CI/SfB			
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	April 2023		

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EC2
Design
Program
Enhanced
2018

Ancon®

Shearfix Punching Shear Reinforcement
for the Construction Industry

Punching Shear Reinforcement

Reinforcing Concrete Slabs at Column Heads

The weight of aslab supported on acolumn induces shear stresses in the slab. These stresses, if sufficient and where additional reinforcement has not been provided, would result in the column 'punching' through the slab. This punching shear is similarly induced in the footing on which the column bears.
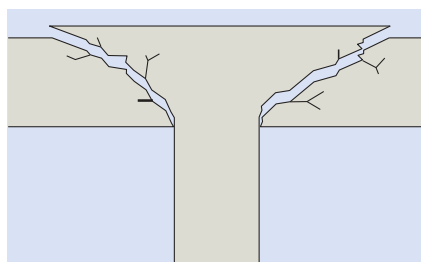
Although punching shear can be relieved by localised thickening of the concrete with downstand beams and enlarged column heads, the construction of flat slabs offers many advantages. Aconsistent head space can reduce the overall height of a building and provide significant time and material savings.

Used within aslab to provide additional reinforcement around columns, Ancon Shearfix is the ideal solution to the design and construction problems associated with punching shear.

The system consists of double-headed studs welded to flat rails, positioned around the column head or base. The shear load from the slab is transferred through the studs into the column.

Contents

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Ancon®

- **Established, trusted name in concrete reinforcement**
- **Free EC2 design program & technical support**
- **BIM Objects available**
- **In-house manufacture from CARES-approved B500C rebar**
- **Rounded rail ends for safer handling**
- **Full material traceability**
- **In-house, traceable batch testing**
- **CARES** **Technical Approval TA7-5041**
- **BSI** **ISO 9001, ISO 14001 & OHSAS 18001**
- **THE QUEEN'S AWARDS FOR ENTERPRISE INNOVATION 2016**

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Shearfix Punching Shear Reinforcement

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Ancon Shearfix

Used within a slab to provide additional reinforcement around columns, Ancon Shearfix is the ideal solution to the design and construction problems associated with punching shear.

The system consists of double-headed studs welded to flat rails, positioned around the column head or base. The shear load from the slab is transferred through the studs into the column.

Shearfix is suitable for all column shapes and is easy to install either 'top down' or 'bottom up', depending on user preference.

Technical Approval

Shearfix has been evaluated by UK CARES for use in reinforced concrete slabs and footings designed in accordance with BS EN1992 (Eurocode 2).

CARES
TECHNICAL APPROVAL
UKAS PRODUCT CERTIFICATION 5041

Shearfix

Comparison with Shear Links

Ancon Shearfix offers many advantages over loose shear links. Links can be time-consuming to both design and install. A Shearfix system is easily detailed with Ancon's free calculation program which generates a layout drawing for inclusion in the building plans and, rather than being installed individually, these studs are supplied to site welded to rails at the appropriate spacing.

When comparing links with studs, research has shown that any additional material costs incurred when purchasing a prefabricated stud system, such as Shearfix, are generally far outweighed by the savings from a significantly reduced fixing time; these systems being up to ten times quicker to install *(source: British Cement Association: Prefabricated punching shear reinforcement for reinforced concrete flat slabs. BCA, Camberley, 2001).*

Details for Specifying/Ordering

Shearfix systems are designed to suit the specific load conditions at individual columns and are therefore manufactured to order. To specify and order an Ancon Shearfix system, download the free design program at www.ancon.co.uk or contact Cortartec/Ancon for technical support.

The Ancon design program generates a 16 digit reference code, which can be used to specify/order Shearfix. Alternatively, should you wish to manually specify each rail of studs please use the following referencing system.

e.g AS12-3-150-180
Where,
AS = Shearfix Code
12 = Stud Diameter (mm)
3 = Number of studs
150 = Stud length (mm)
180 = Stud spacing (mm)

Note: Rail supplied with end distance equivalent to 0.5d (d = effective slab depth) where spacing is 0.75d (0.6667 x spacing). Other end distances available upon request.

Building Information Modelling (BIM)
For a BIM Object of the Shearfix system, please visit www.ancon.co.uk/BIM or the NBS National BIM Library.

NBS BIM

Project Management

Please contact Ancon if you would like help in creating a Shearfix schedule and a programme for delivery to suit progress on site. If advised at the time of ordering, pallets can be packed in priority order e.g by pour number.

Ancon's 'Products for Structural Concrete' division offers a dedicated service to the concrete sector. Contact the team on +44 (0) 114 238 1410 with your Shearfix enquiry.

