Annex A (Examples)

Example 1

Check if the joint shown in fig 1.1 resists the applied moments and forces of fig 1.2

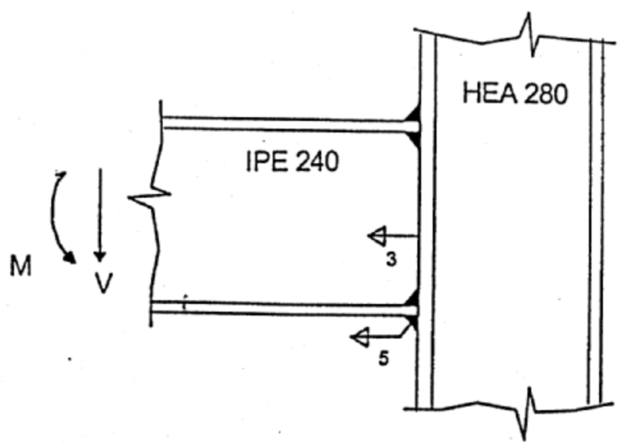


Fig 1.1

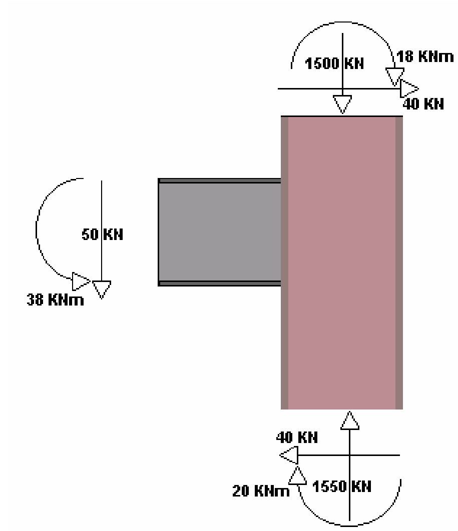
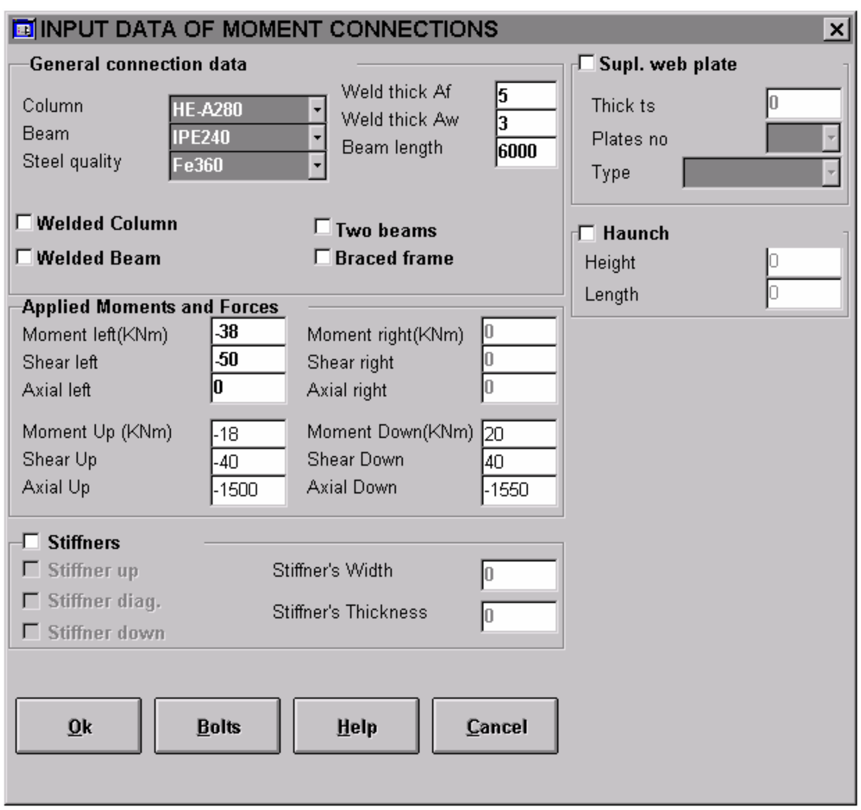


Fig 1.2

The Input Data form according to the data of this example is the following:



INPUT DATA OF MOMENT CONNECTIONS

General connection data

Column: HE-A280
Beam: IPE240
Steel quality: Fe360
Weld thick Af: 5
Weld thick Aw: 3
Beam length: 6000

☐ Welded Column
☐ Welded Beam
☐ Two beams
☐ Braced frame

☐ **Supl. web plate**
Thick ts: 0
Plates no
Type

☐ **Haunch**
Height: 0
Length: 0

Applied Moments and Forces

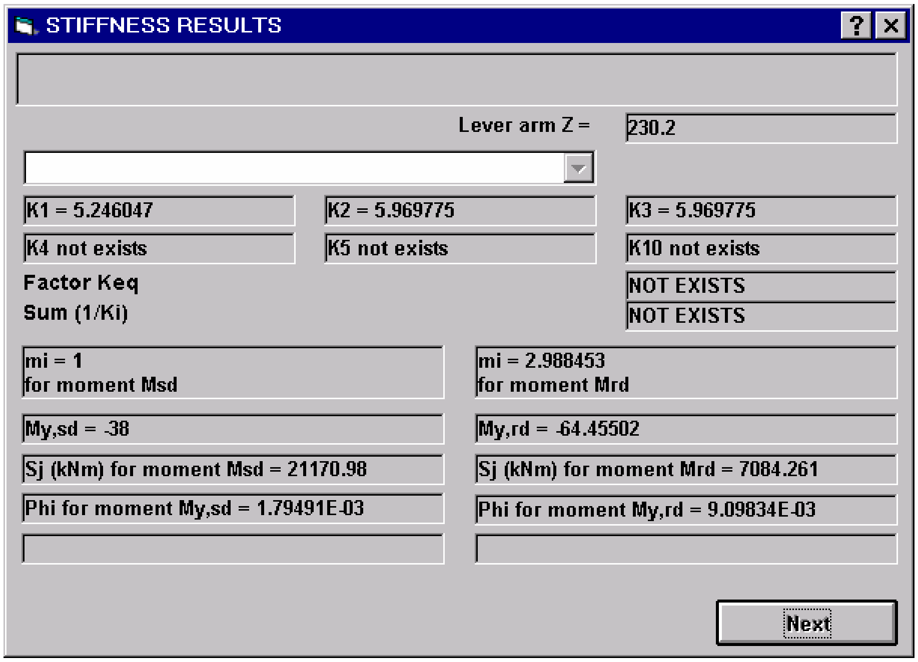
Moment left(KNm): -38
Shear left: -50
Axial left: 0
Moment right(KNm): 0
Shear right: 0
Axial right: 0

Moment Up (KNm): -18
Shear Up: -40
Axial Up: -1500
Moment Down(KNm): 20
Shear Down: 40
Axial Down: -1550

☐ **Stiffners**
☐ Stiffner up
☐ Stiffner diag.
☐ Stiffner down
Stiffner's Width: 0
Stiffner's Thickness: 0

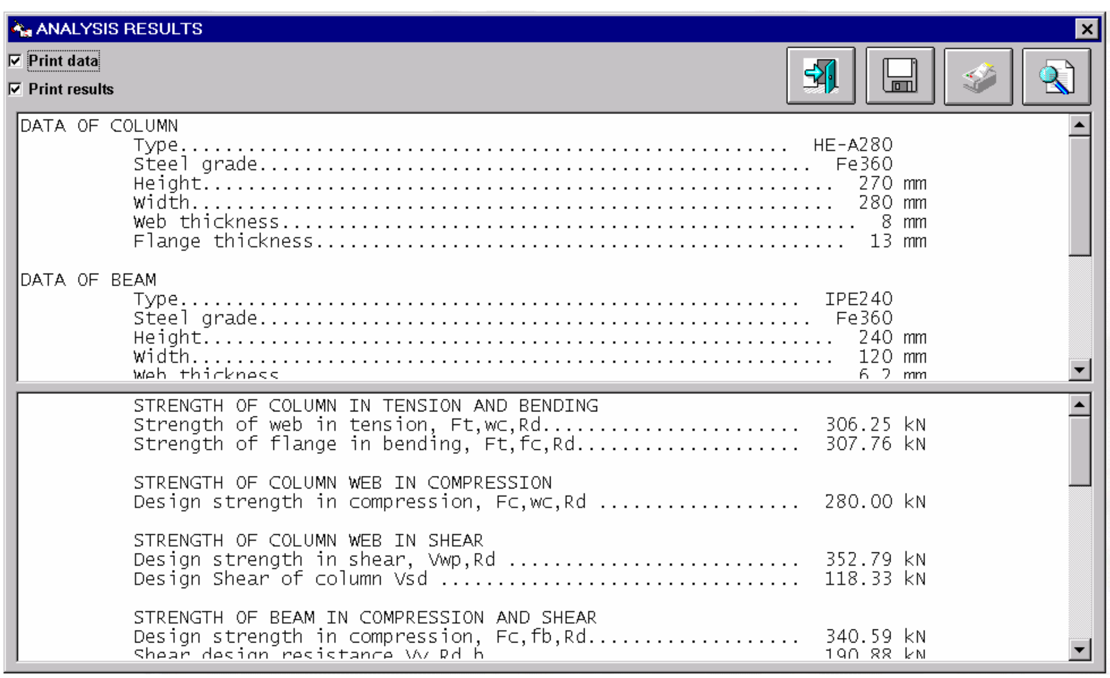
Ok | Bolts | Help | Cancel

Since we do not need to enter bolts data we can click on **OK** to get the results:



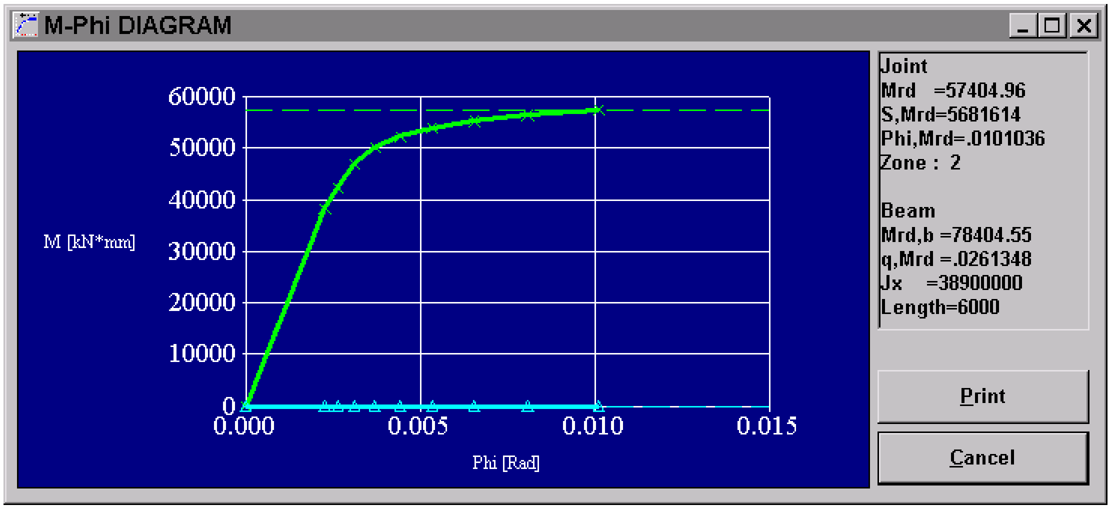
Note that for a welded connection only K_1, K_2, K_3 coefficients appear in the stiffness results.

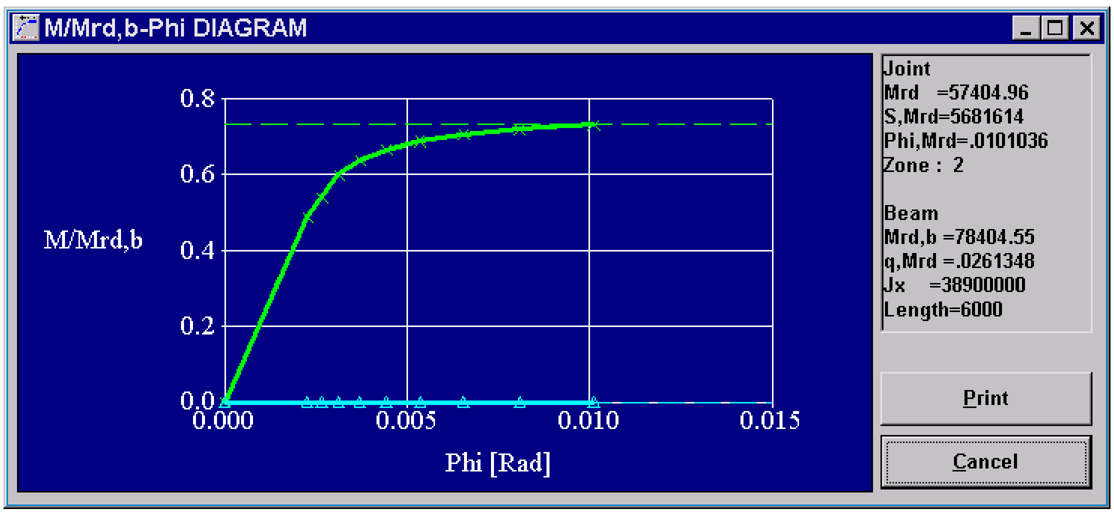
Clicking on **Next** the Analysis Results form appears:



```
DATA OF COLUMN
          Type......................................................  HE-A280
          Steel grade...................................................  Fe360
          Height.......................................................  270 mm
          Width........................................................  280 mm
          Web thickness..................................................  8 mm
          Flange thickness..............................................  13 mm

DATA OF BEAM
          Type.......................................................  IPE240
          Steel grade...................................................  Fe360
          Height.......................................................  240 mm
          Width........................................................  120 mm
                Web
      thickness................................................  6.2 mm
          Flange thickness.............................................  9.8 mm

CONNECTION DETAILS
          Connection type......  Beam to column con. welded or with end plate
          Number of Beams..................................................  1
          Steel grade...................................................  Fe360
          Weld thickness Af................................................  5 mm
          Weld thickness Aw..............................................  3.1 mm


  *****************************************************

          STRENGTH OF COLUMN IN TENSION AND BENDING
          Strength of web in tension, Ft,wc,Rd.......................  306.25 kN
          Strength of flange in bending, Ft,fc,Rd....................  307.76 kN

          STRENGTH OF COLUMN WEB IN COMPRESSION
          Design strength in compression, Fc,wc,Rd .................  280.00 kN

          STRENGTH OF COLUMN WEB IN SHEAR
          Design strength in shear, Vwp,Rd .........................  352.79 kN
          Design Shear of column Vsd ...............................  118.33 kN

          STRENGTH OF BEAM IN COMPRESSION AND SHEAR
          Design strength in compression, Fc,fb,Rd..................  340.59 kN
          Shear design resistance Vy,Rd,b ..........................  190.88 kN

          CONNECTION'S FINAL STRENGTH
          Beam's flange and web in compression check enabled...........  YES
          Applied moment My,sd .....................................  -38.00 KNm
          Moment design resistance My,Rd ...........................  -64.46 KNm
                         THE CONNECTION RESISTS IN MOMENT My

          (My,sd/My,Rd) + (Mz,sd/Mz,Rd) = 0.59 + 0.00 = 0.59 < 1
                         THE CONNECTION RESISTS IN MOMENT

          Shear design resistance Vy,Rd,b ..........................  190.88 kN
          Applied shear Vy,sd ......................................  -50.00 kN
                         THE CONNECTION RESISTS IN SHEAR Vy

          (Vy,sd/Vy,Rd) + (Vz,sd/Vz,Rd) = 0.26 + 0.00 = 0.26 < 1
                         THE CONNECTION RESISTS IN SHEAR

          STRENGTH OF WELDS
          For moments My,sd Mz,sd :
          ow =  < fu/aw = 0.288
          ocomp = 0.027 < fu/Bw*aw = 0.360
          The check of the welds is OK


          For moment My,Rd= Mpl,b = 78.40 kNm (AnnexJ 3.1.3(4)) :
          ow = 0.313 > fu/aw = 0.288
          +++++WARNING  The check of the welds has failed
```

The diagrams for this connection follow:





From the first diagram we can see that the connection is classified by stiffness in zone 2 and the relation between the moment and the rotation of the joint.

From the second diagram we can see that the connection is classified as partial strength.

Example 2

Solve the welded joint of fig. 2.1 for the moment and forces of fig. 2.2

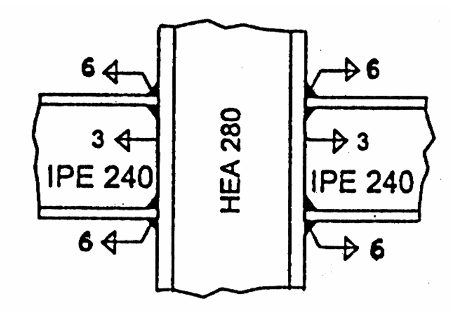


Fig 2.1

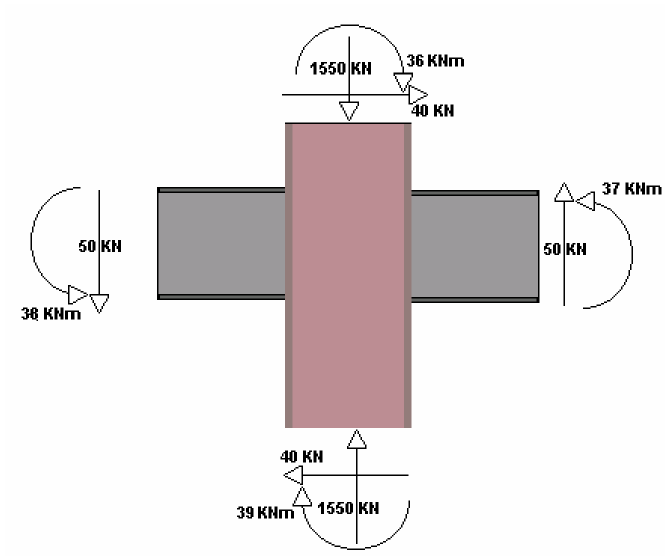
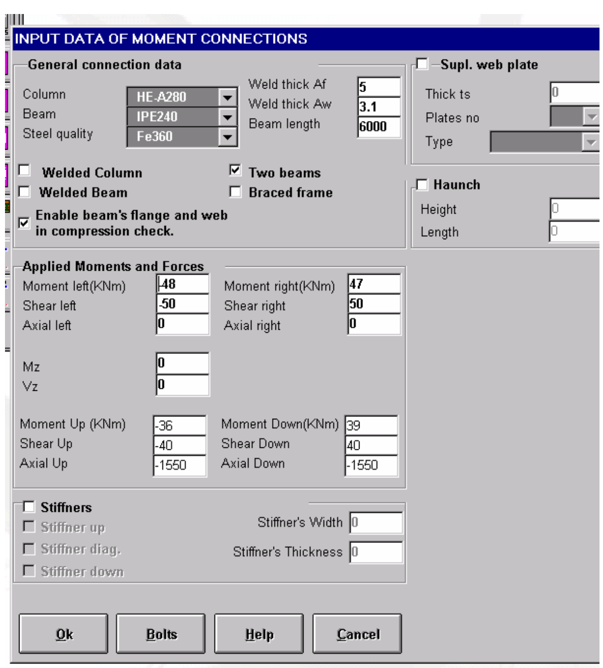


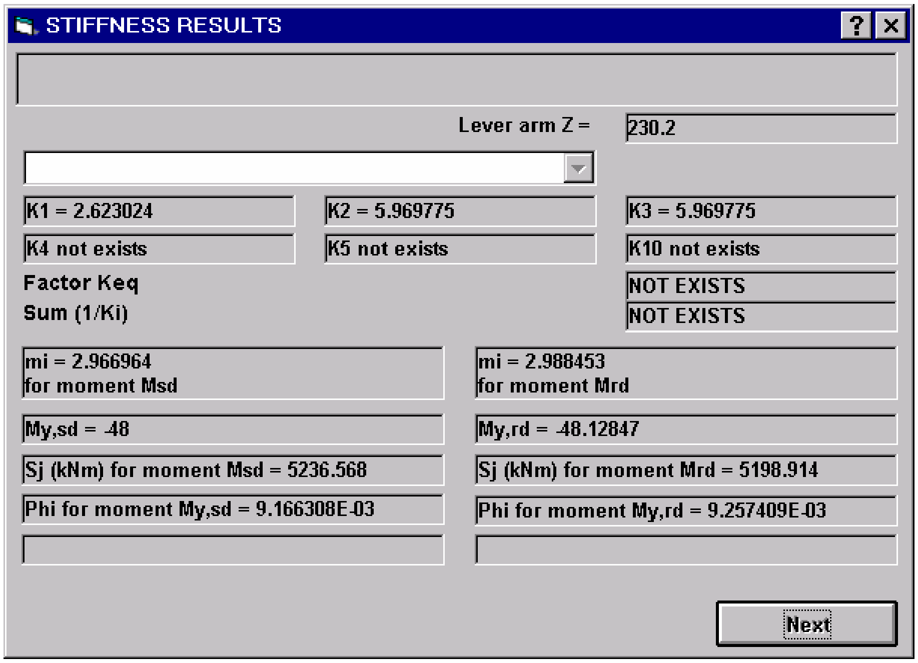
Fig 2.2

After entering the data of the problem to Steel Connections V1.0 the Input Data Form must look like this:

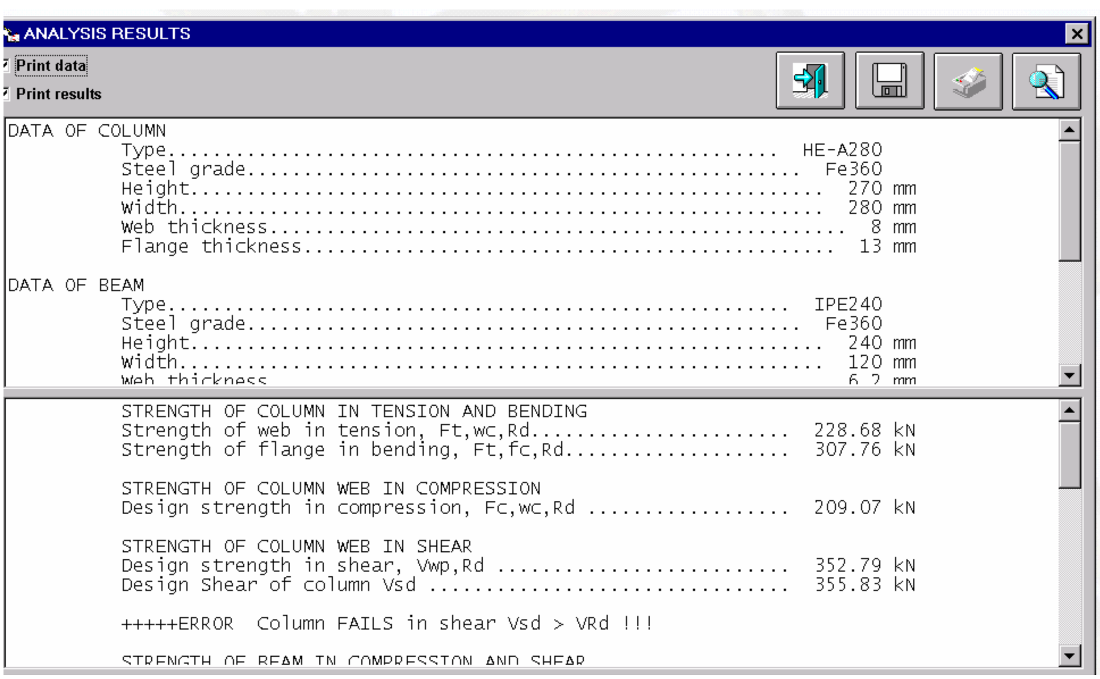
Since we don’t have to enter bolts data , we can click **OK** to proceed with the analysis.



