CADS SWMC FAQ

Why does my base connection fail in shear?

It is quite common to find that the default base connection has little or no shear resistance in one or more load combinations so it is desirable to understand why this may be so that appropriate action can be taken to achieve a connection that passes the design criteria.

CADS Steelwork Moment Connections (SWMC) relies on SCI/BCSA publication *P207/95 Joints in steel construction – moment connections* as its principal authority. Base connections are covered therein in section 6 pp 87-102 with shear transfer to the concrete considered on page 97.

Three mechanisms for shear transfer are discussed:-

1: Friction.

2: Side bearing or dowel action of the bolts in grout/concrete.

3: Shear key or recess.

CADS SWMC provides a further option 'reinforced concrete section analogy'

These options are discussed below.

Friction resistance

A friction coefficient value 0.30 is recommended. As the publication states that "in practice most moment connections are able to rely on friction", this is the default mechanism or calculation model provided in CADS SWMC. However, if the axial compression and moment are low the frictional shear resistance will be low and in cases of net tension, the frictional shear resistance will be zero. Unfortunately this situation is far more common than is implied in SCI-P-207/95.

Reinforced concrete section analogy

As a refinement of the friction model, CADS SWMC provides an alternative calculation called 'reinforced concrete section analogy'. In this model, the interface between the baseplate and the base is visualised as a rectangular reinforced concrete beam section with the tension side bolts treated as equivalent reinforcement bars taking into account their material properties and effective anchorage. The shear resistance of the equivalent section is calculated in accordance with BS 8110 clause 3.4.5 with no shear links. This alternative calculation delivers a modest increase in shear resistance compared with the simple friction model and this may be sufficient to justify some cases for which the friction method indicates failure by a small margin.

Bolt dowel action

As stated in SCI-P-207/95, side bearing or dowel action is "difficult to depend on" when the bolts are placed in sleeves to provide positional tolerance for erection. In fact the grouting of bolt sleeves is so notoriously dependent on site workmanship and unreliable that CADS SWMC does not provide any resistance result from this source if sleeved anchor bolts have been specified as per default. To get a result it is necessary to specify bolts cast-in-situ or resin anchored in predrilled holes. The calculation is then done in accordance with p 97 of SCI-P-207/95 taking into account bolt edge distance within the concrete base.

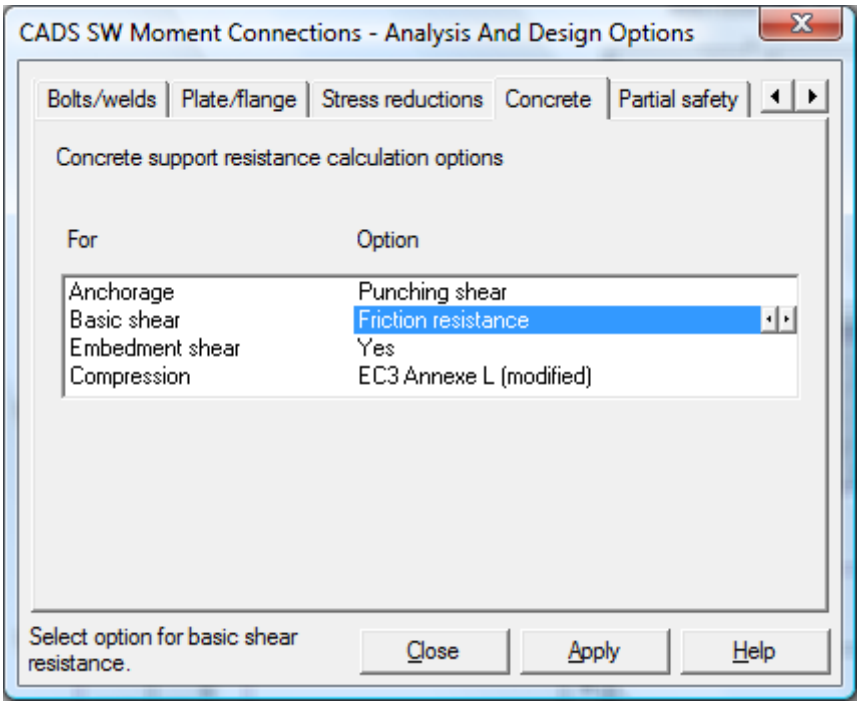
Shear key or recess.

