

## New version of Steel CONnections : 2011.140

A new version of the “Steel CONnections” program for the design of bolted and welded steel connections has been released.

Steel CONnections can now analyze and design:

- Apex Connections with 4 bolt columns
- Beam to column or beam to beam fin plate connections

The analysis and design of apex connections with 4 bolt columns is performed using the methods already utilized in the beam to column end plate connections with 4 bolt columns.

Fin plate connections can transfer shear force in the major and/or minor axis as well as compressive or tensile axial force. Each component is checked according to the final provisions of EN 1993-1-1 and EN 1993-1-8, with the generalized 3D loading that includes forces in all 3 directions as well as bending moments due to load eccentricities.

In particular, the following checks are performed:

- bolt in shear,
- bolts in combined shear and tension,
- block tearing of the beam web due to shear as well as axial force,
- bolts bearing on the beam web due to shear as well as axial force,
- block tearing of the fin plate due to shear as well as axial force,
- bolts bearing on the fin plate due to shear as well as axial force,
- fin plate and beam in combined biaxial bending,
- axial and shear at the most stressed net section and at the notch,
- column/main beam web in bending due to the axial load applied to the (secondary) beam and
- check of the welds using the directional method.



Additionally, the checks performed for the verification of the connections with single or double angle cleats are revised and completed, in order to ensure that the connection performs satisfactory under biaxial shear and axial loading.

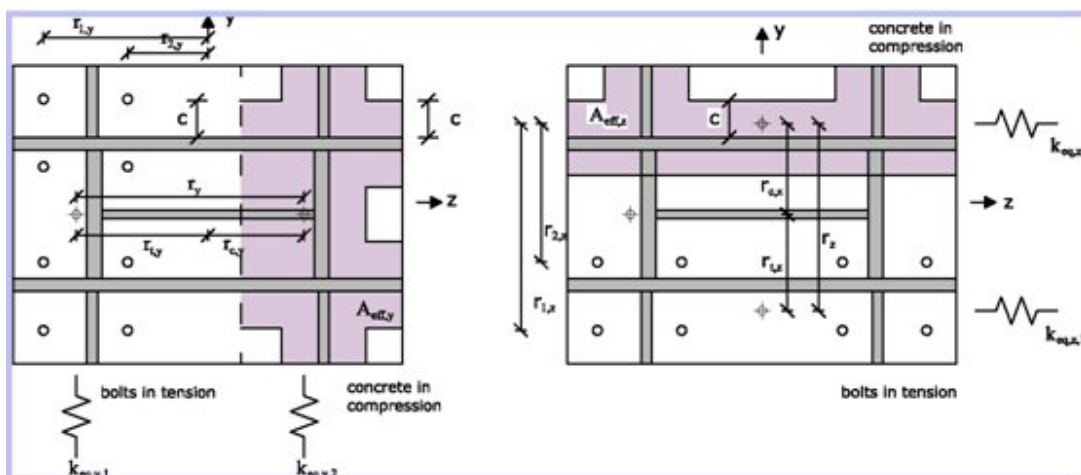
SteelCON is SOFiSTiK Version 25 (2010) as well as Version 23 compatible and can be operated within the SSD integrated SOFiSTiK environment. All geometrical and topological data as well as forces will be taken from the overall structure. Connection design results are then a part of the SOFiSTiK Output Report.

23.05.2011, Munich Germany

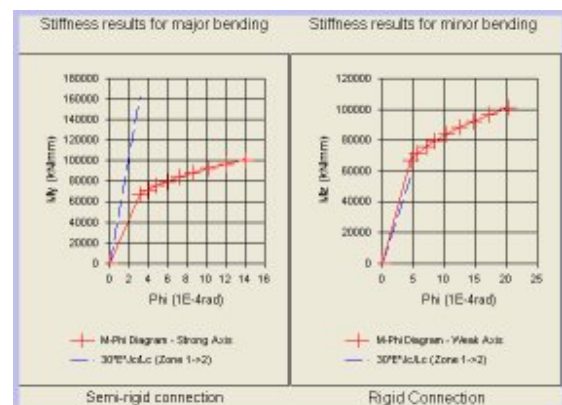
## New version of Steel CONnections : 2010.354

A new version of the “Steel CONnections” program for the design of bolted and welded steel connections has been released. STEELCON can now **calculate the rotational stiffness of a column base plate connection, subjected to biaxial bending and axial force**. For each load case, the **initial rotational stiffness and lever arm** are determined, the **moment – rotation curve** is drawn **and the connection is classified by its stiffness as either semi-rigid or rigid**. All calculations are performed according to the latest provisions of EN 1993-1-8.

The significant axial force acting on the connection as well as the complex phenomenon of the contact between the base plate and the concrete foundation affect greatly the behaviour of column base connections and differentiate them from beam-to-column connections. The analysis method adopted is based on a statically determinate model consisting of 2 equivalent springs, that simulate the tensile and compressive sides of the connection, which is the model proposed by Eurocode 3 and implements the component method. However, this model has been developed only for the analysis of unstiffened connections subjected to uniaxial bending about the major axis, as it solely considers the effective area around the column flanges.



In order to adapt this model to stiffened connections subjected to biaxial bending, the compressive concrete area is analytically determined, considering the effective area of the equivalent rigid plate around the column web and the stiffeners as well. Additionally, the positions of the 2 equivalent springs and the lever arm are calculated for each axis and load cases. No modifications are made to the main assumptions the initial Eurocode model is based on: proportional loading and a fully plastic distribution are assumed, while the analysis and assembly of the basic components is performed according to the Eurocode provisions.



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16.12.2010, Munich Germany

Monday, November 15, 2010

STeelCON : New version 2010.314

The new version of the program for dimensioning steel connections, STeelCON, has been released. The most important improvement is the addition of Italian Rules in all the connections that are currently included. Apart this, a lot of other enhancements are available:

In Beam to Column connection, the program calculates the strength in compression of the beam at the area of the haunch (see left picture below). The results are shown in the printouts, but also at the summary of the exploitation ratios, through the addition of a new one. In the case of failure the program suggests the use of a stiffener (see right picture below), and calculates automatically all the required dimensions.

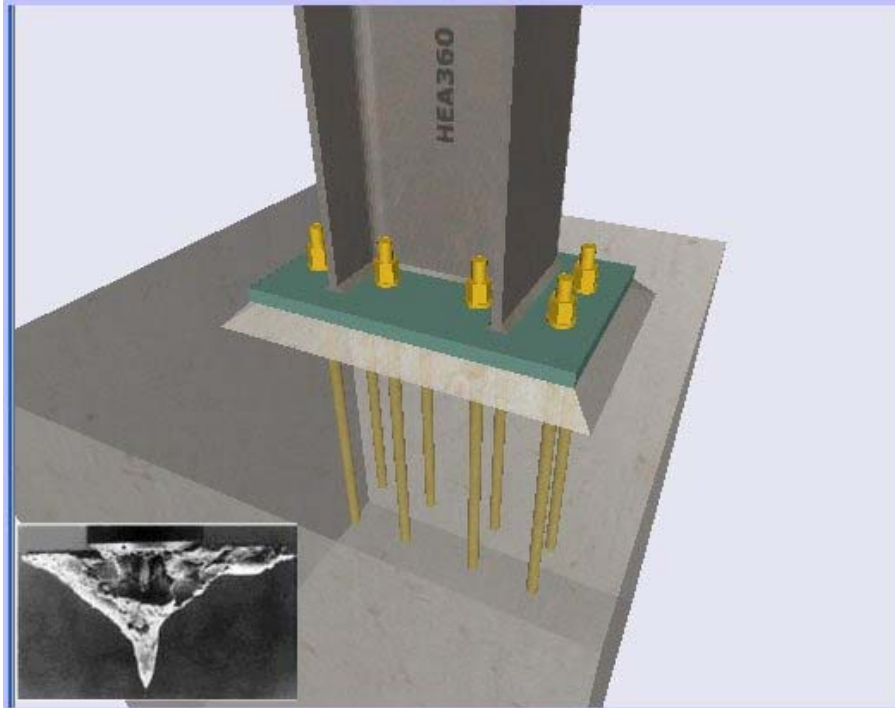


In the foundation plate connection, the anchorage is from now on calculated based on:

**CEN/TS 1992-4-1 2009** (Design of fastenings for use in concrete, part 4- 1 General)

**CEN/TS 1992-4-2 2009** (Design of fastenings for use in concrete, part 4- 2 Headed Bolts)

The anchor lengths that are being calculated based upon these recommendations are a lot smaller than the lengths that were calculated using CEB as design basis. Furthermore, we have the opportunity to take into account the possible reinforcement at the concrete cone area, decreasing the exploitation ratio at concrete cone and splitting failure checks, which were extremely unfavorable when we were assuming non reinforced concrete.