Corner column

Rail

Double-headed Stud 10, 12, 16, 20 and 25mm diameters

System Components

The Ancon Shearfix system comprises double-headed studs welded to flat rails. It is manufactured to suit the specific requirements of each application. The quantity of each component, the dimensions and spacings, and the layout pattern around the column are determined by calculation. Ancon provides free software to determine the optimum system design (see pages 8-9).
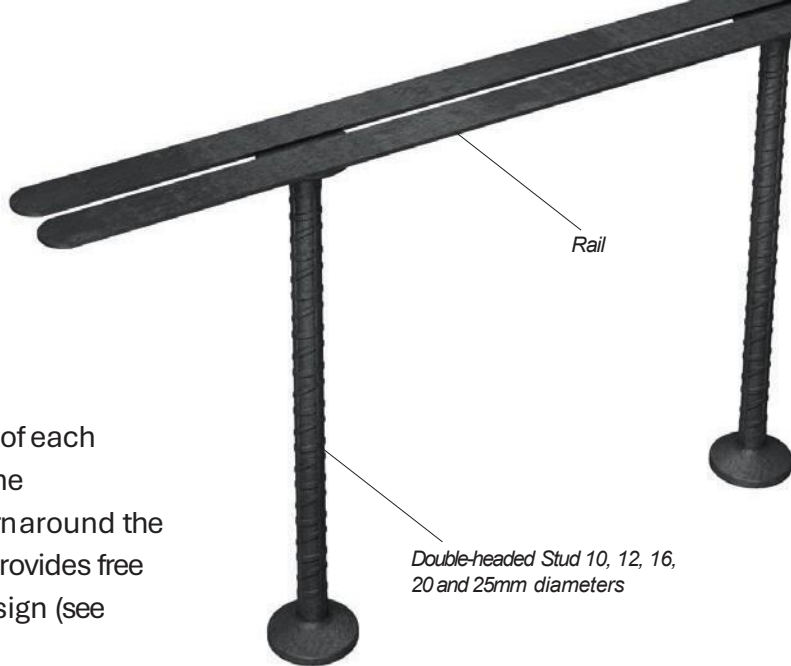
Ancon

Shearfix Studs

Studs are manufactured in five diameters (10, 12, 16, 20 and 25mm) from CARES-approved B500C reinforcing bar. The heads are hot forged to three times the diameter of the bar. Studs are manufactured in virtually any length to suit the depth of slab, but are normally formed in increments of 5mm within the 130-1000mm range. The bar used in this system has a characteristic yield strength of 500N/mm^2. The first and last stud from each production batch is tested in-house to ensure the correct mechanical properties are maintained.

Shearfix Rails

The studs are welded to the rail at the centres determined by Ancon's software or a design calculation. The rail performs no structural function but ensures stud alignment and positioning within the slab.

Shearfix rails are manufactured from strips of steel which are 16mm wide x 3mm thick on studs up to 16mm in diameter and 20mm x 5mm on the larger two stud diameters. The rails feature rounded ends to reduce the risk of injury during handling. The gap between the strips allows for the passage of concrete during pouring and also enables the rail to be nailed through spacers to formwork when fixed 'bottom up' i.e. prior to all other reinforcement.

Spacer Bars (Optional)

Spacer bars should be used with 'top down' fixing of rails which run parallel to T1 reinforcement. The spacer bars are tied to the main T2 reinforcement where it is necessary to raise the level of the studs as if placed on T1 bars.

Product Identification

Each rail of studs carries an identification code generated by the Ancon design program. To ensure the products and documentation can be cross-checked, these 16 digit reference codes are used throughout the process from design to installation. They appear on the calculation summary sheet, the DXF layout file, the parts list and on each physical rail when delivered to site.

Rails also include other references such as column number or floor level if provided at the time of ordering.
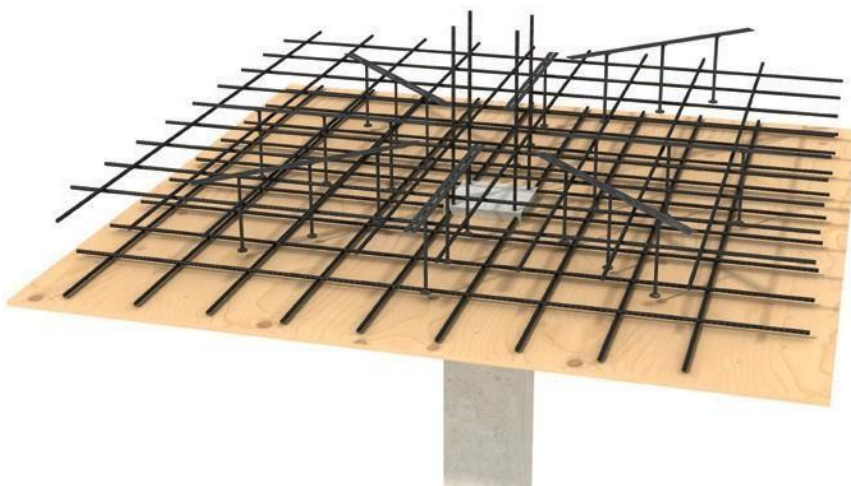
Radial Layout Installation

'Top down' installation. Rail is tied to the main reinforcement

Shearfix Punching Shear Reinforcement

Design Information: BSEN1992 (Eurocode 2)

The design of punching shear reinforcement is typically carried out in accordance with the recommendations contained in BSEN1992 (Eurocode 2). Shearfix designed to BSEN1992 can also be applied to structures designed to BS8110.

