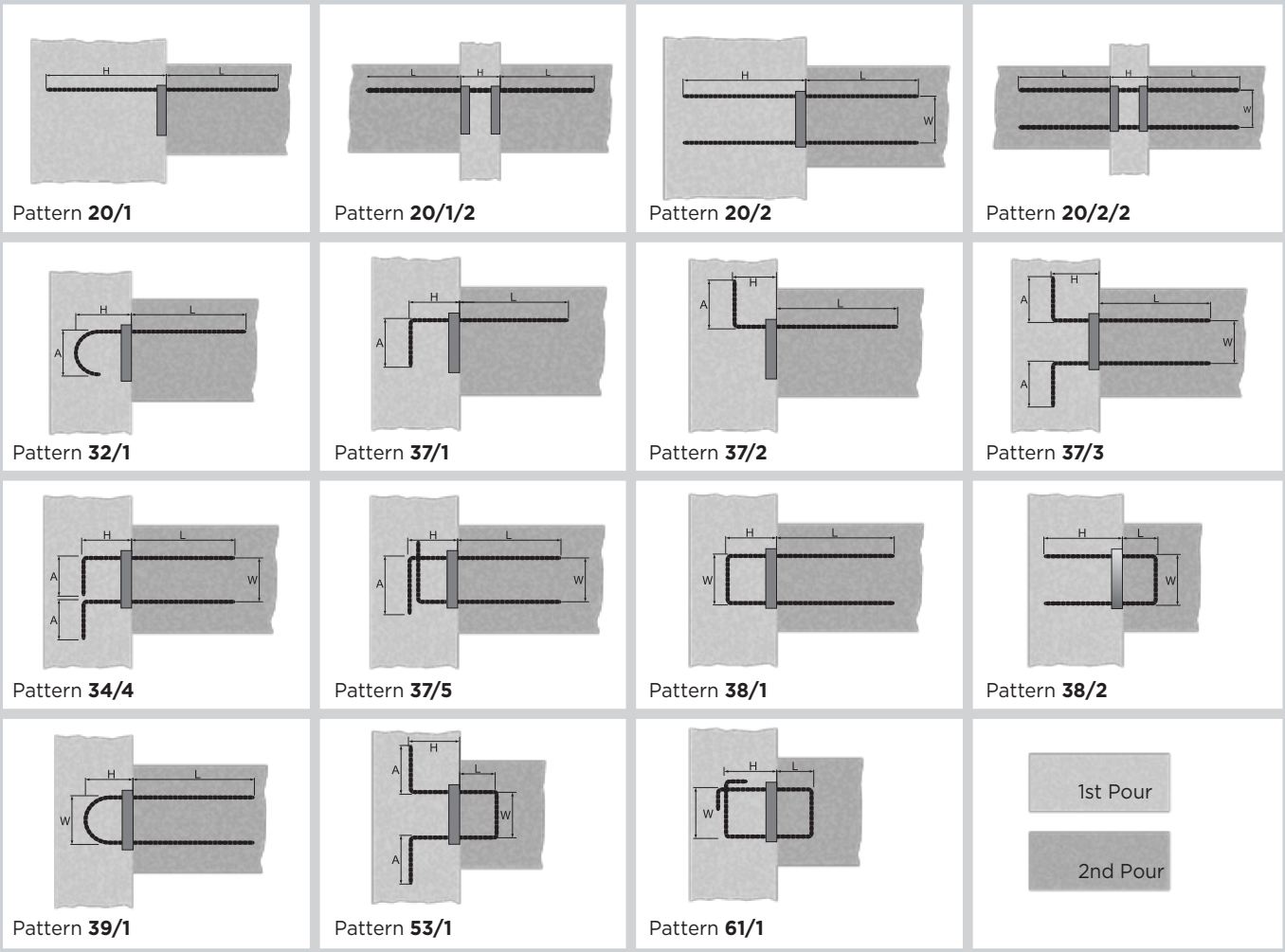



**Figure 1**

The above indicates the more popular shapes requested, and cover most scenarios, however other steel shapes and variations/combinations of the above are available.

# 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 B500C, exhibiting values for Total Elongation at Maximum Load (Agt) of greater than 7.5%.