Finally, the bolt layout feature is now available for the beam splice, beam to beam and beam to column's web with angle cleats connections.

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15.11.2010

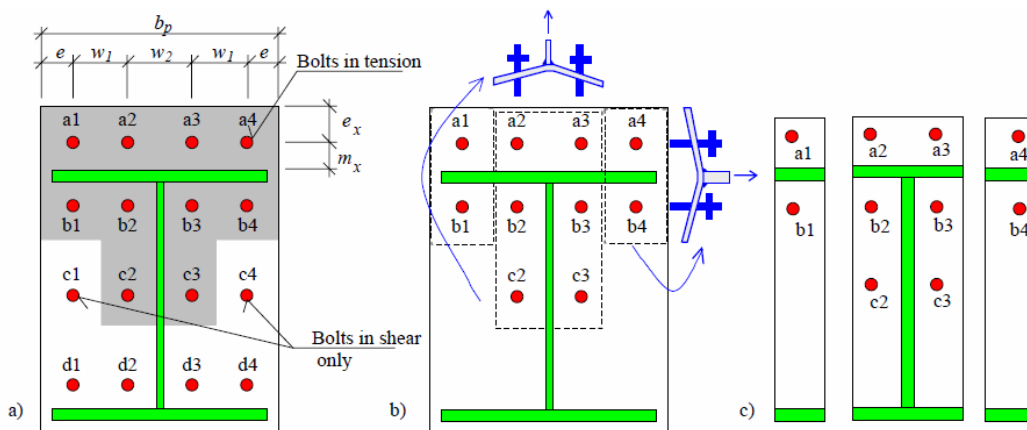
Munich, Germany

## Moment connections with 4 bolt rows (extended end plates)

### Design Assumptions

This connection type is not considered in the Eurocode EN 1993-1-8:2005. The assessment methods adopted follow the Eurocode design assumptions and methods as far as possible.

For tension, all bolts near the beam flange under tension can be taken into account for bending moment resistance calculation (a1-4 and b1-4), see Fig. 1. The bolts c2 and c3 could also be considered. However the bolts c1 and c4 cannot be considered to transfer tension due to the limited stiffness of the end plate. These bolts together with the bolt row d could be useful in shear.



Fi

g. 1 a) End-plate with 4 bolts row, b) separation into T stubs in tension; c) division of top bolt rows into separate T stubs

Depending on the size of the end plate and bolt spacing, there is several possibilities for yield line patterns for bolts in rows a and b.

The bolt row a can be considered as bolt row outside tension flange of the beam. The simplified approach of EN 1993-1-8 can be adopted with modifications of yield lines for the bolt group. The design procedure requires the following assumptions:

- The use of horizontal stiffeners is obligatory. Without stiffeners the outer bolt columns (1 and 4) cannot form T-stub in the column flange, so all the tension is received by the inner columns (2 and 3). This downgrades the connection to a 2 bolt columns connection (as refers to moment resistance), so there is no need to use 4 bolt columns.

- The program expects that the tensioned stiffener will transfer all the tension (in the area between the first two rows a and b), and no tension will pass through the column's web. This can be made sure provided the distance of the inner column from the web ( $0.5 \cdot w_2$ ) is less than the distance of the yield line towards the columns web,  $1.73 \cdot m_x + 0.5 \cdot \text{Stiffener thickness}$ . If this condition is not true for any of the bolt rows near the stiffener, the program informs the user with warning messages.

-For the calculation of the moment resistance in the weak axis, the program does not take into account the outer bolt columns. This feature will be added very soon.

### **Known differences between STEelCON and “Typisierte Anschluesse”.**

#### **a. Moment Resistance.**

1. In “Typisierte Anschluesse” only the tension resistance of the first bolt row is calculated. The resistance of the second bolt row is considered equal to the first. The third bolt row is considered always as under compression. In STEelCON all the bolt rows are calculated separately.
2. In “Typisierte Anschluesse” there is no examination of the formation of prying forces. In 1998-1-8 at table 6.2, is clearly stated that the design resistance of a T-stub depends if prying forces may develop or not. If prying forces cannot develop then the design resistance of the T-stub may be 50% smaller (EC3 adds a fourth failure mode the ‘F1-2’). This may result in major differences between the moment resistance of the connection that STEelCON calculates.
3. The calculation of forces  $F_{Trd6}$  and  $F_{Trd7}$  of the book, are different from those in 1998-1-8 at table 6.2.
4. STEelCON default connection is assumed to be in the last floor. This leads to a smaller effective length of the T-stub formed at the column flange in the upper bolt row region, comparing to the book. The solution is to give a small force at the upper column so the program will assume that the column is continuous.

#### **b. Shear Resistance.**

1. In “Typisierte Anschluesse” several componetnts are checked to determine the strength of the connection in shear (Bolts in shear, plates in bearing, plate in shear fracture) , welds in shear, 50% of Beam web in shear. STEelCON only calculates Bolts in shear acting together with tension, and plates in bearing. The welds are checked independently but do not participate in the shear resistance value calculation.
2. According to 1998-1-8, 3.7(1), the design resistance of a group of fasteners should be taken as the number of fasteners multiplied by the smallest design resistance of any of the individual fasteners (except only if all the fasteners fail under bearing). This leads to very small shear resistances compared to those of the book.

Monday, February 01, 2010

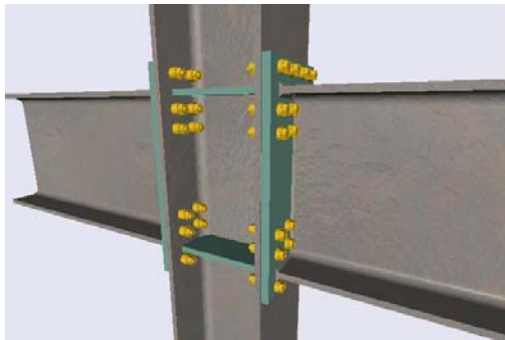
STeelCON : Beam to Column connection, now with four bolt columns

STeelCON can now design Beam to Column connections with four bolt columns according to EC3. Since there are no direct guidelines in the Eurocode, the checks are implemented in accordance with the rules of EC3 EN 1993-1-8 for 2 bolt columns.

By means of the component method, the moment bearing capacity as well as the deformation behaviour of the connection is calculated. Thus semi-rigid connections can be taken into account. According to its rotation rigidity the connection can be classified as rigid, semi-rigid or nominally pinned.

The individual components for the transmission of forces in the connection are modelled as equivalent T-stubs, whose failure mechanisms are described by yield line patterns. A substantial number of mechanisms is examined.

All configuration variations that are implemented in the two bolt column connection, like stiffeners, plates, haunches etc. are also here possible.