The shear stress in the concrete is calculated at the column face and at the basic control perimeter u_1 (2d from the column face) to determine whether punching shear reinforcement is required.

If reinforcement is required, the position of the outer control perimeter at which shear reinforcement is no longer needed (u_{out}) is then calculated. Studs are arranged to start at 0.3d or 0.5d from the column face to within 1.5d of the outer control perimeter (u_{out}); intermediate studs are positioned at 0.75d centres. The Ancon software defaults to a stud start point of 0.5d, although 0.3d is available as an option.

A radial layout will normally provide the most cost-effective solution and rails can be arranged with either 30° or 45° between them. Cruciform rail layout is also an option. The tangential spacing between studs is kept to within 1.5d for studs within the basic control perimeter (u_1) and 2d for studs outside the basic control perimeter; additional secondary rails are added as necessary to comply with this requirement.

For internal, edge and corner columns where lateral stability does not depend on frame action between slabs and columns, and where adjacent spans differ by less than 25%, the recommended β values from BSEN1992 can be applied to the design shear load V_{Ed}. However, β values are most accurately determined on a case-by-case basis, taking the column location, geometry and loading conditions into account. In the Ancon software, by applying the moments, the program calculates these β values automatically. Alternatively, the β values can be calculated manually and input directly into the program.

Openings in the slab

Where there are openings in the slab within 6d of the column face, a section of the slab will be ineffective and the perimeter lengths will be reduced. A series of rectangular or circular openings can be added around each column using the Ancon design program which then calculates the required punching shear reinforcement.
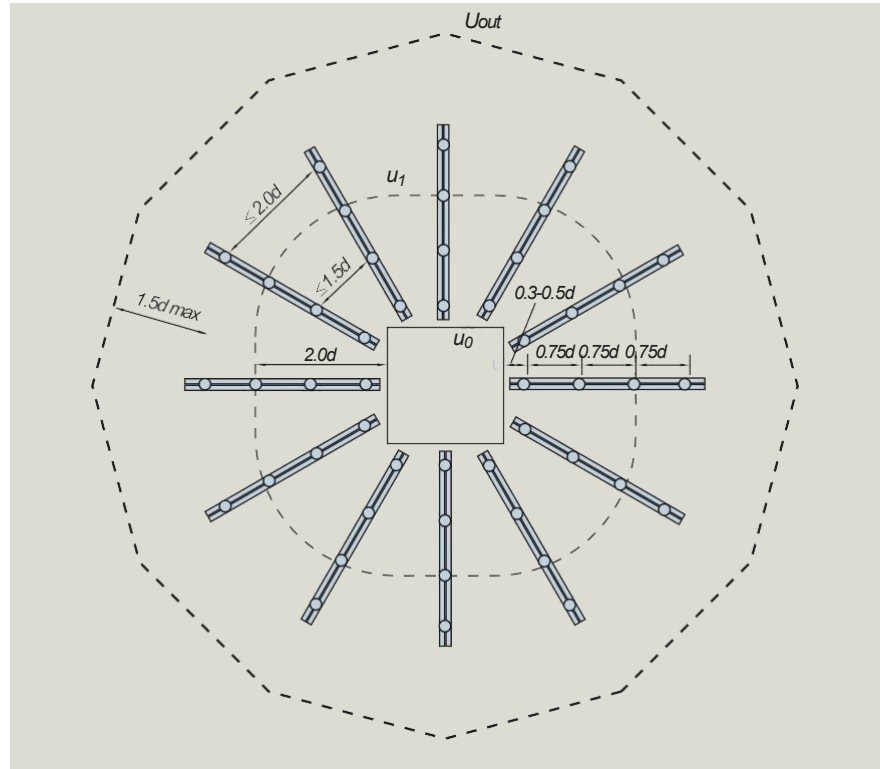
Design Manual

An Ancon Shearfix manual to BSEN1992 (EC2) is available. Contact Ancon for a copy.

