Punching Shear Reinforcement for the Construction Industry

Shearfix

Design Program Available

Ancon®

B U I L D I N G  P R O D U C T S
Ancon designs and manufactures high integrity steel products for the construction industry. Through continuous programmes of new product development, inward investment and employee advancement, the company is committed to maintaining the highest level of customer service within a dynamic and challenging industry.

- Masonry Support Systems
- Windposts andLintels
- Wall Ties and Restraint Fixings
- Channel and Bolt Fixings
- Tension and Compression Systems
- Stainless Steel Fabrications
- Flooring and Formed Sections
- Shear Load Connectors
- Stainless Steel Reinforcement
- Reinforcing Bar Couplers
- Reinforcement Continuity Systems

**Punching Shear Reinforcement**

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Punching Shear Reinforcement

Punching Shear
The weight of a slab supported on a column 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.

The Shearfix Solution
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.

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 Punching Shear Reinforcement Design Program (see pages 6-7). This program 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: Building Research Establishment, UK).

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. A consistent head space can reduce the overall height of a building and provide significant time and material savings.
Sizes and Configurations
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.

Studs are manufactured in four diameters (12, 16, 20 and 24mm) from high strength steel 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 10mm within the 100-500mm range. The bar used in this system has characteristic yield strength of 500MPa.

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, 20mm wide.

<table>
<thead>
<tr>
<th>Stud diameter</th>
<th>Stud length</th>
<th>Overall depth ‘D’</th>
</tr>
</thead>
<tbody>
<tr>
<td>12mm</td>
<td>230mm</td>
<td>120mm</td>
</tr>
<tr>
<td>16mm</td>
<td>230mm</td>
<td>120mm</td>
</tr>
<tr>
<td>20mm</td>
<td>230mm</td>
<td>120mm</td>
</tr>
<tr>
<td>24mm</td>
<td>230mm</td>
<td>120mm</td>
</tr>
</tbody>
</table>

Note: d=effective slab thickness

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.

Call us on 1300 304 320 with your Shearfix enquiry.

Product Identification
Each rail of studs carries the following identification:

Shearfix Code, Stud Diameter x Stud Length, Number of Studs @ Stud Centres, Rail Length
Column/Grid Reference
Floor Level

**e.g. SF12 x 230, 3 @ 180 c/c, 600 long**

**K15**

**Level 2**

All dimensions are in millimetres.
Design Program

Ancon Shearfix is designed to suit the specific requirements of each application. Ancon provides a design program to simplify the specification and ordering of a Shearfix system.

This easy-to-use program determines the optimum design of Shearfix components and generates a printable data sheet and a DXF file of the specified layout. Solutions can be created for all column sizes, shapes and locations including columns offset from edges and corners.

The program allows analysis to AS 3600 (Lim and Rangan), BS EN 1992-1-1 (Eurocode 2) and BS 8110-1.

The program requires the following information:

- Column shape (circular, rectangular or ‘L’ shape)
- Column dimensions
- Column location (interior, edge or corner)
- Slab thickness
- Concrete grade
- Any reductions to the critical shear perimeter
- Cover to reinforcement
- Shear load
- Applied moments

This program can be downloaded from www.ancon.com.au.

The calculation method used in the Ancon design program (Lim and Rangan) is shown on page 9.
Screen shot of a square column, offset from a re-entrant corner

The DXF file generated

The datasheet generated
**Punching Shear Reinforcement**

**Design Information**
The analysis follows the specifications in the standard AS 3600: 2009 clause 9.2, but the major part of the design is based on the research presented by F K Lim and B V Rangan. Please note that AS 3600: 2009 does not have a specific clause on shear stud design. Therefore the software is based on a research paper. We strongly recommend the shear stud design is verified against an alternate standard such as BS EN 1992-1-1 (Eurocode 2) or BS 8110.

The shear capacity of the slab is checked against the design shear forces at the critical shear perimeter (refer to AS 3600: 2009 for further details on determining the critical shear perimeter) and if required Shearfix studs are designed to increase the shear capacity of the slab.

The first stud is positioned 0.5d from the face of the column, i.e. along critical shear perimeter, with the spacing between individual studs taken at 0.7 (D - top cover - bottom cover - 5) with a maximum limit of 500mm. The Shearfix Program designs the rails, firstly at 0.7 (D - top cover - bottom cover - 5) and then checks the shear capacity of the slab. If the shear capacity of the slab is still below the design shear force, the program will then reduce the spacing until the shear capacity of the slab exceeds the design shear force.

The maximum spacing between parallel rails is 600mm or D whichever is less.

The number of studs along a rail is determined by positioning the last stud 2.5d from the column face, and then spacing the studs between the first and the last.

If more than one rail is required for each side of the column, rails should be placed at the corner of the column in the torsion strip.

A check is carried out for over reinforcement - if this check fails, a warning message states that failure due to punching shear is possible and an increase in slab thickness will be required.

**Effect of Slab Penetrations**
Where there are openings in the slab within 2.5b0 (b0 = width of an opening) from the critical shear perimeter (cl. 9.2.1.2), a section of the slab will be ineffective and the critical shear perimeter will need to be reduced. The Ancon design program allows reductions to be applied to the critical shear perimeter as appropriate.
Calculation Method
The design of Shearfix follows the specifications set out in the Clause 9.2 of AS 3600: 2009, but the major part of the design is based on the research presented by F.K Lim and B.V Rangan from the School of Engineering at Curtin University of Technology in Perth.