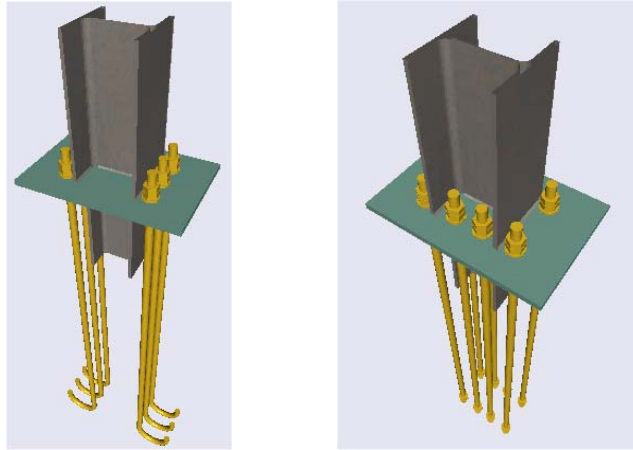


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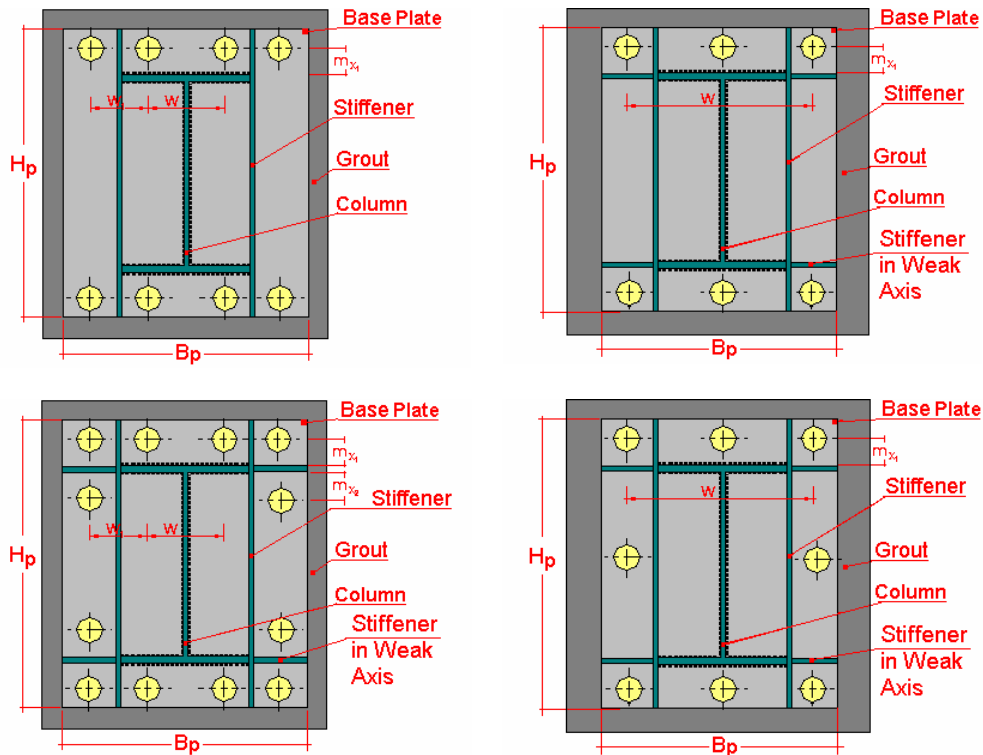
Munich, Germany

## STeelCON – New Version 2009.177

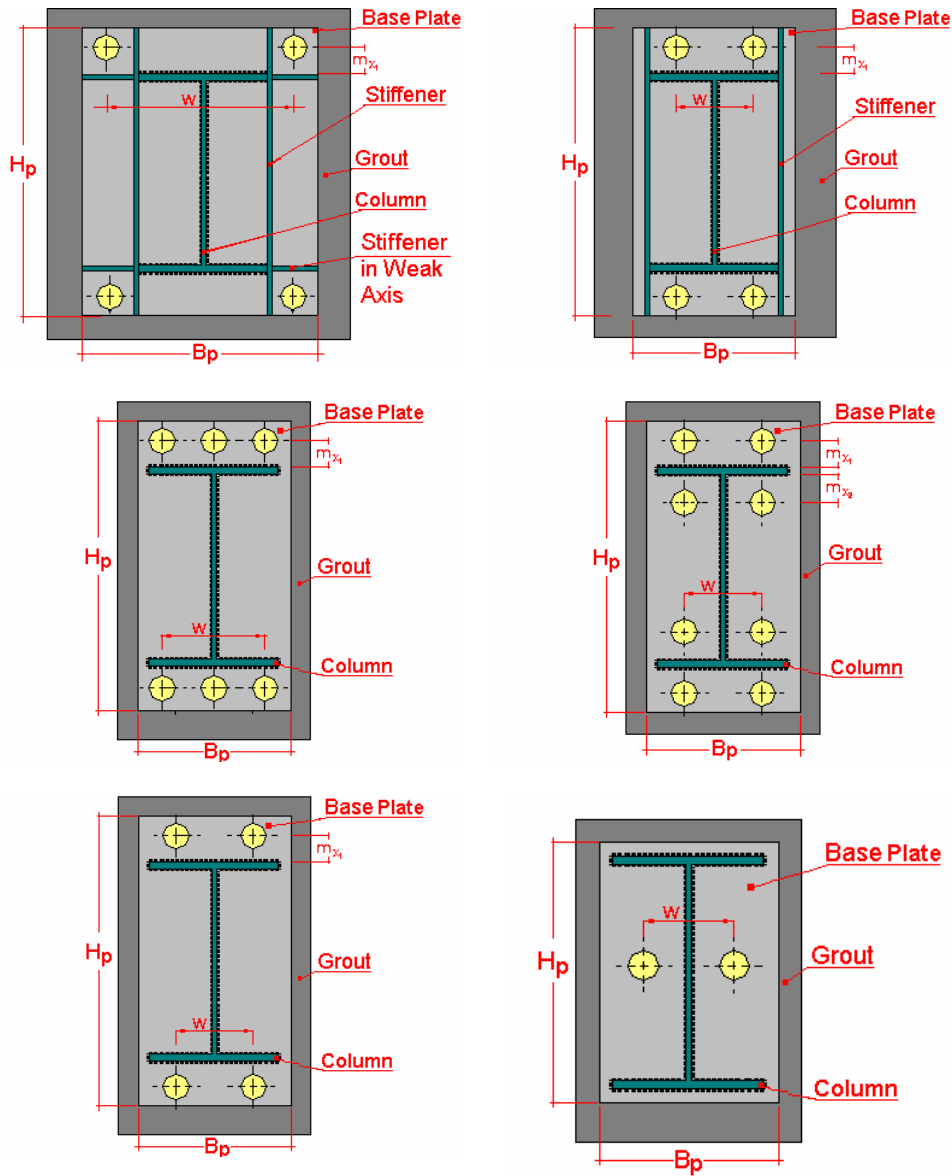
The new Version of the program for designing Steel Connections has been released. New capability is the design of connections for column bases under biaxial bending conditions.



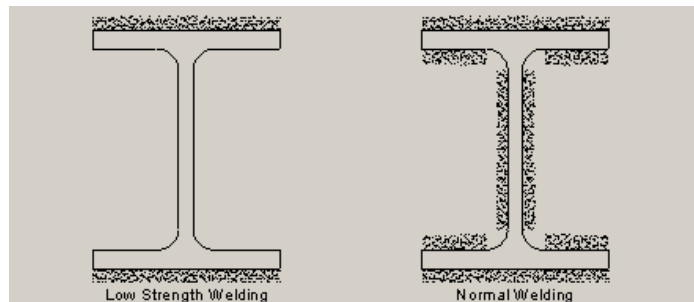
Apart from the already existing geometric types of base plates, new variations have been added, with emphasis on the resistance about the weak axis and with possibility of choice to use a variety of stiffener plates. The stiffener plates are checked henceforth against buckling while all the required thickness of welds are calculated : between the stiffener plates to each other as well to the base plate, between the stiffeners and the column, between the shear nib and the base plate.



