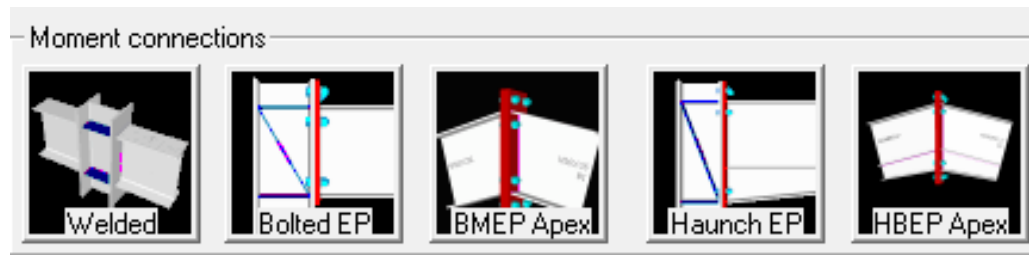
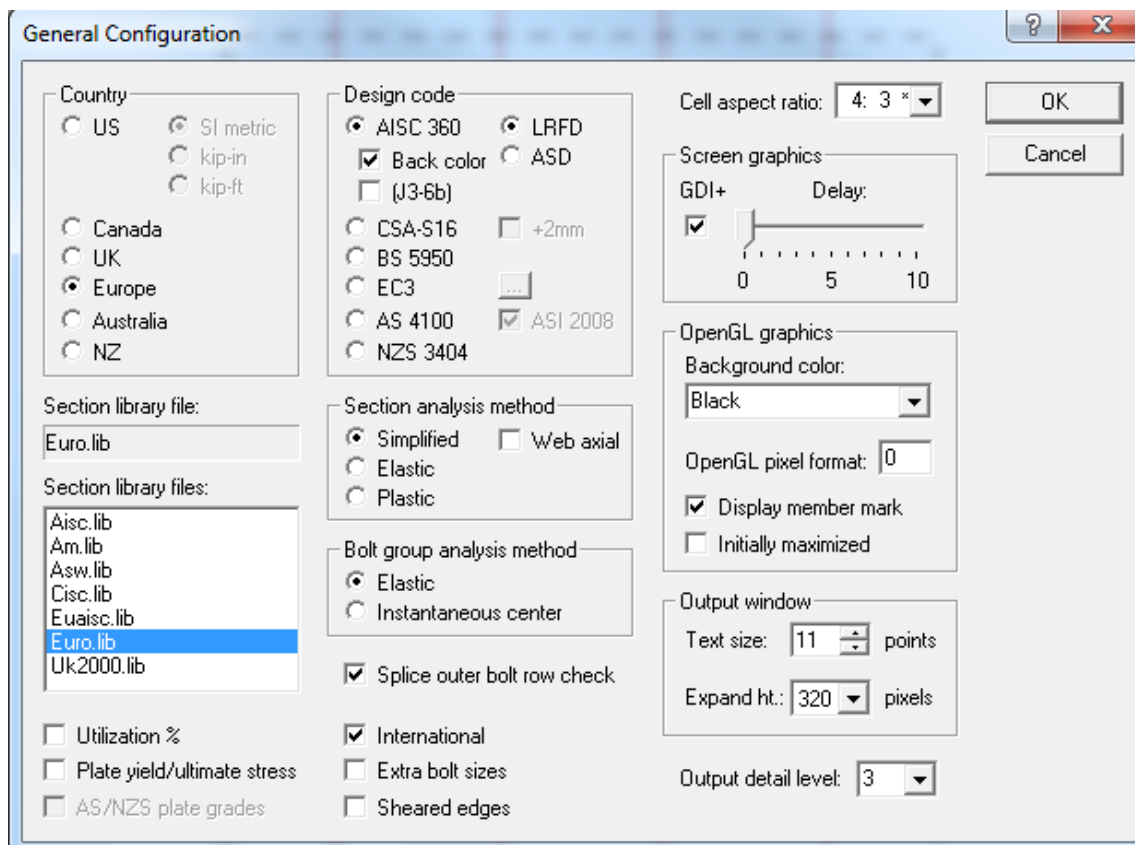


4. Uniones empotradas.

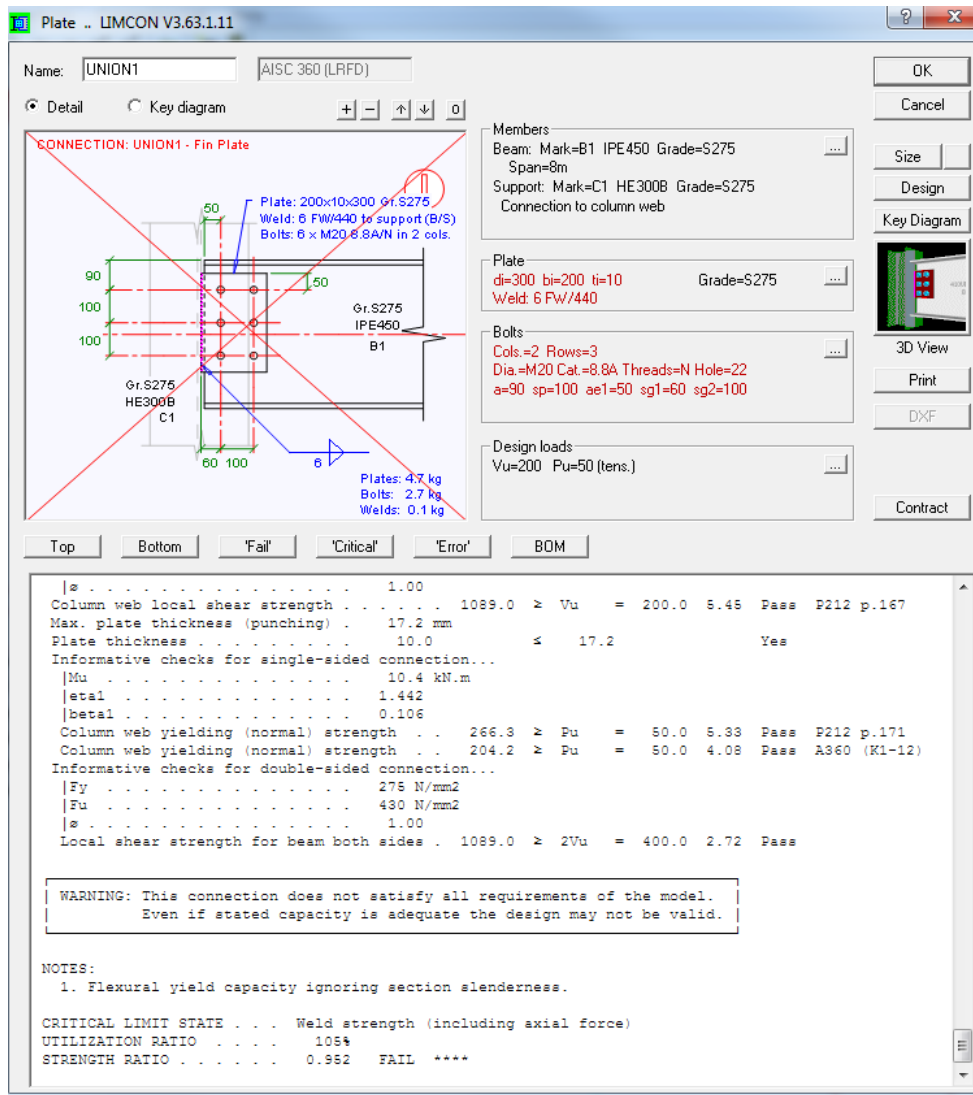
Vamos a ver ahora las uniones empotradas:



Vamos a calcular la unión Haunch EP, pero antes vamos a cambiar la normativa. En lugar de calcular con EC3, calculamos con norma americana AISC (método LRFD, ya que ASD está obsoleto):



Vamos a entrar en la unión 1 que nos cumplía con EC3 y observamos:



CONNECTION: UNION1 - Fin Plate

Members:
Beam: Mark=B1 IPE450 Grade=S275
Span=8m
Support: Mark=C1 HE300B Grade=S275
Connection to column web

Plate:
d=300 bi=200 ti=10 Grade=S275
Weld: 6 FW/440

Bolts:
Cols.=2 Rows=3
Dia.=M20 Cat.=8.8A Threads=N Hole=22
a=90 sp=100 ae1=50 sg1=60 sg2=100

Design loads:
Vu=200 Pu=50 (tens.)

