CARES Technical Approval Report TA7 5043

Issue 4

MAX FRANK Shearail®
Punching Shear Reinforcement System

Assessment of the Shearail® Punching Shear Reinforcement System

TECHNICAL APPROVAL 5043

0002

Product

**MAX FRANK Shearail®
Punching Shear
Reinforcement System**

Product approval held by:

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1 Product Summary

The MAX FRANK Shearail® Punching Shear system (also referred to within this report as the MAX FRANK Shearail® reinforcement system) comprises of lengths of carbon steel reinforcing bar sourced from a CARES supplier hot forged into doubled headed studs. The double headed shear studs are pre-welded to non-structural rails allowing them to be located correctly in accordance with the design under controlled conditions.

The stud heads are three times the diameter of the bar providing end anchorage in the concrete.

The double headed MAX FRANK shear studs are welded to non-structural rails or reinforcing bar to allow them to be located correctly in accordance with the appropriate design so that the studs are correctly positioned within the concrete section and are securely supported during the pouring of the concrete.

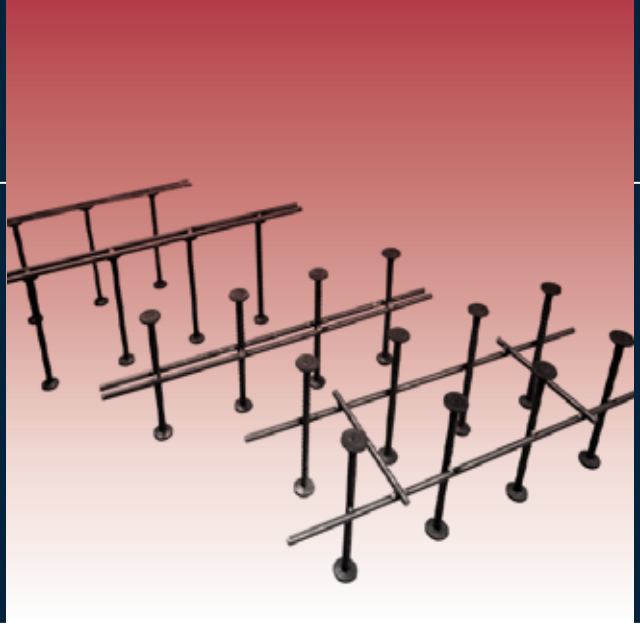
1.1 Scope of Application

The MAX FRANK Shearail® reinforcement system has been evaluated for use in ordinary reinforced and post-tensioned concrete slabs and column bases designed in accordance with BS EN 1992-1-1 (Eurocode 2) and the UK National Annex. It is also suitable as shear reinforcement in piled ground slabs, rafts, etc. as an alternative to traditional loose links for both punching and linear shear applications.

1.2 Design Considerations

Eurocode 2 (EC2) describes punching shear reinforcement in terms of traditional links or bent-up bars arranged along perimeters at calculated distances around a loaded area (e.g. column or pile); with these calculations being relative to the size and position of the loaded area in conjunction with the depth and construction of the adjoining slab.

Where proprietary products are to be used as punching shear reinforcement, EC2 requires that $V_{Rd,\,cs}$ (the design value of punching shear resistance of a slab with shear reinforcement at a control perimeter u_1) should be determined by testing.



In the view of CARES, the basis of design and detailing, adopted for a punching shear reinforcement system other than links or bent-up bars, should be similar to that of the design standard, with amendments made only to take account of particular features of the system in question.

The performance of the system should be experimentally validated against a design method, and the test results should show that the system functions essentially as designed and gives resistances at least equal to the calculated characteristic resistances.

In the view of CARES, double headed shear studs that have been experimentally validated for punching shear may also be used for linear shear in slabs in which the flexural reinforcement complies with clause 9.3.1 of Eurocode 2. The slab edges should contain longitudinal and transverse reinforcement arranged as shown in Figure 9.8 of the code. Additionally, the spacing of the U bars should comply with the requirements of clause 9.3.2 of Eurocode 2 for shear reinforcement. The minimum distance to the slab edge from the stud centreline should not be less than 4.5ϕ where ϕ is the stud diameter.