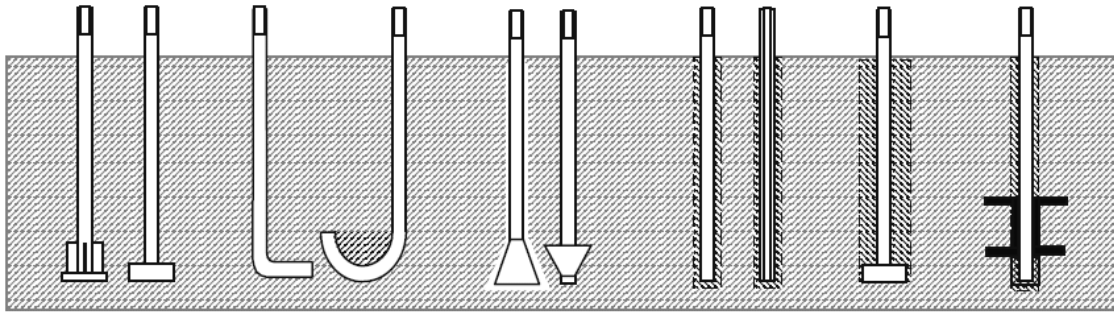




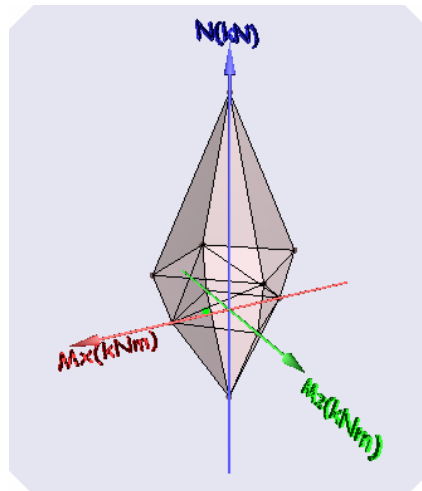
In unstiffened connections, the user has the possibility to select low strength weldings (only at the exterior side of the flanges), in order to achieve economic manufacturing.



Placement of anchorages with very small depth is possible (headed bolts). In this case the program performs all the required checks against concrete cone failure or splitting failure.



For the resistance of the connection in biaxial bending and axial force a diamond shaped modified criterion of interaction has been selected, since a criterion of simple linear interaction of bending and axial loading leads to the reduction of available individual resistances either under tension or compression. However the existence of compression instead of tension acts in a favourable way increasing the available bending resistance.



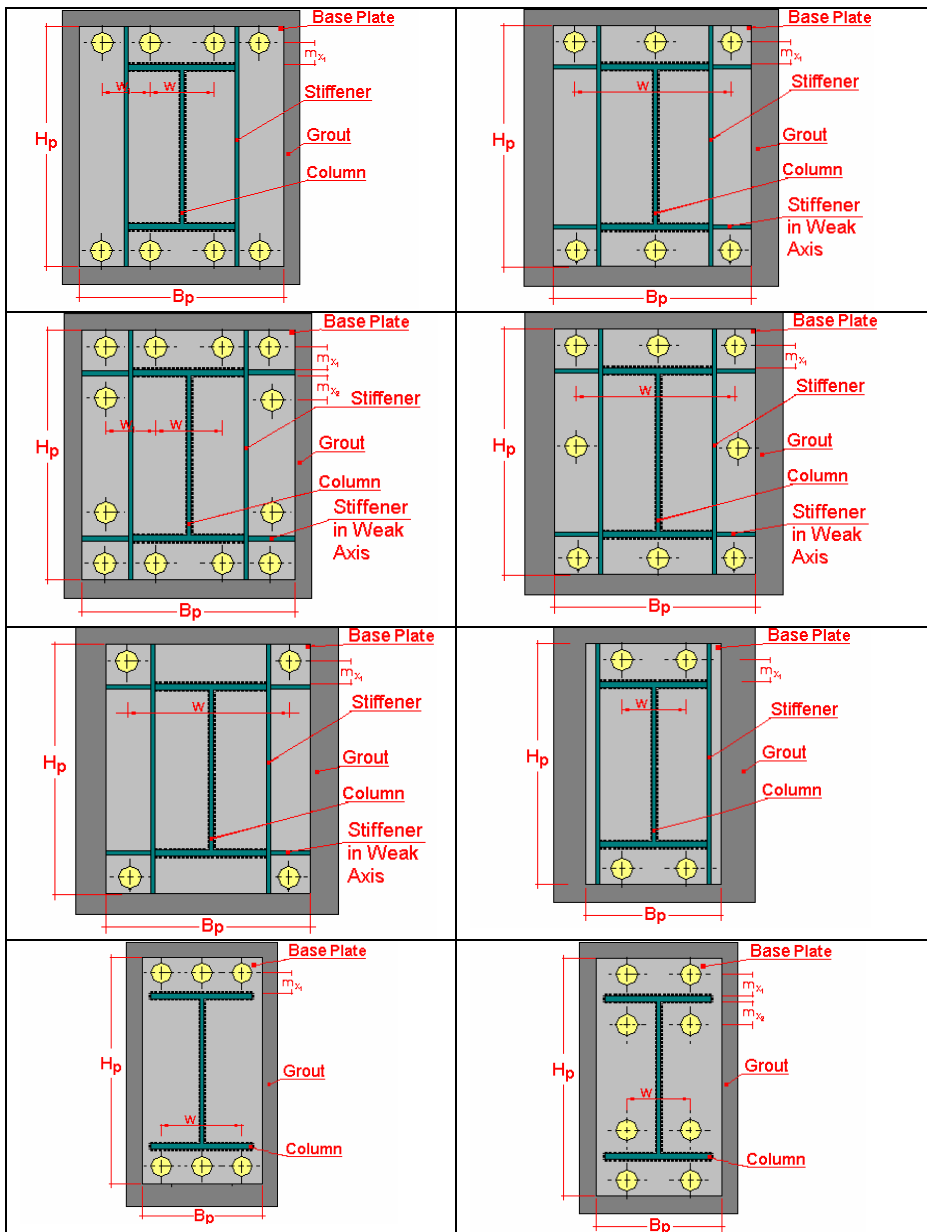
The results of all design checks are referenced to unity for better monitoring of the sufficiency of all elements that compose the connection.

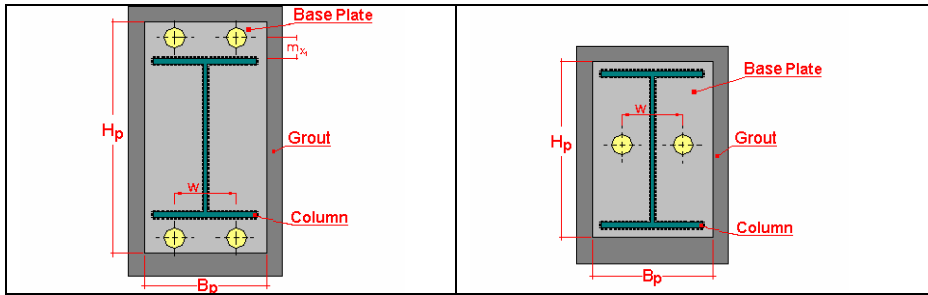
Munich, July 2, 2009  
 FIDES DV-Partner GmbH  
[info@fides-dvp.de](mailto:info@fides-dvp.de)

STeelCON / SOFiSTiK Version 2009.177

Im STeelCON gibt es seit kurzem neue Verbindungen : Fußpunktverbindungen unter zweiachsiger Beanspruchung.

Die im Programm bisher existierende Menüdefinition der Fußpunktverbindung nach EC3 ist mit neuen Varianten und Schraubenbilder erweitert worden. Einige der verfügbaren Varianten sind in der folgenden Abbildung.





Der EC3 beinhaltet keine spezifische Information wie die zweiachsige Biegung berücksichtigt werden soll. Es ist für den allgemeinen Fall schwierig die Lage und den Winkel der neutralen Achse mit beliebiger Geometrie zu ermitteln – die Komponentenmethode kann hier praktisch nicht angewendet werden.

Im Programm wird eine konservative Fließfläche für die Normalkräfte, Haupt- und Nebenmomente angenommen. Dadurch kann die Festigkeit der Verbindung aus der Berechnung der einzelnen Festigkeiten (N, My, MZ) abgeleitet werden. Diese Festigkeiten können unter Verwendung der Anweisungen aus EC3 und vorhandenen Forschungsarbeiten und Veröffentlichungen zuverlässig berechnet werden. Danach wird die Interaktionsformel angewandt :

$$\frac{|N_{sd}|}{N_{pl,Rd}} + \frac{|M_{sd,y}|}{M_{pl,Rd,y}} + \frac{|M_{sd,z}|}{M_{pl,Rd,z}} \leq 1$$

Diese konservative Interaktion wird im EC3 als das passende Kriterium vorgeschlagen. Die Komponenten, werden separat für die Berechnung des Haupt- und Nebenmomentwiderstands überprüft :

- Der Druckbereich - der Beton auf Druck und die Fußplatte auf Biegung.
- Die Zugbereich - die die Anker und andere Komponente auf Zug und die Fußplatte auf Biegung.