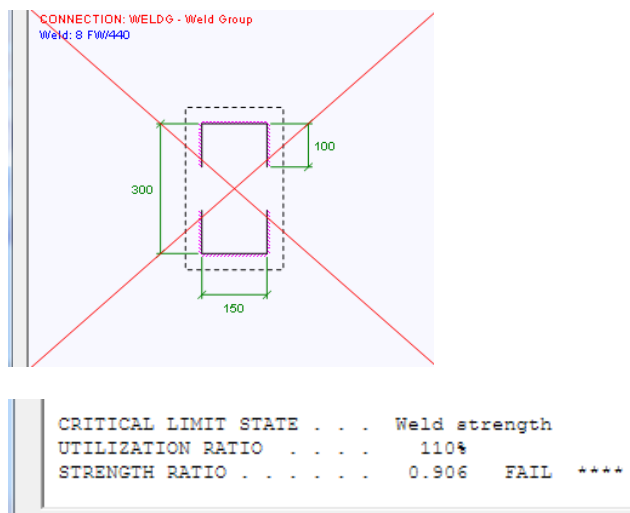
Column web local shear strength	1089.0	≥ Vu = 200.0	5.45	Pass	P212 p.167
Max. plate thickness (punching)	17.2 mm				
Plate thickness	10.0	≤ 17.2		Yes	
Informative checks for single-sided connection...					
Mu	10.4 kN.m				
etal	1.442				
beta1	0.106				
Column web yielding (normal) strength	266.3	≥ Pu = 50.0	5.33	Pass	P212 p.171
Column web yielding (normal) strength	204.2	≥ Pu = 50.0	4.08	Pass	A360 (K1-12)
Informative checks for double-sided connection...					
Fy	275 N/mm2				
Fu	430 N/mm2				
phi	1.00				
Local shear strength for beam both sides	1089.0	≥ 2Vu = 400.0	2.72	Pass	

WARNING: This connection does not satisfy all requirements of the model.
Even if stated capacity is adequate the design may not be valid.

NOTES:
1. Flexural yield capacity ignoring section slenderness.

CRITICAL LIMIT STATE . . . Weld strength (including axial force)
UTILIZATION RATIO . . . 105%
STRENGTH RATIO . . . 0.952 FAIL ****

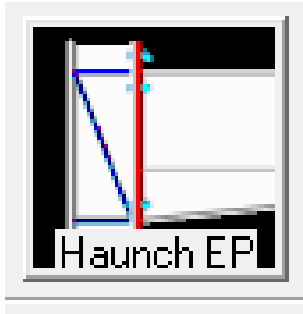
Bajo norma americana tendríamos que aumentar la soldadura. Lo mismo sucede con el grupo de soldaduras:



CONNECTION: WELD6 - Weld Group
Weld: 8 FW/440

CRITICAL LIMIT STATE	Weld strength
UTILIZATION RATIO	110%
STRENGTH RATIO	0.906 FAIL ****

Bien, con norma americana para comprobaciones entramos en HaunchEP:

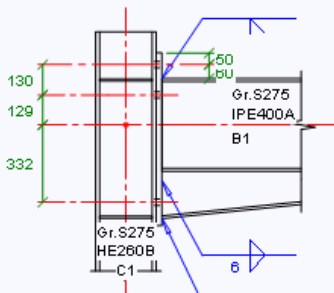


Haunched Beam Bolted Moment End Plate .. LIMCON V3.63.1.11

Name: [] AISC 360 (LRFD)

Detail Key diagram

Haunch: 600 deep x 2000 long
 End plate: 200x25x740 Gr.S275
 Flange weld: CJP/GW/440 - Web weld: 6 FW/440
 Bolts: 6 x M24 8.8E/N at 140 gauge



Stiffeners:
 Top: 90x10x225 Gr.S275 - Weld=6 FW/440 Side=10CBolts: 5.0 kg
 Btm.: 90x10x225 Gr.S275 - Weld=6 FW/440 Side=fu/Welds: 0.6 kg

Plates: 35.4 kg

Arrangement
 Type=K - Eaves connection
 Angle=0.00°

Members
 Beam 1: B1 IPE400A Grade=S275
 Column: C1 HE260B Grade=S275
 Haunch: 600 deep x 2000 long

End plate
 d=740 bi=200 ti=25 Grade=S275
 Weld: fu=440 twf=0 tww=6

Bolts
 Dia.=M24 Cat.=8.8E Threads=N Hole=27
 Top=4 Btm.=2 sg=140 sp=130 sp1=70 ae=50 af=60

Stiffeners
 Grade=S275 Weld: fu=440
 Top: bes=90 ts=10 tw=6 Lw=100 Lwe=1
 Btm.: bes=90 ts=10 tw=6 Lw=1 Lwe=1

Design loads
 Bm. 1: Mu=210 Vu=150 Pu=0 Col.: Vuc=100

Top Bottom 'Fail' 'Critical' 'Error' BOM

```

Bolt rupture strength (prying) . . . . . 420.1 > Mueq = 210.0 2.00 Pass
Prying factor . . . . . 0.26 Informative
Bolt efficiency . . . . . 85% Informative

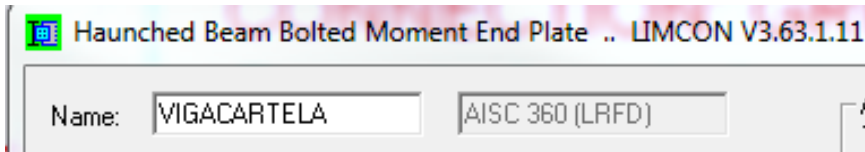
CHECK 23 - Transverse Stiffeners at Beam Compression Flange:
Stiffener width . . . . . 90 ≥ 87 Yes
Stiffener thickness . . . . . 10.0 ≤ 125 Yes
Stiffener side weld . . . . . 195 ≥ 6.0 Yes
Column web yield strength . . . . . 858.3 kN
Column web crippling strength . . . . . 770.4 kN
Column web buckling strength . . . . . 905.0 kN
» Unstiffened column strength . . . . . 770.4 kN
Flange compression . . . . . 357.1 kN
» Check of stiffeners not required.

CHECK 24 - Diagonal Shear Stiffeners:
No diagonal shear stiffeners.

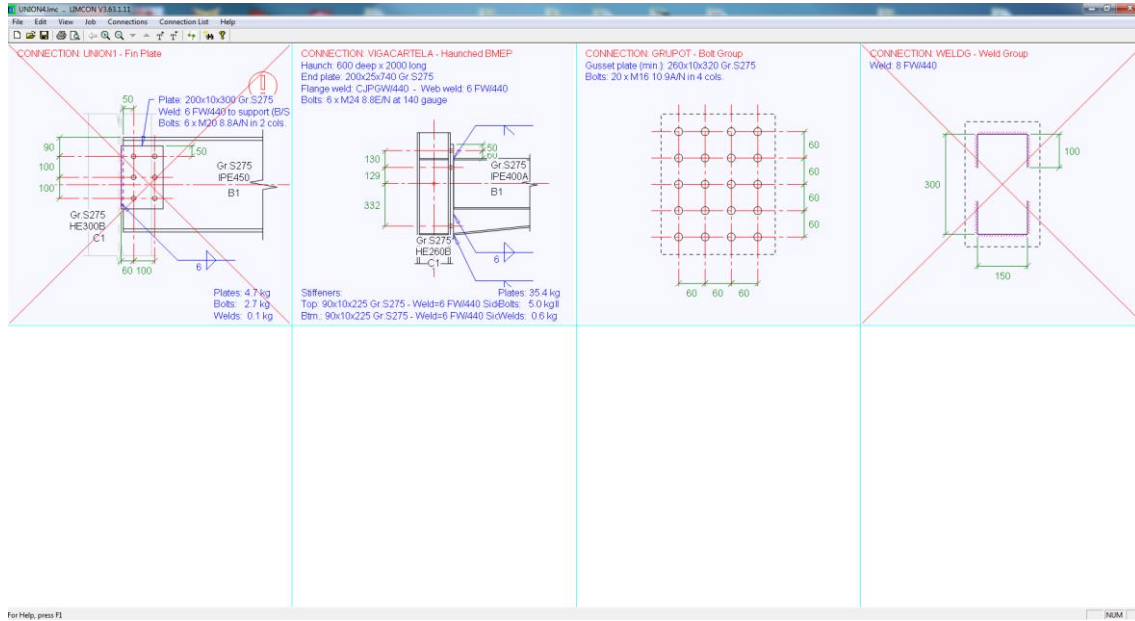
NOTES:
1. Flexural yield capacity ignoring section slenderness.
2. Shear yield capacity ignoring slenderness.
4. Compression yield capacity of section ignoring slenderness.

CRITICAL LIMIT STATE . . . . . Column web panel shear strength, σRv
UTILIZATION RATIO . . . . . 67%
STRENGTH RATIO . . . . . 1.501 Pass
  