Deviations from the design standard in relation to detailing requirements, spacing or extending design limitations should be validated by full scale structural testing. The design standard contains various detailing requirements, particularly in relation to the spacing of the elements of shear reinforcement and various limits on, for example, the concrete compressive strength which may be taken into account when designing against against shear in slabs.

1.3 Conclusion

It is the opinion of CARES that MAX FRANK's Shearail® Reinforcement System is satisfactory for use within the limits stated in paragraph 1.1.

L. Brankley
Chief Executive Officer
July 2022

2 Technical Specification

2.1 General

The MAX FRANK Shearail® is a prefabricated punching shear reinforcement system for concrete slabs, manufactured from CARES approved Grade B500C reinforcing bars. The bars are forged to produce double headed studs.

Rails are manufactured to the specific requirements of the design in accordance to BS EN 1992-1-1 (EC2). (Refer to Section 3.3). This determines the layout patterns, spacing, number and diameters of studs.

Studs are available up to 25mm in diameter and lengths to suit most slab depths. All studs are welded to carrier rails according to the design specification, in most cases the rails are symmetrical and can be placed either way round on site.

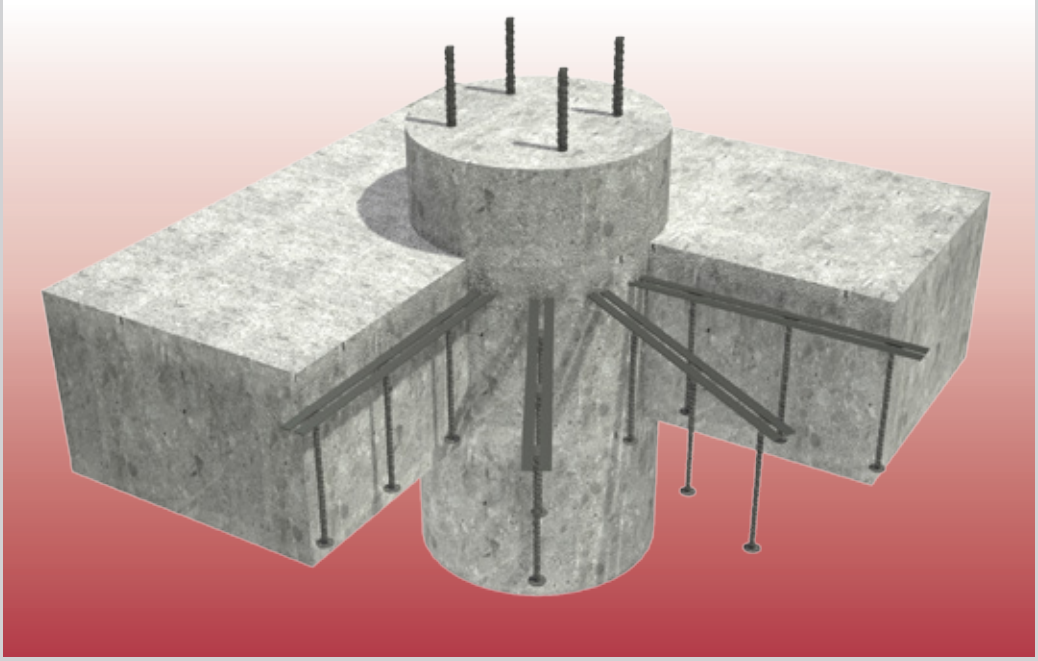


Figure 1 - Shearail®

3 Product Performance and Characteristics

3.1 Material Properties

The MAX FRANK Shearail® shear studs are manufactured from CARES approved grade B500C ribbed carbon steel reinforcing bars with characteristic yield strength of 500 MPa.

The non-structural carrier rails are made from strips of mild steel S275JR in compliance with BS EN 10025 or equivalent.

Figure 2 - Studs

3.2 Production Processes

All process are carried out under a BS EN ISO 9001:2008 Quality Management Systems.