Zusätzliche Eingabedaten sind jetzt die Fundament-Abmessungen sowie Vergusszement-Dicke und -Material

Es gibt auch neue Optionen :

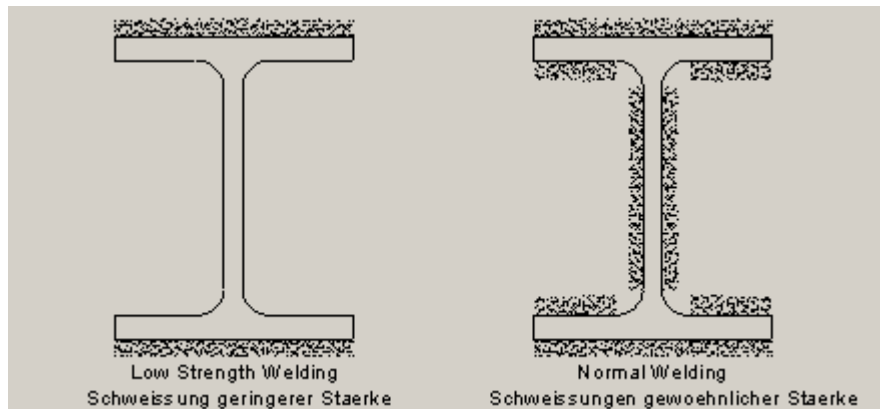
Annahme : gerissener Beton : Die Beanspruchbarkeit der Verbindung bezieht sich auf gerissenem Beton

Schweißungen geringerer Stärke: Erlaubt dem Benutzer kostengünstige Schweißungen geringerer Stärke zu verwenden um bei kleinen Bauten wirtschaftlicher arbeiten zu können.

Untere Ankerplatte: Die untere Platte des Ankers innerhalb des Betons ist rechteckig.

Diese Programmversion kann die Festigkeit des Betons und ihre Mitwirkung in der Festigkeit der Verbindung berücksichtigen. Der Benutzer kann gerissenen Beton annehmen.

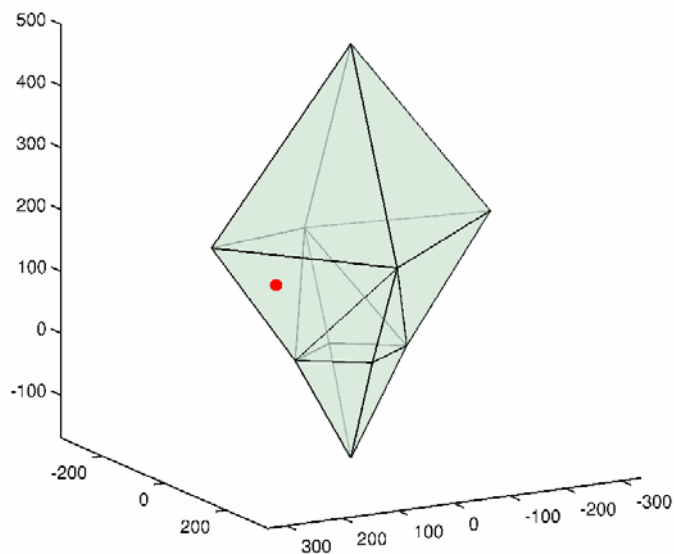
Ferner, es wird ein kegelförmiger Betonausfall berechnet. Dadurch können kurze Anker verwendet werden.



Schweißung geringerer Stärke

Schweißungen gewöhnlicher Stärke

Es wird ein 3D-Interaktionsdiagramm ( $M_y$ ,  $M_z$ ,  $N$ ) für die Visualisierung der Ergebnisse generiert.



Die Ergebnissausgabe ist entsprechend erweitert worden.

Alle Neuheiten die hier beschrieben werden, nutzen die Ergebnisse aus der Berechnung des Gesamtsystems mit SOFiSTiK.

6.2.5. Resistance of the connection in the biaxial bending (BETA VERSION)

All the following results have been produced by pre-release code, and should be considered

**Anchors Resistances**

Anchor's Resistance in Tension.....	0.00 kN
Anchors Resistance in Shear.....	62.18 kN
Applied Shear.....	0.00 kN

**Anchorage**

Anchors Minimum Length.....	0.00 mm
Required supporting plate dimension (diameter or side).....	0.00 mm
Concrete cone resistance per anchor.....	0.00 kN
Splitting resistance per anchor.....	0.00 kN
Required anchorage resistance in tension per anchor.....	0.00 kN
Concrete edge resistance per anchor.....	0.00 kN
Required shear resistance per anchor.....	0.00 kN

**Base Plate**

Resistance of base plate in tension - major moment.....	114.91 kN
Resistance of base plate in tension - minor moment.....	114.91 kN

**Welds**

Welds resistance.....	0.21 kN/mm <sup>2</sup>
Welds applied resultant stress for design loads.....	0.41 kN/mm <sup>2</sup>
Welds localized stress due to anchors in tension.....	0.00 kN/mm <sup>2</sup>

**Column in double bending and shear**

Shear resistance in yy direction.....	1295.10 kN
Shear resistance in zz direction.....	606.85 kN
Axial force and biaxial bending interaction safety.....	0.79 <b>O.K.</b>

**Shear nib**

Shear resistance in yy direction.....	93.94 kN
Concrete resistance in bearing - yy direction.....	294.39 kN
Shear resistance in zz direction.....	124.26 kN
Concrete resistance in bearing - zz direction.....	282.29 kN
Applied bending moment - yy direction.....	775.00 kN
Applied bending moment - zz direction.....	0.00 kN
Biaxial bending interaction safety.....	0.19 <b>O.K.</b>

**Connection**

Bending resistance in yy axis.....	101.20 KNm
Bending resistance in zz axis.....	58.00 KNm
Tensile resistance.....	114.91 kN
Compressive resistance.....	2864.02 KNm

**Plastic axis in the middle - yy direction**

Bending resistance.....	257.92 KNm
Compressive Axial Resistance.....	1202.18 kN

**Plastic axis in the middle - zz direction**

Bending resistance.....	140.84 KNm
Compressive Axial Resistance.....	1202.18 kN

**Final Resistance**

Ratio of the connection.....	1.73 <b>X</b>
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**Structural Steel Design with SOFiSTiK: New capabilities of Steel Joints Design for typified Connections**

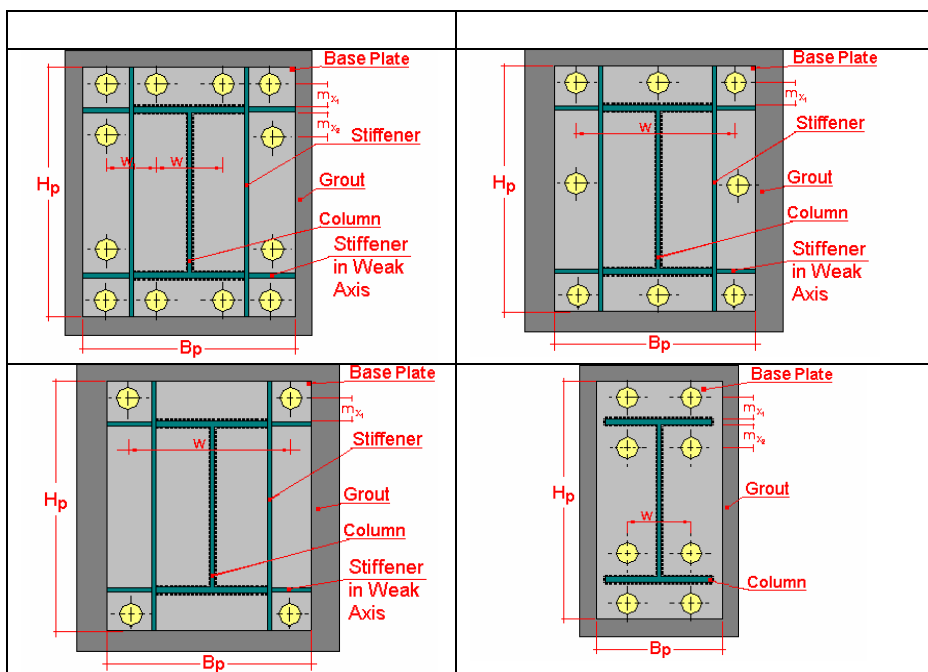
The module STeelCON is a tool for analysis and design of welded and bolted connections in 3D steel structures according to EC3. New revised connections for column bases as well as optimized beam to column connections are now available.