```

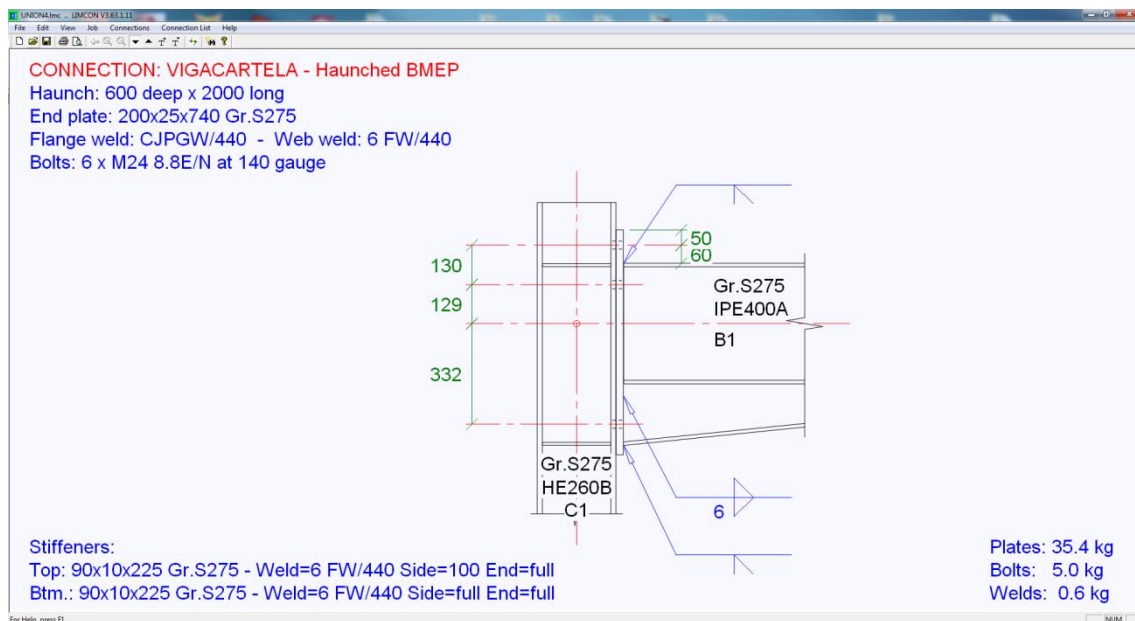
La llamamos VIGACARTELA y damos OK, vemos que la norma AISC ya nos aparece en la ventana:



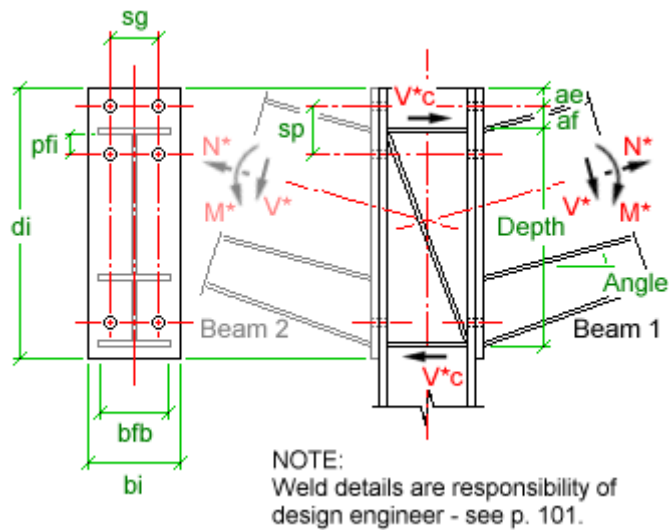
Las uniones que tenemos:



Centrándonos en nuestra unión:



Damos Key diagram para ver los parámetros:

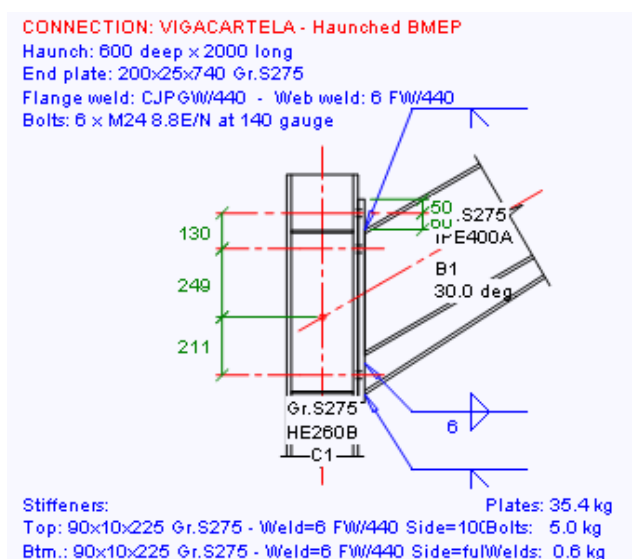


En arrangement, podemos definir un ángulo para la unión, por ejemplo 30°:

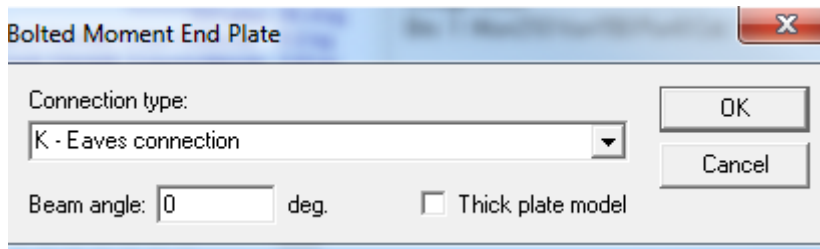
Arrangement
 Type=K - Eaves connection
 Angle=0.00°

Bolted Moment End Plate
 Connection type:
 K - Eaves connection
 Beam angle: 30 deg. Thick plate model

OK
Cancel



En nuestro caso lo dejamos horizontal:



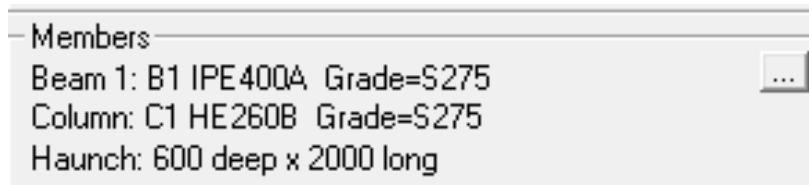
Bolted Moment End Plate

Connection type:
K - Eaves connection

Beam angle: 0 deg. Thick plate model

OK
Cancel

A continuación definimos las secciones de viga y pilar y el tamaño de la cartela:

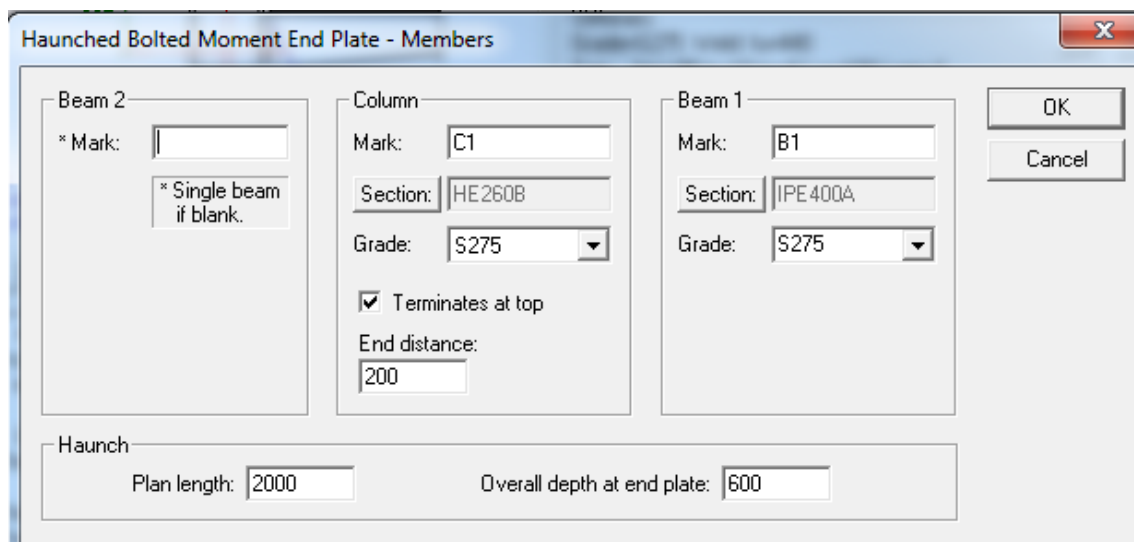


Members

Beam 1: B1 IPE400A Grade=S275

Column: C1 HE260B Grade=S275

Haunch: 600 deep x 2000 long



Haunched Bolted Moment End Plate - Members

Beam 2: * Mark: * Single beam if blank.

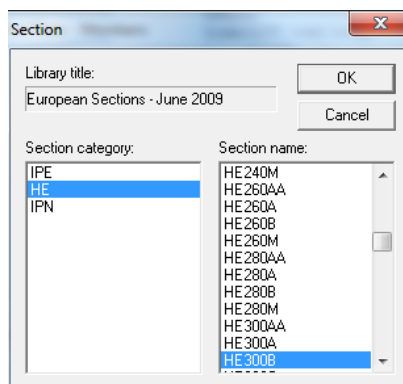
Column: Mark: C1 Section: HE260B Grade: S275 Terminates at top End distance: 200

Beam 1: Mark: B1 Section: IPE400A Grade: S275

Haunch: Plan length: 2000 Overall depth at end plate: 600

OK
Cancel

Vamos a considerar una columna HEB300 acero S275 y desmarcamos "Terminates at top" para que tenga una longitud indefinida, que es el caso de vigas de plantas intermedias:



Section

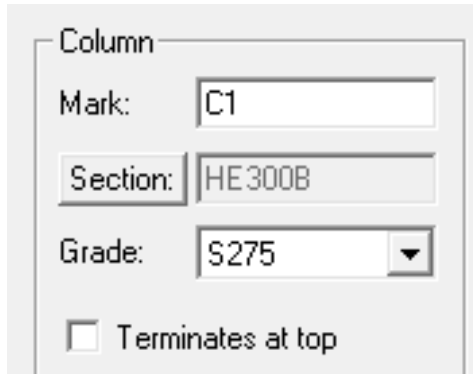
Library title: European Sections - June 2009

Section category: IPE HE IPN

Section name: HE240M HE260AA HE260A HE260B HE260M HE280AA HE280A HE280B HE280M HE300AA HE300A HE300B

OK
Cancel

Resulta:



Column

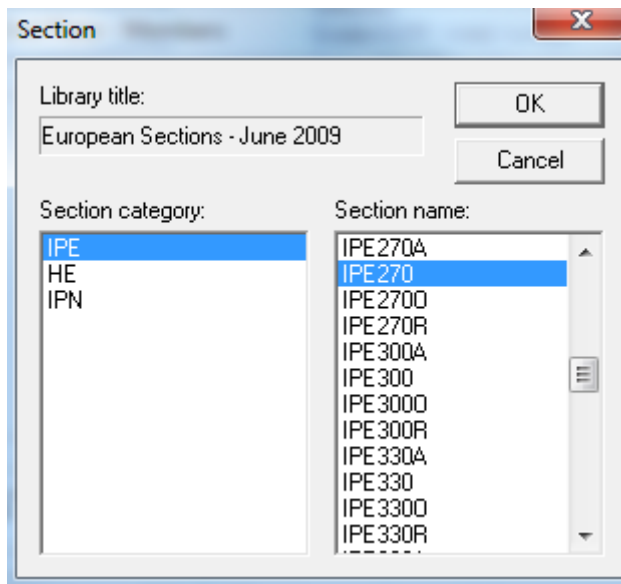
Mark:

Section:

Grade:

Terminates at top

Para la viga ponemos IPE 270 hacer S275:



Section

Library title:

Section category:

IPN
HE
IPN

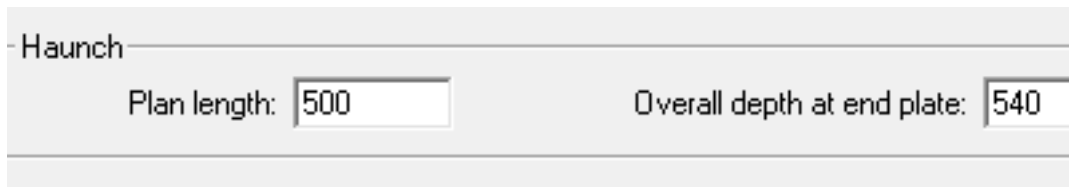
Section name:

IPN
HE
IPN
IPE270A
IPE270
IPE2700
IPE270R
IPE300A
IPE300
IPE3000
IPE300R
IPE330A
IPE330
IPE3300
IPE330R

OK

Cancel

Definimos la cartela, en "Plan length" ponemos dimensión horizontal, por ejemplo 500 mm. En "Overall depth at end plate" ponemos la dimensión vertical de la cartela medida desde el ala superior de la viga, si queremos que sea de 270 mm, le tenemos que sumar el canto de la viga (270 mm), por lo que ponemos 540 mm:

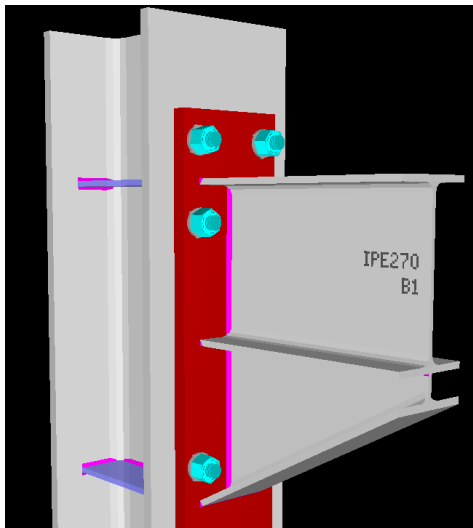
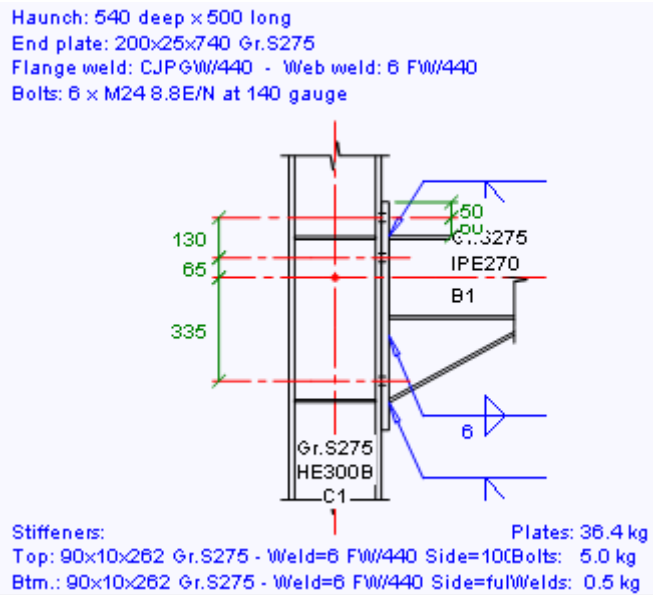