The MAX FRANK Shearail® shear studs are manufactured from CARES approved grade B500C reinforcing bar and hot forged to produce double headed studs in a controlled environment to maintain the original characteristic of the steel's yield strength and ductility values.

Studs are welded to the carrier rails at predetermined centres in accordance with the specification and design.

The finished rails are individually labelled with the floor level, column location and palletised ready for site delivery.

3.3 Design Method and Detailing Requirements

The design methodology is determined by BS EN 1992-1-1-2004 (EC2) incorporating the UK National Annex.

An EC2 design for punching shear will normally produce a radial or cruciform layout pattern, however square patterns can also be achieved following certain procedures with the basic design principles below being maintained.

Outline design procedures:

The following outline is written in relation to ordinary rc suspended slabs and is written in terms of shear stresses. The design value of the applied shear stress (V_{Ed}) is to be obtained as $v_{Ed} = \beta V_{Ed}/u\ d$, where β is a coefficient accounting for the effects of eccentricity of loading as given in EC2, V_{Ed} is the design applied shear force and u is the length of the perimeter considered (u_o, u_1, u_1^* or u_{out} as appropriate).

1. The direct shear at the edge of the loaded area (column or pile) is checked and satisfied.

   EC2: $v_{Ed\ 0} \leq v_{Rd.max}$ u_o perimeter must be calculated in accordance with EC2

2. The punching shear stress at the control perimeter u_1 is determined; if it's within the concrete punching stress resistance no punching reinforcement is required and no further action is required.

   EC2: $v_{Ed\ 1} \leq v_{Rd.c}$ u_1 perimeter is 2d from loaded area in accordance with EC2

3. If the concrete stress is exceeded, punching shear reinforcement can be added to increase the resistance of the slab up to a maximum of 2 $v_{Rd.c}$. The area of shear reinforcement required at each perimeter is given by

   $$A_{sw} = (v_{Ed.1} - 0.75\ v_{Rd.c})u_1 s_r / 1.5\ f_{ywd.\ ef}$$

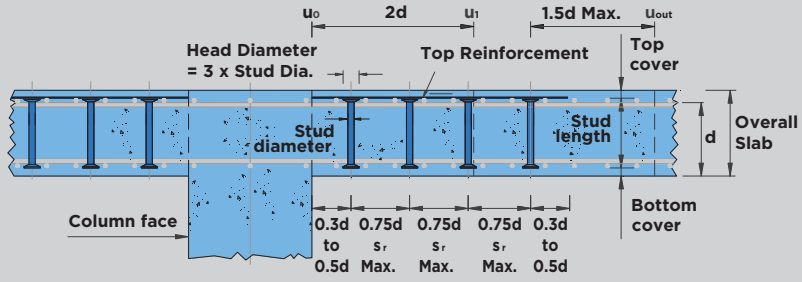
   and the area of each stud must be at least