Design Sheet

In addition to the Shearfix design program (see pages 8-9), a design sheet is available to download from www.ancon.co.uk, which allows engineers to summarise the critical details of their project and request technical assistance with a Shearfix design.
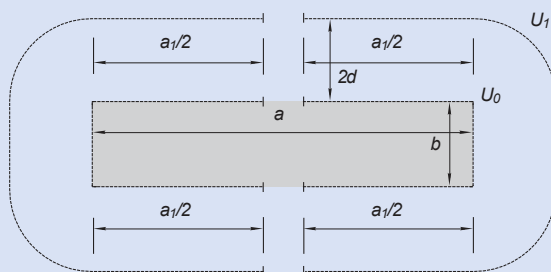

Ineffective shear perimeter

Opening

Any opening within 6d of column face must be considered
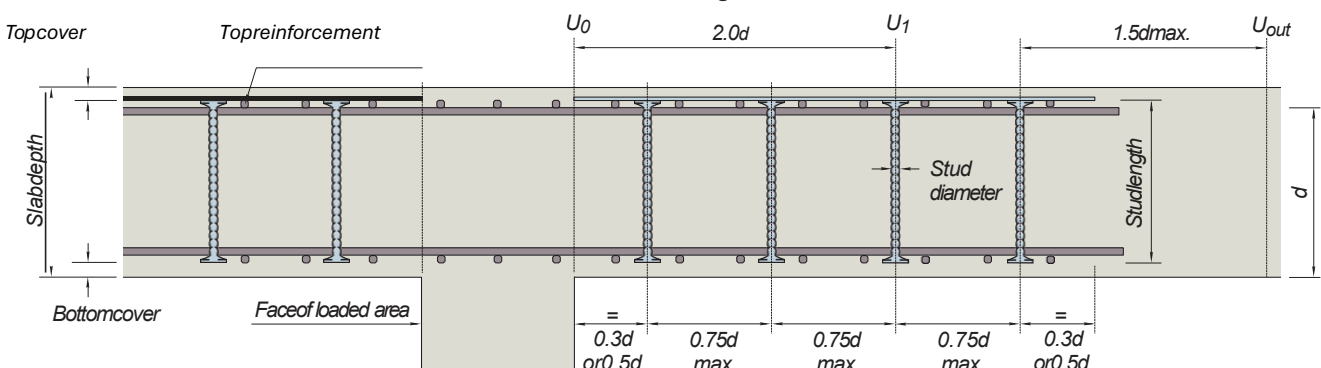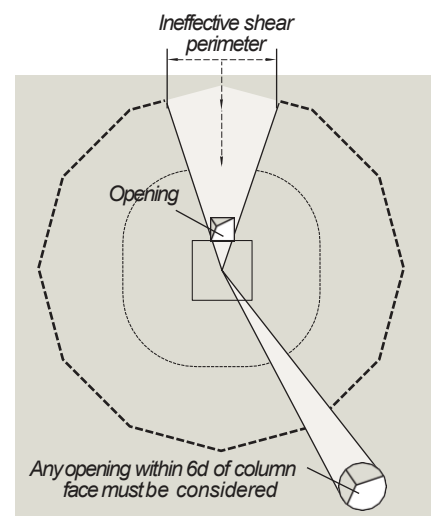
Large and Elongated Columns

Research[1] suggests that punching shear stresses are greater at column corners than along column edges. This effect is more pronounced for larger or elongated columns. The current Eurocode does not explicitly recognise this effect, although the latest Model Code 2010[2] and other publications do. The only limit in the current Eurocode is the aspect ratio which differentiates a column from a wall, i.e. 1:4 (BSEN1992-1-1, 9.5.1).

Ancon's design program allows the designer to select between two options for dealing with large and elongated columns: "EC2" and "Best Practice". Ancon recommends "Best Practice" which reflects latest research findings and the rules in the widely-accepted Model Code 2010, as we believe this to produce a more accurate design. Both options provide valid solutions, however there may be differences to the length and number of rails.

EC2

Where:
$a_1 = \min(a, 4b)$
$u_0 = 2a_1 + 2b$
$u_1 = 2a_1 + 2b + 4\pi d$
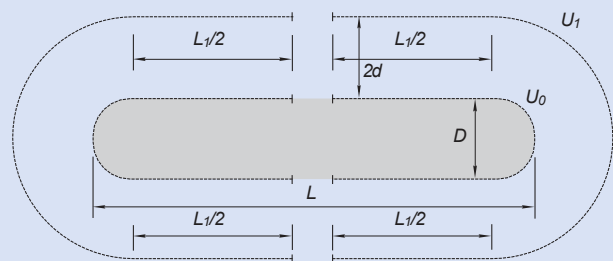
Where:
$L_1 = \min(L-D, 3D)$
$u_0 = 2L_1 + \pi D$
$u_1 = 2L_1 + \pi(D + 4d)$