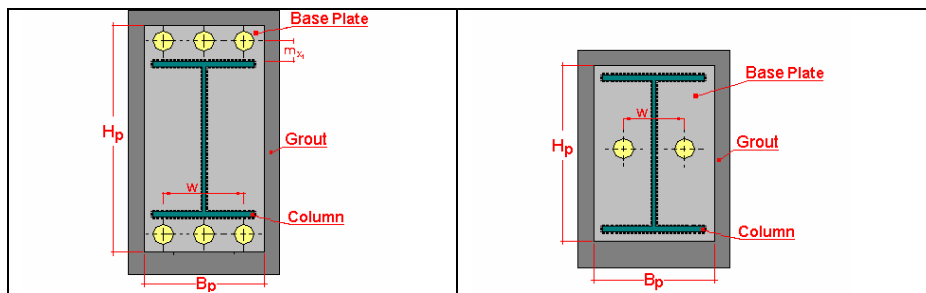
A *column base* which is a system of column, base plate and holding down assembly is mainly in compression. However, there are cases of large bending moments or uplift where stiffeners (brackets) can be used to strengthen the base plate.

EN 1993-1-8 provides no specific information on how to address biaxial bending conditions in moment connections. In STeelCON a conservative yield surface for the column base has been adopted for axial forces, major and minor bending. Considering a proper yield criterion, the calculation of the column base strength is simplified to the calculation of the resistances in axial force (tensional or compressive), major moment and minor moment. These resistances can be reliably calculated using the EC3 instructions and existing research work and publications.

The proper anchorage of the bolts is very important in order to reassure that the bolts will develop the estimated resistance. Different types of anchors are provided, such as cast-in-site headed bolts, hooked bars, undercut anchor bolts etc.

With this general approach, a large number of variations are now available, some of which are shown in the pictures.





A further new capability are optimized Beam to Column Connections. Determining the appropriate geometry of a beam to column connection is a time-consuming and complicated procedure, due to the large number of the connection components and the checks to be performed according to EC3. Engineers need to design economical connections that meet certain geometrical criteria and at the same time have sufficient resistance and rotational stiffness. A usual way is to describe a starting connection layout and after a first solution to try to strengthen the most important bolt rows. If the result is not satisfactory the procedure is repeated. The modifications between these manual 'iterations' often lead to overweighted connections because a "strengthening" needed in an early step may not affect the connection's resistance in the last layout. Moreover, this procedure consumes valuable time and demands a lot of experience by the connection designer.

As a solution to this problem, STEELCON has introduced a tool that helps in evaluating the optimal connection that meets certain criteria of strength and/or geometry, as defined by the user.

Optimization can be performed by selecting either the "Maximum Strength" or the "Optimal design" solution. In the first case, the objective is to find the connection with the maximum moment resistance that meets all the criteria set. In the second case, the objective is to find the "Desired" number of allowed connection's layouts that have moment ( $M_{rd}$ ) and shear ( $V_{rd}$ ) resistance greater or equal to the respective resistances defined by the user (listed in increasing "overstrength" sequence).

The strength criteria can include: i) only Negative moment and shear force (top beam flange in tension), ii) only Positive moment and shear force (top beam flange in compression) or iii) both.

These options determine the optimal bolt arrangement, so that the applied forces are effectively transferred from the beam to the column.

The designer can also prevent the 'column flange in bending' and 'end plate in bending' components from failing in failure mode 3, where a brittle fracture of the bolts occurs. This is an unfavorable failure mode and should be avoided, especially when ductile behavior (e.g. plastic hinges) is required.

Regarding geometry, the designer has plenty of available options. All the possible stiffener plates (haunch, horizontal and diagonal stiffeners, supplementary web plates, back plates) may (or not) be allowed in the optimization's solution tree. Another important geometrical specification is the maximum end plate length, and the designer may define its limit. The program calculates the end-plate height, taking into account the defined optimization criteria as well as the haunch's influence.

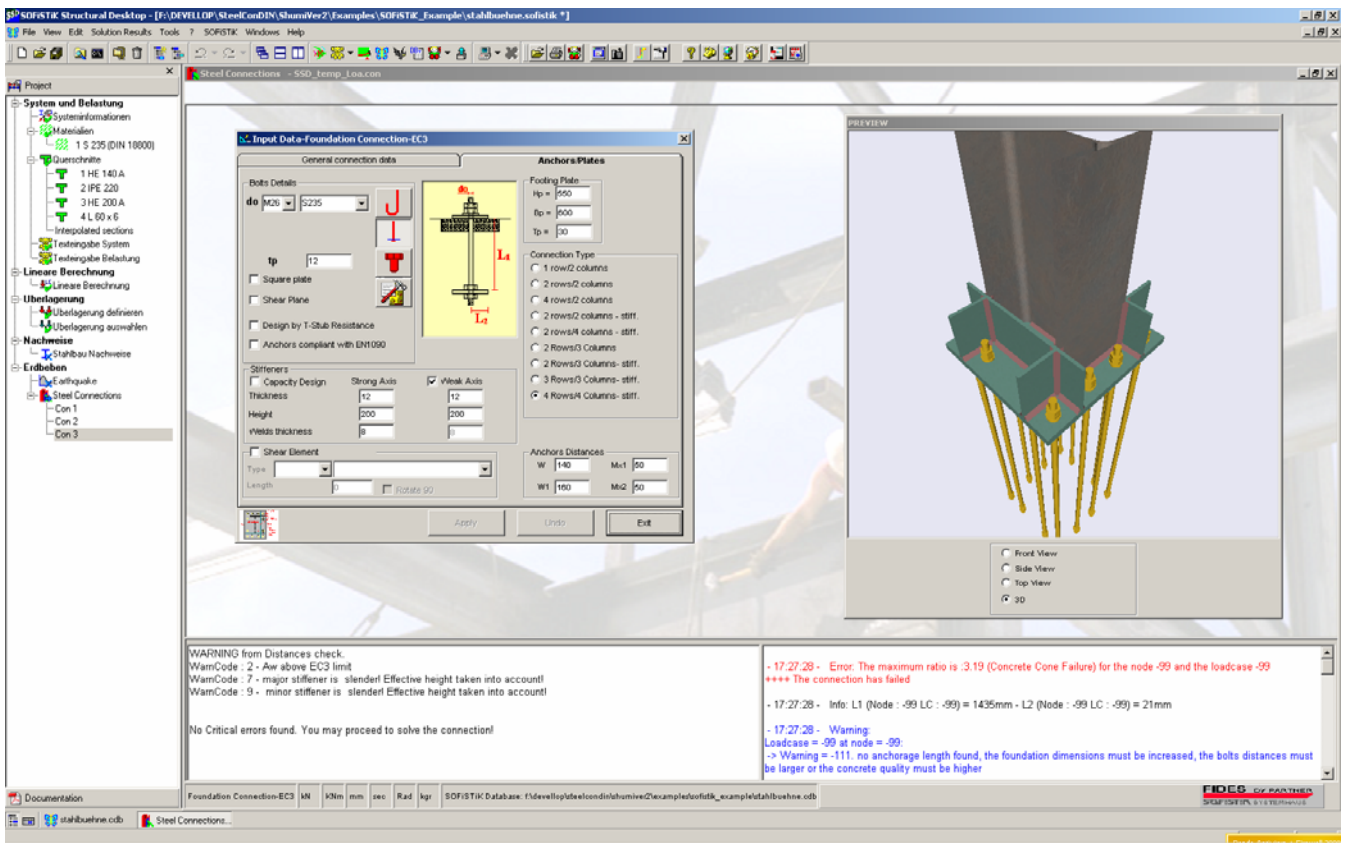
Furthermore, the designer may limit the optimization results to any range of bolts diameters and qualities and a range for the desired number of bolt rows.