   $$A_{stud} = (0.08\sqrt{f_{ck}}/f_{yk})(1.5\ s_r\ s_t)$$

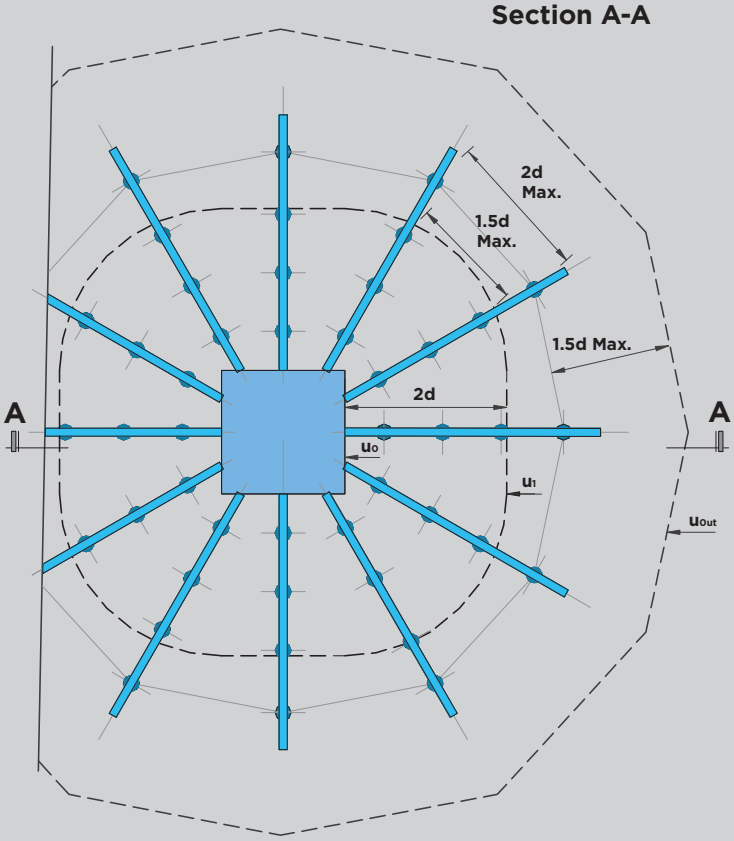
4. Perimeters of punching shear reinforcement are required to within k x the effective depth from the perimeter u_{out} where the slab is able to resist the applied shear, without shear reinforcement

Studs may be used as reinforcement for linear shear in slabs provided compression reinforcement is not included in the flexural resistance calculation. The shear reinforcement should be designed in accordance with Section 6.2.3 of Eurocode 2. The placement of studs within the depth of the slab should be as described in Section 4.1 of this Technical Approval. The maximum longitudinal and transverse spacings of the studs should respectively be in accordance with requirements of clauses 9.3.2 (4) and 9.3.2(5) of Eurocode 2. The maximum diameter of studs used for linear shear should not exceed $\phi_{max} = 16\sqrt{d/200}$.

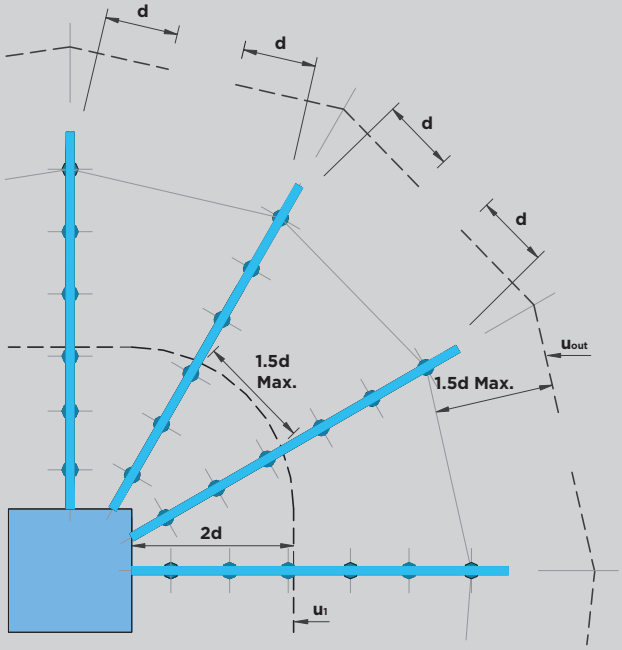
MAX FRANK offer an in house design and detailing service. Free design software and design manual are also available from MAX FRANK.