The stiffness results for this connection are presented in the following form:



Clicking on **Next** the Analysis Results form appears:



```
DATA OF COLUMN
         Type.....................................................  HE-A280
         Steel grade...............................................  Fe360
         Height....................................................  270 mm
         Width.....................................................  280 mm
         Web thickness..............................................  8 mm
         Flange thickness..........................................  13 mm

DATA OF BEAM
         Type......................................................  IPE240
         Steel grade...............................................  Fe360
         Height....................................................  240 mm
         Width.....................................................  120 mm
         Web thickness.............................................  6.2 mm
         Flange thickness..........................................  9.8 mm

CONNECTION DETAILS
         Connection type......  Beam to column con. welded or with end plate
         Number of Beams............................................  2
         Steel grade...............................................  Fe360
         Weld thickness Af..........................................  5 mm
         Weld thickness Aw.........................................  3.1 mm


  *****************************************************

         STRENGTH OF COLUMN IN TENSION AND BENDING
         Strength of web in tension, Ft,wc,Rd......................  228.68 kN
         Strength of flange in bending, Ft,fc,Rd...................  307.76 kN

         STRENGTH OF COLUMN WEB IN COMPRESSION
         Design strength in compression, Fc,wc,Rd .................  209.07 kN

         STRENGTH OF COLUMN WEB IN SHEAR
         Design strength in shear, Vwp,Rd .........................  352.79 kN
         Design Shear of column Vsd ...............................  355.83 kN

         +++++ERROR  Column FAILS in shear Vsd > VRd !!!

         STRENGTH OF BEAM IN COMPRESSION AND SHEAR
         Design strength in compression, Fc,fb,Rd..................  340.59 kN
         Shear design resistance Vy,Rd,b ..........................  190.88 kN

         CONNECTION'S FINAL STRENGTH
         Beam's flange and web in compression check enabled...........  YES
         Applied moment My,sd .....................................  -48.00 KNm
         Moment design resistance My,Rd ...........................  -48.13 KNm
         +++++ERROR  THE CONNECTION FAILS IN MOMENT My

         (My,sd/My,Rd) + (Mz,sd/Mz,Rd) = 1.00 + 0.00 = 1.00 < 1
                        THE CONNECTION RESISTS IN MOMENT

         Shear design resistance Vy,Rd,b ..........................  190.88 kN
         Applied shear Vy,sd ......................................  -50.00 kN
                        THE CONNECTION RESISTS IN SHEAR Vy

         (Vy,sd/Vy,Rd) + (Vz,sd/Vz,Rd) = 0.26 + 0.00 = 0.26 < 1
                        THE CONNECTION RESISTS IN SHEAR

         STRENGTH OF WELDS
         For moments My,sd Mz,sd :
         ow =  < fu/aw = 0.288
         ocomp = 0.027 < fu/Bw*aw = 0.360
         The check of the welds is OK


         For moment My,Rd= Mpl,b = 78.40 kNm (AnnexJ 3.1.3(4)) :
         ow = 0.313 > fu/aw = 0.288
         +++++WARNING  The check of the welds has failed
```

From a quick view at the results we can easily see that the column's web fails in shear because of the applied moments (that is the reason that the final result for the connection indicates that it fails in moment). To solve the problem we must simply add two stiffner panels of 9mm thickness and 120 mm width (the length must always be from column's left to right flange), and the connection takes the form of fig 2.3

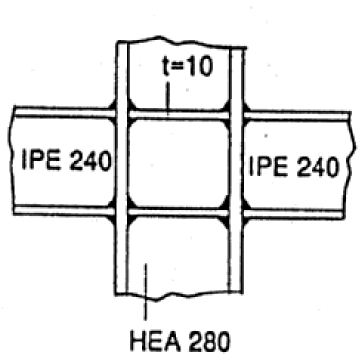
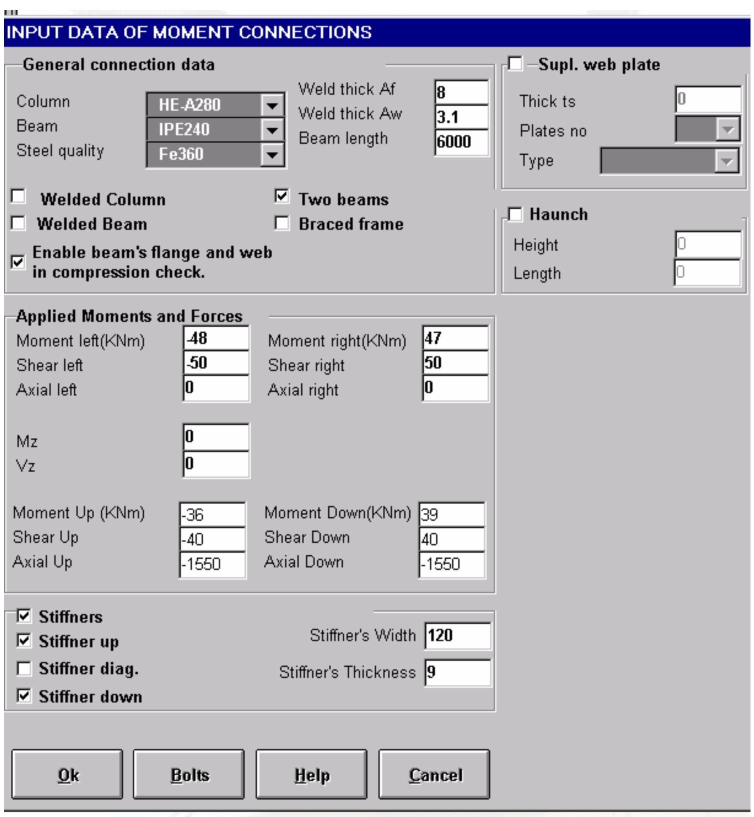


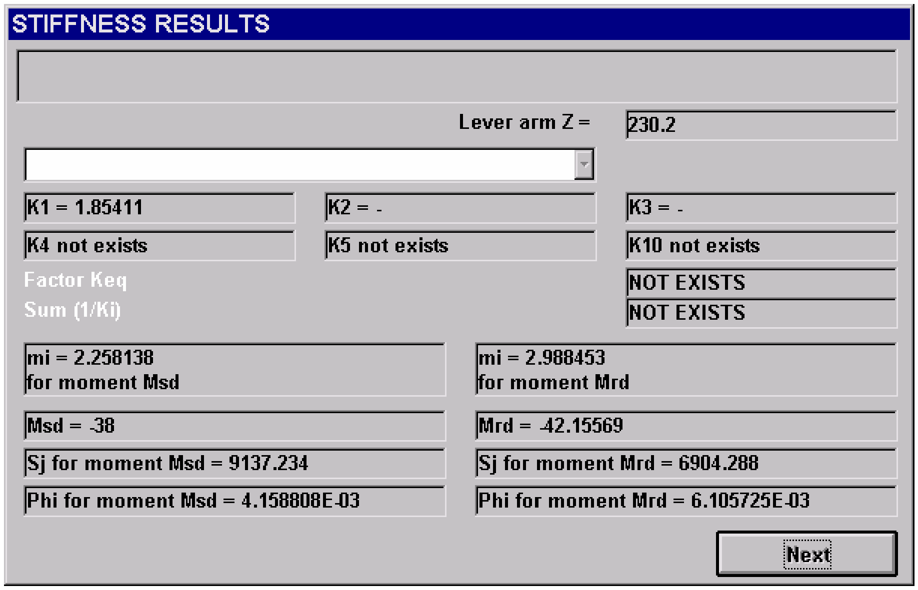
Fig 2.3

The Input Data form must now look like this :



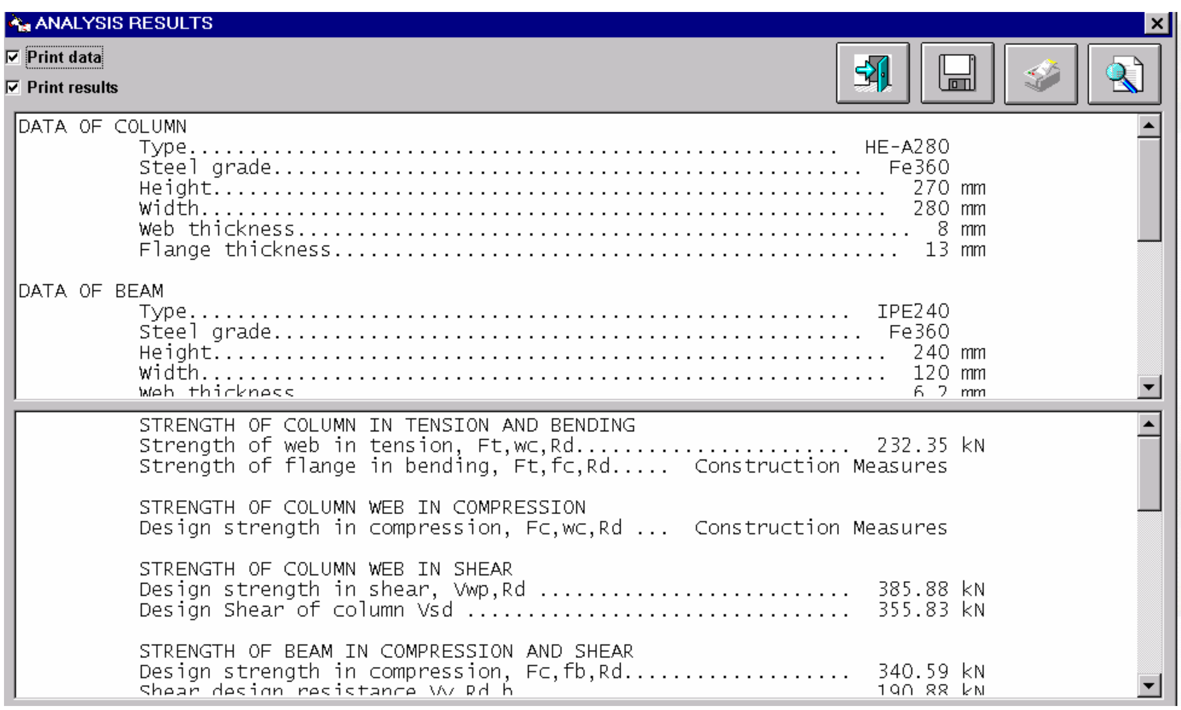
Note that we increased the Af weld's thickness to 8 mm because the check of the flange's welds has failed.

Clicking on **OK** and then on the Analysis Results button, we take the following stiffness results:



Note that the K_2 and K_3 coefficients are not been computed because horizontal stiffeners are being used.

By pressing Next we take the following results :



```
DATA OF COLUMN
        Type.....................................................  HE-A280
        Steel grade..............................................  Fe360
        Height...................................................  270 mm
        Width....................................................  280 mm
        Web thickness............................................  8 mm
        Flange thickness.........................................  13 mm

DATA OF BEAM
        Type.....................................................  IPE240
        Steel grade..............................................  Fe360
        Height...................................................  240 mm
        Width....................................................  120 mm
        Web thickness............................................  6.2 mm
        Flange thickness.........................................  9.8 mm

CONNECTION DETAILS
        Connection type......  Beam to column con. welded or with end plate
        Number of Beams..........................................  2
        Steel grade..............................................  Fe360
        Weld thickness Af........................................  8 mm
        Weld thickness Aw........................................  3.1 mm

        +++++WARNING Stiffeners Dimensions are less than minimum
        Program took into account the min. allowed dimensions by EC3.

        Stiffener's Width b .....................................  120.0 mm
        Stiffener's Thickness t .................................  10 mm

  *****************************************************

        STRENGTH OF COLUMN IN TENSION AND BENDING
        Strength of web in tension, Ft,wc,Rd.....................  232.35 kN
        Strength of flange in bending, Ft,fc,Rd.....  Construction Measures

        STRENGTH OF COLUMN WEB IN COMPRESSION
        Design strength in compression, Fc,wc,Rd ...  Construction Measures

        STRENGTH OF COLUMN WEB IN SHEAR
        Design strength in shear, Vwp,Rd ........................  385.88 kN
        Design Shear of column Vsd ..............................  355.83 kN

        STRENGTH OF BEAM IN COMPRESSION AND SHEAR
        Design strength in compression, Fc,fb,Rd.................  340.59 kN
        Shear design resistance Vy,Rd,b .........................  190.88 kN

        CONNECTION'S FINAL STRENGTH
        Beam's flange and web in compression check enabled...........  YES
        Applied moment My,sd ....................................  -48.00 KNm
        Moment design resistance My,Rd ..........................  -53.49 KNm
                       THE CONNECTION RESISTS IN MOMENT My

        (My,sd/My,Rd) + (Mz,sd/Mz,Rd) = 0.90 + 0.00 = 0.90 < 1
                       THE CONNECTION RESISTS IN MOMENT

        Shear design resistance Vy,Rd,b .........................  190.88 kN
        Applied shear Vy,sd .....................................  -50.00 kN
                       THE CONNECTION RESISTS IN SHEAR Vy

        (Vy,sd/Vy,Rd) + (Vz,sd/Vz,Rd) = 0.26 + 0.00 = 0.26 < 1
                       THE CONNECTION RESISTS IN SHEAR

        STRENGTH OF WELDS
        For moments My,sd Mz,sd :
        ow =  < fu/aw = 0.288
        ocomp = 0.019 < fu/Bw*aw = 0.360
        The check of the welds is OK

        For moment My,Rd= Mpl,b = 78.40 kNm (AnnexJ 3.1.3(4)) :
        ow = 0.208 < fu/aw = 0.288
        The check of the welds is OK
```

Note that the minus (-) symbol before the design moment resistance M_{Rd} is used to declare that the connection is being solved for the negative moments <u>of the left beam</u> (moments that compress the beam's lower flange).

Example 3

Solve the connection of figure 3.1 for :

1) M_{sd} = -100 KNm and V_{sd} = -50 KN.

2) Find M_{Rd} and V_{Rd} for moments that cause tension at beam's lower flange.

Bolts type is M20, their quality is 8.8 and the steel quality for the connected members is Fe360

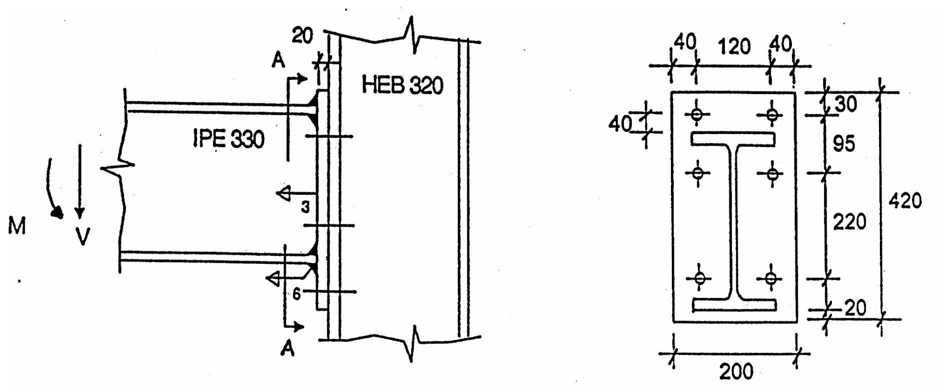
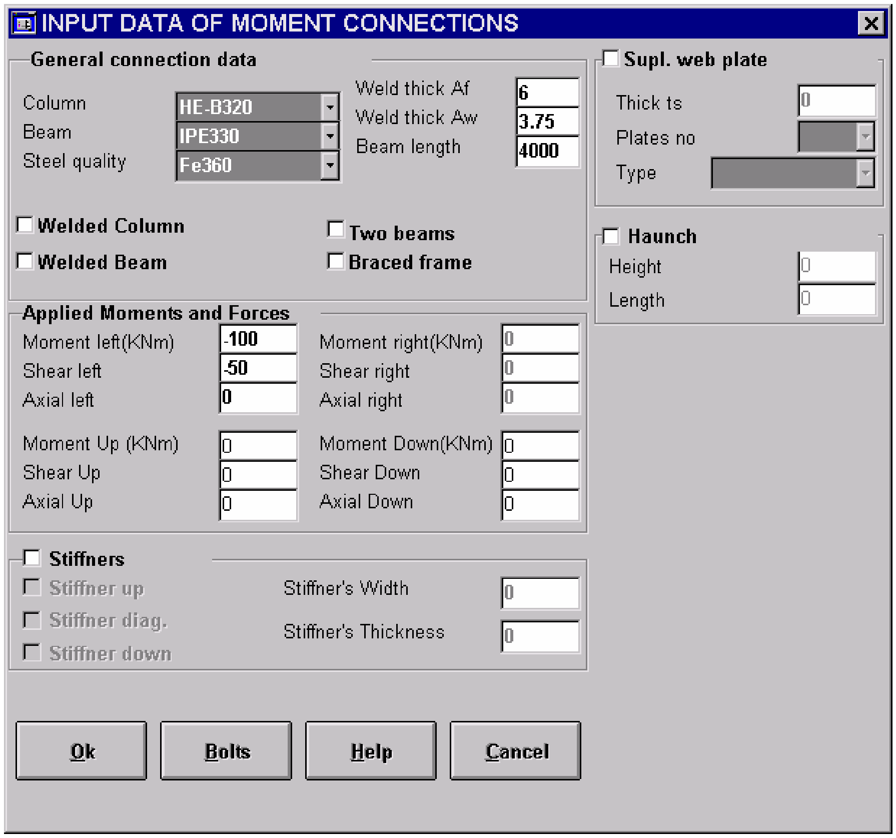


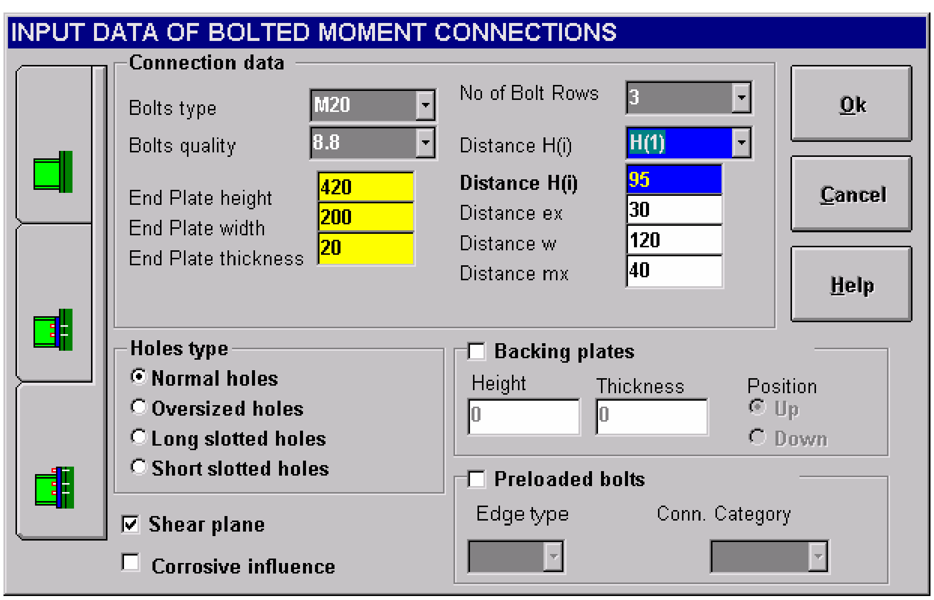
FIG. 3.1

(1.)