Haunch

Plan length:

Overall depth at end plate:

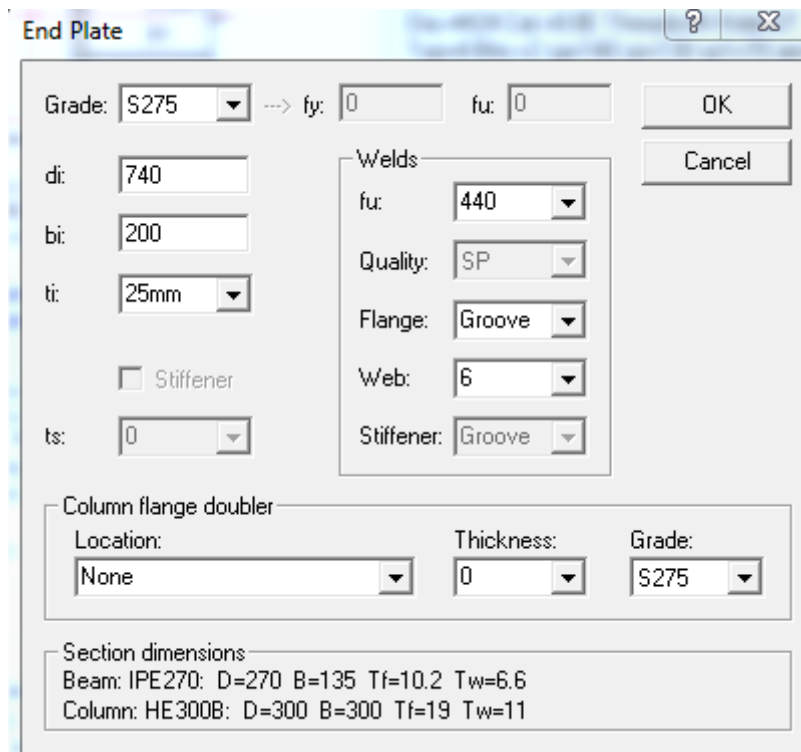
El resultado:



Definimos las características de la chapa frontal y la posibilidad de meter chapas de refuerzo en el ala del pilar en el siguiente menú:

End plate
 di=740 bi=200 ti=25 Grade=S275
 Weld: fu=440 twf=0 tww=6

Pinchamos y nos aparece:



End Plate

Grade: S275 --> fy: 0 fu: 0

di: 740

bi: 200

ti: 25mm

Stiffener

ts: 0

Welds

fu: 440

Quality: SP

Flange: Groove

Web: 6

Stiffener: Groove

Column flange doubler

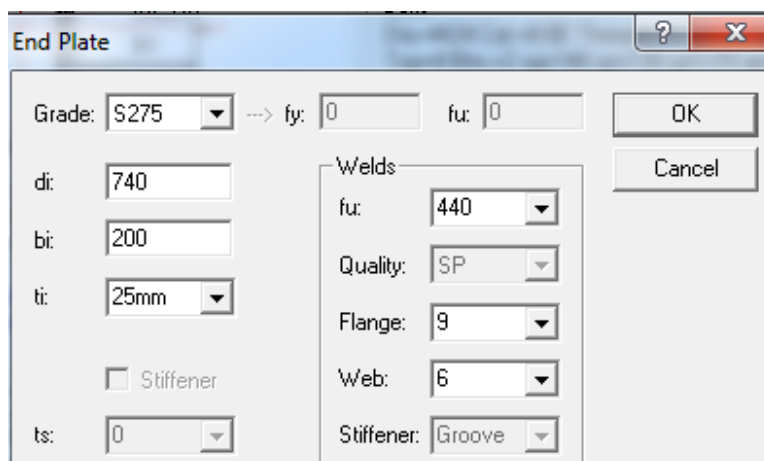
Location: None Thickness: 0 Grade: S275

Section dimensions

Beam: IPE270: D=270 B=135 Tf=10.2 Tw=6.6

Column: HE300B: D=300 B=300 Tf=19 Tw=11

Dejamos las dimensiones de chapa por defecto y marcamos las soldaduras. Ponemos en el ala 9 y en el alma 6, si dejamos puesto "Groove" estamos marcando soldadura de penetración, que cumple sin necesidad de cálculo:



End Plate

Grade: S275 --> fy: 0 fu: 0

di: 740

bi: 200

ti: 25mm

Stiffener

ts: 0

Welds

fu: 440

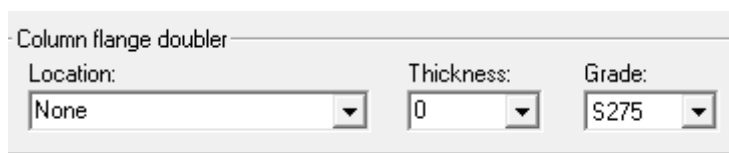
Quality: SP

Flange: 9

Web: 6

Stiffener: Groove

Si necesitásemos colocar chapas de refuerzo del ala del pilar vamos a "Column flange doubler":