The optimization procedure is very fast and efficient. The proposed layouts are listed by a unique descriptive name. While browsing the list, a graphical representation of each



layout is displayed, together with the main geometrical and strength data, making the decision for the optimum connection much easier.

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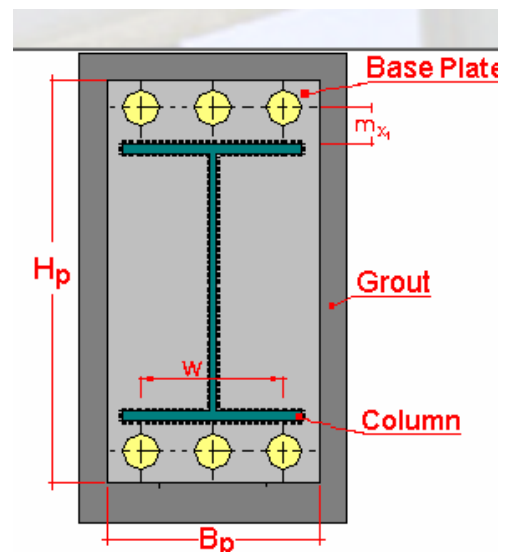
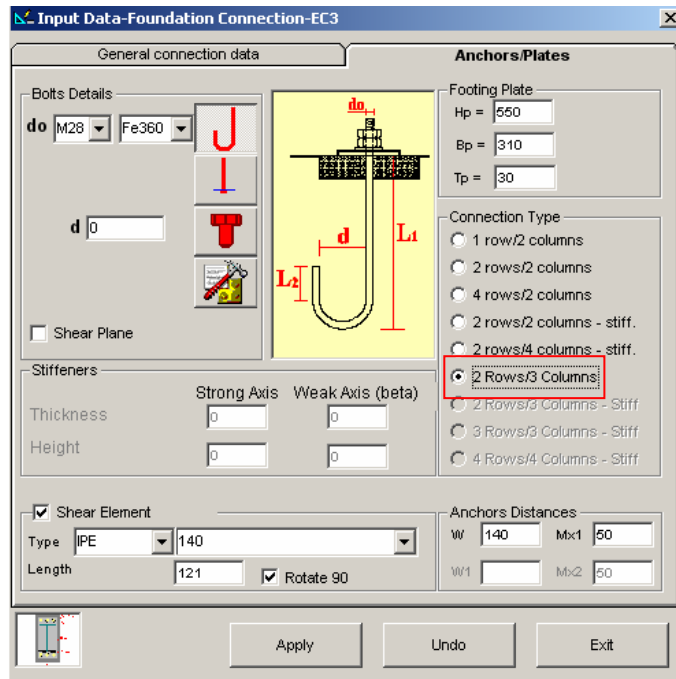
Version 2009.177

STeelCON Version 2008.333

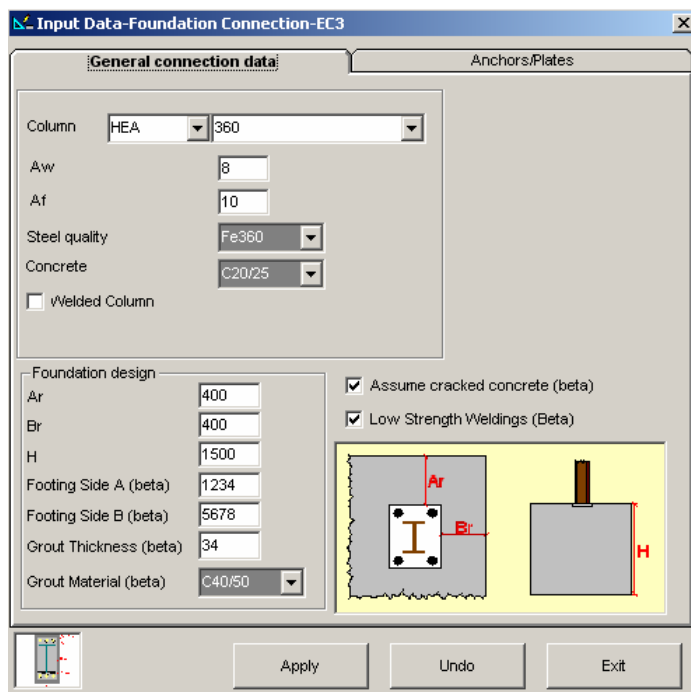
New capability : Biaxial Bending in Footing Plates.

All capabilities described below take full advantage of the SOFiSTiK analysis results. The program can be fully operated within SOFiSTiK-SSD.

In this new version of the program, the calculation in biaxial bending. is included.



A set of new data has been added:



Dimensions of the Foundation :

- Footing side A : The width of the footing, parallel to Ar distance
- Footing side B : The width of the footing, parallel to Br distance

Grout Dimensions :

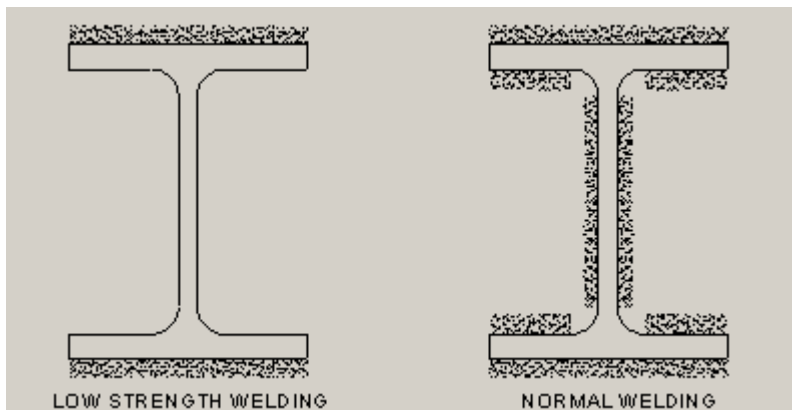
- Grout Thickness: The thickness of the grout
- Grout Material : The material of the grout

New Options :

- Assume Cracked concrete: Connections strength refers to cracked concrete
- Low strength weldings. Allows the user to calculate low strength weldings for economy in small buildings
- Use square plate: The lower plate (inside concrete) is square.

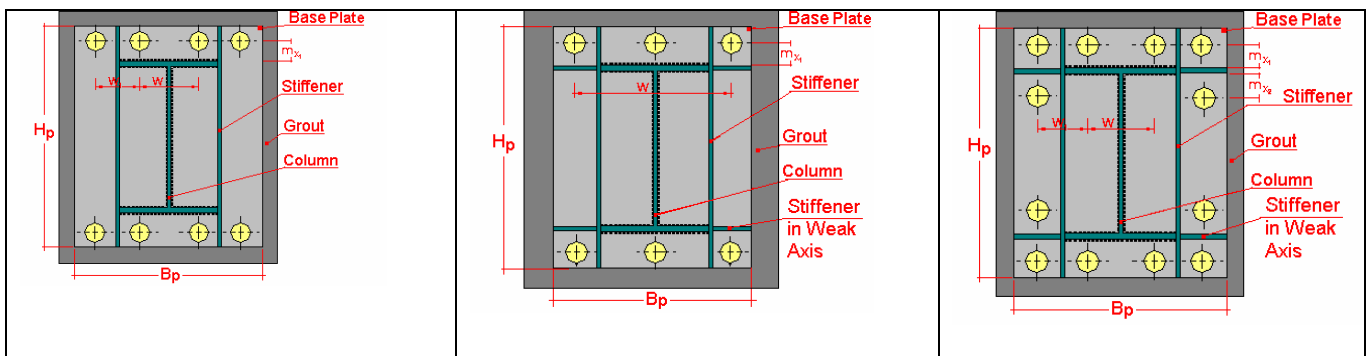
In this version the program can calculate the strength of the grout and its participation in the strength of the connection.