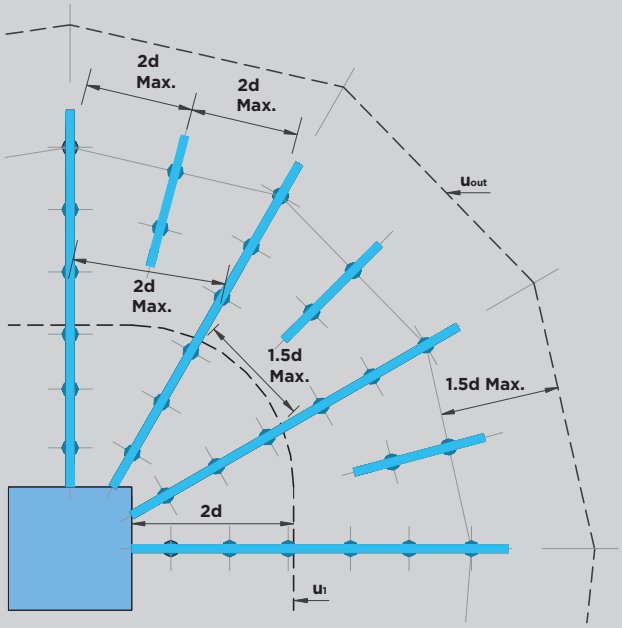
Section A-A



Radial Shearail® layout pattern

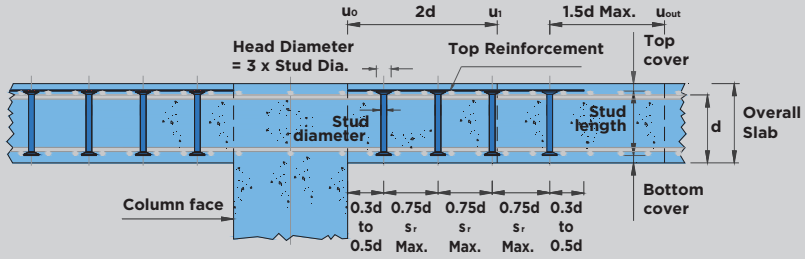


Extended Shearails® without spacers rails

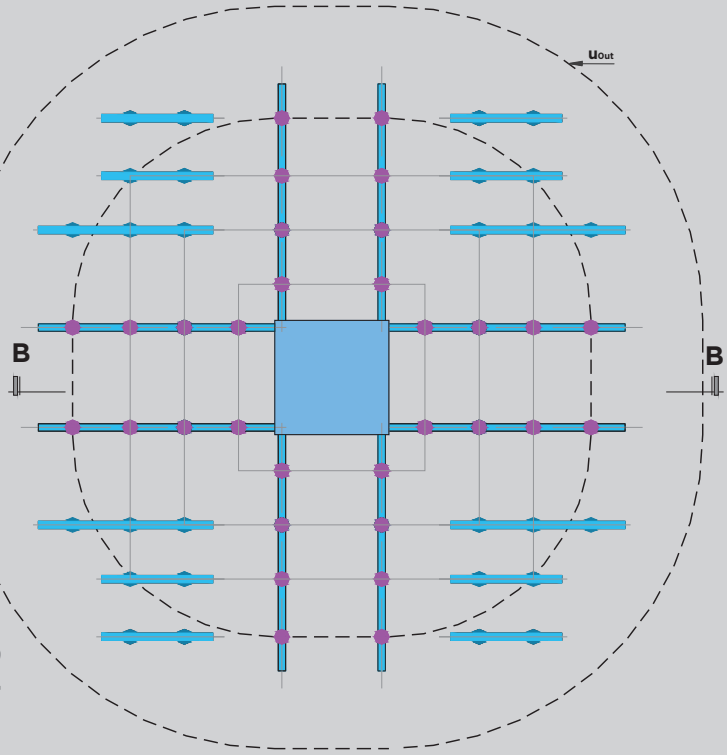


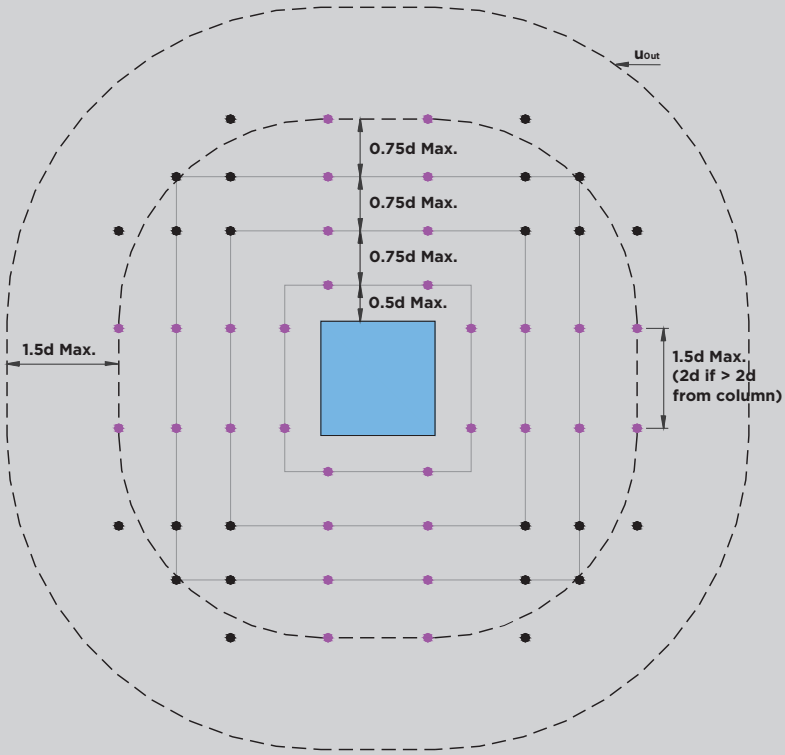
Extended Shearails® with spacers rails

Figure 3
Detailing requirements Shearail® radial layout pattern



Section B-B





Orthogonal Shearail® layout pattern

Links are replaced by studs on a like for like area basis

Note: the studs indicated in blue are not used in the punching shear design

Traditional link layout as designed by the Project Engineer in accordance to the Concise Eurocode 2, published by the Concrete Centre

Note: the links indicated in black are not used in the punching shear design

Figure 4
Detailing requirements Shearail® orthogonal pattern

4 Installation

4.1 Placement of the Studs