Column flange doubler

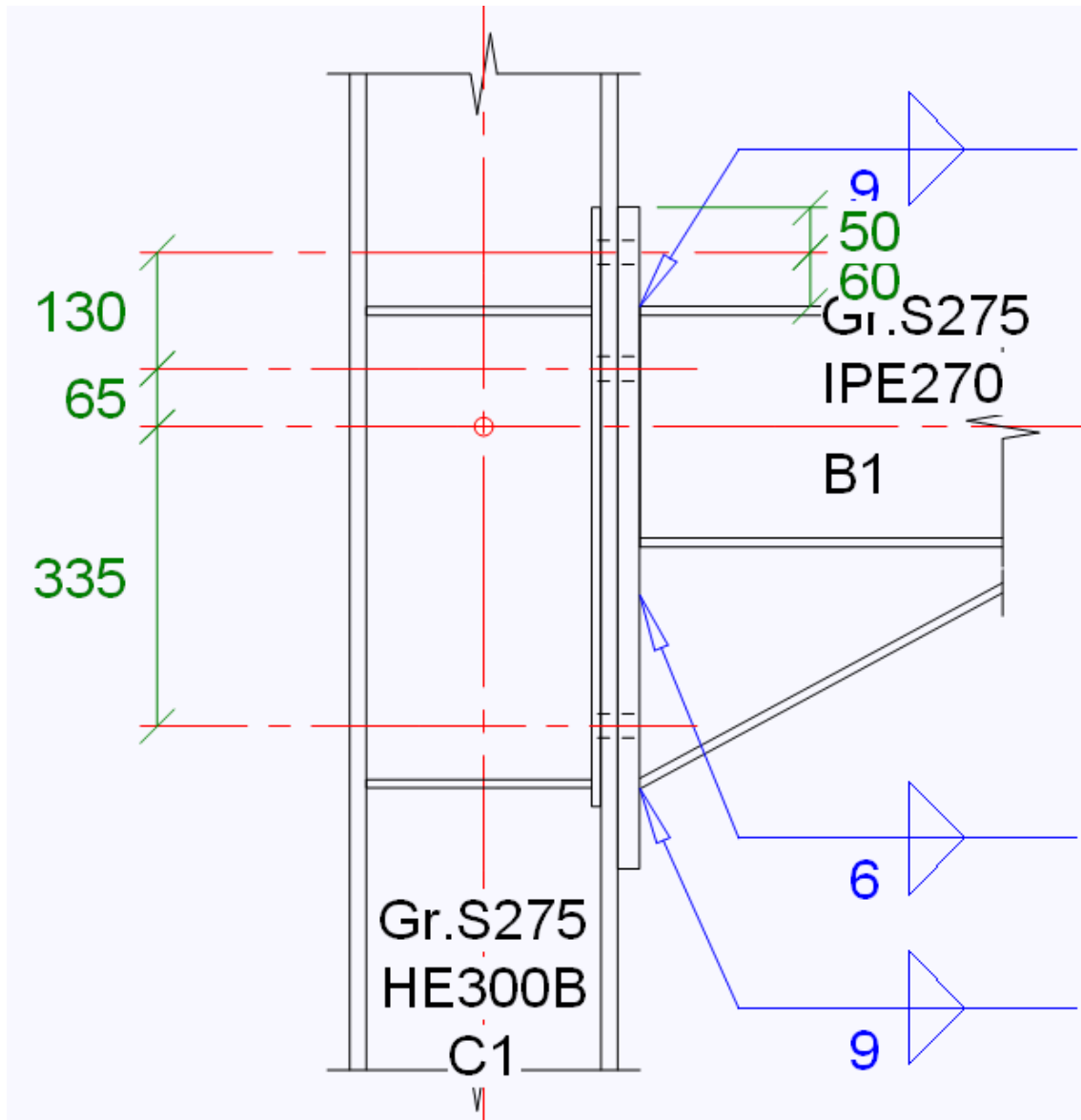
Location: None Thickness: 0 Grade: S275

Vamos a considerar chapas de 10 mm de espesor en toda la altura de la unión:

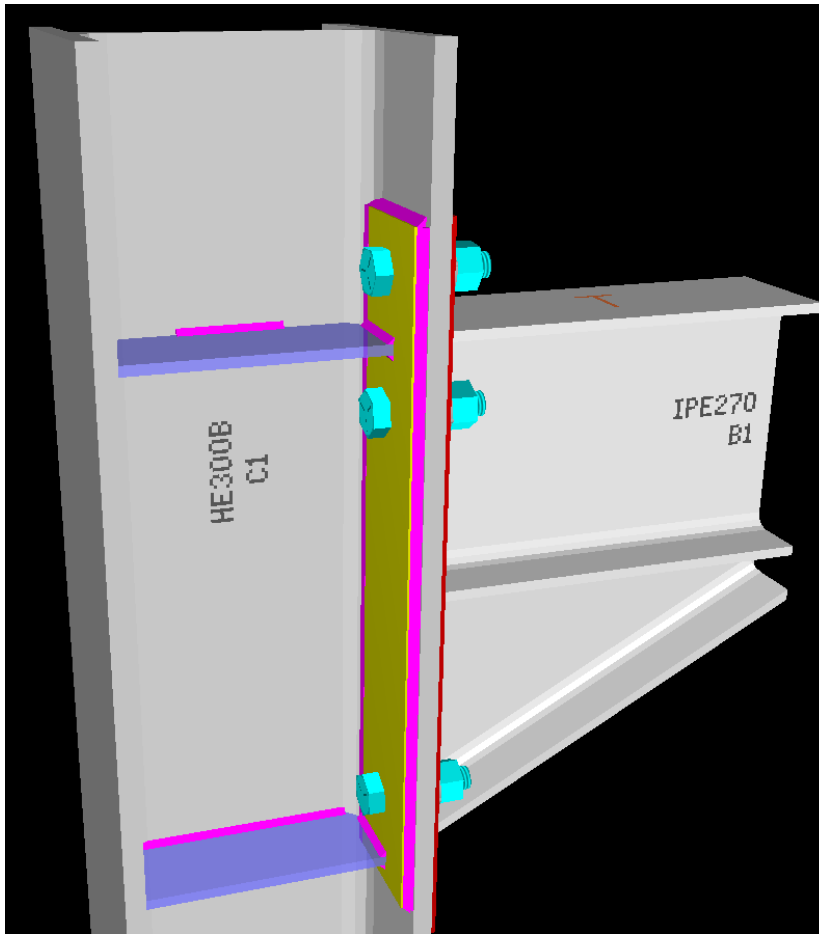
Column flange doubler

Location:	Thickness:	Grade:
Full height	10mm	S275

Resulta:



La vista 3D:



Vamos a definir tornillos:

Bolts
Dia.=M24 Cat.=8.8E Threads=N Hole=27
Top=4 Btm.=2 sg=140 sp=130 sp1=70 ae=50 af=60

Consideramos M24 en 10.9:

Dia.:	M24
Categ.:	10.9A
Threads:	N

Vamos a suponer que no podemos poner tornillos por encima del ala superior. Entonces marcamos asociado al ala superior 2 tornillos por debajo de ella. Y asociado al ala inferior (en realidad es al ala de la cartela) 4 tornillos, 2 arriba y 2 abajo:

2 cols. 4 cols.

No. bolts at top flange

Total:	Outer:	Inner:
2	0	2

No. bolts at bottom flange

Total:	Outer:	Inner:
4	2	2

El resto de parámetros los dejamos igual:

Bolted Moment End Plate - Bolts

Dia.: M24

ae: 50

sp1/sp3: 70

OK

Cancel

2 cols. 4 cols.

No. bolts at top flange

Total:	Outer:	Inner:
2	0	2

af/pfo: 60

sg: 140

Threads: N

sp/sp2: 130

sg1: 70

Prying factor: 0.2

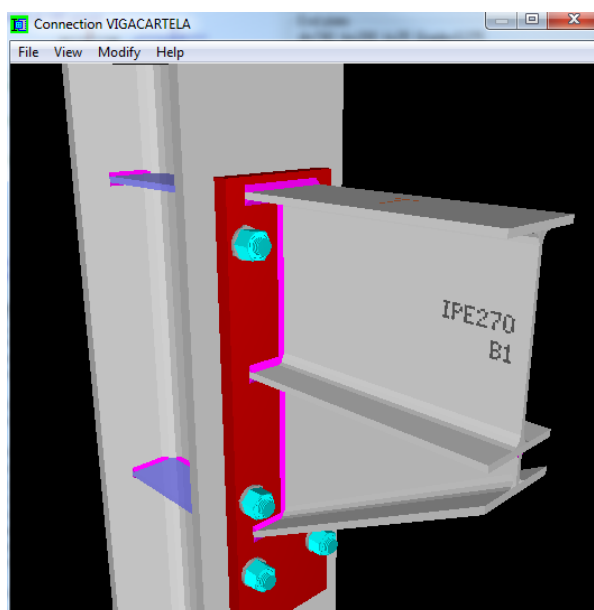
No. bolts at bottom flange

Total:	Outer:	Inner:
4	2	2

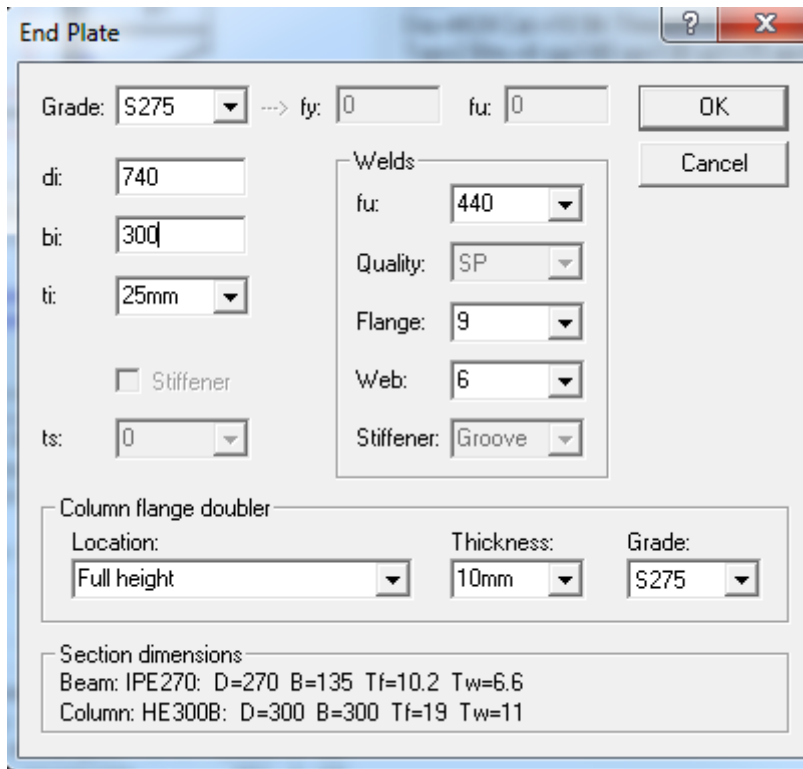
pfi: 59.8

Key Diagram

El aspecto de la unión:



Si queremos que el ancho de la chapa frontal coincida con el ala del HEB300, cambiamos su ancho a 300 mm:



End Plate

Grade: S275 → fy: 0 fu: 0

di: 740

bi: 300

ti: 25mm

Stiffener

ts: 0

Welds:

fu: 440

Quality: SP

Flange: 9

Web: 6

Stiffener: Groove

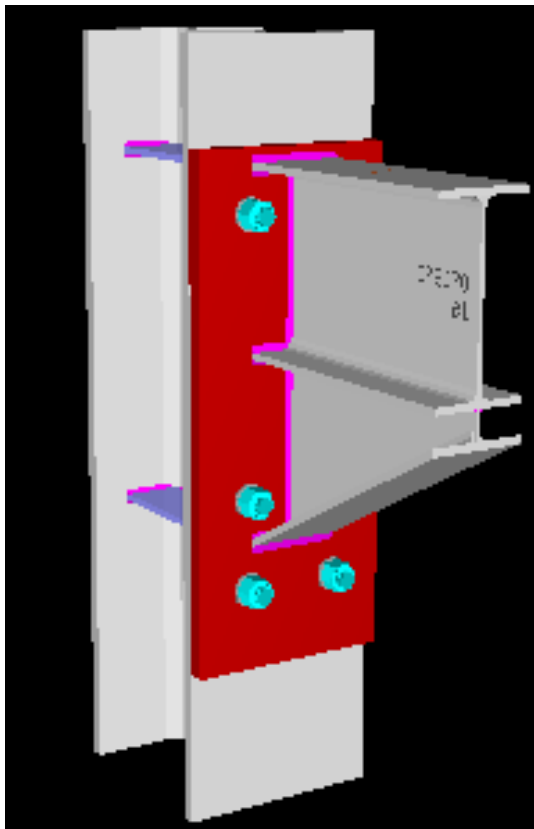
Column flange doubler:

Location: Full height Thickness: 10mm Grade: S275

Section dimensions:

Beam: IPE270: D=270 B=135 Tf=10.2 Tw=6.6

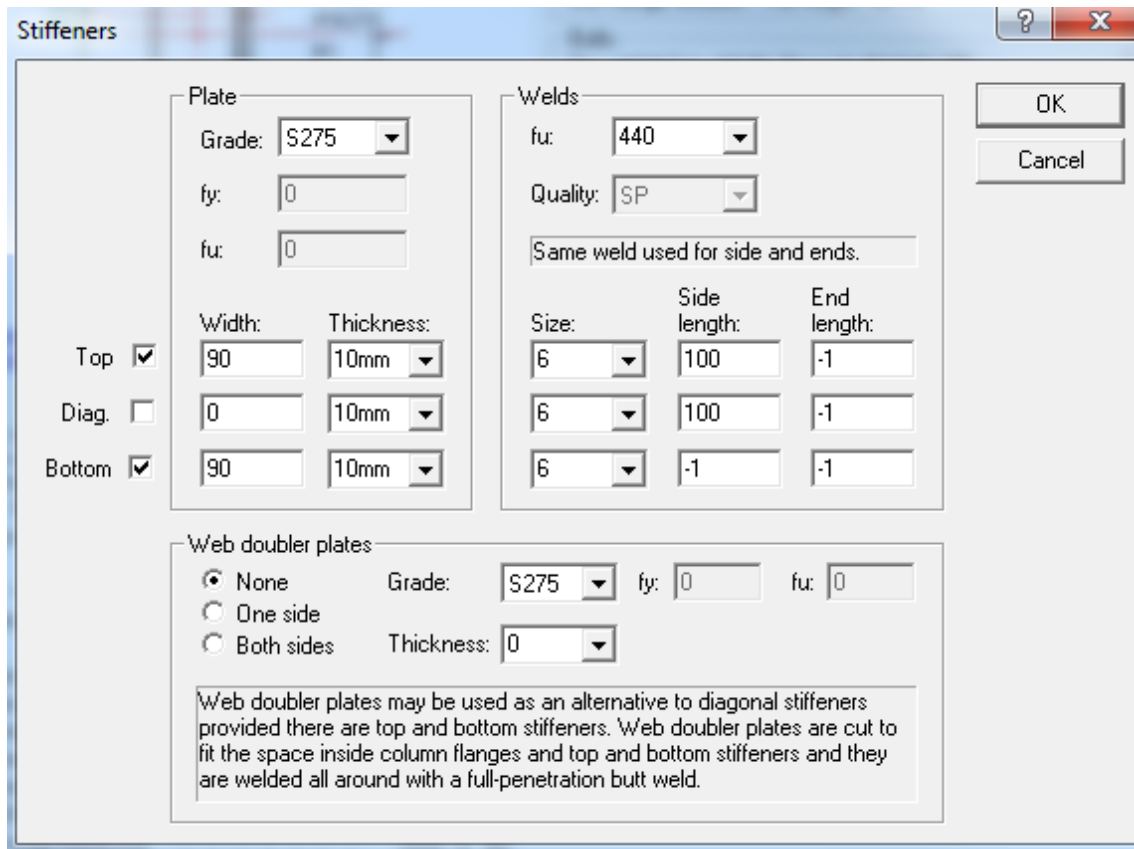
Column: HE300B: D=300 B=300 Tf=19 Tw=11



Ahora vamos a entrar en los rigidizadores del pilar:

Stiffeners
 Grade=S275 Weld: fu=440
 Top: bes=90 ts=10 tw=6 Lw=100 Lwe=-1
 Btm.: bes=90 ts=10 tw=6 Lw=-1 Lwe=-1

La pantalla que nos sale:



The screenshot shows the 'Stiffeners' dialog box with the following settings:

- Plate:** Grade: S275, fy: 0, fu: 0
- Welds:** fu: 440, Quality: SP, Same weld used for side and ends.
- Dimensions:**

	Width:	Thickness:	Size:	Side length:	End length:
Top <input checked="" type="checkbox"/>	90	10mm	6	100	-1
Diag. <input type="checkbox"/>	0	10mm	6	100	-1
Bottom <input checked="" type="checkbox"/>	90	10mm	6	-1	-1
- Web doubler plates:**
 - None
 - One side
 - Both sides
 - Grade: S275, fy: 0, fu: 0
 - Thickness: 0

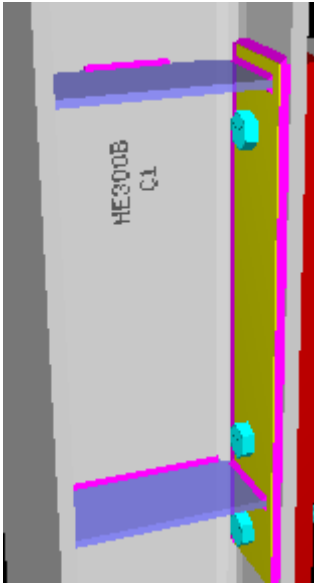
Web doubler plates may be used as an alternative to diagonal stiffeners provided there are top and bottom stiffeners. Web doubler plates are cut to fit the space inside column flanges and top and bottom stiffeners and they are welded all around with a full-penetration butt weld.