Best Practice
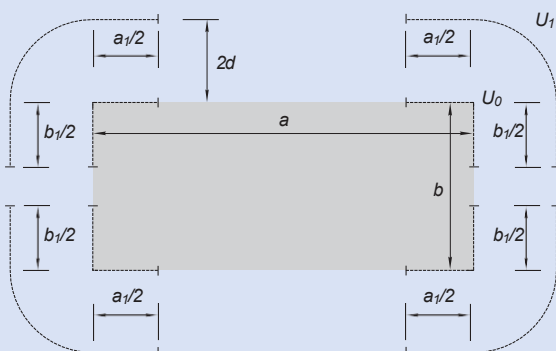
Where:
$a_1 = \min(a, 4b, 3d)$
$b_1 = \min(b, 3d)$
$u_0 = 2a_1 + 2b_1$
$u_1 = 2a_1 + 2b_1 + 4\pi d$
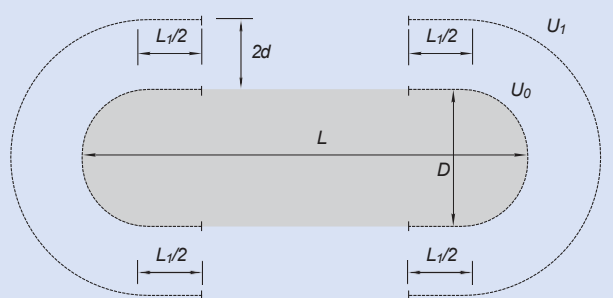
Where:
$L_1 = \min(L-D, 3D, 3d)$
$u_0 = 2L_1 + \pi D$
$u_1 = 2L_1 + \pi(D + 4d)$

There is no limit to the perimeter length effective in resisting punching shear of a circular column as a circular column has no ends or corners at which the shear stresses could focus.

[1] Einpaul, J., Bujnak, J., Fernandez Ruiz, M. and Muttoni, A. (2016). "Study on Infuence of Column Size and Slab Slenderness on Punching Strength" ACI Structural Journal, V.113, No. 1, pp. 135-146

[2] fib (2013). 7.3.5 Punching, Model Code for Concrete Structures 2010, pp.227-234

Shearfix Punching Shear Reinforcement

Design Program (2018 Version 5 Release)

Shearfix is designed to suit the specific requirements of each application. Ancon provides a free design program to simplify the specification and ordering of a Shearfix system. An advanced version of this software was released in 2018, version 5.

This easy-to-use program allows the optimum system design to be determined and generates a printable calculation sheet, a DXF file and a parts list of the specified layout.

Solutions can be created for a wide range of column sizes, shapes and locations including columns offset from edges and corners.

The following combinations of column shape and location are permissible in the Ancon Shearfix Design Program.

Column location	Column shape		
	Rectangular	Circular	Oval
Internal	3	3	3
Edge	3	3	3
Corner	3	3	3
Re-entrant corner	3	3	7
Wall corner	3	7	7
Wall end	3	7	7

The program allows analysis to BS EN 1992 (Eurocode 2).

Where there are openings close to the column, a section of the slab will be ineffective and perimeters will need to be reduced; the Ancon design program allows these reductions to be applied to each perimeter.

The program requires the following information and is requested in a logical sequence as the user works through the 'input' tabs:

- Column shape
  (circular, rectangular or oval)
- Column dimensions
- Column location
  (interior, edge, external corner, re-entrant corner, wall corner, wall end)
- Dimension to concrete edge
  (for offset corner and edge columns)
- Slab thickness
- Concrete grade
- Reinforcement size and spacing
- Cover to reinforcement
- Size and location of slab openings
- Shear load
- Applied moments

This free program can be downloaded from www.ancon.co.uk or emailed on request. Contact Ancon on +44 (0) 114 275 5224 or info@ancon.co.uk.

Latest Features of the Ancon Shearfix Design Program

Project Management
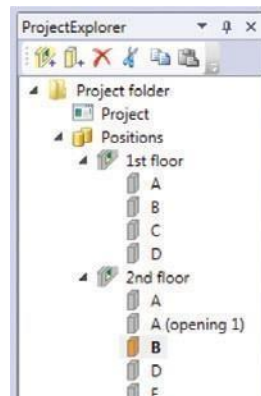
The Ancon Shearfix Design Program contains a calculation management tool, allowing multiple column locations to be designed within a single project file. The calculations can be arranged in a system of sub-directories to ease project management. When exporting design information, any number of column locations can be included in a bulk export as a PDF calculation report, a DXF file or a PDF parts list.

Automatic b Value Calculation

The load eccentricity factor, b, can be automatically calculated for any column shape or location, provided that the designer inputs the applied design moments.

### Interactive 2D Graphic Display

A clear 2D graphic automatically updates as data is entered, illustrating the column and opening dimensions, and the locations of openings relative to the column. Each dimension can be edited via the 2D graphic or via the main input window. Furthermore, it is possible to 'grab and drop' the openings via the 2D graphic.

Slab Openings

Any number of rectangular and circular slab openings can be applied to a design calculation and the software arranges the design solution to suit.

