MASTER IN NUMERICAL METHODS

COMUNICAION SKILLS II

FINITE ELEMENT ANALYSIS OF T JOINTS OF TUBULAR STRUCTURES WITH RHS PROFILES

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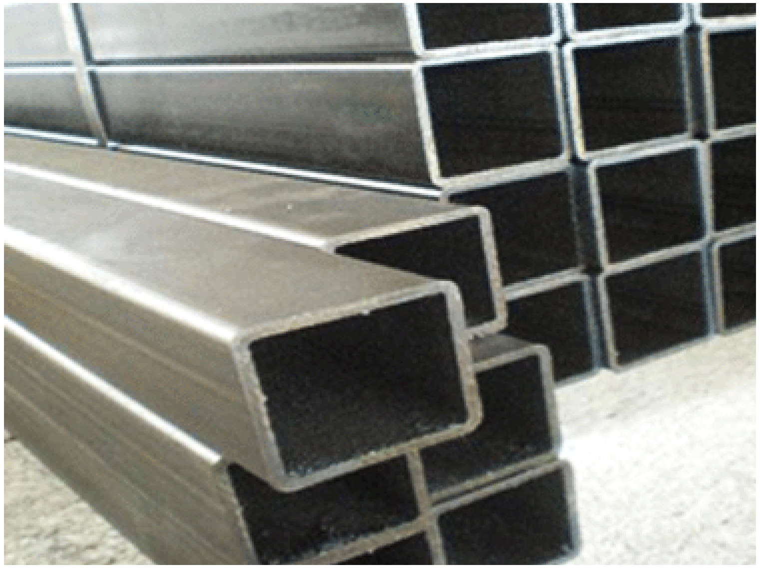
Motivation.

- Tubular SHS profiles are commonly used nowadays.
- Design joint formulation are set by European standards
- Stardards are based in thickness more than 2,5 mm.
- **Why don´t use less sheet thickness?**



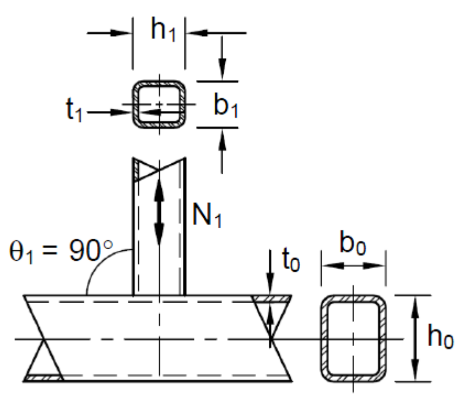
Generalities.

Generalities

Hotel Burj Al Arab, Dubai

Munich Airport

London Eye



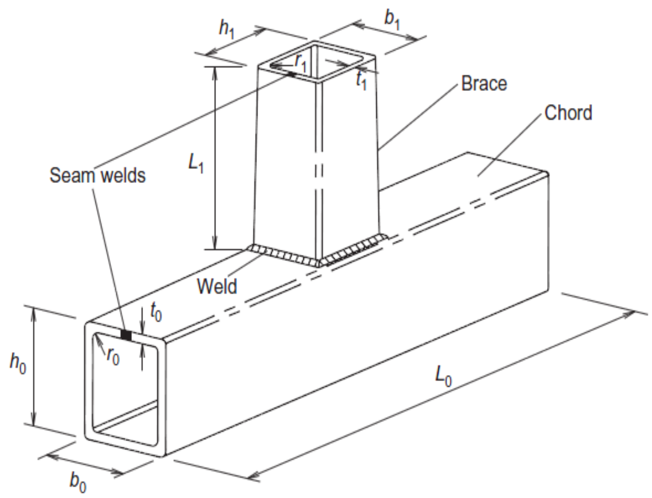
Ratios

$$\beta = \frac{b_1}{b_0} \qquad 2\gamma = \frac{b_0}{t_0}$$

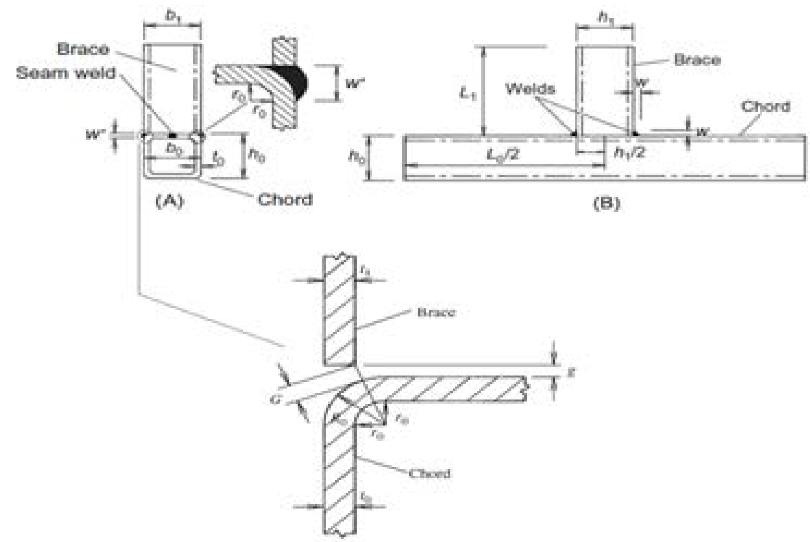
$$\eta = \frac{h_1}{b_0} \qquad \tau = \frac{t_1}{b_0}$$

Geometry and experimental test.