Each Shearail® is labelled with a project number and site reference/location, floor and column reference and must be placed in accordance with the Engineers drawings, ensuring a regular stud pattern is maintained and maximum spacings are not exceeded.

Shearail® is designed wherever possible to be made symmetrically in each direction, hence its can be placed either way round to avoid errors, the double headed stud design means can be placed toeing up or toeing down.

The Stud lengths are designed to capture the top and bottom reinforcement mats.

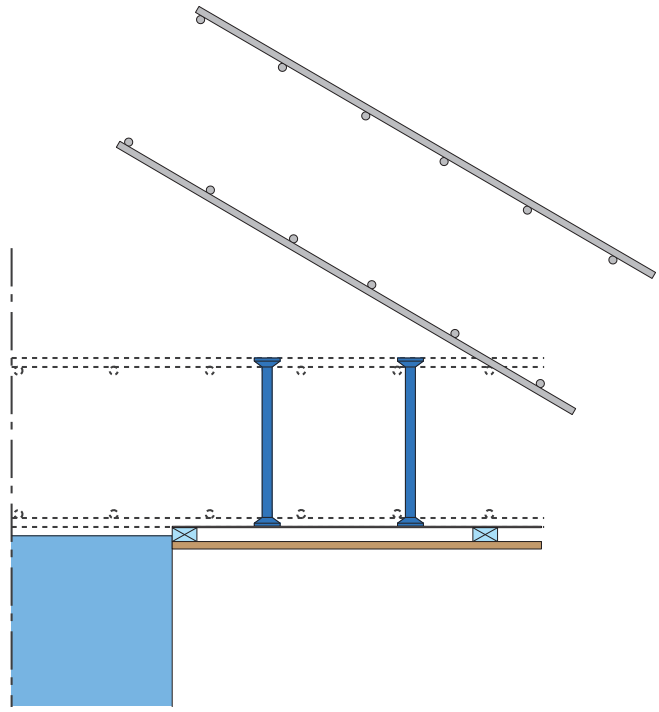
The common method of placing the top rail version is 'Top down' (studs toeing down) with the rails on top of the T1 top reinforcement, however on heavily congested reinforcement or in post tensioned slabs it is recommended to fix the rails to the formwork on spacers 'Bottom up' (studs toeing up) and place the reinforcing bars afterwards.