## 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.

The two tests demonstrated that the joints can develop high resistances to longitudinal shear, the resistance is directly proportional to the yield resistance (stress x area) of the continuity reinforcement crossing the joint and the maximum shear stress calculated, assuming the shear to be transmitted only by the indented back face of the Startabox insert can reach the maximum limit of BS8110 for monolithic concrete. The following expression may be used, subject to upper limits of BS8110 based on the area of the back face and the concrete strength $v_{Rd} = A_s f_{yd}/A_c \leqslant 0.8 \sqrt{f_{cu}}$ (or $0.89 \sqrt{f_c}$) $\leqslant 6.25$ MPa.

Where $V_{Rd}$ is the shear stress calculated for the area $A_c$.
$A_s$ is the area of continuity reinforcement passing through the back face of the casing within the area $A_c$ and fully anchored at both sides. $A_c$ is the area of the back face of the casing in the length considered. Shear transfer in the cover to the casing should not be relied upon.

## 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 BS EN 1992-1-1 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

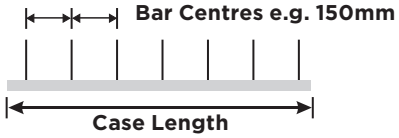
Crack widths at joints are not generally assessed in BS EN 1992-1-1 designs but where a calculation is required, the following equation can be used:

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

Where $\sigma_s$ is the steel stress in the crack,
$\phi_s$ is the bar diameter,
$\tau$ 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 (1990): $\tau = 0.465\ f_{cu}^{2/3}$ for short-term instantaneous loading and $\tau = 0.35\ f_{cu}^{2/3}$ for long-term repeated loading.

# 4 Installation

| | | |
|---|---|---|
| 1 |  | Nail to the inside of formwork |
| 2 |  | Face of box will show when formwork is struck |
| 3 |  | Peel off outer face |
| 4 |  | Straighten bars with rebending tool ready for use |
| |   | |

# 4 Installation

## 4.1 Fixing in Formwork

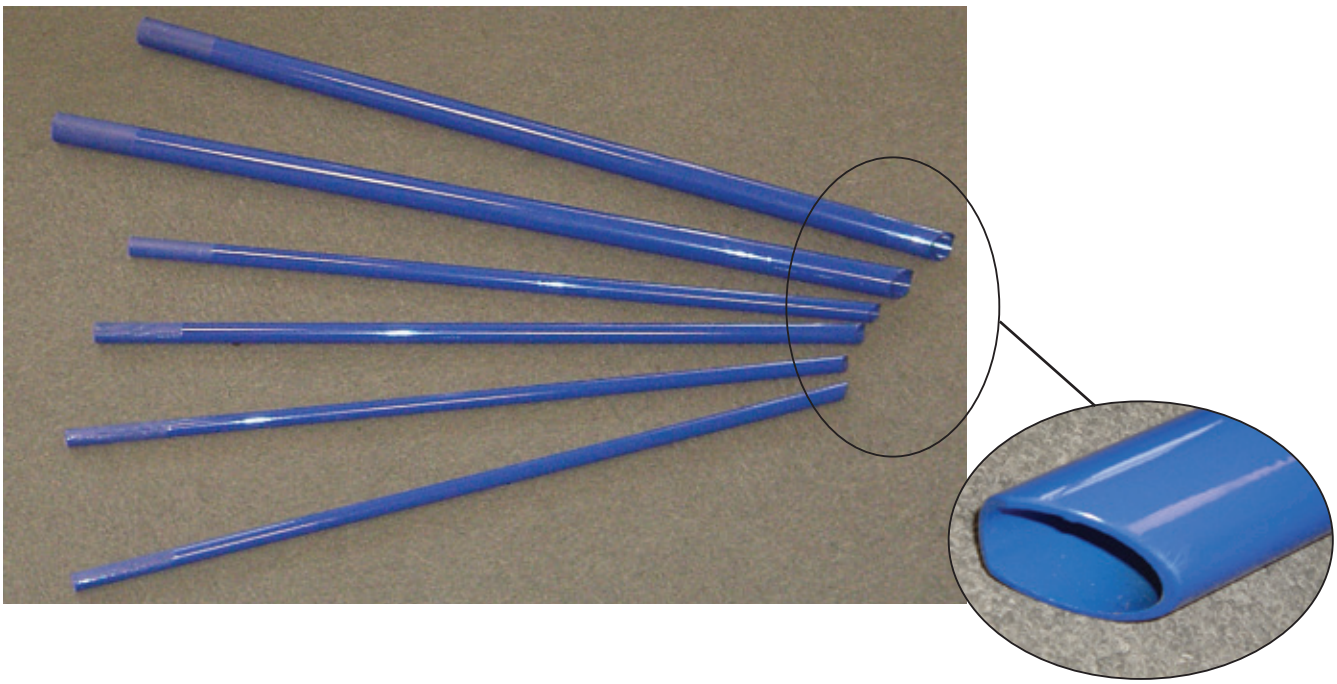
The STARTABOX cases are simply nailed to the formwork where possible. In the case of excessively heavy cases or with steel shuttering the cases are tied securely to the wall reinforcing steel. In either situation the STARTABOX is contained within the wall pour.