As stated in SCI-P-207/95, this is the safest option available in circumstances where high shear is combined with significant axial tension when using sleeved anchor bolts. The baseplate is solidly cast into a recess preformed in the base concrete. However, no published guidance appears to be available for calculating the resistance of a shear key. In SWMC it is assumed that the shear resistance of the recess is governed by the lesser of bearing resistance of the baseplate edge on the concrete / bedding material and shear resistance of

the failure surface lying between the baseplate and the base edge. Concrete above the baseplate, if present, is conservatively ignored.

Selecting the calculation options

Select *Analysis* > *Analysis options.* Using the left/right toggle keys, locate and select the tab *Concrete.* The following dialog will appear:-



Select the *Basic shear* options. The default selection 'Friction resistance' is highlighted and left/right toggle keys allow the three options to be viewed and selected.

Additional embedment shear resistance can be included or excluded by selecting Yes/No. This is useful for a quick check on the effect of removing a previously specified shear key.

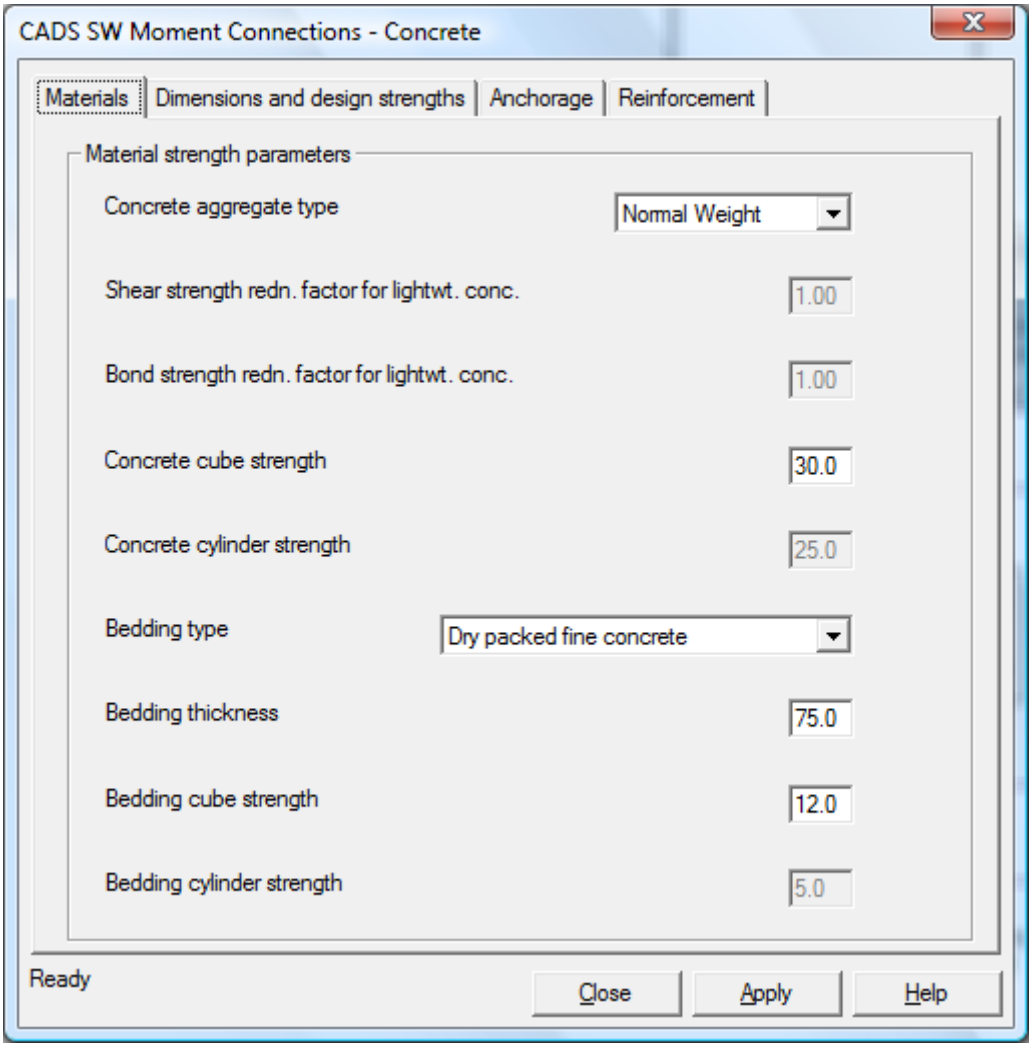
Select *Close* or *Apply* to confirm the selections and remove any existing calculation results.