Note: In 'Top down' fixing, where rails run parallel to the T1 reinforcement, short pieces of reinforcing bar can be wired to T2 bars to act as spacers. In square patterns corner rails can be rotated 90 degree to avoid this situation.

Alternatively, studs with a side connection or stud assemblies should be fixed on spacers and/or to reinforcement bars so that the studs are correctly positioned within the concrete section and are securely supported and remain vertical during the concrete pour.

Figure 5
Placement of studs

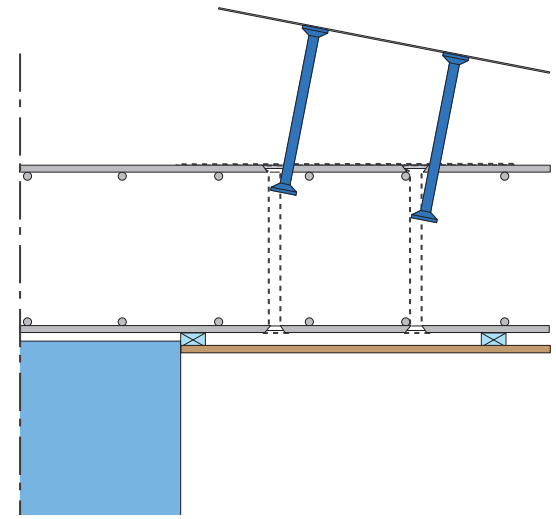
Bottom up



1. Rails are fitted first by spacing the rails off the formwork using concrete spacers and nailing to the formwork through the carrier rail and spacer.

2. The bottom and top rebars are then laid in the usual manner around the Shearails®.

Top down



1. The top and bottom rebar is fitted as per usual.

2. The rails are then placed through the rebar and so the carrier rails sit on top of the T1. These are then securely wire tired to the rebar so that when the concrete is poured, they do not move.

Figure 6
Installation of the Shearails® when on site

4.2 Storage

MAX FRANK Shearail® is delivered to site normally in pour or floor sequence, each individual rail is labelled indicating column, floor level and coded for Identification.

Rails arrangements for each column head are grouped together for ease of site placement, these rail groups are stacked interlaced on wooden pallets to achieve a stable load, pallets are then banded and shrink wrapped, labelled for delivery & schedules attached. Pallets should be off-loaded by forklift or crane and stored near to where needed or if stored with the first deliveries being orderly positioned for first access, banding and packaging should be kept in place if the pallet is to be relocated before use.

Delivery notes & schedules should be retained in the site office for product traceability.

Shearail® being a fabricated steel product is robust in nature, however, it is good practise to store in a manner where it is unlikely to be damaged. As with other reinforcement products some reasonable surface rust is acceptable and very unlikely to affect the structural performance. If they are to be stored for long periods of time or in adverse weather condition exposed rails should be covered to protect the identification labels.

Figure 7 - Storage

5 Safety Considerations

Appropriate safety and standard Personal Protective Equipment such as gloves, safety footwear and eye protection should be worn.

Care should be taken when cutting any steel banded pallets.

Normal sized individual rails are easily handled by site personnel, but Shearail® is a steel product and collectively it can soon become very heavy.

Whilst fixing a group of rails around a column, extra care should be taken storing the rails for next use on top of the reinforcement mat as they blend in and become a trip hazard for others.

Where rails are installed toe down by wiring from the top reinforcement this will lessen the need to reach inside the reinforcement mats.

On a congested building site extra care should be taken transporting rails by hand.

6 Product Testing and Evaluation

The MAX FRANK Shearail® punching shear system has been independently tested at the Cambridge University test facilities for CARES Technical Approval. The results of this and earlier testing have been used in the approval process.

The test slabs all reached their calculated characteristic resistances and behaved as expected on the basis of EC2, while individual studs developed yield stresses.

Samples of shear studs are subject to on-going mechanical testing to ensure the stud material consistently achieves the tensile properties of BS4449.

CARES have been made aware by Max Frank that they have commissioned independent testing of these headed studs in concrete in accordance with ISO 15698-2:2012 to validate linear shear. For further details please contact Max Frank. As these tests were undertaken outside of the scope of the current CARES Technical approval scheme they do not form part of this Technical Report.