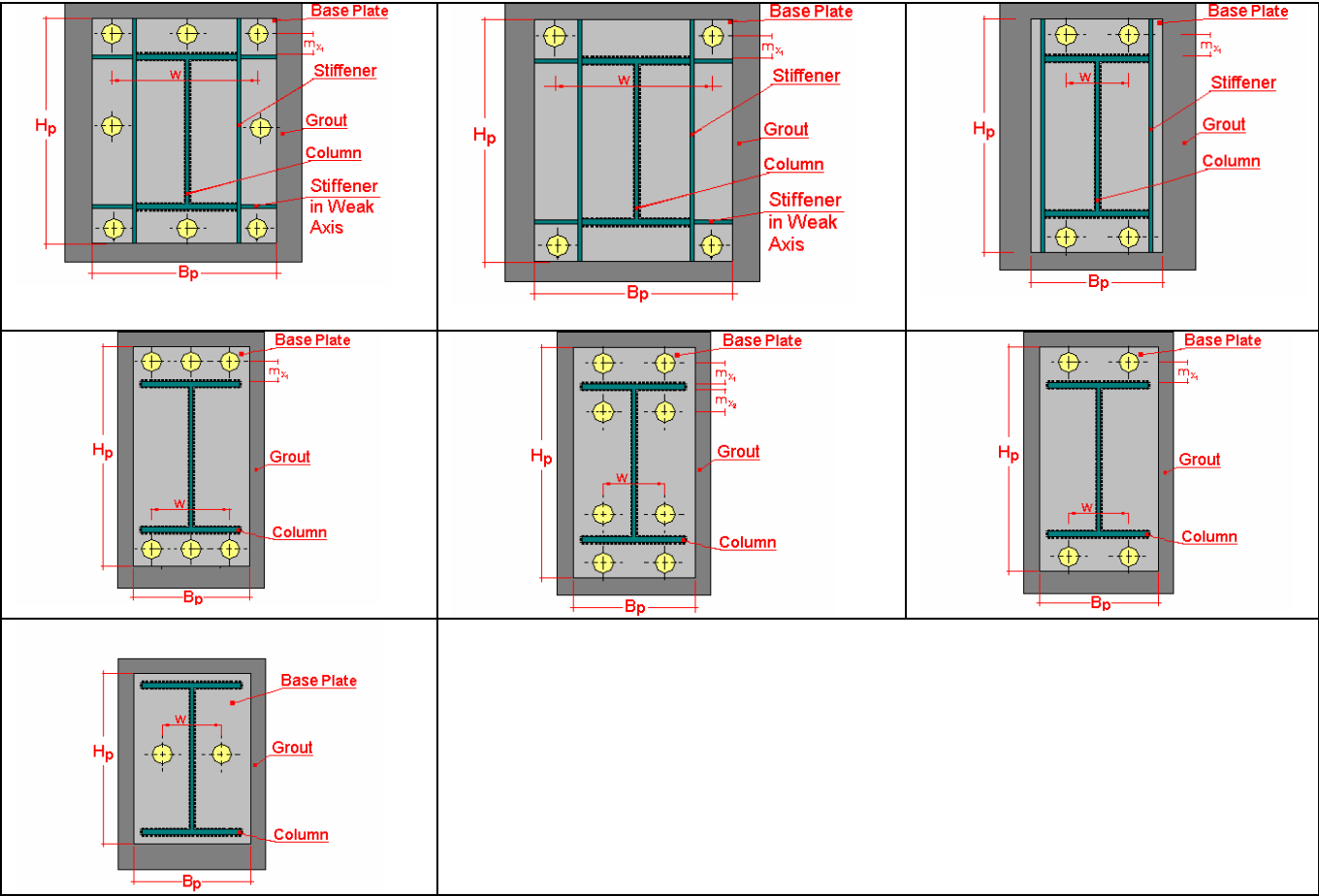
The program can calculate the capacity of low strength welding, for economy in small structures.



When the user has selected one of these two connection types, the program will calculate the connection for biaxial bending, in addition to the uniaxial bending.

Now many types of Footing connections are available:

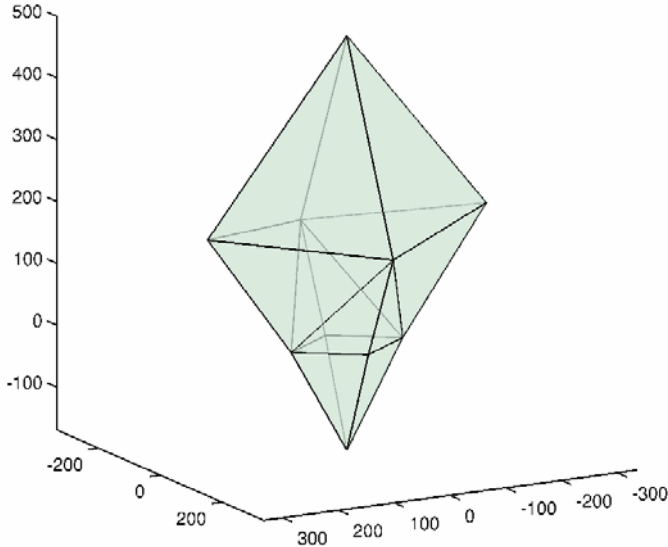




The user is now able to select cracked concrete assumption.

Concrete cone failure is now calculated, allowing the use of short anchors.

A 3D interaction diagram is presented ( $M_y$ ,  $M_z$ ,  $N$ ), for the visualization of the results.



The printout has been extended. There is a new block of results, added in the end of the input file, that contains the calculation of the connection in biaxial bending.

#### 6.2.5. Resistance of the connection in the biaxial bending (BETA VERSION)

All the following results have been produced by pre-release code, and should be considered

##### Anchors Resistances

Anchor's Resistance in Tension.....	0.00 kN
Anchors Resistance in Shear.....	62.18 kN
Applied Shear.....	0.00 kN

##### Anchorage

Anchors Minimum Length.....	0.00 mm
Required supporting plate dimension (diameter or side).....	0.00 mm
Concrete cone resistance per anchor.....	0.00 kN
Splitting resistance per anchor.....	0.00 kN
Required anchorage resistance in tension per anchor.....	0.00 kN
Concrete edge resistance per anchor.....	0.00 kN
Required shear resistance per anchor.....	0.00 kN

##### Base Plate

Resistance of base plate in tension - major moment.....	114.91 kN
Resistance of base plate in tension - minor moment.....	114.91 kN

##### Welds

Welds resistance.....	0.21 kN/mm <sup>2</sup>
Welds applied resultant stress for design loads.....	0.41 kN/mm <sup>2</sup>
Welds localized stress due to anchors in tension.....	0.00 kN/mm <sup>2</sup>

##### Column in double bending and shear

Shear resistance in yy direction.....	1295.10 kN
Shear resistance in zz direction.....	606.85 kN
Axial force and biaxial bending interaction safety.....	0.79 <b>O.K.</b>

##### Shear nib

Shear resistance in yy direction.....	93.94 kN
Concrete resistance in bearing - yy direction.....	294.39 kN
Shear resistance in zz direction.....	124.26 kN
Concrete resistance in bearing - zz direction.....	282.29 kN
Applied bending moment - yy direction.....	775.00 kN
Applied bending moment - zz direction.....	0.00 kN
Biaxial bending interaction safety.....	0.19 <b>O.K.</b>

##### Connection

Bending resistance in yy axis.....	101.20 KNm
Bending resistance in zz axis.....	58.00 KNm
Tensile resistance.....	114.91 kN
Compressive resistance.....	2864.02 KNm

##### Plastic axis in the middle - yy direction

Bending resistance.....	257.92 KNm
Compressive Axial Resistance.....	1202.18 kN

##### Plastic axis in the middle - zz direction

Bending resistance.....	140.84 KNm
Compressive Axial Resistance.....	1202.18 kN

##### Final Resistance

Ratio of the connection.....	1.73 <b>X</b>
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