Obviously no embedment shear resistance will be returned unless a shear key embedment depth greater than the bedding thickness is entered in the *Support member – concrete* dialog.

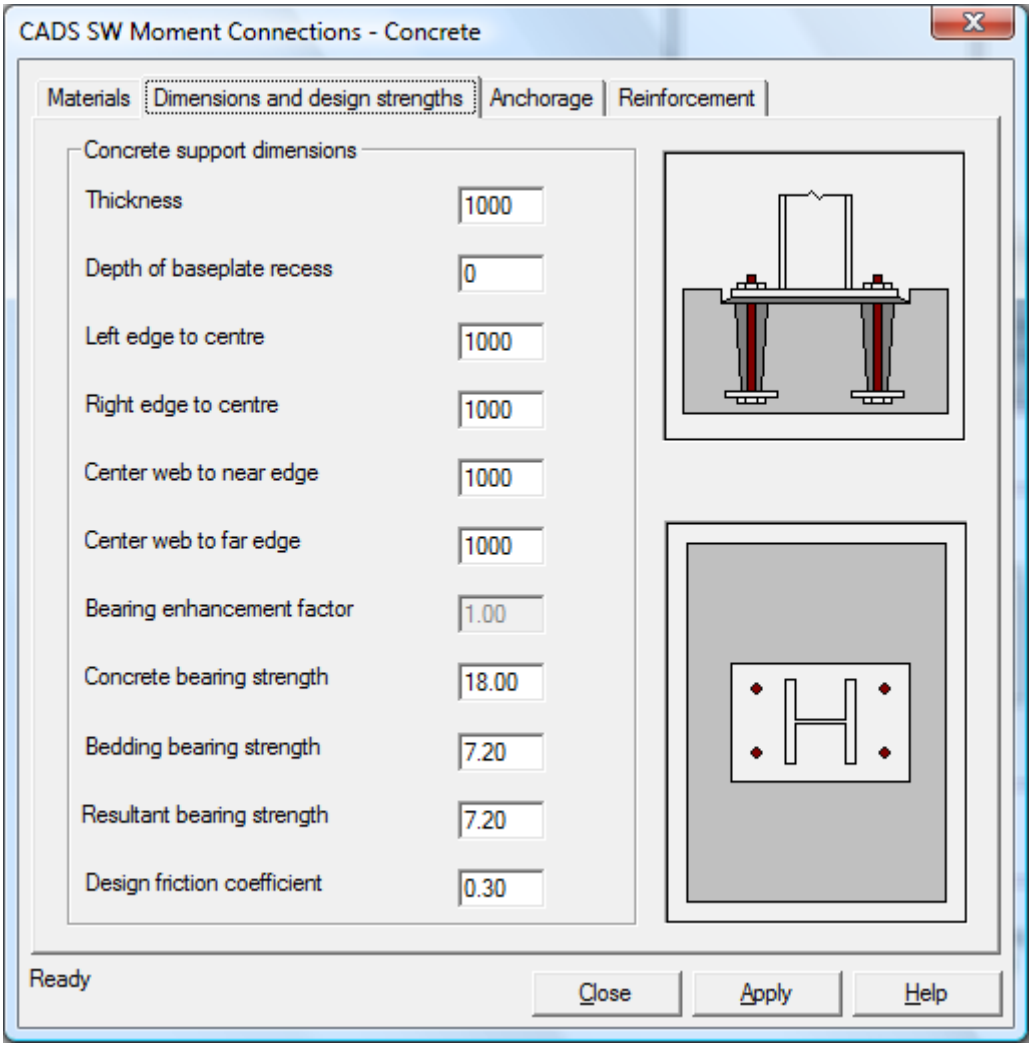
Similarly, from the above discussion, it will be clear that no basic shear resistance will be returned if *Dowel action of bolts* is selected in conjunction with sleeved anchor bolts.