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

## 4.2 Straightening/Counterbending of Bars

Once the concrete has been poured and 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-TECH straightening tool (consult RFA-TECH Straightening procedure). In order to alleviate damage to surrounding concrete, RFA-TECH advise allowing at least seven days curing before any attempt is made to straighten bars.

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



### 4.2.1 Straightening Procedure

- 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-TECH 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.

### 4.3 Storage

RFA-TECH advise that material is left on the pallets until required for use. Ensure 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 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 but not being lapped onto immediately, RFA-TECH 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, 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 (see table 1 in section 2.1).

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 B500C (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 and wall/wall construction joints were formed using Startabox reinforcement continuity system; the tests were full scale in terms of bar size and member thickness. 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 that 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 BS EN 1991-1-1 Eurocode 2. Rotation of the slab at the joint occurred in an opening between the rear face of the casing and the concrete in front of it and/or in a crack in line with the inner face of the wall. At bar stress of 300 MPa the maximum movement at the level of the top reinforcement was slightly greater than 0.3 mm and movements at this level can be predicted satisfactorily as the 'w' of the equation given in 3.3.3 above. The maximum crack width/joint opening occurs where the top surface of the slab meets the face of the wall and can be calculated as w(h-x)/(d-x) where h and d are the overall and effective depths of the slab and x is the elastic neutral axis depth.

The structural tests were evaluated by Professor P. E. Regan (Evaluation of the RFA-TECH 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-TECH under an ISO 9001 quality system that is certified by 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 (England and Wales)

### Structure, Approved Document A

RFA-TECH Startabox reinforcement continuity system, when used in EC2 based designs using the data contained within this technical approval, satisfy the relevant requirements of The Building Regulations (England and Wales), Approved Document A.

### Materials and Workmanship, Approved Document

This technical approval gives assurance that the RFA-TECH Startabox reinforcement continuity system comply with the material requirements of EC2.

## 8.2 The Building Regulations (Northern Ireland)

### Materials and Workmanship

This technical approval gives assurance that RFA-TECH Startabox reinforcement continuity system comply with the material requirements of EC2 by virtue of regulation *23, Deemed to satisfy provisions regarding the fitness of materials and workmanship.*

## 8.3 The Building Standards (Scotland)

### Fitness of Materials

This technical approval gives assurance that RFA-TECH Startabox reinforcement continuity system comply with the material requirements of EC2 by virtue of *Clause 0.8*.

### Structure

RFA-TECH Startabox reinforcement continuity system, when used in EC2 based designs using the data contained within this technical approval, satisfy the requirements of *The Building Standards (Scotland) clause 1.*

# 9 References


- BS 4449:2005 Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product.
- BS 8110:Part 1:1997 Structural use of concrete, Code of practice for design and construction.
- BS8666: 2005 Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete.
- BS EN ISO 9001: 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-TECH Startabox Continuity System from tests of Reinforced Concrete Specimens, by Professor P.E. Regan October 2003.
- BS EN 1992-1-1 Eurocode 2: Design of concrete structures. General rules and rules for buildings.

## 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 are unchanged.
   b) The materials, method of manufacture and location 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-TECH 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 etc 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 CARES.

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