First we must input the general data for the connection. The Input Data form must look like this :

Then we must input the bolt's data .After clicking on **Bolts** we must fill in the appropriate values as shown below:



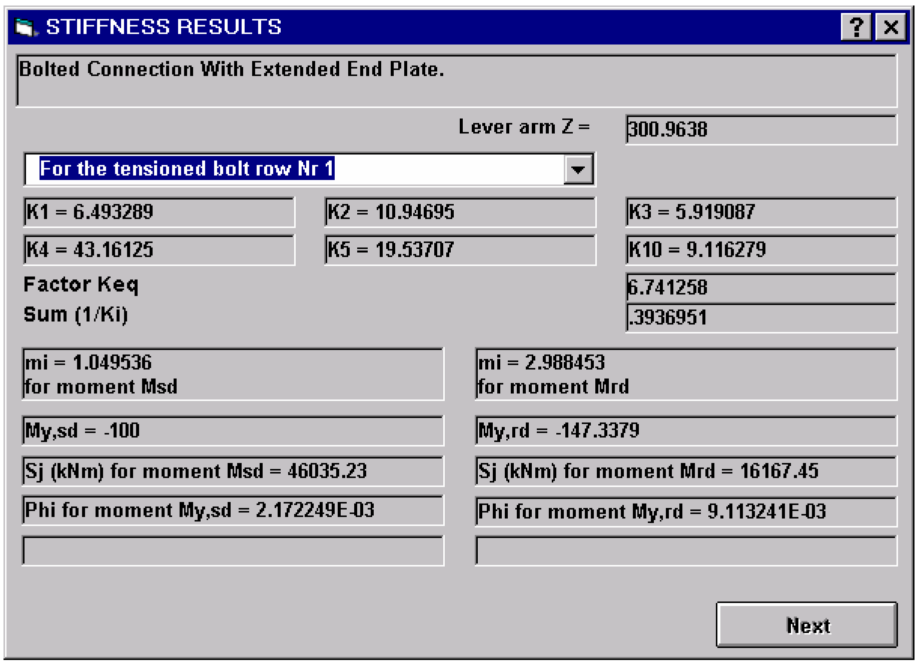
For a three bolt rows connection like this one, we have two H(i) distances. To enter the correct distance values we shall follow the next steps:

First we select H(1) from the **Distance H(i)**

Then we select H(2) from the **Distance H(i)**

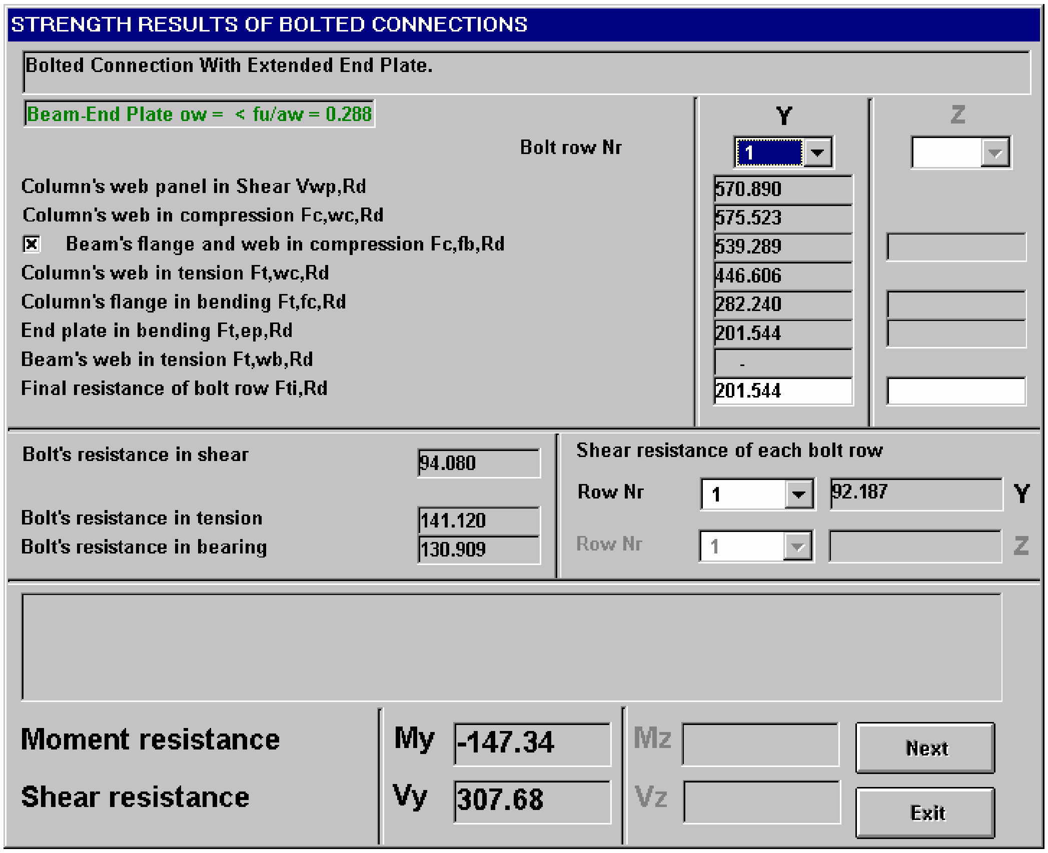
After entering all data we can click on **OK** to return to the Input Data form and on **OK** again to calculate the results.

By pressing the results button the Stiffness Results form appears:



Note that for a bolted connection the combo box becomes active and we can choose the bolt row <u>in tension</u> to see the results. (In this example the upper two bolt rows are tensioned).

Then by pressing **Next** the Strength Results of the Bolted Connections form appears:



In this form we can see the strength of the connection in moment and shear (note again the minus symbol (-) before moment resistance as in example 1 and 2).

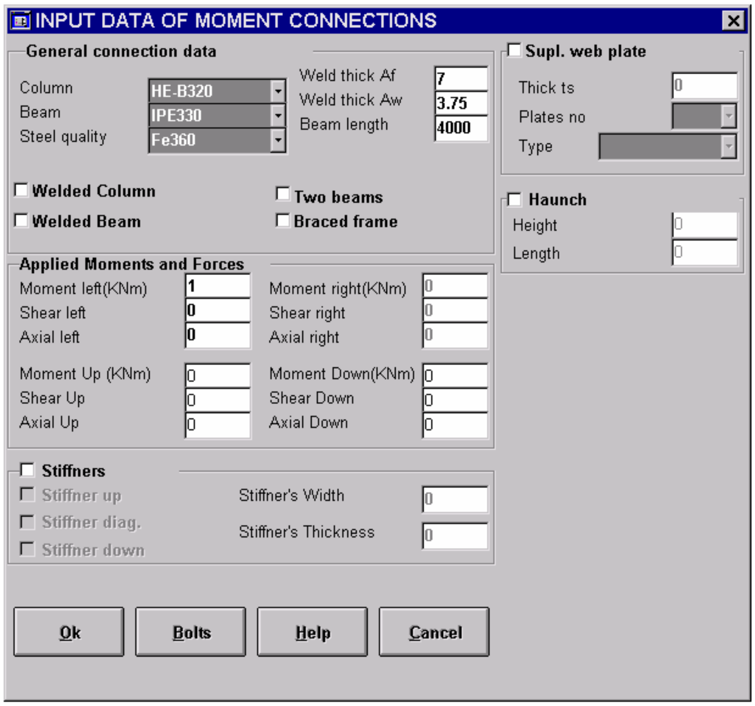
We can also examine the results of the checks of the connection's "basic components", and see that for the first bolt row the end plate's in bending check is the critical one. Note that for the first bolt row, the beam web in tension check have not been performed, because the first bolt row is outside the beam's area and does not interfere with the beam's web.

Clicking on the **Next** button we can take the results:

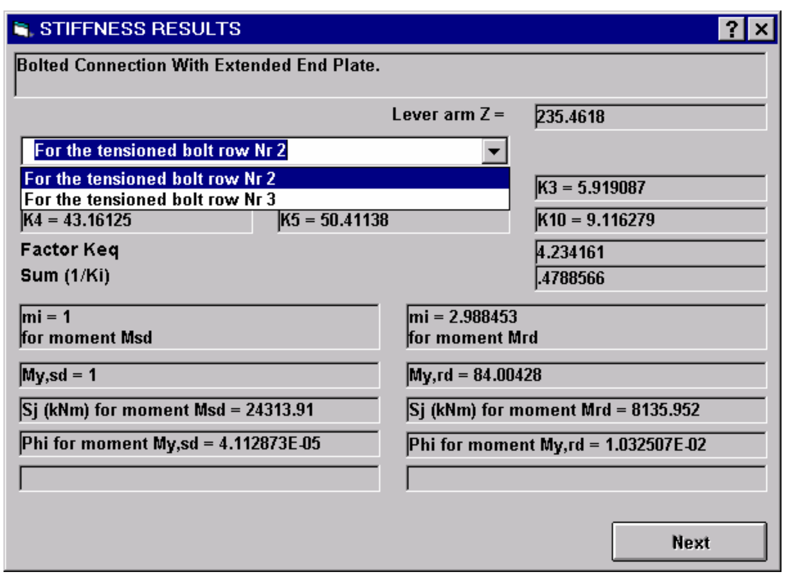
```
DATA OF COLUMN
          Type.....................................................  HE-B320
          Steel grade..............................................  Fe360
          Height...................................................  320 mm
          Width....................................................  300 mm
          Web thickness............................................  11.5 mm
          Flange thickness.........................................  20.5 mm

DATA OF BEAM
          Type.....................................................  IPE330
          Steel grade..............................................  Fe360
          Height...................................................  330 mm
          Width....................................................  160 mm
          Web thickness............................................  7.5 mm
          Flange thickness.........................................  11.5 mm

CONNECTION DETAILS
          Connection type......  Beam to column con. welded or with end plate
          Number of Beams..........................................  1
          Steel grade..............................................  Fe360
          End plate's Height.......................................  420 mm
          End plate's Width........................................  200 mm
          End plate's Thickness....................................  20 mm
          Distance from top of end plate to top of beam..................  70 mm
          Weld thickness Af........................................  6 mm
          Weld thickness Aw........................................  3.75 mm

BOLTS
          Bolts type...............................................  M20
          Bolt's steel grade.......................................  8.8
          Distance W...............................................  120 mm
          Edge distance............................................  40 mm
          Distance H(1)............................................  95 mm
          Distance H(2)............................................  220 mm
          Top edge distance........................................  30 mm
          Bottom edge distance.....................................  75 mm
          Number of bolt rows......................................  3
          Number of bolt columns...................................  2

  *****************************************************


          CONNECTION'S STRENGTH RESULTS
          Tension resistance Ftr,Rd of bolt-row  1..................  201.54 kN
          Tension resistance Ftr,Rd of bolt-row  2..................  260.42 kN
          Tension resistance Ftr,Rd of bolt-row  3..................  77.33 kN
          Bolt's resistance in Tension .............................  141.120 kN
          Bolt's resistance in Shear   .............................  94.080 kN
          Bolt's resistance in Bearing .............................  130.909 kN

          CONNECTION'S FINAL STRENGTH
          Beam's flange and web in compression check enabled............  YES
          Applied moment My,sd .....................................  -100.00 KNm
          Moment design resistance My,Rd ...........................  -147.34 KNm
                         THE CONNECTION RESISTS IN MOMENT My

          (My,sd/My,Rd) + (Mz,sd/Mz,Rd) = 0.68 + 0.00 = 0.68 < 1
                         THE CONNECTION RESISTS IN MOMENT

          Applied shear Vy,sd ......................................  -50.00 kN
          Shear design resistance Vy,Rd,b ..........................  307.68 kN
                         THE CONNECTION RESISTS IN SHEAR Vy

          (Vy,sd/Vy,Rd) + (Vz,sd/Vz,Rd) = 0.16 + 0.00 = 0.16 < 1
                         THE CONNECTION RESISTS IN SHEAR


          STRENGTH OF WELDS
          For moments My,sd Mz,sd :
          ow =  < fu/aw = 0.288
          ocomp = 0.016 < fu/Bw*aw = 0.360
          The check of the welds is OK


          For moment My,Rd= Mpl,b = 171.76 kNm (AnnexJ 3.1.3(4)) :
          ow = 0.299 > fu/aw = 0.288
          +++++WARNING  The check of the welds has failed
```

(2.)

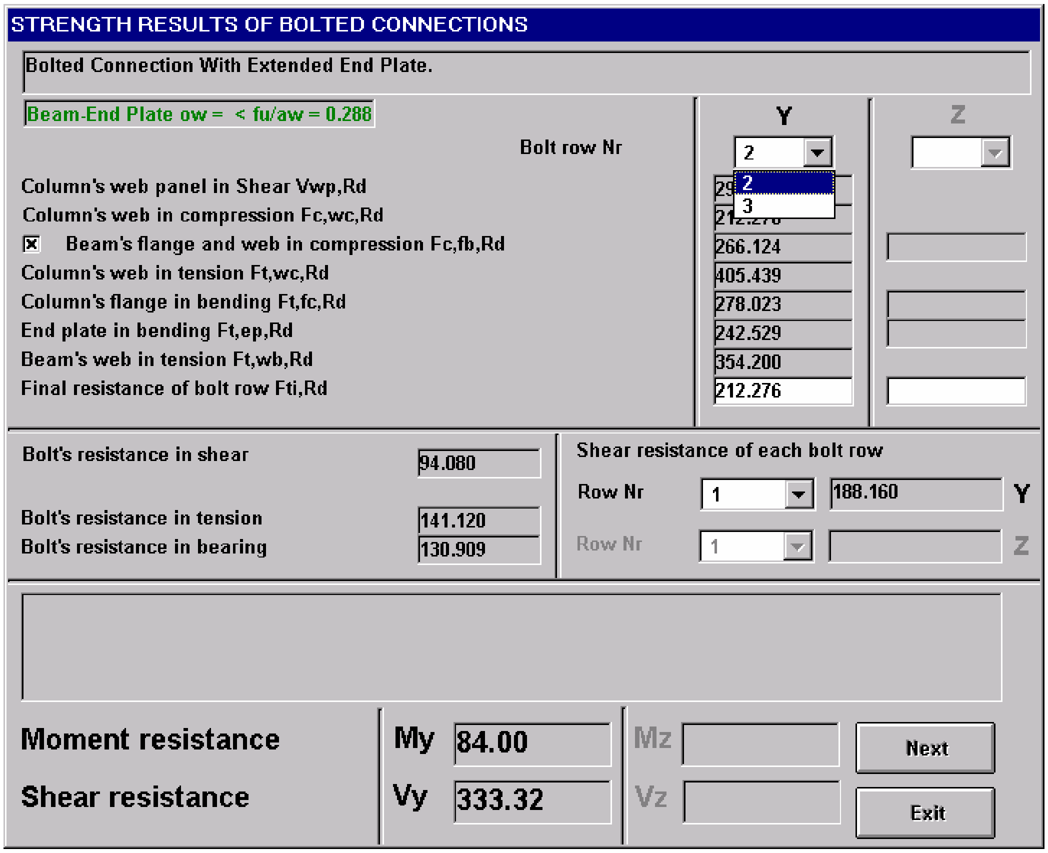
To solve the connection for moments that cause tension in the beam's lower flange we must simply load the left beam with a random positive moment (i.e +1KNm). All the other data of the connection remain the same. The input data form must look like this:



Since we do not need to change anything about the bolts data, we press OK to start the calculations and then the results button to get the results:



Note that solving for positive (clockwise at left beam) moments the 2nd and 3rd bolt rows are in tension instead of the 1st and 2nd in leg (1.).



Note that the moment resistance is positive and different than before because the connection is not symmetric. The user now knows the strength of the connection in moment and shear under positive moments.

Example 4

Find the moment and shear resistance of the bolted connection of the top frame joint shown in figure 4.1.

Bolts type is M20, their quality is 8.8 and the steel quality of the connected members is Fe360.

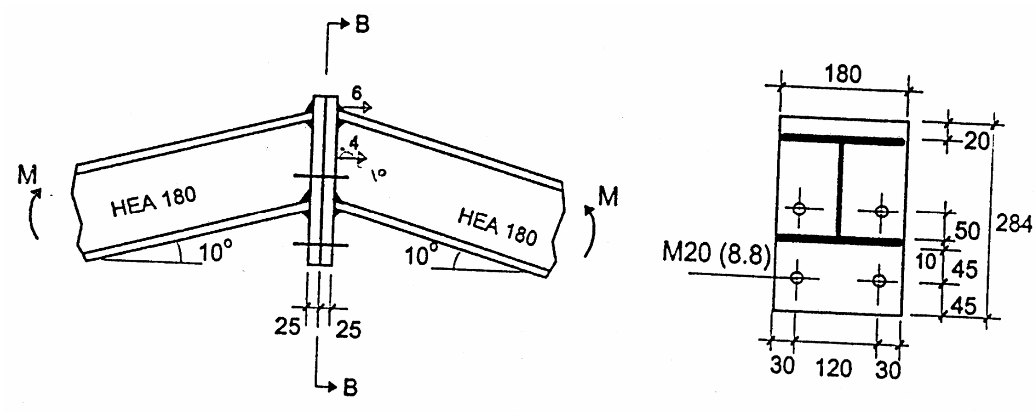
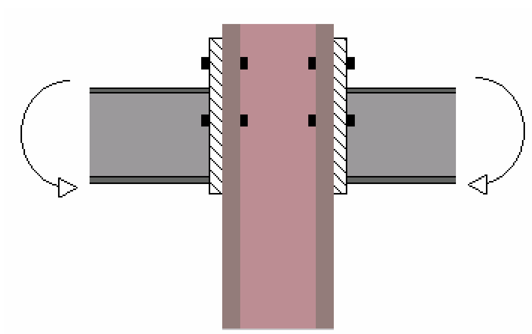


Fig. 4.1

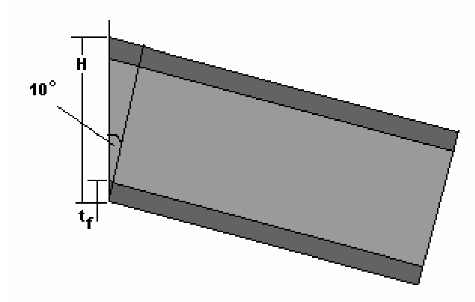
To transform the connection to a type compatible with Steel Connections V1.0 we must use the following model :



This is a two beams connection with extended end plates. We must pay attention to the following:

- ➢ The column's cross section must be much bigger than the cross sections of the beams and of the end plates, so that none of the checks of the column's "basic components" will be critical for the connection.

- In case the roof's slope is big enough, the differences between the geometric characteristics of the horizontal and the inclined beam should be taken under consideration.