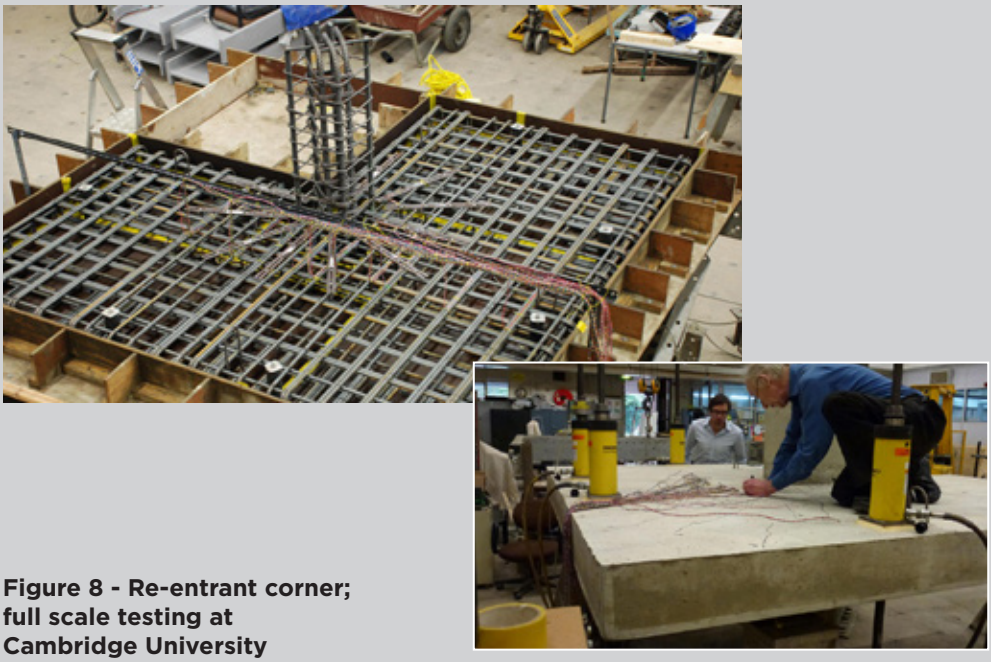


Figure 8 - Re-entrant corner; full scale testing at Cambridge University

7 Quality Assurance

The MAX FRANK Shearail® system is made under an ISO 9001 Quality Management System to ensure that it continues to comply with the conditions of this Technical Approval.

CARES: Quality Management System Certificate No 5043.

8 Building Regulations

8.1 The Building Regulations (England and Wales)

Structure, Approved Document A

MAX FRANK Punching Shear Reinforcement (Shearail®) 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 MAX FRANK Punching Shear Reinforcement (Shearail®) system comply with the material requirements of EC2.

8.2 The Building Regulations (Northern Ireland)

Materials and Workmanship

This technical approval gives assurance that MAX FRANK Punching Shear Reinforcement (Shearail®) 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 MAX FRANK Punching Shear Reinforcement (Shearail®) system comply with the material requirements of EC2 by virtue of *Clause 0.8.*

Structure

MAX FRANK Punching Shear Reinforcement (Shearail®) 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

- Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings, BS EN 1992-1-1:2004
- NA to BS EN 1992-1-1:2004. UK National Annex to Eurocode 2: Design of concrete structures. General rules and rules for buildings.
- PD 6687:2006. Background paper to the UK National Annexes to BS EN 1992-1.
- CARES Appendix TA7 Quality and Operations Schedule for the Technical Approval of Stud Shear Reinforcing Systems for Flat Slabs.
- BS 4449:2005+A2:2009: Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification.
- BS EN ISO 9001 Quality Management Systems. Requirements.

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 Max Frank Limited 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 5043. Confirmation that this technical approval is current can be obtained from CARES.

TECHNICAL APPROVAL 5043

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Validate with the CARES Cloud App

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Independent Product Assessments for the Construction Industry

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