Editing the concrete and anchorage details

Click on the *Support member* icon or select *Geometry* > *Supporting member.* This dialog has four tabs, the first of which is concerned with the concrete and bedding material properties.



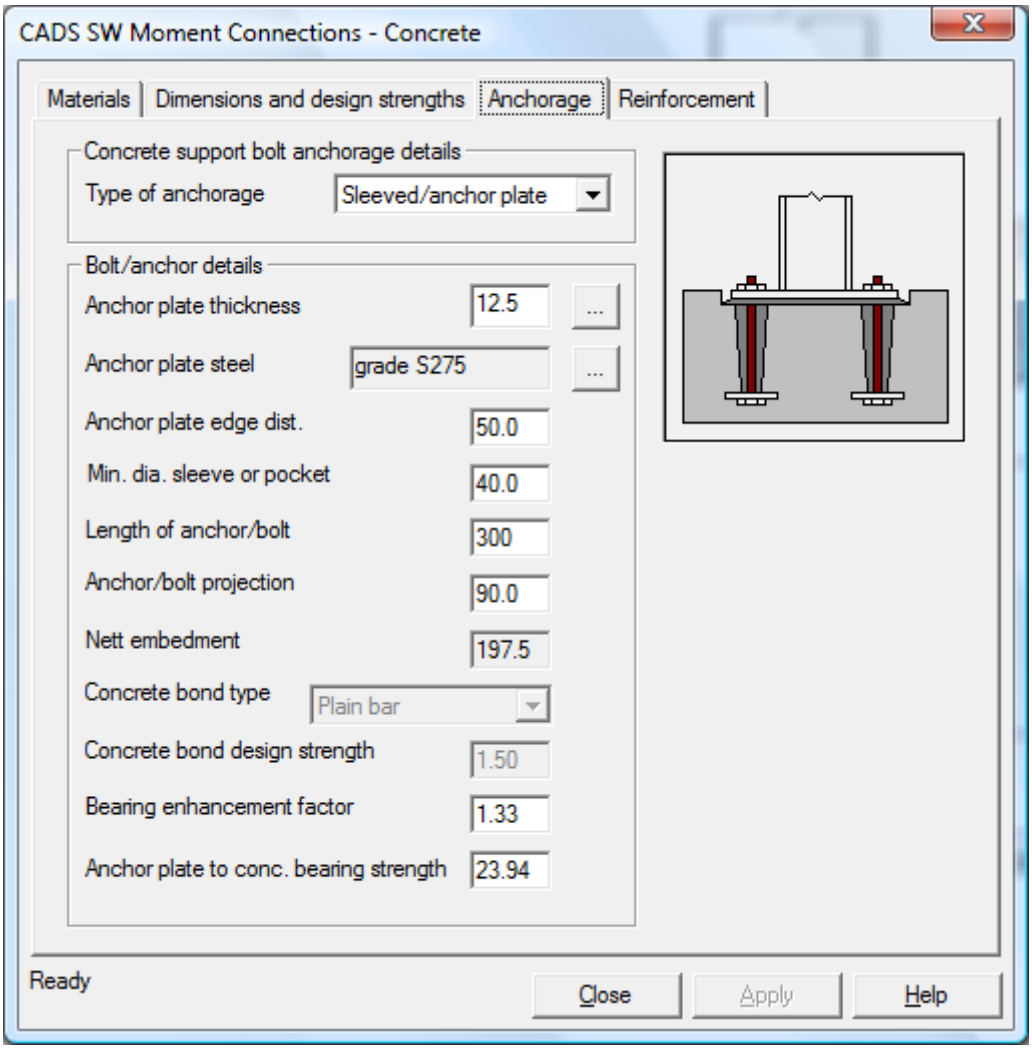
For shear resistance at the underside of baseplate and bolt side bearing, the strength properties of the weaker material are adopted. The default bedding material is relatively weak to reflect uncontrolled site construction. Selecting a stronger bedding material to match the base concrete will result in higher embedment and dowel resistance and may enhance the reinforced concrete section analogy result.