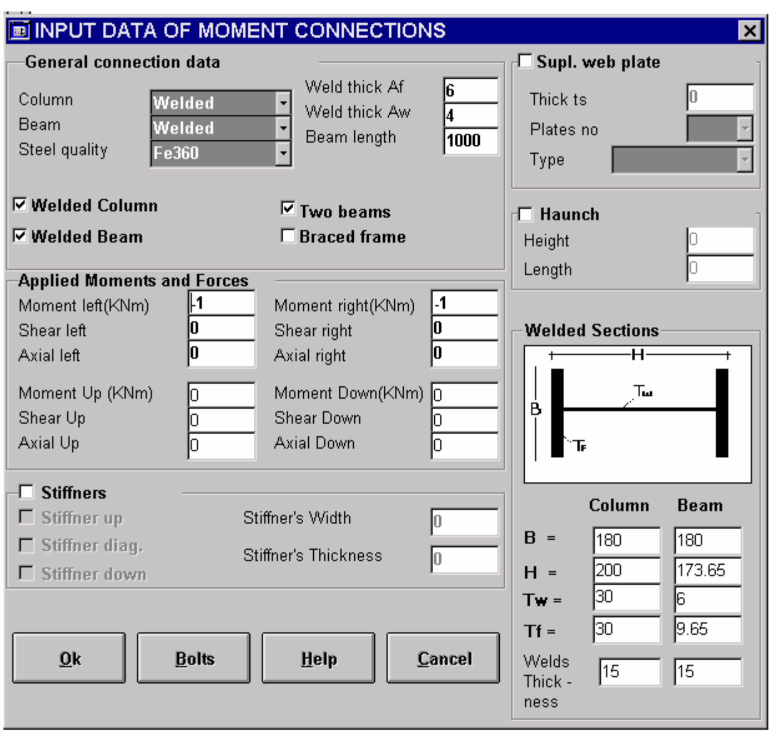


In this example the beam's height is 171 mm and the beam's flange thickness is 9.5mm. For a slope of 10° we should make the following transformations:

BEAM'S HEIGHT: $H = \frac{171\text{mm}}{\cos(10)} = 173.64$ mm

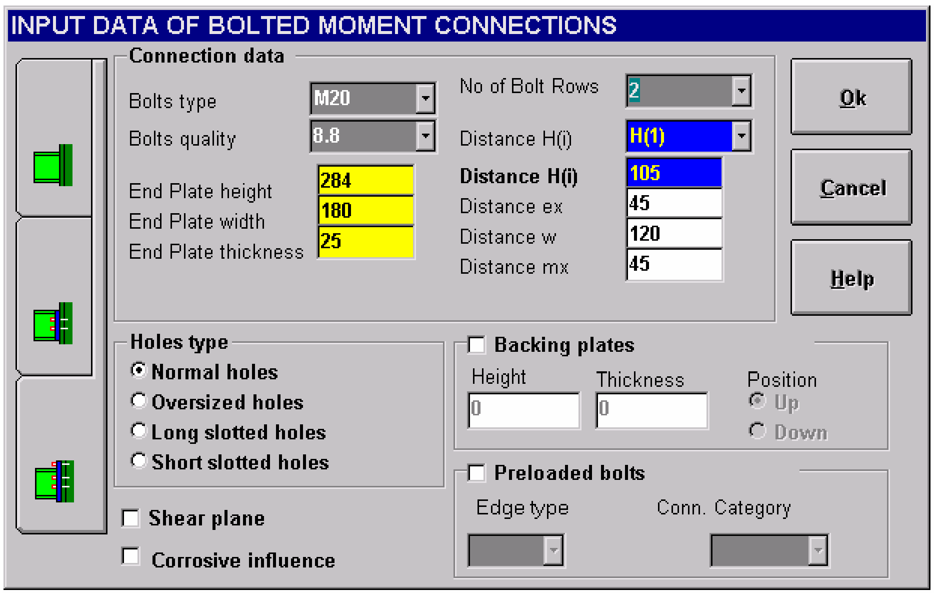
FLANGE'S THICKNESS: $t_f = \frac{9.5\text{mm}}{\cos(10)} = 9.65$mm

The Input Data form for this example must look like this:

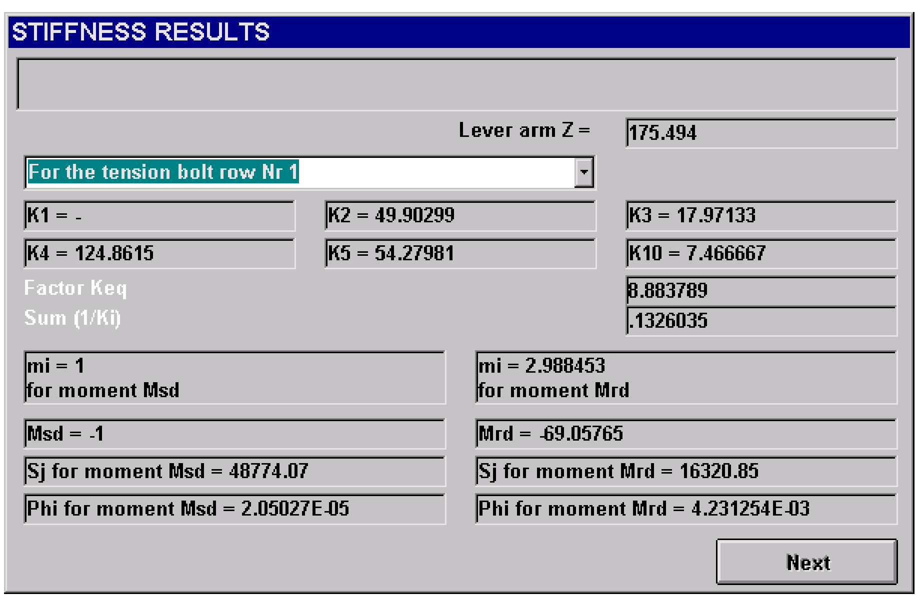


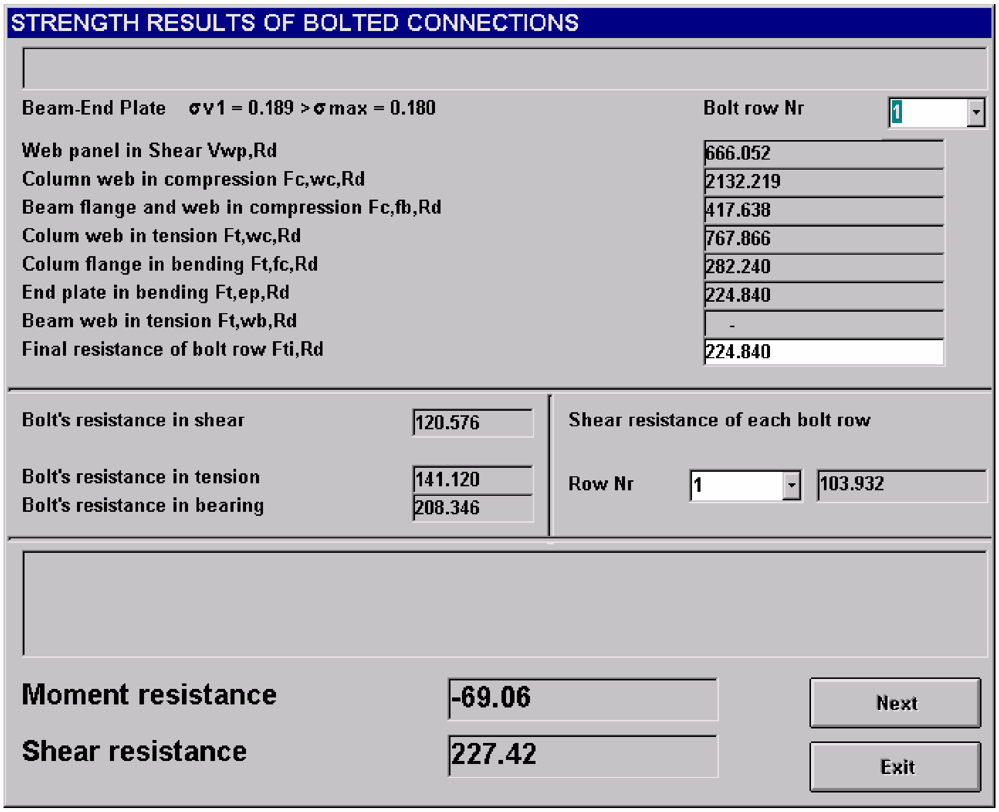
Note that the column is given as Welded allowing us to give large Tw and Tf thickness in order to obtain a large strength. The beam is also welded so we can enter the right height and flange thickness values, as described above.

After entering all the values in the Input Data form we ca click on **OK** to pass to the Input Data of Bolted Moment Connections form:



After completing the input data procedure we shall click on **OK** to return to the Input Data form and then **OK** again to calculate the results which are:





STRENGTH RESULTS OF BOLTED CONNECTIONS

Beam-End Plate σv1 = 0.189 > σmax = 0.180 — Bolt row Nr: 1

Web panel in Shear Vwp,Rd	666.052
Column web in compression Fc,wc,Rd	2132.219
Beam flange and web in compression Fc,fb,Rd	417.638
Colum web in tension Ft,wc,Rd	767.866
Colum flange in bending Ft,fc,Rd	282.240
End plate in bending Ft,ep,Rd	224.840
Beam web in tension Ft,wb,Rd	-
Final resistance of bolt row Fti,Rd	224.840

Bolt's resistance in shear	120.576
Bolt's resistance in tension	141.120
Bolt's resistance in bearing	208.346

Shear resistance of each bolt row

Row Nr: 1 — 103.932

Moment resistance: -69.06

Shear resistance: 227.42

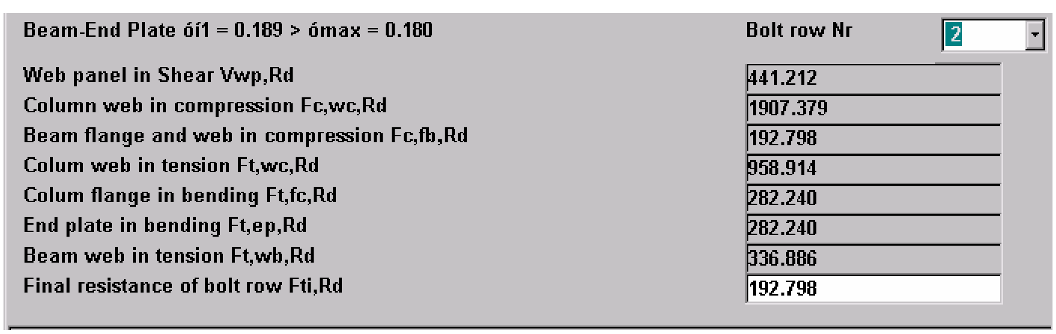
Next

Exit

In this form we can easily see the resistance of the connection in moment and shear.

In this example the column exists only for the program's needs. For that reason we must be certain that any check on the "basic components" relative to the column is not critical.

For the first bolt row the check of the end plate in bending is the critical one.



Beam-End Plate óí1 = 0.189 > ómax = 0.180 — Bolt row Nr: 2

Web panel in Shear Vwp,Rd	441.212
Column web in compression Fc,wc,Rd	1907.379
Beam flange and web in compression Fc,fb,Rd	192.798
Colum web in tension Ft,wc,Rd	958.914
Colum flange in bending Ft,fc,Rd	282.240
End plate in bending Ft,ep,Rd	282.240
Beam web in tension Ft,wb,Rd	336.886
Final resistance of bolt row Fti,Rd	192.798

For the second bolt row the beam's flange and web in compression check is the critical one.

So we can assume that the modeling we introduced was right and the results can be evaluated. If a check in a column's basic component is critical for the connection then the strength of the column should be increased and then the results recalculated.

Note that now only the left view of the program's graphics shows the real connection. All the other views represent the model.

Example 5

Solve the connection of fig 4.1 for the applied moment and forces (slope is 20^o).

Beam IPE300 ,Column IPE400 ,steel quality Fe360.

Bolts M20, quality is 8.8.

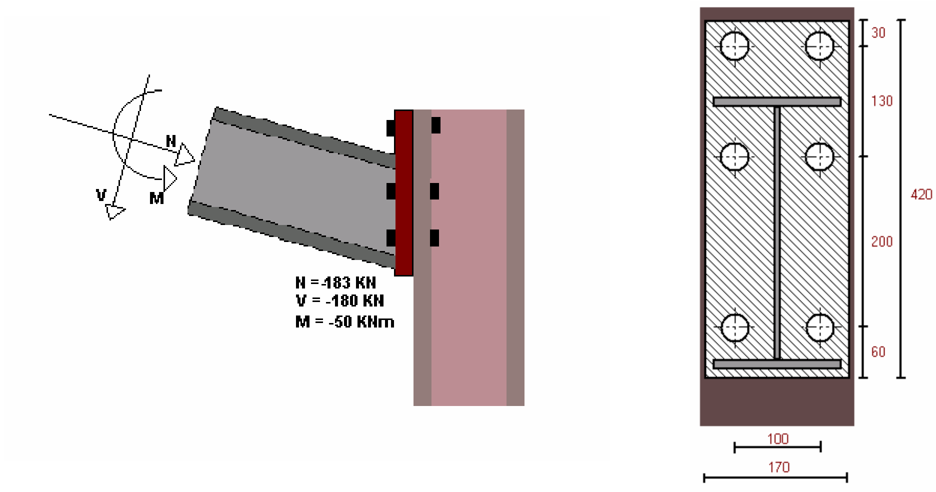


FIG. 5.1

First we must transform the forces according to a coordinates system with the N axis placed horizontally.

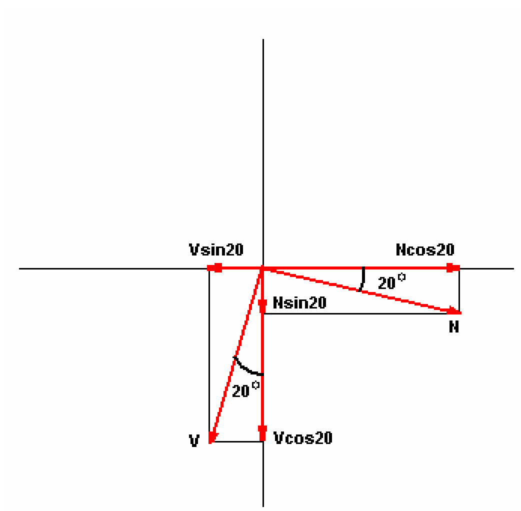


FIG. 5.2

Based upon Fig. 5.2 we can find the Shear(V_1) and Axial (N_1) forces for our model:

V1 = -(Vcos20 + Nsin20) = -(180cos20 + 183sin20)KN = 231.68 KN

N1 = Vsin20 – Ncos20 = 180sin20 KN – 183cos20 KN = 110.4 KN

Then we must transform the beam's height and flange thickness in order to represent those of a IPE 300 beam with an angle cut of 20o in the right edge. Working as described in example 4, we can write:

BEAM'S HEIGHT: H = 319.25 mm

FLANGE'S THICKNESS: t_f = 11.39mm

Therefore we can introduce the model of the connection as follows:

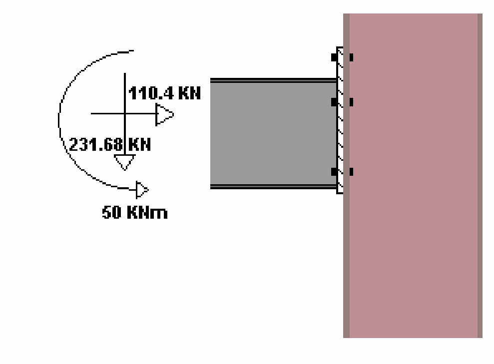
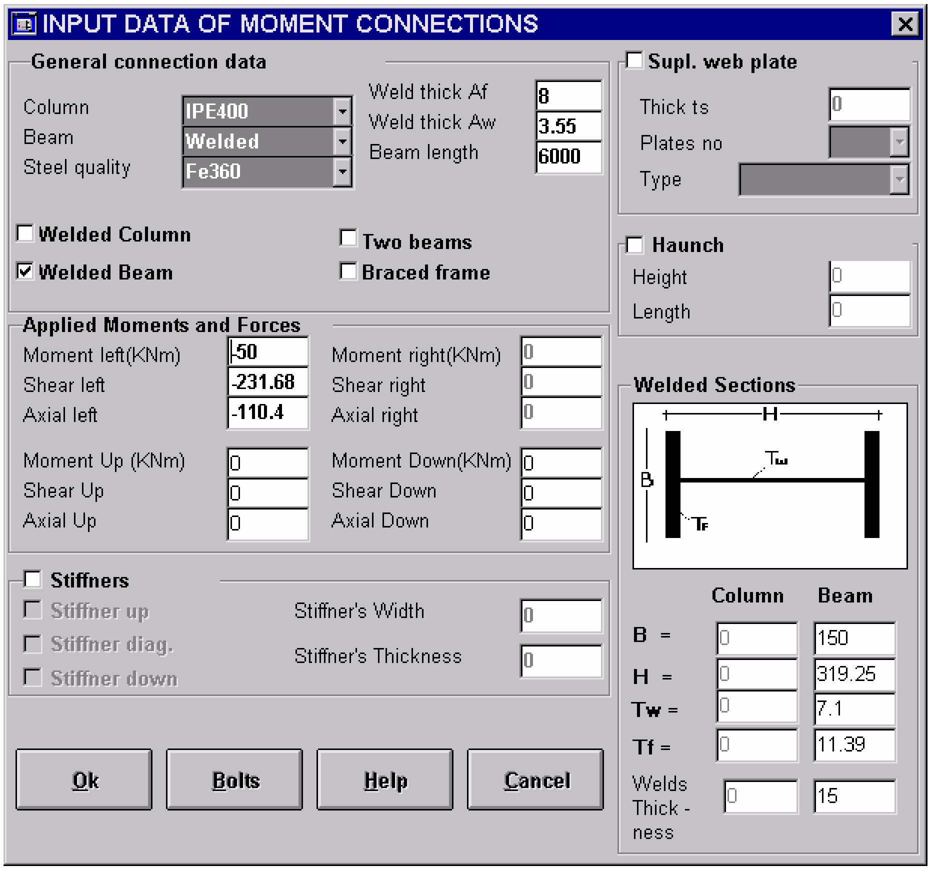
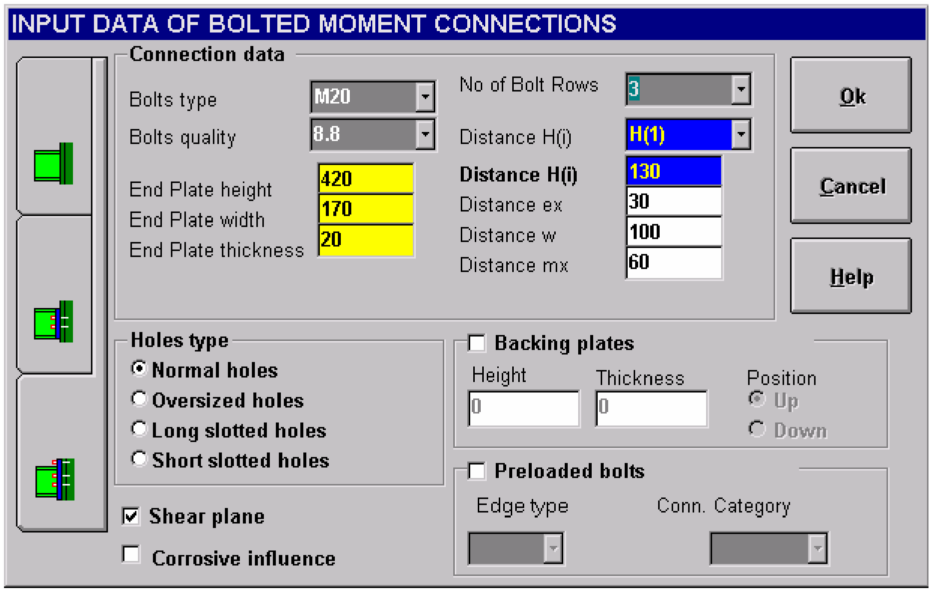


FIG. 5.3

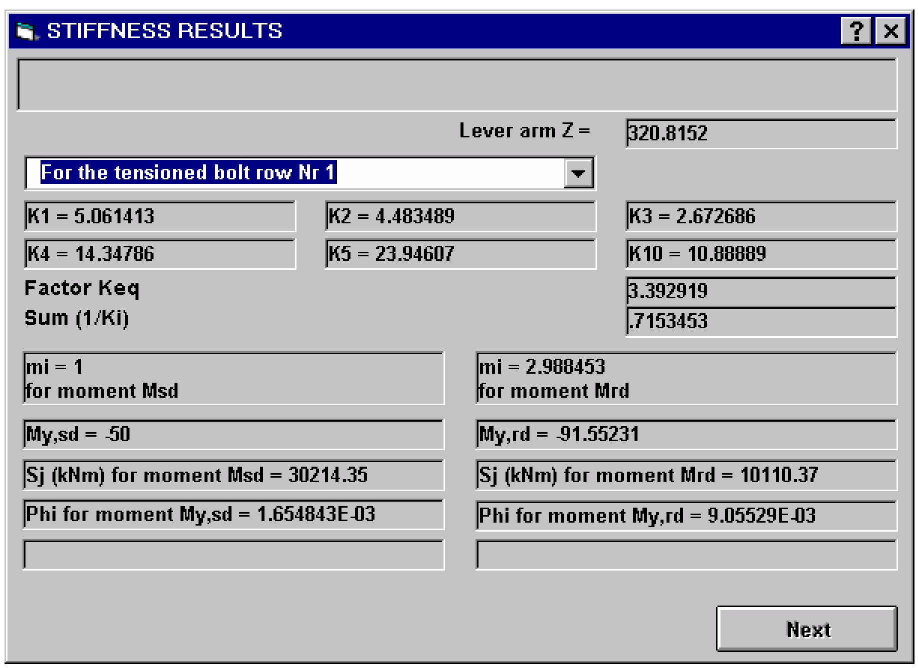
The Input Data form must look like this:

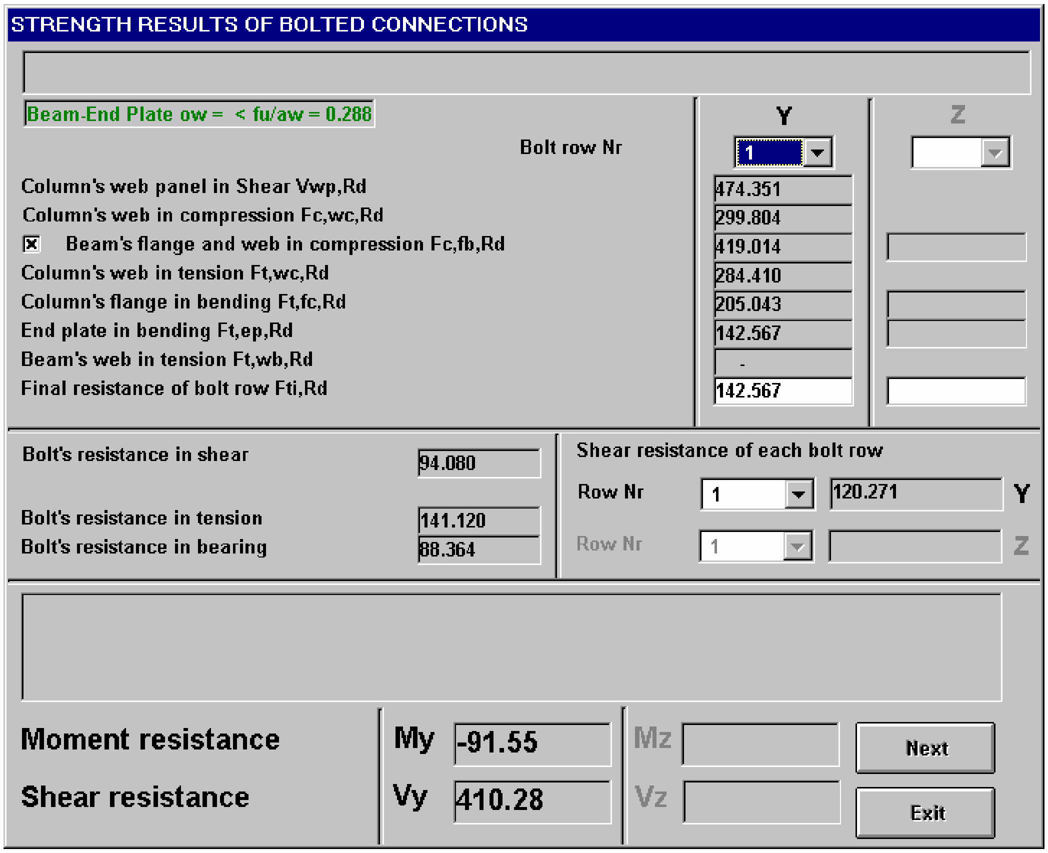


And for the bolts data:



After entering all the data we must lick on **OK** to return to the Input Data form and then **OK** again to calculate the results, which are:




STRENGTH RESULTS OF BOLTED CONNECTIONS
Beam-End Plate ow = < fu/aw = 0.288
Bolt row Nr
Y
Z
1
Column's web panel in Shear Vwp,Rd
Column's web in compression Fc,wc,Rd
Beam's flange and web in compression Fc,fb,Rd
Column's web in tension Ft,wc,Rd
Column's flange in bending Ft,fc,Rd
End plate in bending Ft,ep,Rd
Beam's web in tension Ft,wb,Rd
Final resistance of bolt row Fti,Rd
474.351
299.804
419.014
284.410
205.043
142.567
-
142.567
Bolt's resistance in shear
94.080
Bolt's resistance in tension
141.120
Bolt's resistance in bearing
88.364
Shear resistance of each bolt row
Row Nr
1
120.271
Y
Row Nr
1
Z
Moment resistance
My
-91.55
Mz
Shear resistance
Vy
410.28
Vz
Next
Exit

Clicking on **Next** we can get the following output:

```
DATA OF COLUMN
          Type.......................................................  IPE400
          Steel grade................................................  Fe360
          Height......................................................  400 mm
          Width.......................................................  180 mm
          Web thickness...............................................  8.6 mm
          Flange thickness...........................................  13.5 mm

DATA OF BEAM
          Type.......................................................  Welded
          Steel grade................................................  Fe360
          Height....................................................  319.25 mm
          Width.......................................................  150 mm
          Web thickness...............................................  7.1 mm
          Flange thickness..........................................  11.39 mm

CONNECTION DETAILS
          Connection type......  Beam to column con. welded or with end plate
          Number of Beams.............................................  1
          Steel grade................................................  Fe360
          End plate's Height..........................................  420 mm
          End plate's Width...........................................  170 mm
          End plate's Thickness.......................................  20 mm
          Distance from top of end plate to top of beam.................  90 mm
          Weld thickness Af............................................  8 mm
          Weld thickness Aw..........................................  3.55 mm

BOLTS
          Bolts type..................................................  M20
          Bolt's steel grade..........................................  8.8
          Distance W..................................................  100 mm
          Edge distance................................................  35 mm
          Distance H(1)...............................................  130 mm
          Distance H(2)...............................................  200 mm
          Top edge distance............................................  30 mm
          Bottom edge distance.........................................  60 mm
          Number of bolt rows...........................................  3
          Number of bolt columns........................................  2

  *****************************************************

          CONNECTION'S STRENGTH RESULTS
          Tension resistance Ftr,Rd of bolt-row  1..................  142.57 kN
          Tension resistance Ftr,Rd of bolt-row  2..................  157.24 kN
          Bolt's resistance in Tension ............................  141.120 kN
          Bolt's resistance in Shear   .............................  94.080 kN
          Bolt's resistance in Bearing .............................  88.364 kN

          CONNECTION'S FINAL STRENGTH
          Beam's flange and web in compression check enabled...........  YES
          Applied moment My,sd .....................................  -50.00 KNm
          Moment design resistance My,Rd ...........................  -91.55 KNm
                         THE CONNECTION RESISTS IN MOMENT My

          (My,sd/My,Rd) + (Mz,sd/Mz,Rd) = 0.55 + 0.00 = 0.55 < 1
                         THE CONNECTION RESISTS IN MOMENT

          Applied shear Vy,sd .....................................  -231.68 kN
          Shear design resistance Vy,Rd,b ..........................  410.28 kN
                         THE CONNECTION RESISTS IN SHEAR Vy

          (Vy,sd/Vy,Rd) + (Vz,sd/Vz,Rd) = 0.56 + 0.00 = 0.56 < 1
                         THE CONNECTION RESISTS IN SHEAR


          STRENGTH OF WELDS
          For moments My,sd Mz,sd :
          ow =  < fu/aw = 0.288
          ocomp = 0.069 < fu/Bw*aw = 0.360
          The check of the welds is OK

          For moment My,Rd= Mpl,b = 145.70 kNm (AnnexJ 3.1.3(4)) :
          ow = 0.227 < fu/aw = 0.288
          The check of the welds is
```

Example 6

Solve the connection of fig. 6.1. Bolts type is M12 and their quality is 8.8. Steel quality of the connected members is Fe360.

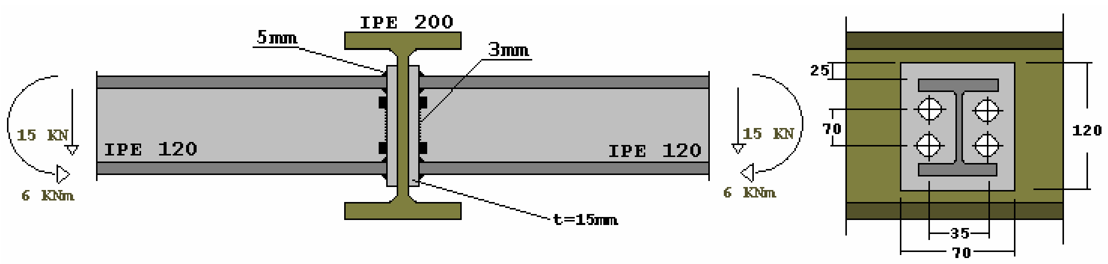


FIG. 6.1

To transform the connection to a type compatible with Steel Connections V1.0 we shall create the following model:

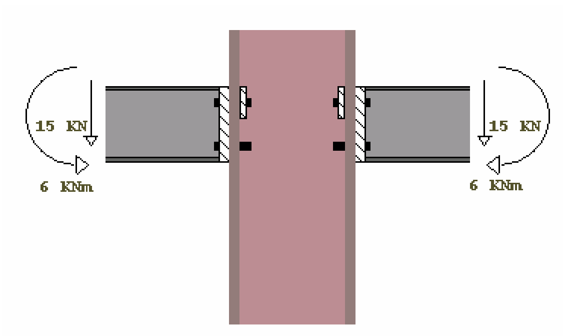
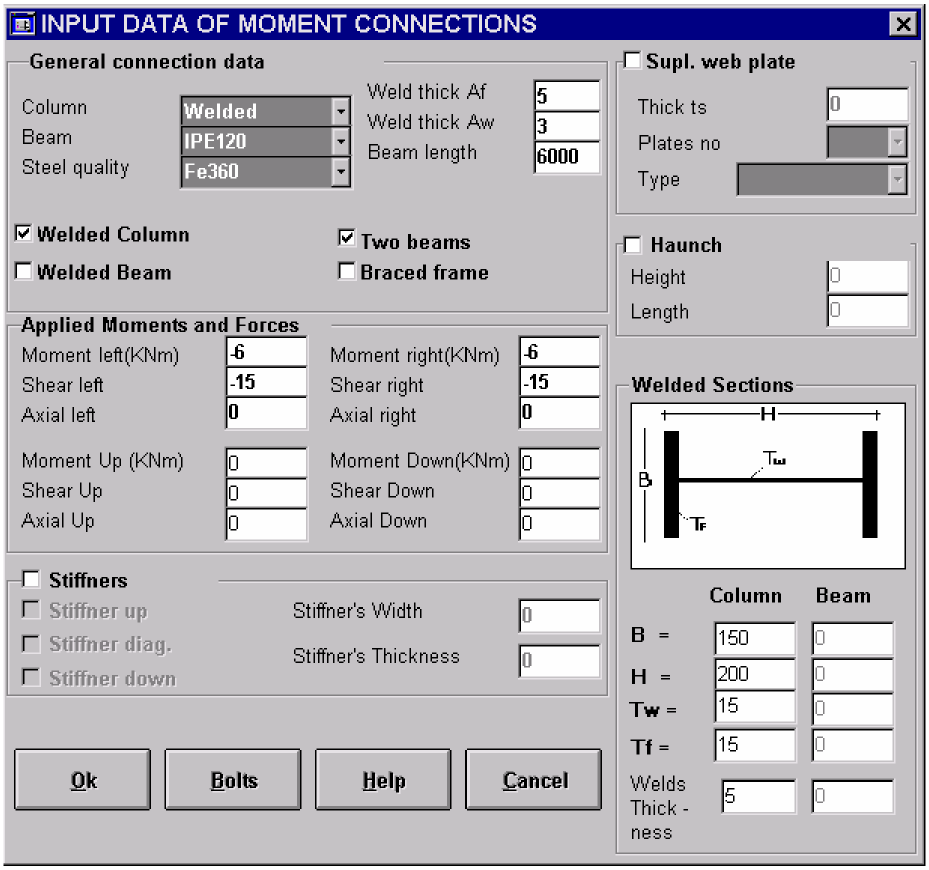


FIG. 6.2

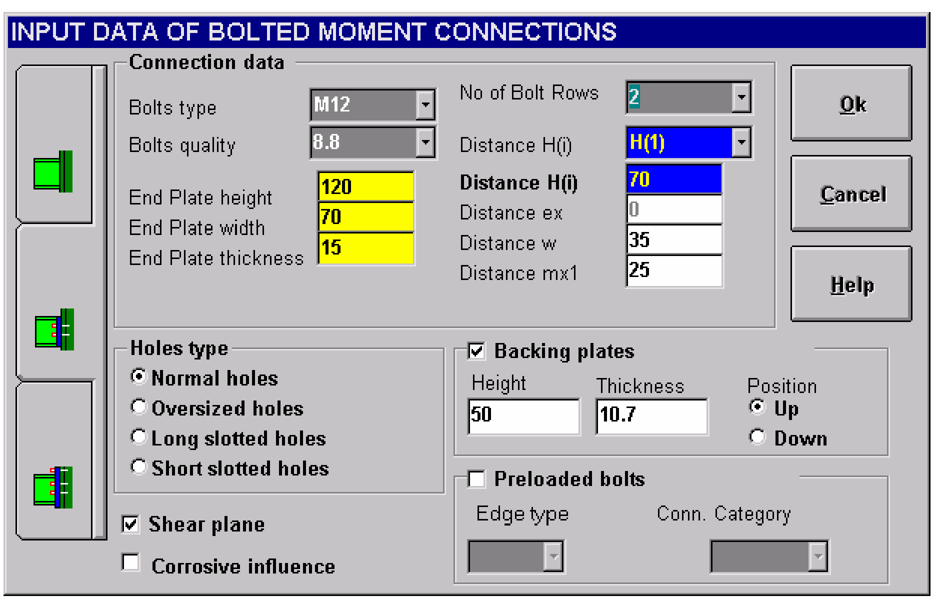
- The column will be given as welded so we can be sure that no check of its “basic components” will be critical.
- The supporting beam (IPE 200) will be represented by the backing plates. When checking the first bolt row area in bearing, the program takes in consideration the thinner plate(end plate, flange or backing plate). If the backing plate has a thickness equal to the thickness of the supporting beam’s web, then the check will be the same as checking the supporting beam’s web in bearing, which as a matter of speaking is the only one we need to do for this beam.

- For a IPE 200 beam we have (from tables) 10.7mm web's thickness. This is the thickness of the backing plates for our model.

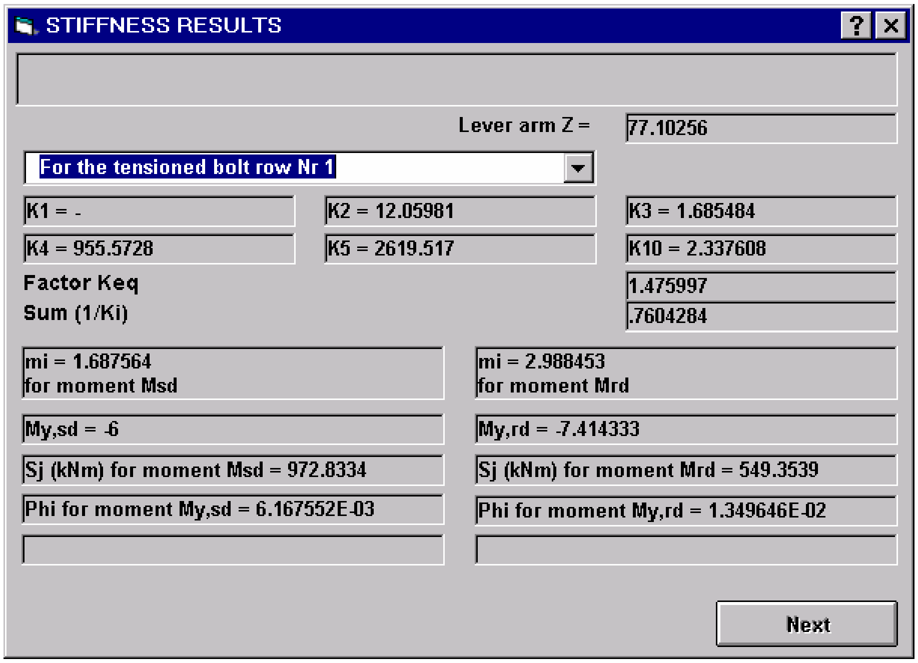
The Input Data form must look like this:

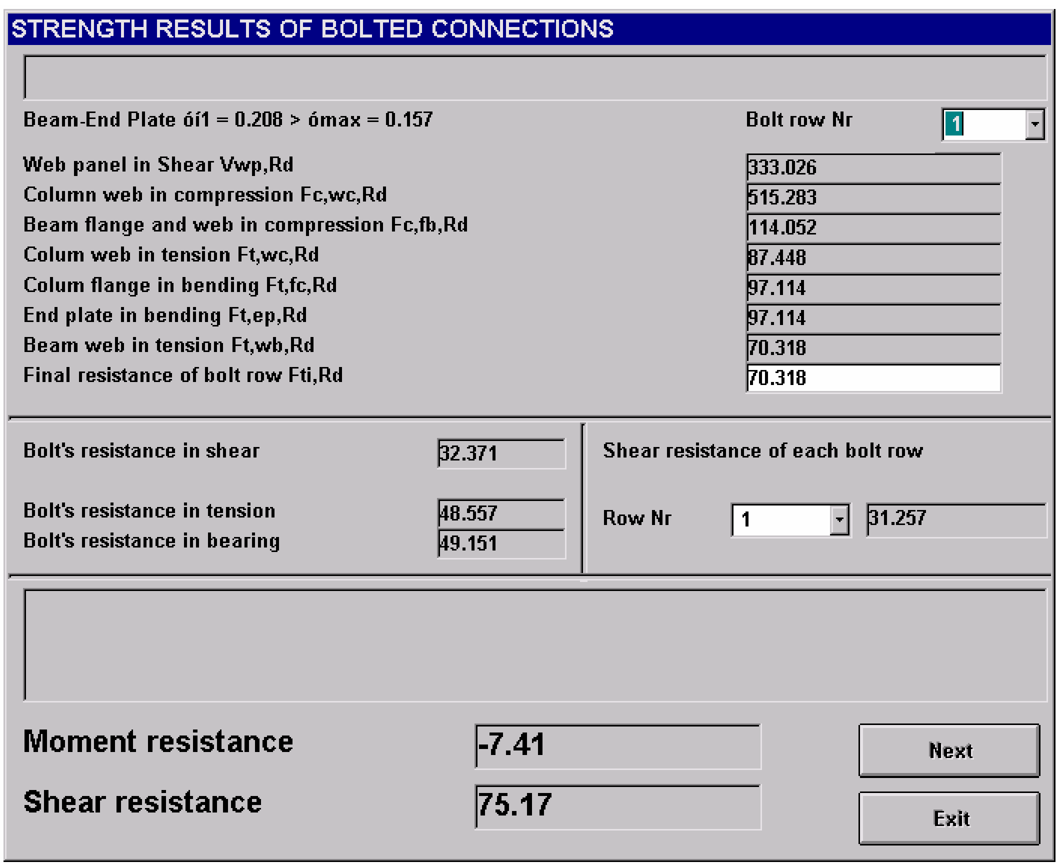


And the bolts data:

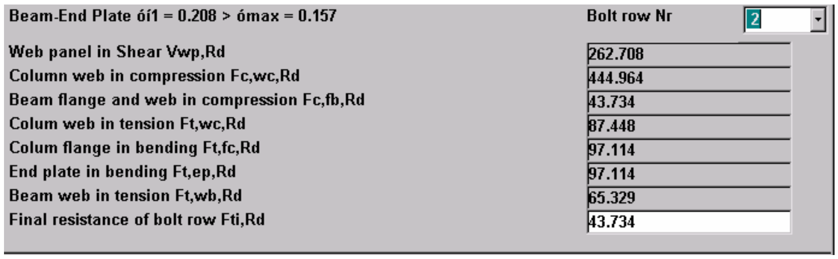


After the end of the input data procedure we can see the results





For the first bolt row the beam’s web in tension check is critical.



Beam-End Plate óí1 = 0.208 > ómax = 0.157	Bolt row Nr 2
Web panel in Shear Vwp,Rd	262.708
Column web in compression Fc,wc,Rd	444.964
Beam flange and web in compression Fc,fb,Rd	43.734
Colum web in tension Ft,wc,Rd	87.448
Colum flange in bending Ft,fc,Rd	97.114
End plate in bending Ft,ep,Rd	97.114
Beam web in tension Ft,wb,Rd	65.329
Final resistance of bolt row Fti,Rd	43.734

For the second bolt row the beam’s flange and web in compression check is critical. Since no check of the column’s basic components is critical for the connection, the model may represent the real connection and the results can be evaluated.

DATA

```
DATA OF COLUMN
Type....................................................... Welded
Steel grade.................................................. Fe360
Height....................................................... 200 mm
Width........................................................ 150 mm
Web thickness................................................. 15 mm
Flange thickness.............................................. 15 mm
DATA OF BEAM
Type....................................................... IPE120
Steel grade.................................................. Fe360
Height....................................................... 120 mm
Width......................................................... 64 mm
Web thickness................................................ 4.4 mm
Flange thickness............................................. 6.3 mm
CONNECTION DETAILS
Connection type........................ Beam to column connection
Number of Beams................................................ 2
Steel grade.................................................. Fe360
End plate's Height........................................... 120 mm
End plate's Width............................................. 70 mm
End plate's Thickness......................................... 15 mm
Distance from top of end plate to top of beam................. 25 mm
Weld thickness Af.............................................. 5 mm
Weld thickness Aw.............................................. 3 mm
DETAILS OF BACK PLATE
Steel grade.................................................. Fe360
Plate's height................................................ 50 mm
Plate's width............................................... 49.5 mm
Plate's thickness........................................... 10.7 mm

BOLTS GROUP ON COLUMN
Bolts type..................................................... M12
Bolt's steel grade............................................. 8.8
Distance W.................................................... 35 mm
Edge distance................................................. 35 mm
Distance H(1)................................................. 70 mm
Top edge distance............................................. 25 mm
Bottom edge distance.......................................... 25 mm
Number of bolts rows............................................ 2
Number of bolts columns......................................... 2
```

RESULTS

```
CONNECTION'S STRENGTH RESULTS
Tension resistance Ftr,Rd of bolt-row  1...................  70.32 kN
Tension resistance Ftr,Rd of bolt-row  2...................  43.73 kN
Bolt's resistance in Tension =............................ 48.557 kN
Bolt's resistance in Shear   =............................ 32.371 kN
Bolt's resistance in Bearing =............................ 49.151 kN

CONNECTION'S FINAL STRENGTH
Applied moment Msd =......................................  -6.00 KNm
Moment design resistance MRd =............................  -7.41 KNm
               THE CONNECTION RESISTS IN MOMENT
Applied shear Vsd =....................................... -15.00 kN
Shear design resistance VRd,b =...........................  75.17 kN
               THE CONNECTION RESISTS IN SHEAR
```

```
STRENGTH OF WELDS
Design strength of weld in Shear.........................  116.4770 kN
Design Shear Vsd is......................................  15.0000 kN
Design strength of weld in Tension.......................  113.8997 kN
Design Tension force Bfb*Tfb*Fy/gm0 is...................  86.1382 kN
The check of web's welds is OK
The check of flange's welds is OK
```

Example 7

Solve the connection of figure 7.1 for :

3) M_{sd} = -10 KNm and V_{sd} = -40 KN.

4) Find M_{Rd} and V_{Rd} for moments that cause tension at beam's lower flange.