Slab Reinforcement

Where structures contain multiple layers of tensile slab reinforcement, the software will automatically calculate the effective slab depth and reinforcement ratio associated with these (a maximum of two layers of tensile reinforcement in each orthogonal direction can be accommodated).
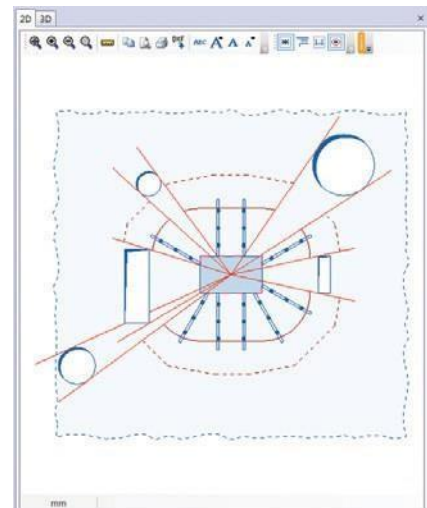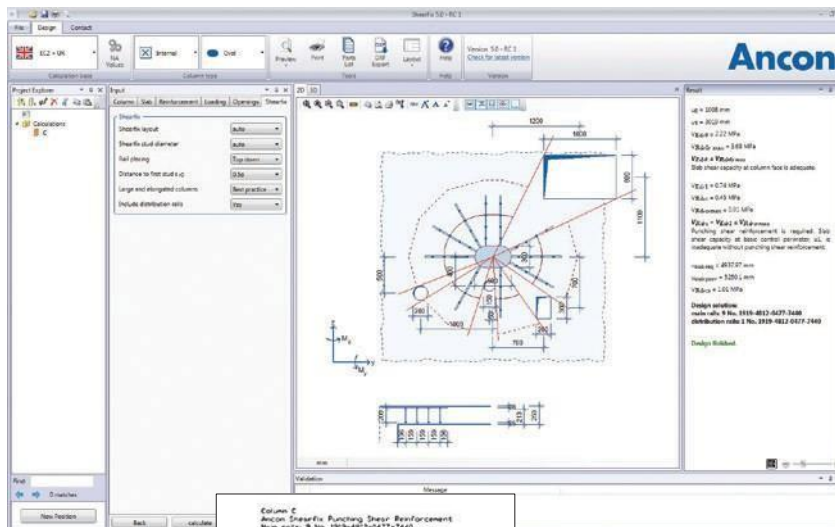

Example of multiple openings
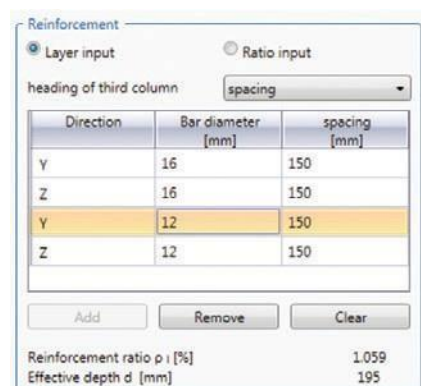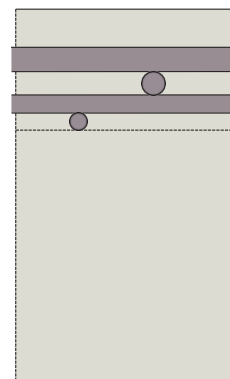
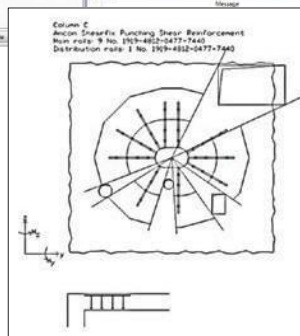Example of multiple reinforcement layers

Help File

A help file can be accessed by clicking the 'Help' icon within the design program or call Ancon on +44 (0) 114 238 1410 for advice.
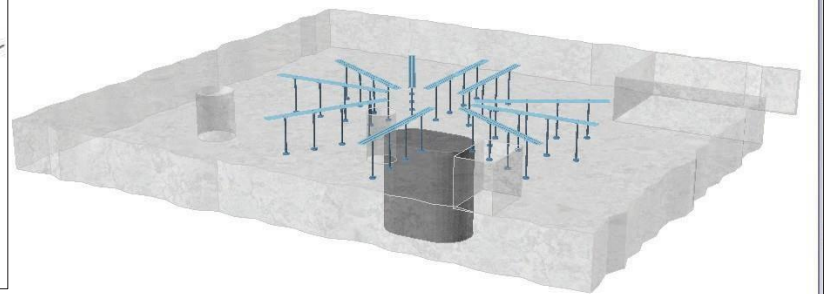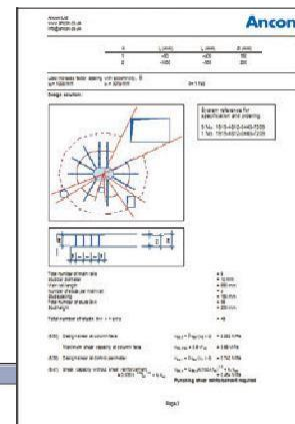
Radial Design Example