Primero definimos los rigidizadores que dan continuidad a las alas de la viga, consideramos un ancho de rigidizador superior e inferior de 120 mm y espesor 10 mm:

Stiffeners dialog box settings for web doubler plates:

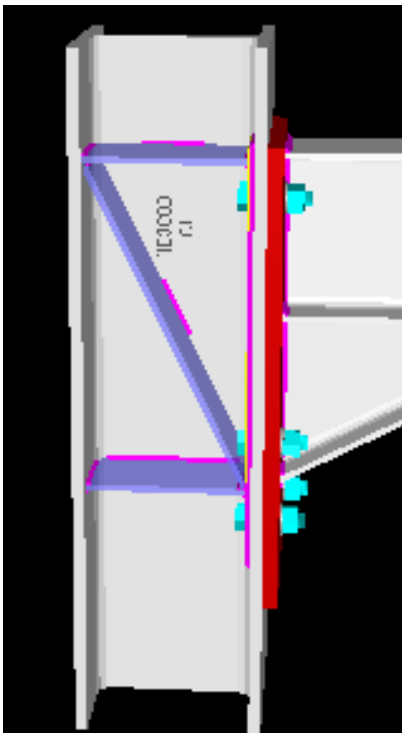
	Width:	Thickness:
Top <input checked="" type="checkbox"/>	120	10mm
Diag. <input type="checkbox"/>	0	10mm
Bottom <input checked="" type="checkbox"/>	120	10mm

Resulta:



Podemos incluir un rigidizador diagonal:

	Width:	Thickness:
Top <input checked="" type="checkbox"/>	<input type="text" value="120"/>	<input type="text" value="10mm"/>
Diag. <input checked="" type="checkbox"/>	<input type="text" value="120"/>	<input type="text" value="10mm"/>
Bottom <input checked="" type="checkbox"/>	<input type="text" value="120"/>	<input type="text" value="10mm"/>



En cuanto a la soldadura de estos rigidizadores ponemos tamaño 6 mm y marcamos "-1" en el resto para que se suelden en toda su longitud:

Welds

fu: 440

Quality: SP

Same weld used for side and ends.

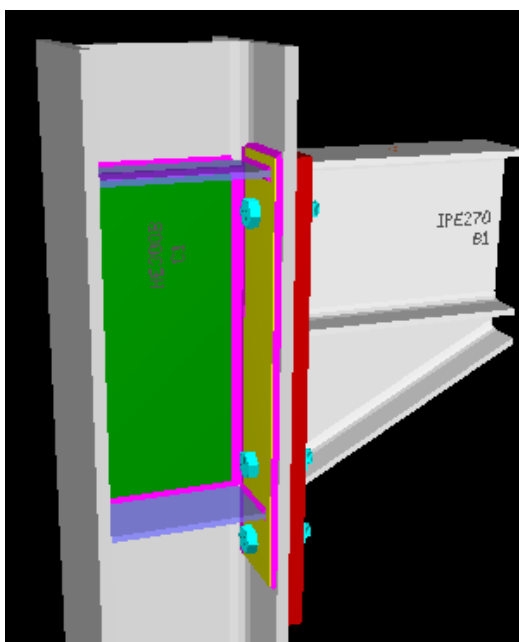
Size:	Side length:	End length:
6	-1	-1
6	-1	-1
6	-1	-1

Por otra parte, si queremos sustituir el rigidizador diagonal por una chapa de refuerzo del alma marcamos su espesor, por ejemplo 10 mm y si lo queremos en un lado o en ambos:

Web doubler plates

None Grade: S275 fy: 0 fu: 0
 One side
 Both sides Thickness: 10

Web doubler plates may be used as an alternative to diagonal stiffeners provided there are top and bottom stiffeners. Web doubler plates are cut to fit the space inside column flanges and top and bottom stiffeners and they are welded all around with a full-penetration butt weld.



Por último introducimos las cargas:

Design loads

Bm. 1: Mu=210 Vu=150 Pu=0 Col.: Vuc=-100

Loads

No.	Mu1	Vu1	Pu1	Vuc	Puc	Mu2	Vu2	Pu2
1	210.00	150.0	0.0	-100.0	0.0	0.00	0.0	0.0

Right-click in cell to set minimum action.

Minimum design actions
BM 0% Shear 0% Shear 0 Tens. 0% Comp. 0%

Section available capacities
IPE270: Bending=119.8 Shear=294 Tens.=1136 Comp.=1136

Mu1, Vu1 y Pu1 son las cargas de la viga. También se puede introducir el cortante en el pilar Vuc y el axil en el pilar Puc. Nosotros introducimos las cargas de nuestra viga, por ejemplo:

Loads

No.	Mu1	Vu1	Pu1	Vuc	Puc	Mu2	Vu2	Pu2
1	200.00	100.0	100.0	0.0	0.0	0.00	0.0	0.0

Right-click in cell to set minimum action.

Minimum design actions
BM 0% Shear 0% Shear 0 Tens. 0% Comp. 0%

Section available capacities
IPE270: Bending=119.8 Shear=294 Tens.=1136 Comp.=1136

Vemos que cumple al 98 %:

Haunched Beam Bolted Moment End Plate .. LIMCON V3.63.1.11

Name: VIGACARTELA AISC 360 (LRFD)

Arrangement: Type=K - Eaves connection Angle=0.00°

Members: Beam 1: B1 IPE270 Grade=S275 Column: C1 HE300B Grade=S275 Haunch: 540 deep x 500 long

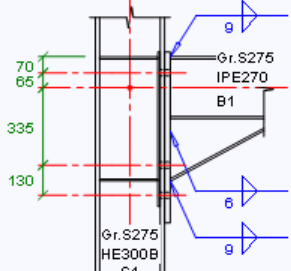
End plate: di=740 bi=300 ti=25 Grade=S275 Weld: fu=440 tw=9 tww=6 Col. flange doubler: Full height td=10

Bolts: Dia.=M24 Cat.=10.9A Threads=N Hole=27 Top=2 Btm.=4 sg=140 sp=130 sp1=70 ae=50 af=60

Stiffeners: Grade=S275 Weld: fu=440 Top: bes=120 ts=10 tw=6 Lw=-1 Lwe=-1 Web doubler both sides: 500x226x10 Grade=S275 Btm.: bes=120 ts=10 tw=6 Lw=-1 Lwe=-1

Design loads: Bm. 1: Mu=200 Vu=100 Pu=100t Col.: Vuc=0

CONNECTION: VIGACARTELA - Haunched BMEP
 Haunch: 540 deep x 500 long
 End plate: 300x25x740 Gr.S275 Doublers: 117x10 Gr.S275
 Flange weld: 9 FW/440 - Web weld: 6 FW/440
 Bolts: 6 x M24 10.9A/N at 140 gauge



Stiffeners:
 Top: 120x10x252 Gr.S275 - Weld=6 FW/440 Side=fuPlates: 83.1 kg
 Web doubler both sides: 226x10x500 Gr.S275 CJP@Bolts: 5.2 kg
 Btm.: 120x10x252 Gr.S275 - Weld=6 FW/440 Side=fuWelds: 3.7 kg

Top Bottom 'Fail' 'Critical' 'Error' BOM

Stiffener width	120	≥	64	Yes
Stiffener thickness	10.0	≥	5.1	Yes
Stiffener side weld	232	≥	212	Yes
Column web yield strength	1071.5 kN			
Column web crippling strength	951.3 kN			
Column web buckling strength	1025.1 kN			
» Unstiffened column strength	951.3 kN			
Flange compression	353.0 kN			
» Check of stiffeners not required.				

CHECK 24 - Diagonal Shear Stiffeners:
 No diagonal shear stiffeners.

WARNING: This connection does not satisfy all requirements of the model.
 Even if stated capacity is adequate the design may not be valid.

NOTES:
 1. Flexural yield capacity ignoring section slenderness.
 2. Shear yield capacity ignoring slenderness.
 4. Compression yield capacity of section ignoring slenderness.

CRITICAL LIMIT STATE . . . Bolt rupture strength (no prying)
 UTILIZATION RATIO 98%
 STRENGTH RATIO 1.025 Pass