Bolts type is M20, their quality is 8.8 and the steel quality for the connected members is Fe360

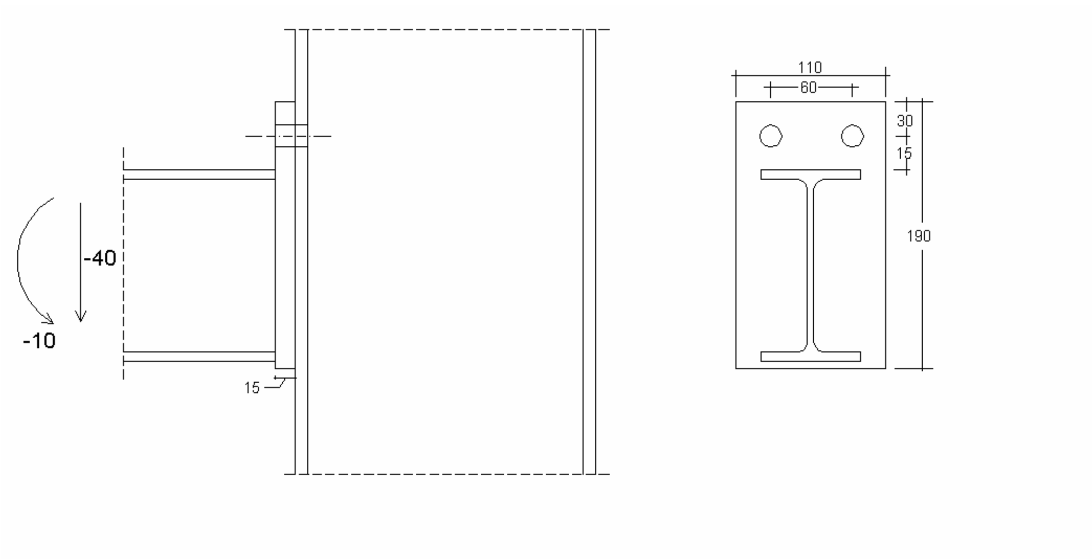
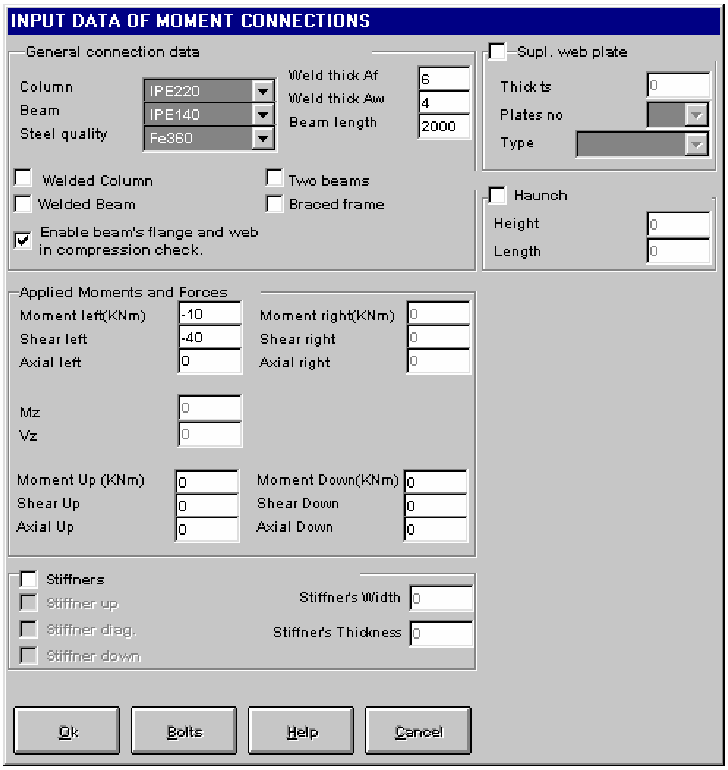


FIG. 7.1

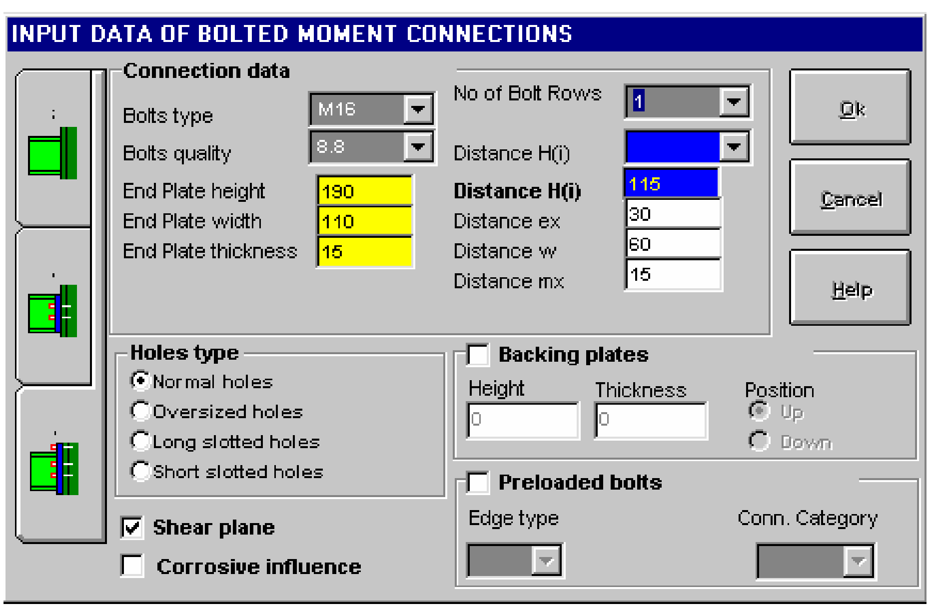
(1.)

First we must input the general data for the connection. The Input Data form must look like this :



NOTE : In the input data form the fields Mz and Vz are not enabled because the connection must have at least two bolt rows in order to have resistance in the minor axis of the cross section.

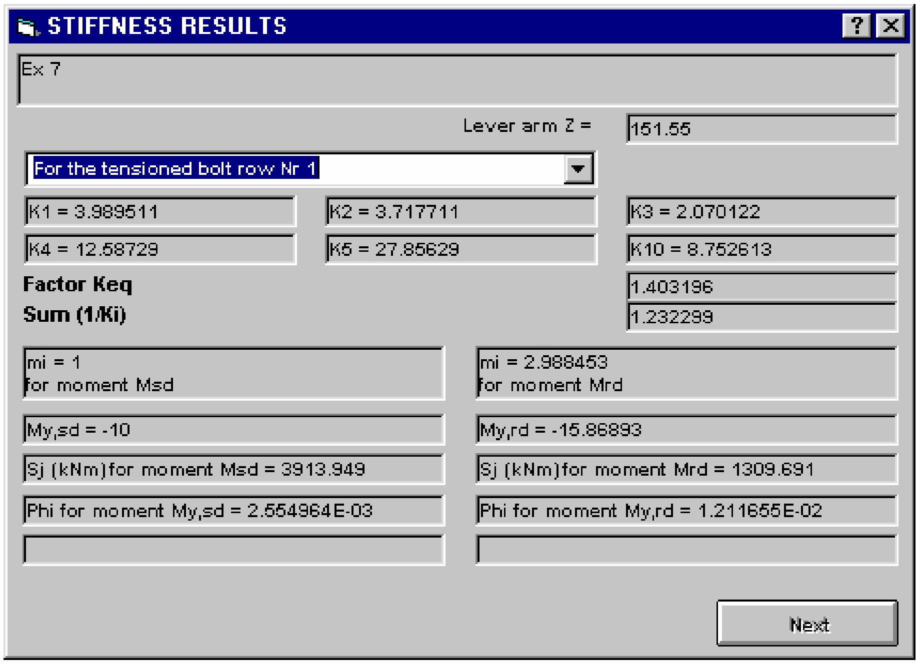
Then we must input the bolt's data .After clicking on **Bolts** we must fill in the appropriate values as shown below:



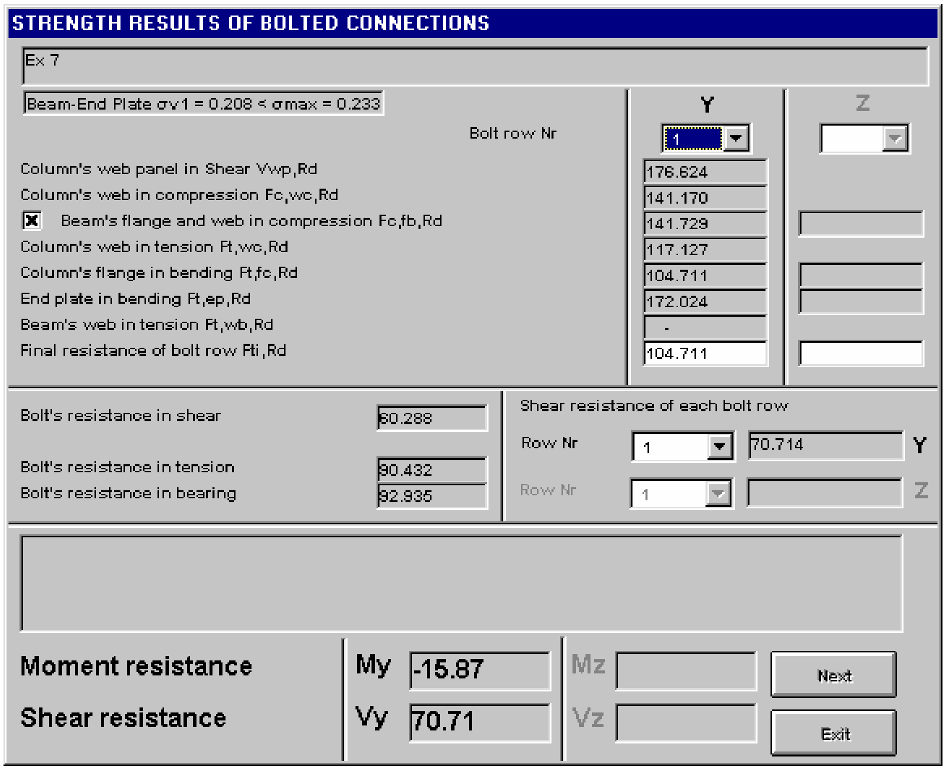
Note that for a one bolt row connection like this one, we have no H(i) distances

After entering all data we can click on **OK** to return to the Input Data form and on **OK** again to calculate the results.

By pressing the results button the Stiffness Results form appears:



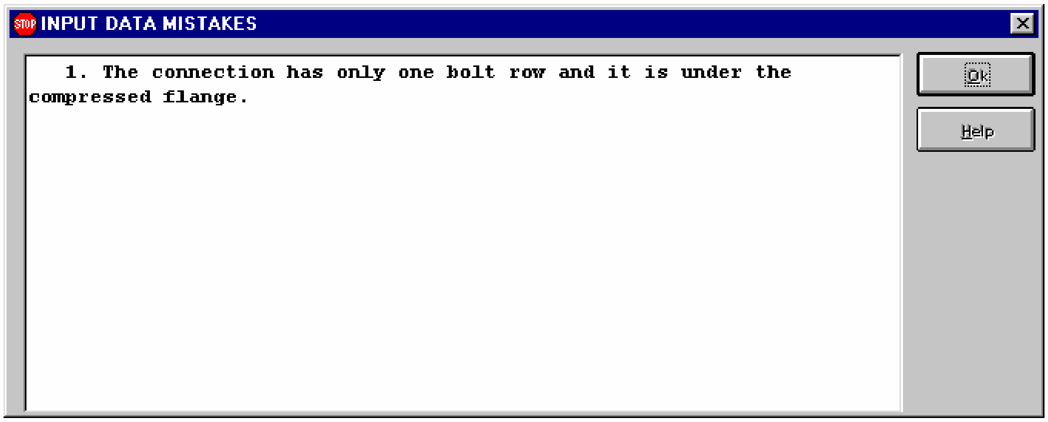
Then by pressing **Next** the Strength Results of the Bolted Connections form appears:


STRENGTH RESULTS OF BOLTED CONNECTIONS
Ex 7
Beam-End Plate σv1 = 0.208 < σmax = 0.233
Y
Z
Bolt row Nr
1
Column's web panel in Shear Vwp,Rd
176.624
Column's web in compression Fc,wc,Rd
141.170
Beam's flange and web in compression Fc,fb,Rd
141.729
Column's web in tension Ft,wc,Rd
117.127
Column's flange in bending Ft,fc,Rd
104.711
End plate in bending Ft,ep,Rd
172.024
Beam's web in tension Ft,wb,Rd
-
Final resistance of bolt row Fti,Rd
104.711
Bolt's resistance in shear
60.288
Bolt's resistance in tension
90.432
Bolt's resistance in bearing
92.935
Shear resistance of each bolt row
Row Nr
1
70.714
Y
Row Nr
1
Z
Moment resistance
My
-15.87
Mz
Shear resistance
Vy
70.71
Vz
Next
Exit

(2.)

To solve the connection for moments that cause tension in the beam's lower flange we must simply load the left beam with a random positive moment (i.e. +1KNm). All the other data of the connection remain the same.

As soon as we press the OK button we get the following error message



An Extended end Plate connection with only one bolt row cannot resist positive moments because the position of the single bolt row is under the "compressed flange" of the beam.

Example 8

Solve the connection of figure 8.1 for :

5) M_{sd} = -6 KNm and V_{sd} = -15 KN.

6) Find M_{Rd} and V_{Rd} for moments that cause tension at beam's lower flange.

Bolts type is M20, their quality is 8.8 and the steel quality for the connected members is Fe360

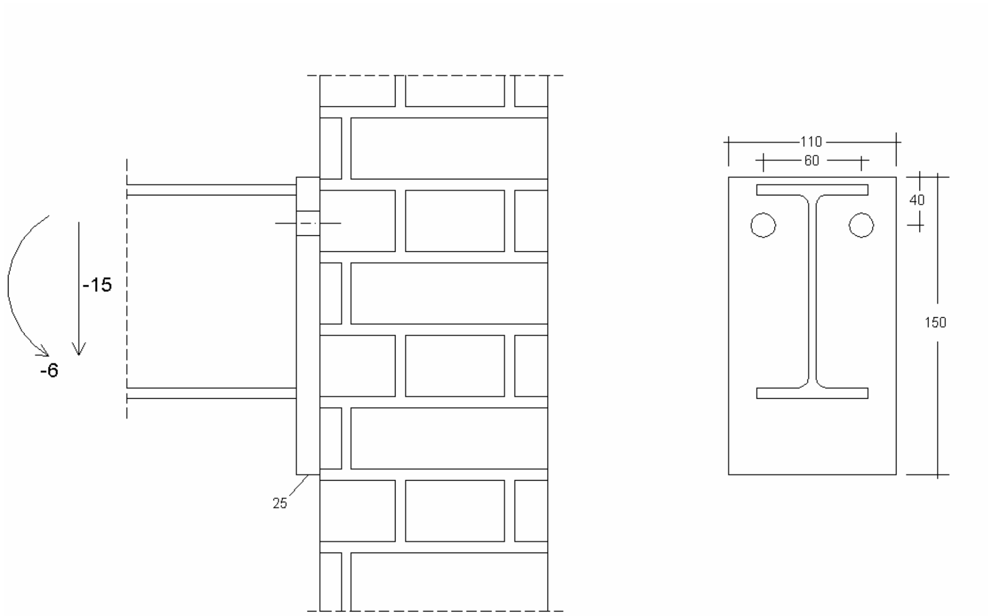


FIG. 8.1

To transform the connection to a type compatible with Steel Connections V1.0 we shall create the following model:

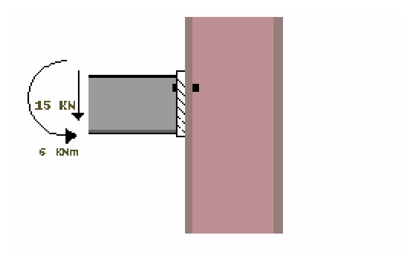
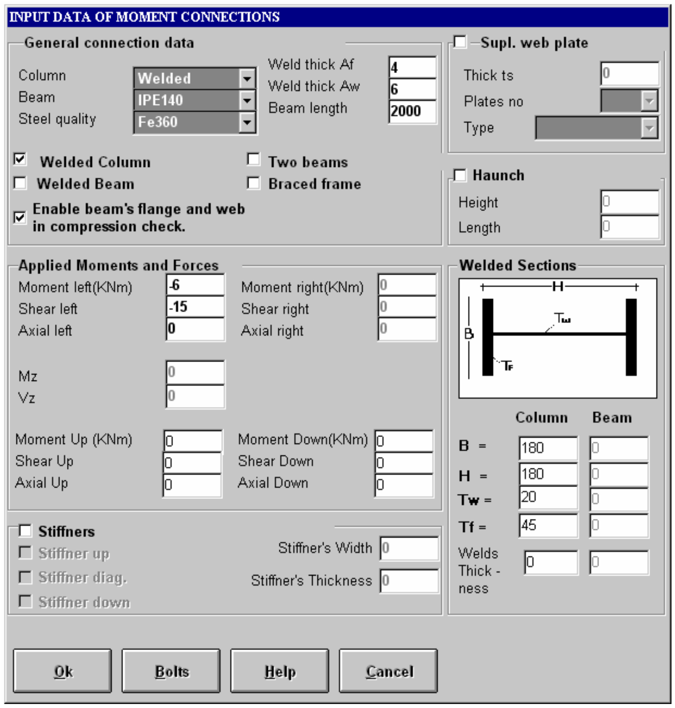


FIG. 8.2

- The wall will be given as welded column with very big cross section dimensions in order to be sure that no check of its “basic components” will be critical.

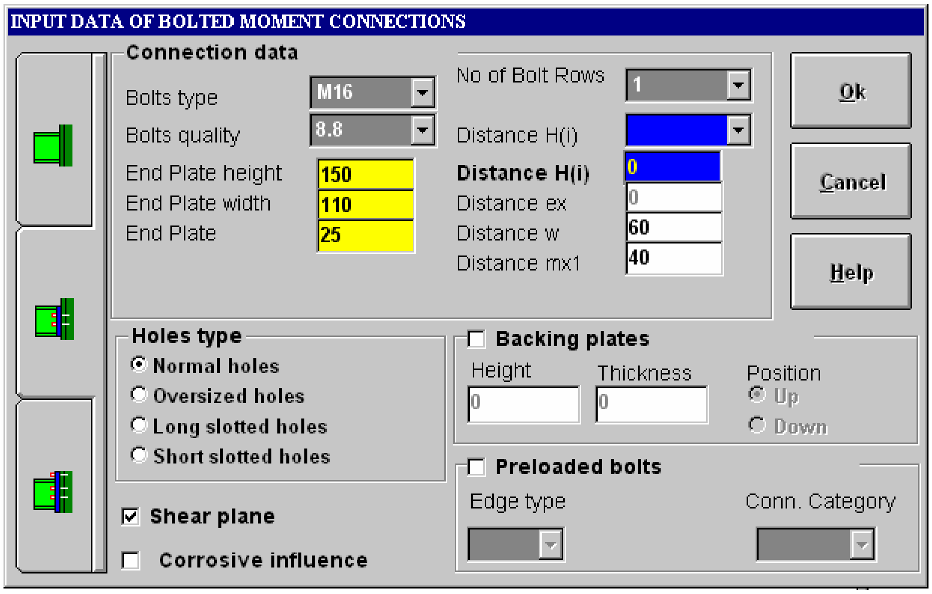
(1.)

First we must input the general data for the connection. The Input Data form must look like this :



NOTE : In the input data form the fields Mz and Vz are not enabled because the connection must have at least two bolt rows in order to have resistance in the minor axis of the cross section.

Then we must input the bolt’s data .After clicking on **Bolts** we must fill in the appropriate values as shown below:


INPUT DATA OF BOLTED MOMENT CONNECTIONS
Connection data
Bolts type
M16
Bolts quality
8.8
End Plate height
150
End Plate width
110
End Plate
25
No of Bolt Rows
1
Distance H(i)
Distance H(i)
0
Distance ex
0
Distance w
60
Distance mx1
40
Ok
Cancel
Help
Holes type
Normal holes
Oversized holes
Long slotted holes
Short slotted holes
Backing plates
Height
0
Thickness
0
Position
Up
Down
Preloaded bolts
Edge type
Conn. Category
Shear plane
Corrosive influence

After entering all data we can click on **OK** to return to the Input Data form and on **OK** again to calculate the results.

All the following steps for viewing and printing the analysis results are the same as in Example 7.

(2.)

To solve the connection for moments that cause tension in the beam's lower flange we must simply load the left beam with a random positive moment (i.e +1KNm). All the other data of the connection remain the same.

NOTE : A flash end Plate connection with only one bolt row can resist positive moments because the position of the single bolt row is over the "compressed flange" of the beam. Of course we must expected very small design moment resistance (at least in typical connections) because of the small lever arm Z (fig.8.3). For the particular example the values of design resistance moment is M_{Rd}=4.81kNm and the value for design resistance in shear is V_{Rd}=57.90kN.

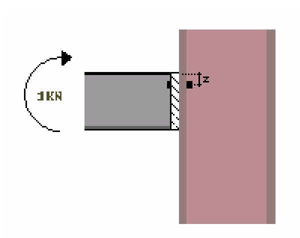


FIG. 8.3

Example 9

Find the moment and shear resistance of the bolted connection of the joint shown in figure 9.1. The column is HEA 140, the beam is a IPE 140 and the angle cleat is a 100X50X10.

Bolts type is M12, their quality is 8.8 and the steel quality of the connected members is Fe360.