In this dialog page most of the inputs like 'depth of baseplate recess' are self explanatory but some have particular influence on base shear resistance. The four subsequent input fields define the proximity of the column and its baseplate and bolts to the edges of the base. The default values are for a typical 2m x 2m x 1m thick plain concrete base and are not the result of base design. Before the design is finalised the actual base dimensions should be substituted and the connection recalculated because the edge distances not only affect the shear results for the bolt dowel action model (if selected) and embedment shear resistance but also the pull out tension resistance. Note that the default value of the design friction coefficient is 0.30 in accordance with SCI-P-207/95. This can be varied in the range 0.15 to 0.60 as a user option if reliable data is available to justify it.

The *Anchorage* page shown below currently provides a choice of anchorage systems - *Sleeved with anchor plate* and *Cast in-situ/resin bonded* (without anchor plate). The latter will eventually be split into two categories so that allowance can be made for anchor plates with cast in-situ bolts. As noted earlier, the *Bolt dowel action* model is incompatible with sleeved bolts and will result in zero basic shear resistance. The remaining information input on this page directly affects the pull-out or tension resistance of individual bolts and groups and indirectly the shear resistance calculated by the *Reinforced concrete section analogy* method. Note that the strength properties of the bolts themselves is defined separately in the *Bolts* > *Bolt details* page which is common to the other connection types covered by SWMC.