Screenshot of an oval, internal column with a radial stud layout
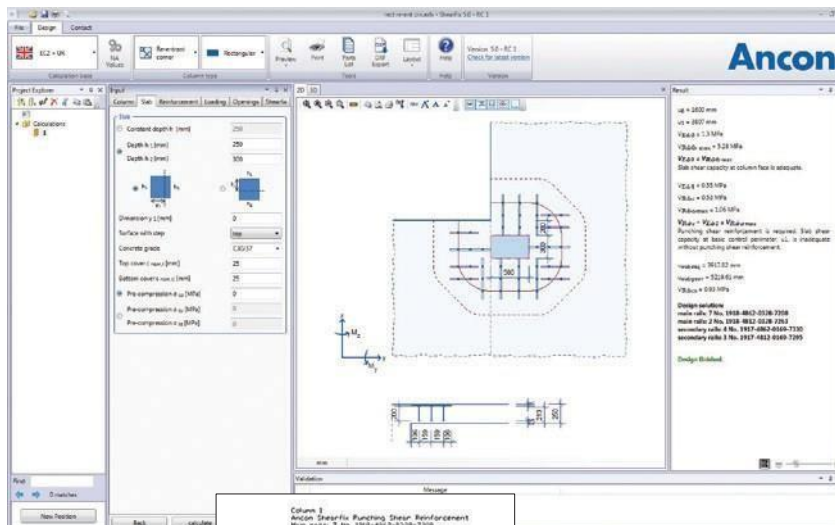

The DXF file generated

The PDF datasheet generated

3D view in software
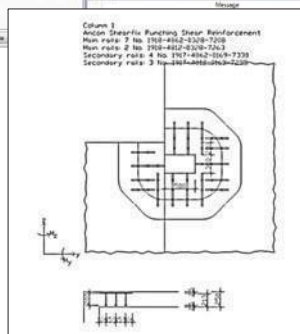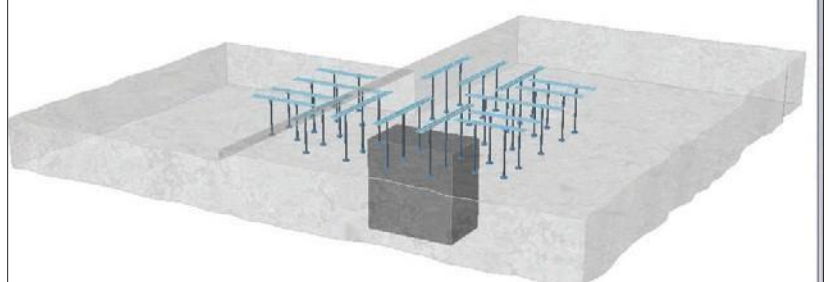
Cruciform Design Example
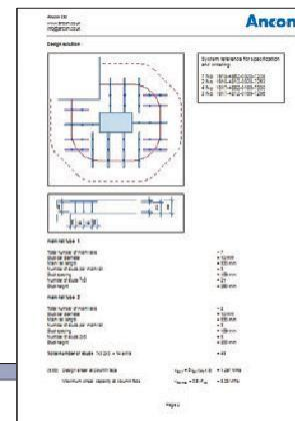

Screenshot of a rectangular column at a re-entrant corner, with a cruciform stud layout
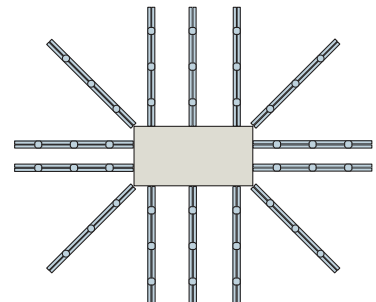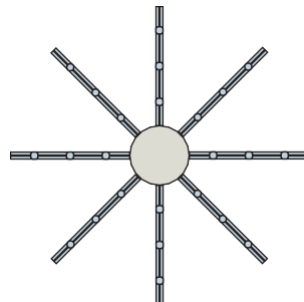

The DXF file generated

The PDF datasheet generated
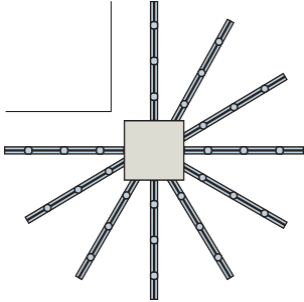

3D view in software

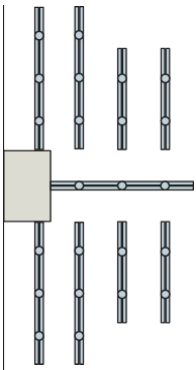# Shearfix Punching Shear Reinforcement

Typical Rail Arrangements

Shearfix is suitable for a wide range of column shapes and locations. Some typical arrangements are shown here.