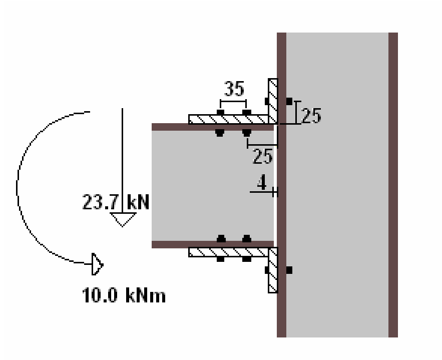
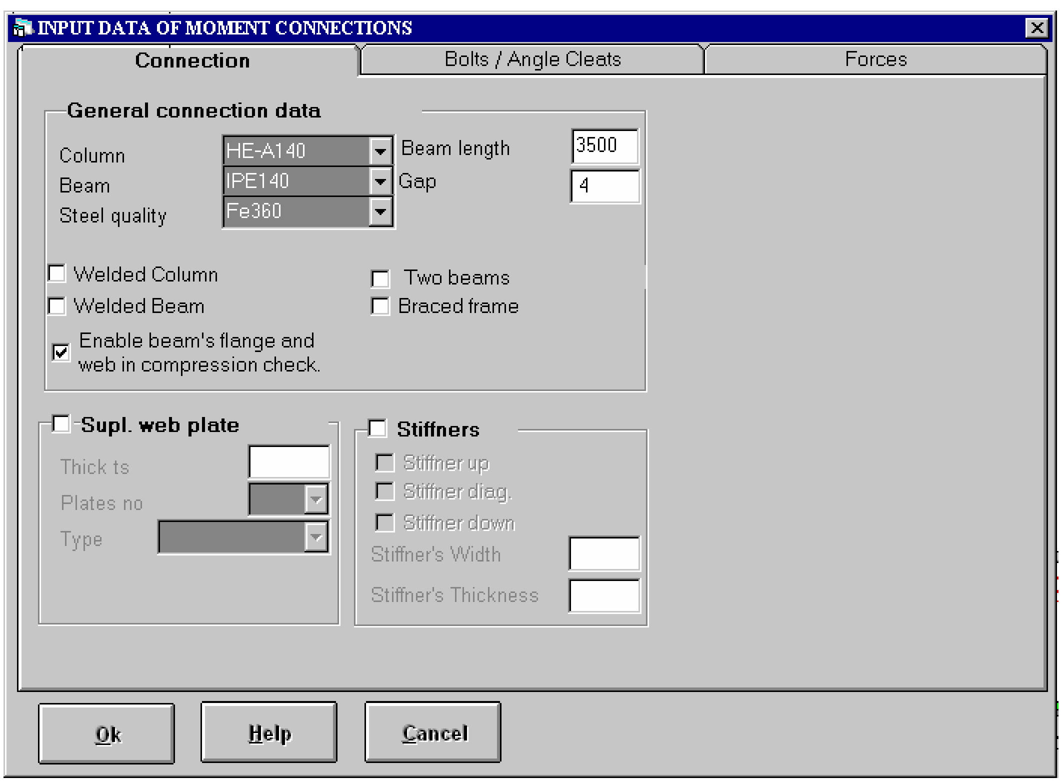


Fig. 9.1

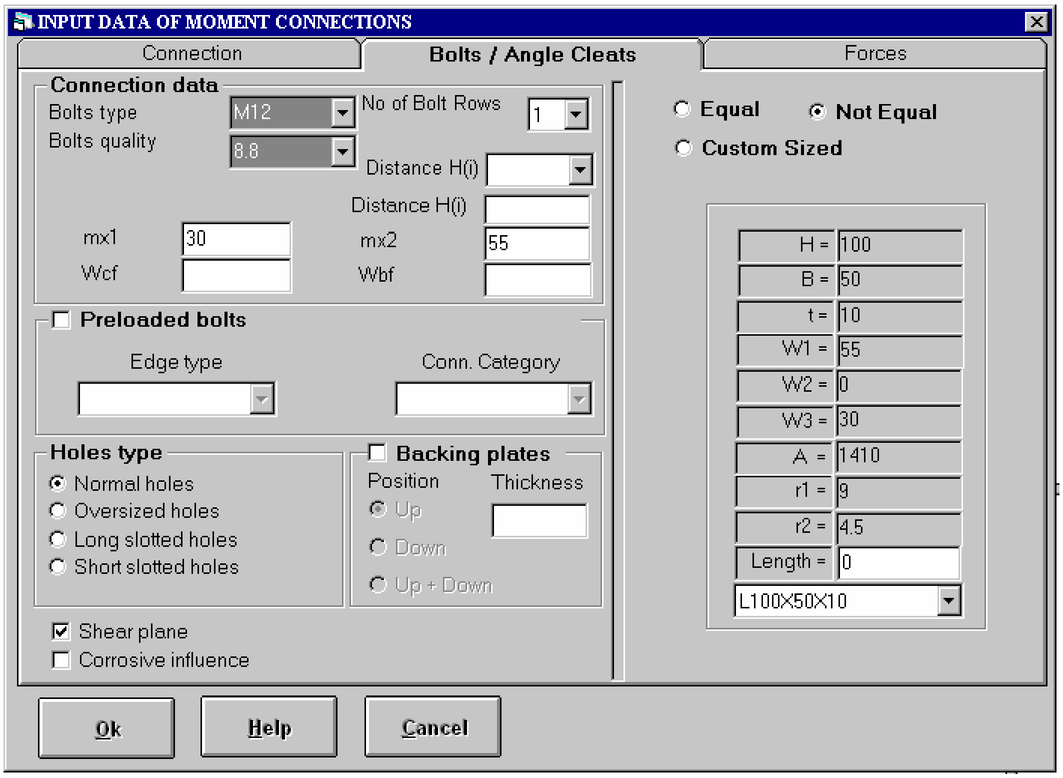
The Input Data form for this example must look like this:



Then we shall press the “Bolts/Angle Cleats” Tab to enter the rest of the data

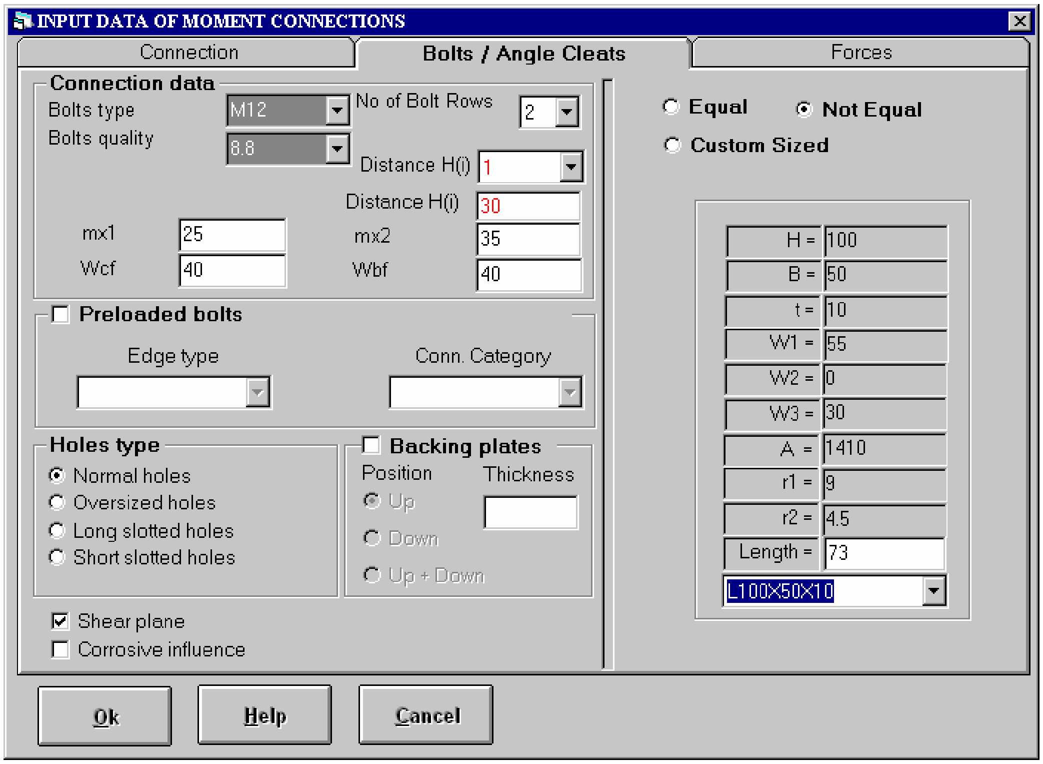
First we select the “Not Equal” option and then the cleat 100X50X10. Then we select the bolts type M12 of 8.8 quality.

The input data form will look like this:



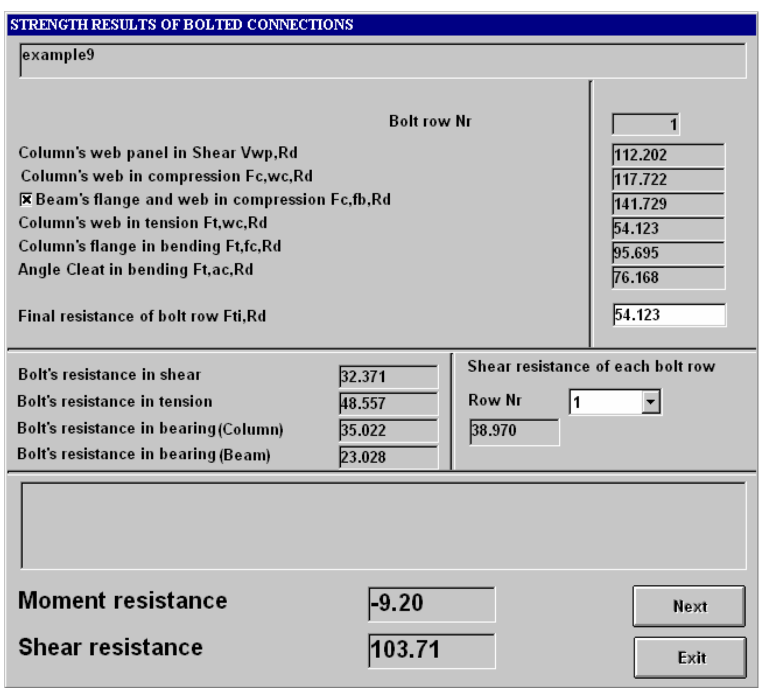
The program automatically fills all the fields with the values found in the angle cleats database. But we are not obliged to keep these values.

So we shall increase the number of bolt rows from 1 to 2 and determine the other dimensions as in the form shown below:

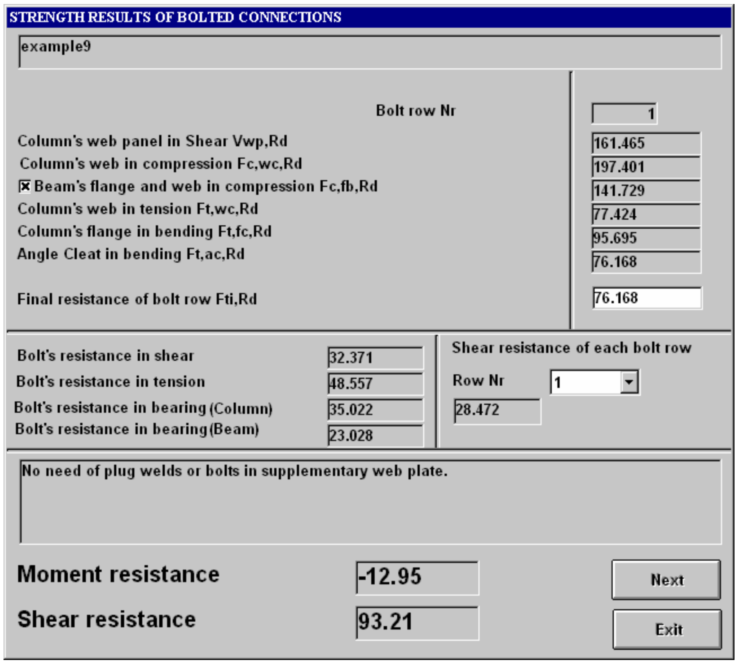


Then after entering the forces of the connection we press OK to solve.

After showing the results form we see that the connection can not resist the applied moment, as you can see below:



The critical check is the one of the column's web in tension. So we can reinforce the connection by adding a supplementary web plate with 8mm thickness as shown below:



Now the connection resists the applied moment. It is important to note that the column's web in tension check is not any more the critical one. Now the angle cleat is failing, and if we wanted to reinforce it again we should change the angle cleat type.

Example 10

Check if the base plate connection in fig 1.1 resists the following applied moments and forces M=44kNm , V= 25kN, N=120kN. Anchors M30/S355.

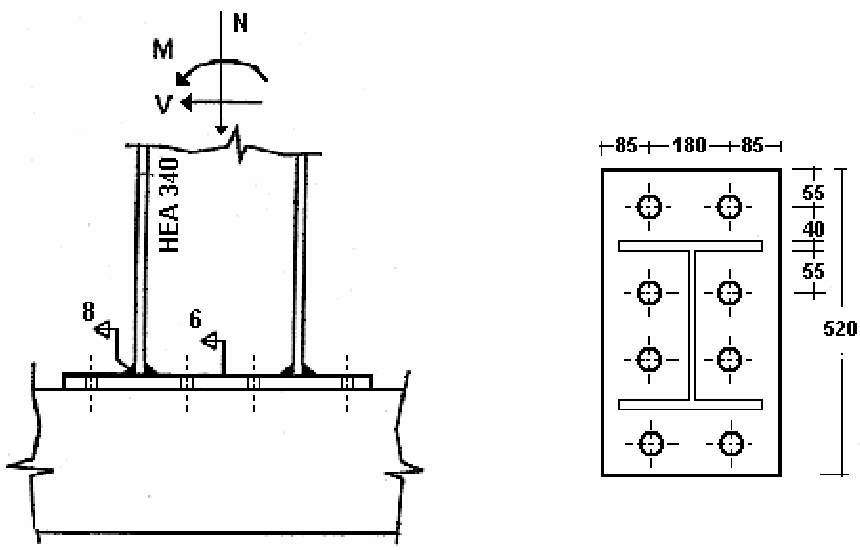
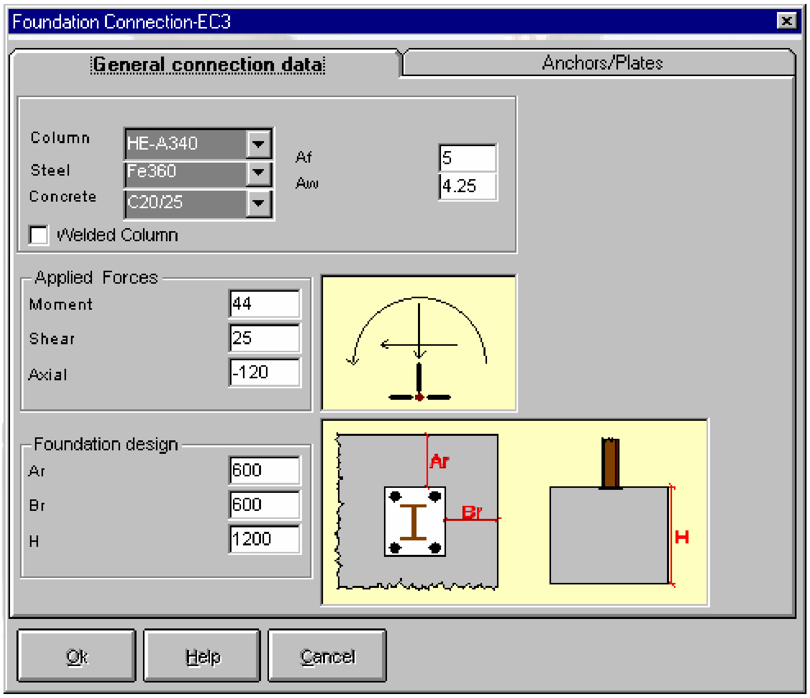
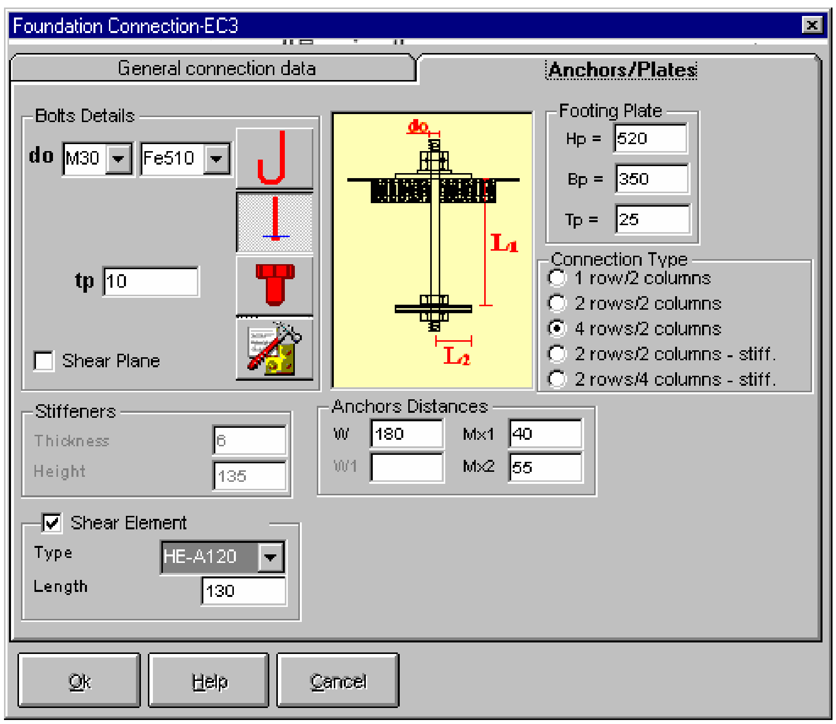


Fig 1.1

The Input Data forms according to the data of this example are the following:





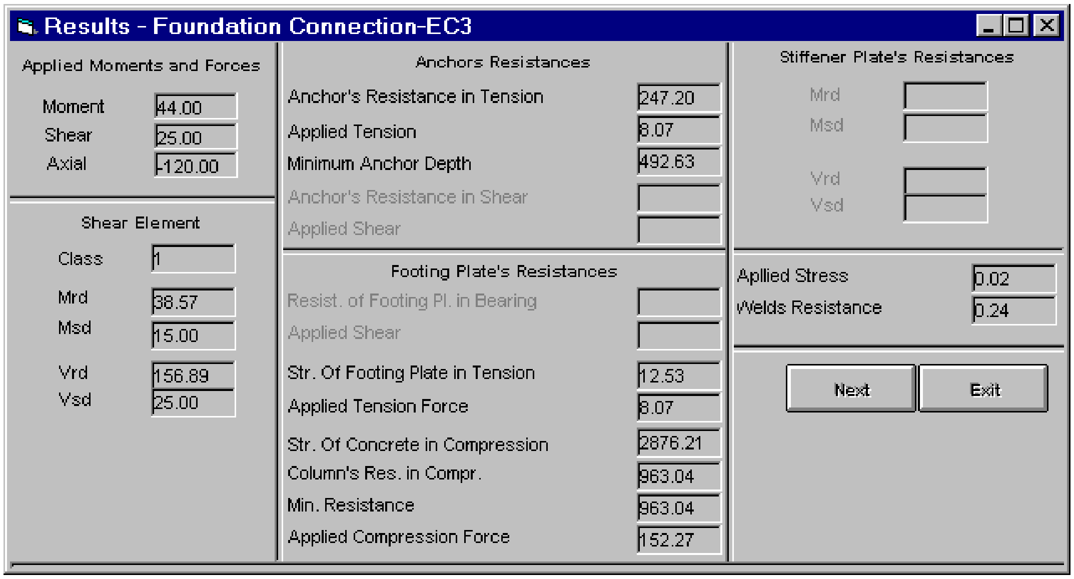
At the first (General connection data) form we define the general data of the connection like the cross section of the column and the quality of the material the dimensions of the concrete foundation and the applied moment and forces.

At the second (Anchors/Plates) form we define the type and the geometry of the connection, the type of anchors, the stiffeners and the shear element if they exist. Note that because of the double symmetric of the connection only the distances from the one flange of the column required.

In case the connection has a shear element all the shear force is considered to be applied on it.

If there is no shear element the program checks also the anchors in shear and the base plate in bearing. If the shear plane passes through the portioned part of the anchors (reduced shear area) then the user must define it by checking the appropriate text box.

By pressing the results button the Results form appears:



The resistance of the connection is checked by the resistance of its basic components.

As concerns the shear element the program classiffies its cross section and compares the resistance in moment and shear with the applied moment and shear force.

The resistance of one anchor in tension is compared with the applied tension force on it. The minimum allowed anchor depth is also calculated by the program.

The same way the strength of the base plate in tension is checked. For the resistance in compression zone of the connection the program finds the minimum value between the strength of the concrete and the strength oh the equivalent T-stub and compares it with the applied compression force.

Note that if one of the above mentioned checks fails the corresponding values are presented with red color.

Example 11

Hollow section joint composed from SHS cross sections.

Check the strength of the joint of the following figure if the overlap of the diagonal braces is λ_{ov} = 40 %, and the steel quality of the connected members is Fe 360.