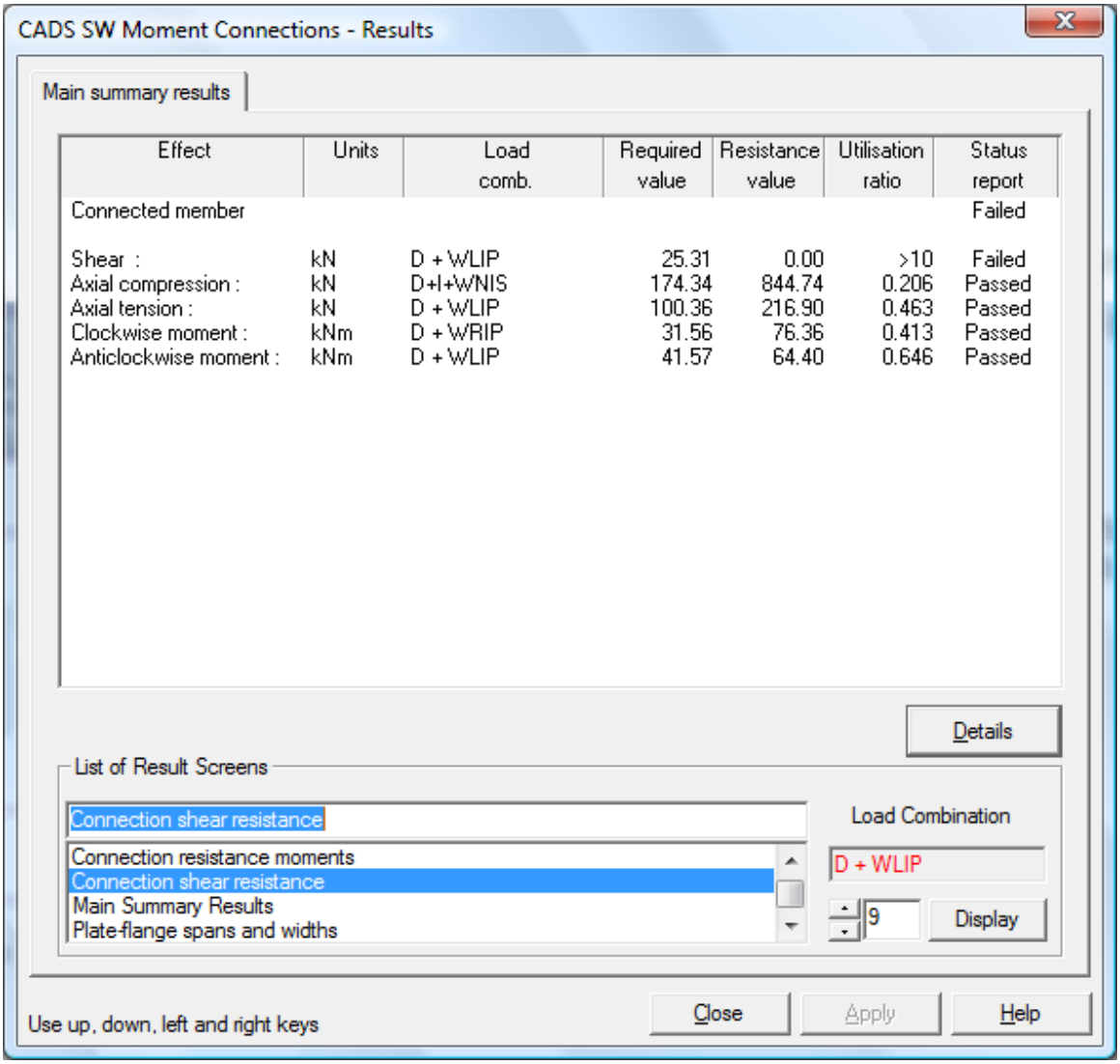
The *Reinforcement* page may be used to add or allow for existing top face reinforcement to augment the pull-out resistance of bolts calculated using the default *Punching shear* model. This may in turn affect the shear resistance calculated by the *Reinforced concrete section analogy* method. Note that by default no base reinforcement is provided.