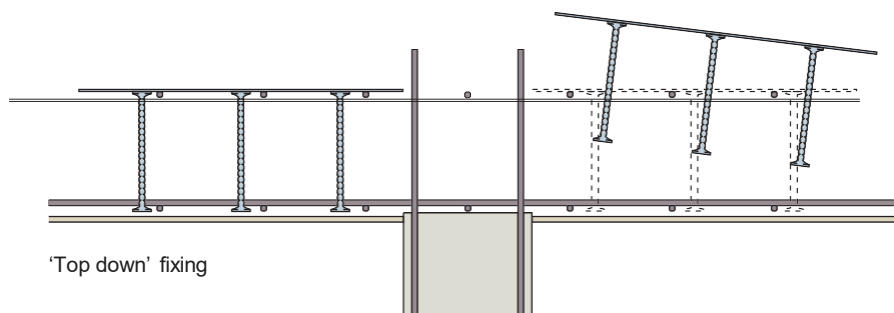**Radial Layouts**

Cruciform Layouts
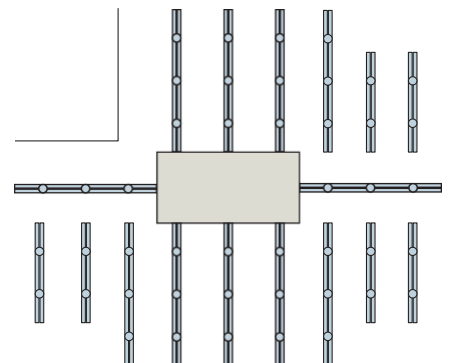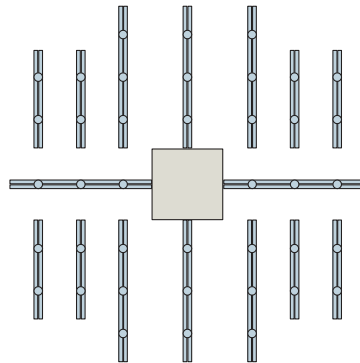
Installation Procedure

Ancon Shearfix is quick and simple to install. It can be fitted either 'top down' (after all other reinforcement) or 'bottom up' (prior to other reinforcement).

'Top Down' Fixing

- Fix all main reinforcement in position
- Place Shearfix rails around the column to the layout detailed on job drawings by passing the studs through the reinforcement grid and resting the carrier rails on the top layer of reinforcement. Use spacer bars where required –
  see page 5 for details
- Tie rails with wire to main reinforcement and pour concrete

'Bottom Up' Fixing

- Tie rails with wire to concrete spacers in order to maintain cover
- Place rail and spacer units around the column to the layout detailed on job drawings
- Hammer nails through gap in rails to fix the system to formwork
- Fix main reinforcement in position and pour concrete taking care not to displace the studs

'Top down' fixing
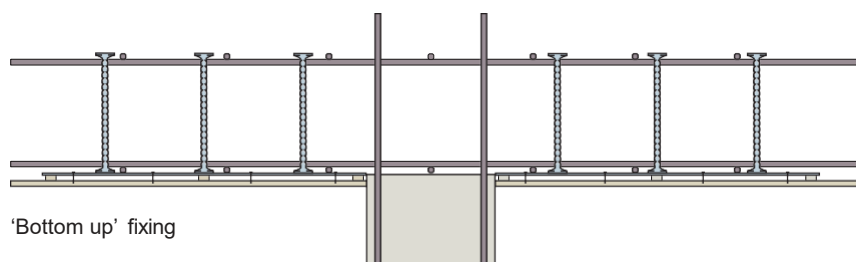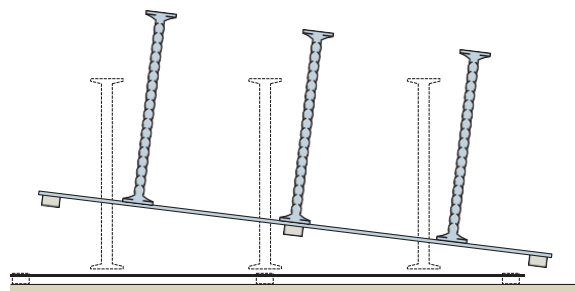
'Bottom up' fixing

Masonry Support Systems

Lintels

Masonry Reinforcement

Windposts and Parapet Posts

Wall Ties and Restraint Fixings

Channel and Bolt Fixings

Tension and Compression Systems

Insulated Balcony Connectors

Shear Load Connectors

Punching Shear Reinforcement

Reinforcing Bar Couplers

Reinforcement Continuity Systems

Stainless Steel Fabrications

Flooring and Formed Sections

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