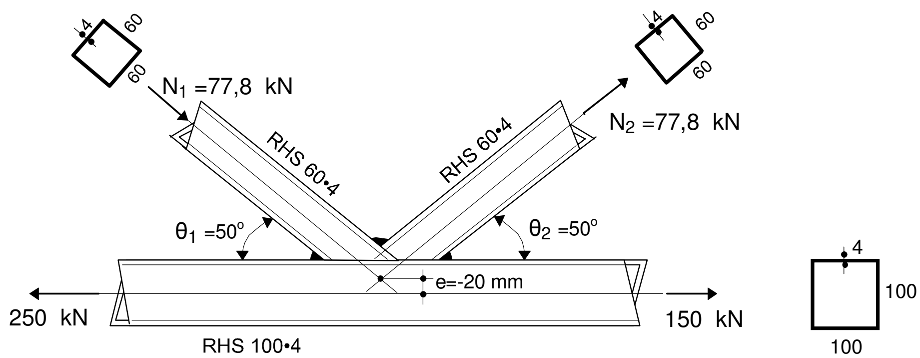


figure 1. Hollow section joint

Range of validity of the EC3.

$$\frac{b_i}{b_o} = \frac{60}{100} = 0{,}60 > 0{,}25$$

$$\frac{b_1}{t_1} = \frac{60}{4} = 15 < 1{,}1\sqrt{\frac{E}{f_{yi}}} = 1{,}1\cdot\sqrt{\frac{210000}{235}} = 32{,}9$$ (compression)

$$\frac{b_2}{t_2} = \frac{60}{4} = 15 < 35$$ (tension)

$$\frac{b_o}{t_o} = \frac{100}{4} = 25 < 35$$ (tension)

$$\frac{h_i}{b_i} = \frac{h_o}{b_o} = 1 \begin{array}{l} > 0{,}5 \\ < 2{,}0 \end{array}$$

25 % $<\lambda_{ov} = 40$ %< 100 %, and

$$\frac{b_1}{b_2} = \frac{60}{60} = 1 > 0{,}75$$

From the above we conclude that the joint is in the range of validity of the EC3

Cross sections category 1 (pure comression)

$f_y = 235$ N/mm^2 < 355 N/mm^2

$t_i = 4$ mm > 2,5 mm

$t_o = 4$ mm < 25 mm

min$\theta_I = 30{,}96^o > 30^o$

e = –20 mm > –0,55 d_o = –0,55 · 100 = –55 mm

(we can ignore the moments resulting from the eccentricity).

Resistance of the joint according to EC3 (table 7.10).

We have to check only the overlapping braced member.

$$b_{eff} = \frac{10}{\frac{100}{4}} \cdot \frac{235 \cdot 4}{235 \cdot 4} \cdot 60 = 24 \text{ mm} < 60 \text{ mm}$$

$$b_{e,ov} = \frac{10}{\frac{60}{4}} \cdot \frac{60 \cdot 4}{60 \cdot 4} \cdot 60 = 40 \text{ mm} < 60 \text{ mm}$$

$k_n = 1,0$ (tension)

for : ($25\ \% < \lambda_{ov} = 40\ \% < 50\ \%$)

$$N_{2,Rd} = 23,5 \cdot 0,4 \cdot \left[2,4 + 4 + \frac{40}{50} \cdot (2 \cdot 6 - 4 \cdot 0,4) \right] \frac{1,10}{1,10} = 138,4 \text{ kN} > 77,8 \text{ kN}$$

For steel quality Fe 360 :

$$\frac{\alpha}{t} = \frac{3,5}{4} = 0,875 > 0,84 \ \alpha = 0,84$$

The resistance of the joint and the welds is sufficient.

Installation Instructions.

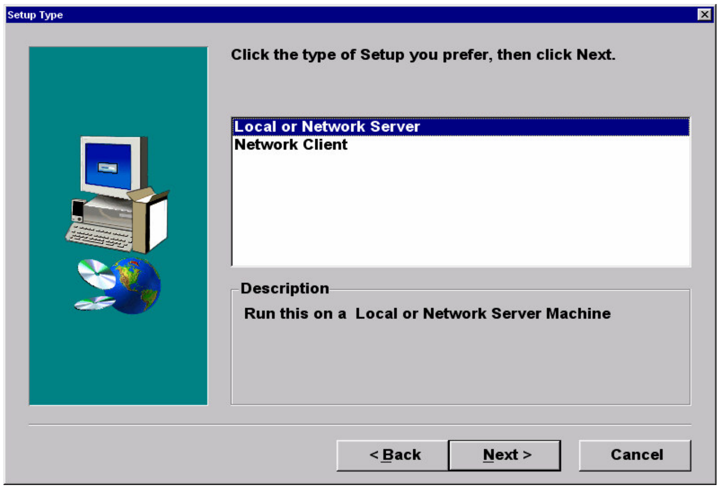
1. Insert the installation CD into the CD-ROM drive.

2. If AutoRun is enabled on your system, the Steel Connections Autoplay form will appear on your screen. Otherwise, double click the 'My Computer' Icon on your Windows Desktop, then Right-click on your CD-ROM drive icon and click **Autoplay.**

3. Click on the **Installieren** Button to proceed with the installation or otherwise click on the **Abort** Button to abort the Installation.

4. Follow the instructions on screen to complete the installation.

5. When the Setup type form appears:



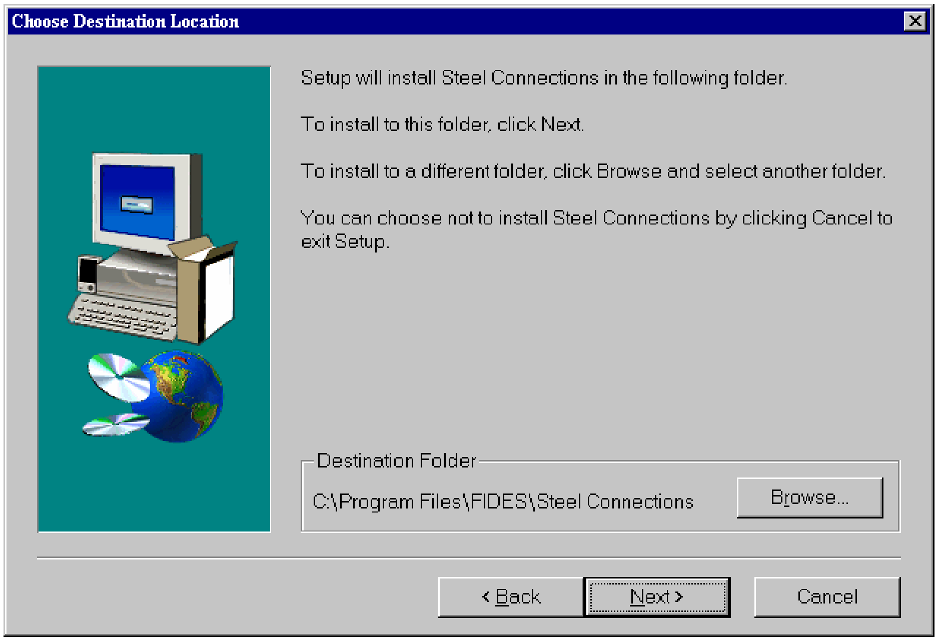
Choose according to the following description:

- If you are installing Steel Connections to run from a single computer (that is having obtained a *demo* or *local* license) Or if you are installing the Server portion of a Network Installation choose *Local or Network Server*.

- If you are installing a Steel Connections Network client, choose *Network client*.

Next one of two forms appear according to the kind of installation we choose to perform in the previous step.

- If you have chosen *Local or Network Server* the following screen prompts you for a destination folder where the steel Connections files will be installed



- If you have chosen *Network client* the following screen prompts you for the folder on the server where the Steel Connections (Network server installation) application resides

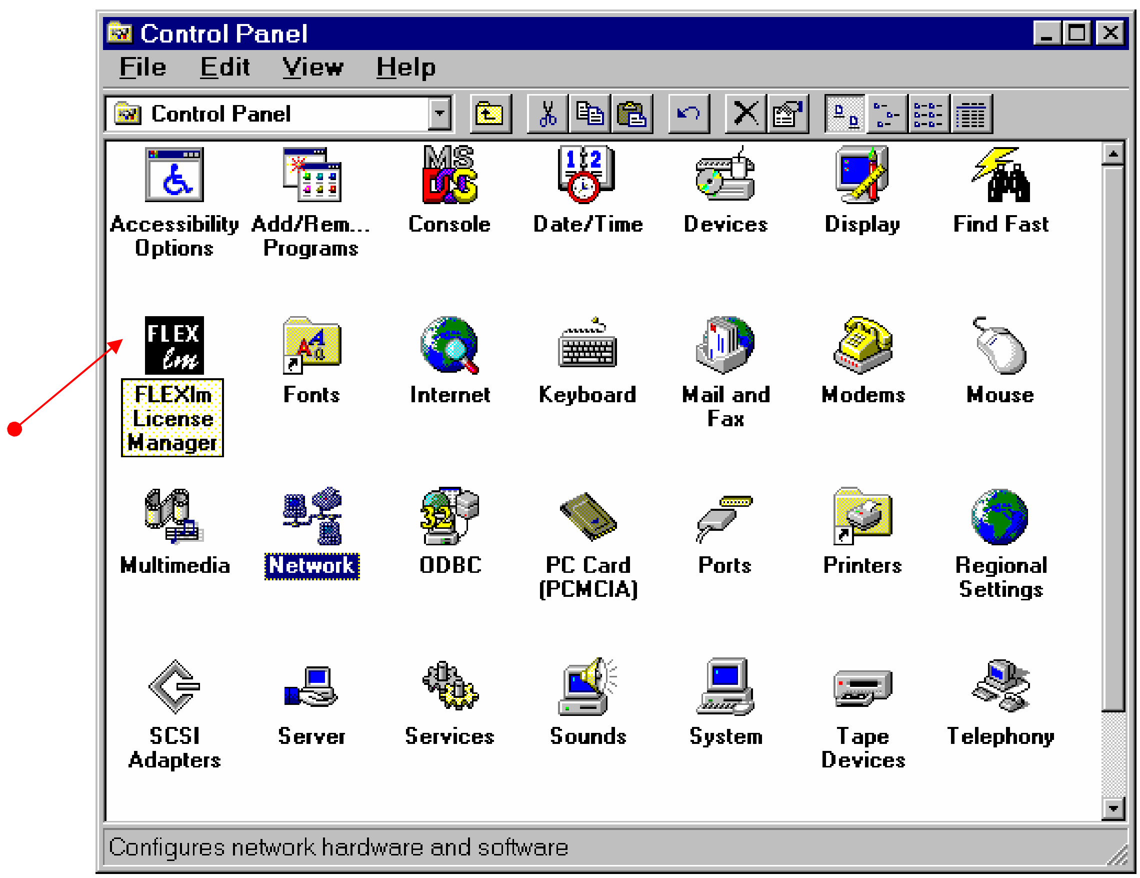
The selection of this folder is needed in order to create the shortcuts at your desktop and start menu. If you like you can omit this step and manually create the shortcuts later.

SETTING UP YOUR APPLICATION IN THE NETWORK

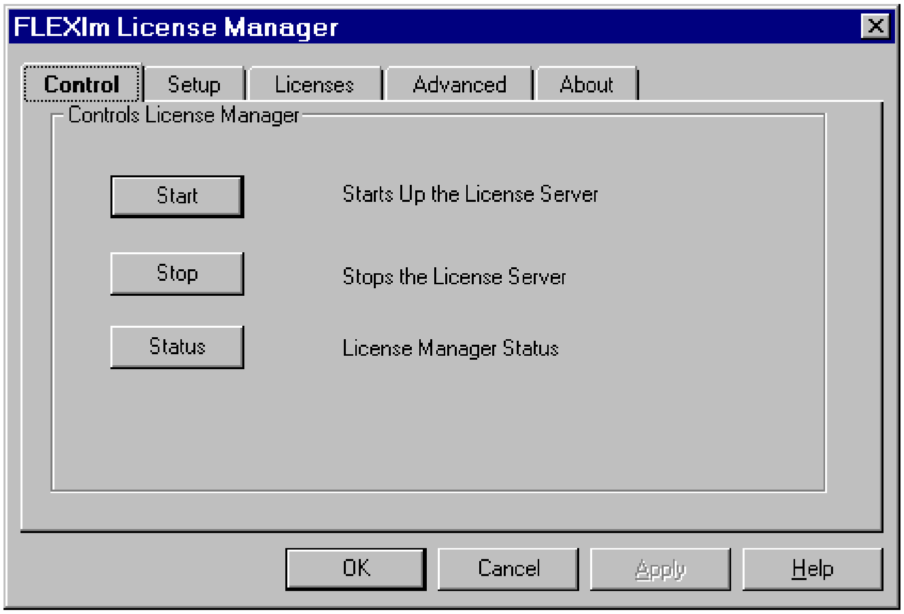
In case you have purchased the multi user version of the program, you will have to set up the authentication and licensensing checking on your license server computer first, before running the application. The license Checking software relies on the TCP/IP protocol to ferry license information through your network, so before doing anything else, you will have to set up TCP/IP for every workstation that is going to run the application. Please refer to your operating System Manual for Details on that procedure.

To configure the license Checking Software you'll have to start the licensing checker control center utility provided with your setup disks, which is installed in your system as a control panel application.

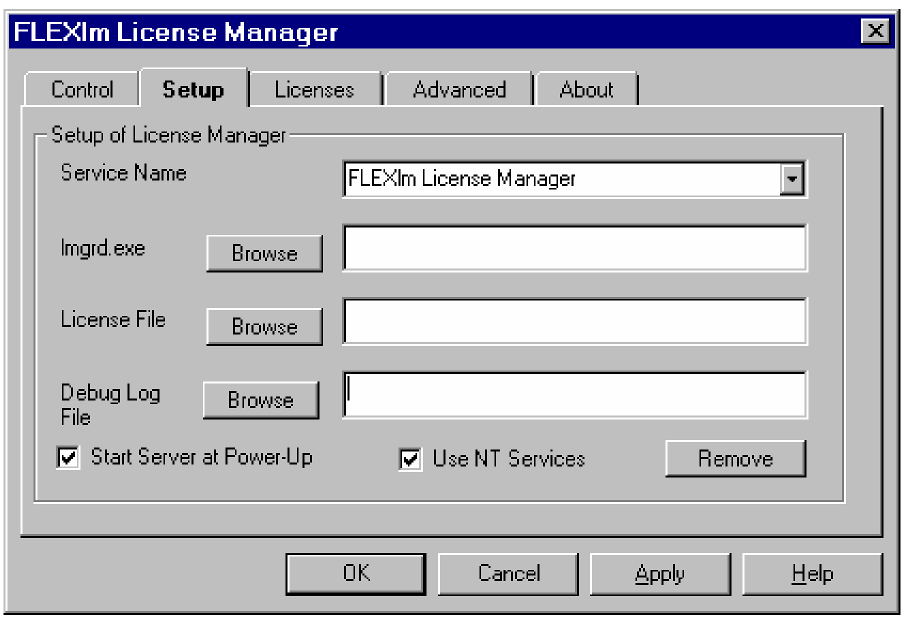
Start control panel (Start Menu\Settings\Control Panel) double click on the FLEXlm License Manager icon as seen in the following screen shot.



And the Flexlm control centre will appear on your screen:



Click on the Setup tab and you will see the following card:



Then you will have to fill in the fields for lmgrd.exe, License File and Debug Log File.

The first two files are located in the \Protect directory under the directory you chose to install the application (\Program Files\Fides\Steel Connections\ by default). The log file is created the first time you start the licensing checker.

You can click on the Browse button and locate the files by a standard open file dialog

Or type the complete pathname of the files in the corresponding fields.

Note that after using Browse to locate a file, locating the rest in same way starts the open file dialog in the same directory chosen before.

After providing this information you must check out:

- Both the *Start Server at Power-Up* and Use NT Services check boxes if your system is Windows NT and you would like to start the license checker automatically every time you start your computer or only the *Use NT Services* check box in case you like to start the license checker manually before starting the application

- Or only the *Start Server at Power-Up* check box if your System is Windows 95 and you would like to start the license checker automatically every time you start your computer.

Note that in that case the *Use NT Services* check box is grayed out and cannot be checked.

You can stop the automatic startup of the license checker at any later time by starting the Licensing checker control centre, going to the Setup tab and pressing the Remove button.

After doing all that, you must press the Apply button in order to make changes permanent. The control utility will prompt you with a Yes, No, Cancel message box,

Press the Yes button to complete the action.

That's all you need to do to set up the license checker. You can now either restart your computer in order to start the license checker (if you chose the Start Server at Power-Up option) or press the control tab on the license checker control centre window in order to manually control the license checker.

As you can see in figure 2 there are 3 buttons in the control tab:

- Start : starts the license checker
- Stop : stops the license checker
- Status : Checks the status of the license checker

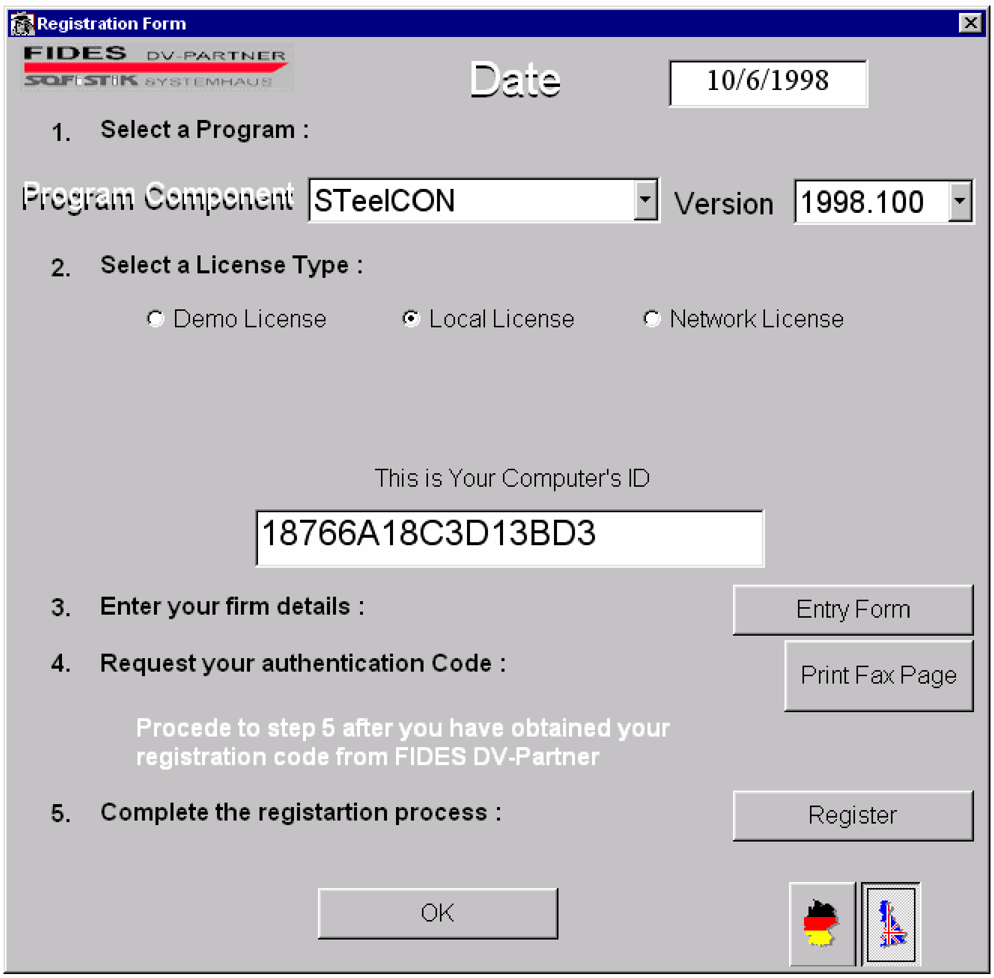
Note: Clicking on the License Tab of the license checker control centre lets you edit your license in Notepad. DO NOT change your license file unless you know what you 're doing. Modifying your license file may render it useless and prevent the application from starting. Handling of the license file is done through the special application supplied with your installation CD.

STARTING THE APPLICATION FOR THE FIRST TIME

After setting up the license checker you may try to launch the application by clicking on its icon on the programs section of start menu. Every time the application starts, it tries to validate your license. In case it can't do so it displays a message describing what it thinks went wrong.

If something is wrong with your license or if you are starting the application for the first time you must (re)enable your license by starting Mr. Register (register.exe) located in the \protect folder under the folder you installed your application.

This has the following form:



You must enter the required information in the fields to reflect your correct license in case it is damaged or you can specify a new license adding or even removing permissions. That is provided you own a license key to validate that you really have the right to use what you asked for.

You can choose from the following 3 basic license styles:

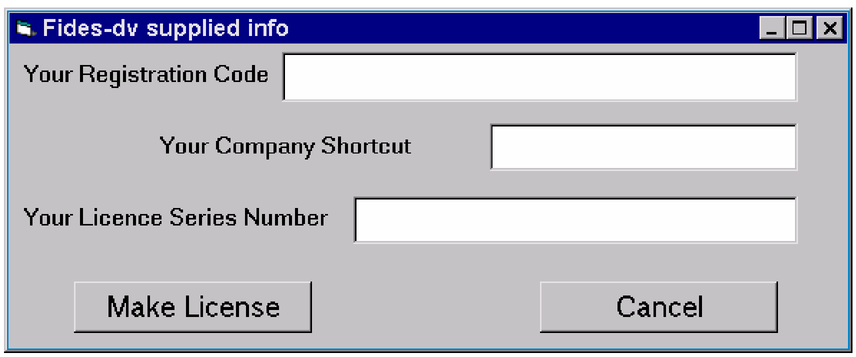
Demo: A license expiring in 6 weeks.

Local: A license for a single computer.

Network: A license for many computers running from a central Server also used for license checking.

- You must type in a valid date if you go for a Demo license
- Your Server computer name or better its IP address and how many network licenses you want If you go for a Network license

After filling the fields you can press the Register Button and the following form appears:



Here you fill in info supplied by us after we have received a letter/FAX with your request.

By pressing print on the first form a third one appears with all of your details to fill in and print your request by clicking the print button so you can fax it to us and we will sent you your registration Code, your company Shortcut and your license serial number which you can enter in the appropriate field of the previous form and get your application ready to start.