The design calculations check the shear stresses imposed on the critical shear perimeter surrounding the column, with Shearfix stud reinforcement provided as required.

Design Actions
When checking the shear capacity of the slab, the design shear force V* and design transfer moment from the slab into the support M* must be taken into account.

In the Shearfix Design Program, these values must be calculated and inputted into the program.

Critical Shear Perimeter
The critical shear perimeter “u” is the boundary of the effective area of a support or concentrated loads located at a distance of d/2, (d = effective depth of the slab).

For rectangular columns –

\[ u = 2(x + \frac{d}{2} + \frac{d}{2}) + 2(y + \frac{d}{2} + \frac{d}{2}) \]

Where there are critical openings within 2.5 b0 from the critical perimeter, the projected width of the opening will be ineffective and will reduce the length of the critical perimeter.

Calculation of Shear Stress
The shear capacity of the slab is determined in accordance to Clause 9.2.3 for the case where there are no transfer moments (M* is zero), or Clause 9.2.4 for the case where there are transfer moments (M* is not zero).

For the case where M* is zero –

\[ V_u = \frac{ud(\sigma_y + 0.3\sigma_p)}{1 + \frac{M_u}{V_u}} \]

Clause 9.2.3a, AS 3600: 2009

Where –

\[ V_u = \text{shear capacity of the slab} \]
\[ \sigma_y = \text{average pre-stress in concrete} \]
\[ M_u = \text{concrete shear strength, where} \]
\[ f_{cu} = 0.17(1 + 2\beta_1)\sqrt{f'_c} \]
\[ f'_c = 0.34\sqrt{f_c} \]
\[ \beta_1 \text{is the ratio of the effective loaded area} \]
\[ X/Y (XeY) \]

For the case where M* is not zero –

\[ V_u = \frac{V_u}{1 + \frac{M_u}{V_u}} \]

Clause 9.2.4, AS 3600: 2009

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\[ f_{vy} = \text{Yield strength of the stud (500 MPa)} \]
\[ A_v = \text{cross sectional area of a row of studs in the slab strip} \]
\[ s = \text{spacing of the studs} \]
\[ b = \text{width of the critical shear perimeter} \]
\[ \beta = \text{Detailing} \]

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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
- Tie rails with wire to main reinforcement and pour concrete

‘Bottom up’ Fixing
- Clip rails to spacers in order to maintain cover
- Place rail and spacer units around the column to the layout detailed on job drawings
- Fix main reinforcement in position and pour concrete

Typical Arrangements
Shearfix is suitable for all column shapes and locations. Some typical arrangements are shown here.

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Other Ancon Products

Reinforcing Bar Couplers
The use of reinforcing bar couplers can provide significant advantages over lapped joints. Design and construction of the concrete can be simplified and the amount of reinforcement required can be reduced. The Ancon range includes BT parallel threaded couplers and MBT mechanically bolted couplers.

Reinforcement Continuity Systems
Reinforcement Continuity Systems are an increasingly popular means of maintaining continuity of reinforcement at construction joints in concrete. The Ancon Keybox system eliminates the need to drill shuttering and can simplify formwork design, thereby accelerating the construction process. It is available in both standard units and special configurations. Ancon KSN Anchors eliminate the need for on-site bar straightening and are available to accept reinforcement of 12mm, 16mm and 20mm diameter. The system is also available with a re-useable rebate former.

Shear Load Connectors
Ancon DSD and ESD Shear Load Connectors are used to transfer shear across expansion and contraction joints in concrete. They are more effective at transferring load and allowing movement to take place than standard dowels, and can be used to eliminate double columns at structural movement joints in buildings. A ‘Lockable’ dowel is also available for temporary movement joints in post-tensioned concrete frames.

Masonry Support Systems and Fixings
Ancon manufactures support systems for masonry cladding on concrete and steel framed buildings. A wide range of channels and bolts are available to fix these systems to the structural frame. Cast-in channels and expansion bolts are used for fixing to the edges of concrete floors and beams.

Tension Systems
Tie bars are increasingly being used in structures and buildings as an architectural as well as a structural element. Ancon Tension Systems comprise a range of components which can be supplied in carbon steel or stainless steel in a variety of sizes and finishes. A variety of assemblies can be created from simple tie bars to complex bracing systems involving several bars joined at one point.

Special Fabrications
Ancon is an ASSDA accredited specialist fabricator and has a wealth of experience in working with a variety of material grades. High integrity steel components are supplied to a wide range of industries including Civil Engineering, Building, Infrastructure, Water Treatment, Nuclear and Mining.
The construction applications and details provided in this literature are indicative only. In every case, project working details should be entrusted to appropriately qualified and experienced persons.

Whilst every care has been exercised in the preparation of this document to ensure that any advice, recommendations or information is accurate, no liability or responsibility of any kind is accepted in respect of Ancon Building Products.

With a policy of continuous product development Ancon Building Products reserves the right to modify product design and specification without due notice.