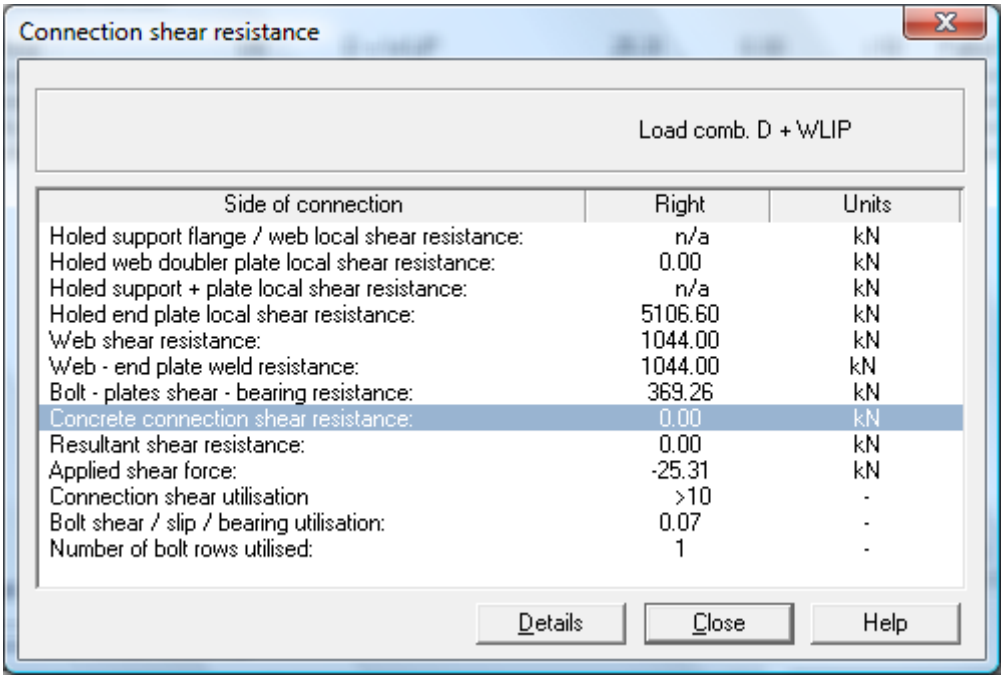
Results

The base shear resistance results in common with all other aspects of a connection analysis may be explored on-screen or presented as print-out. The illustration below shows the *Main summary results* in terms of applied effects, resistances, utilisation ratios and status and the critical load combination for each effect. This connection fails only in shear, but decisively so with zero shear resistance in load combination 9: D + WLIP.

Use the vertical toggles to select the relevant load combination and the detailed results page *Connection shear resistance.* Press the *Display* button



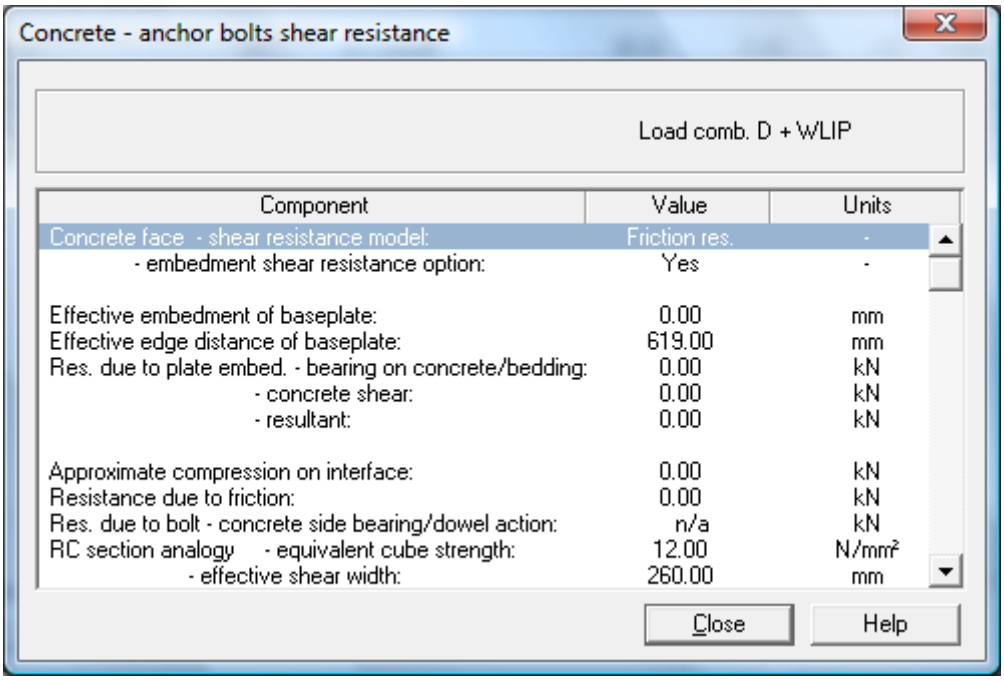
Use the vertical toggle to select the relevant load combination and the detailed results page *Connection shear resistance.* Press the *Display* button to produce the following page:-



This page provides the shear resistance of each component in the shear load path.

Clearly the steel components are not critical and resistance is governed by the concrete interface.

Select this line and press the *Details* button for more information as shown below.



This clearly shows that the approximate compression on the interface including axial and bending effects is zero for this load combination and therefore shear resistance based on friction is zero.

Changing the friction coefficient would have no effect. The result of changing the calculation model to RC section analogy is shown below. A positive resistance is obtained but not in this case sufficient to match the applied shear. Changing the bedding material to dry-packed concrete 75 mm thick and 30 N/mm2 cube strength produced the desired result.