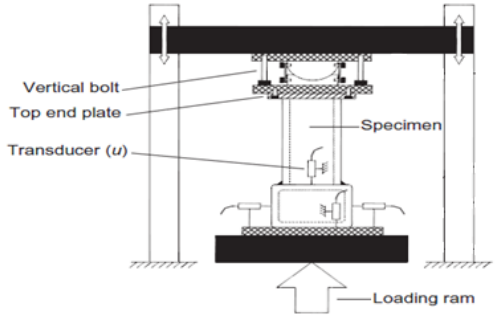
Case 1: $\beta < 1,0$

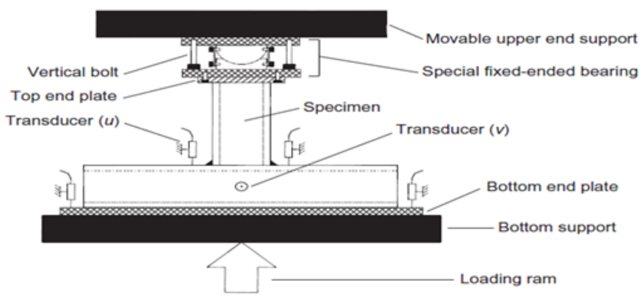


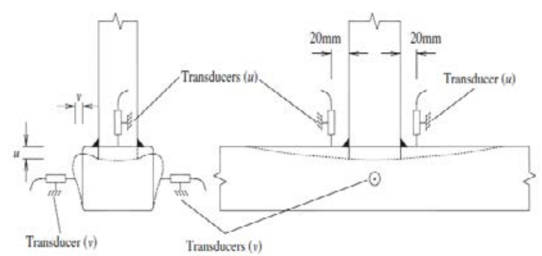
Case 2: $\beta = 1,0$



Testing Bench



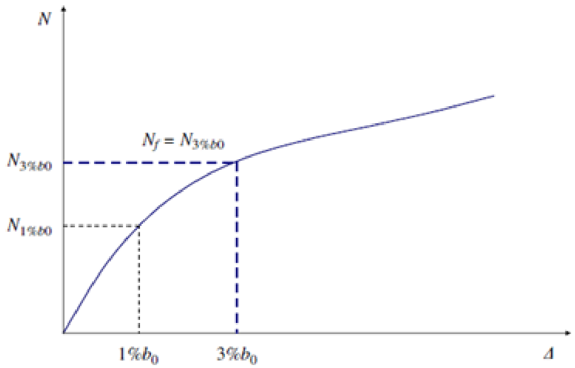


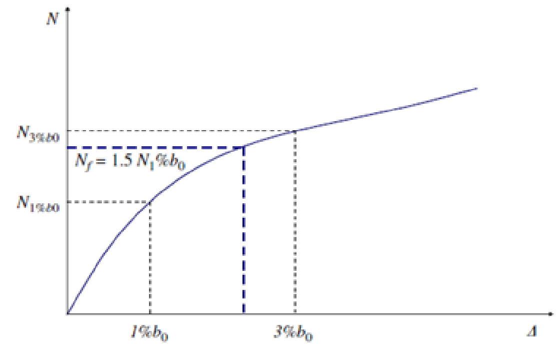


Deformation Limit Criteria.

Case 1: $\beta \leq 0{,}85$

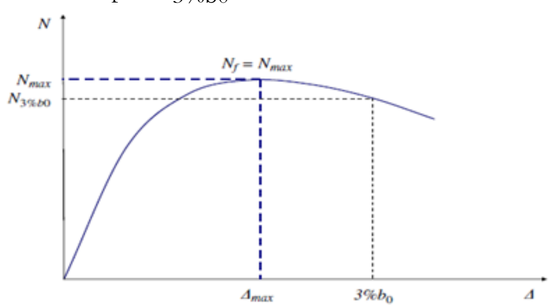
- If $N_{3\%b0}$ (corresponding to a strain equal $3\%b_0$) is less than $1{,}5N_{1\%b0}$ (corresponding to a strain equal $1\%b_0$), then failure forcé is N_f=$N_{3\%b0}$.
- If $N_{3\%b0}$ is upper than 1,5 $N_{1\%b0}$, then failure force is N_f=$1{,}5N_{1\%b0}$.

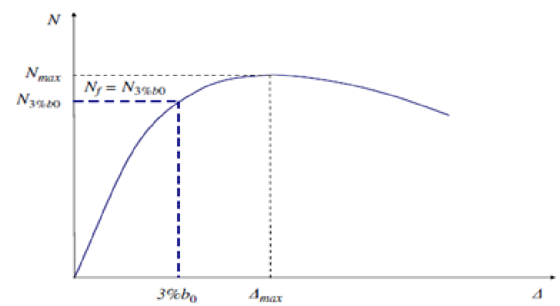




Case 2: $0{,}85 < \beta \leq 1{,}0$

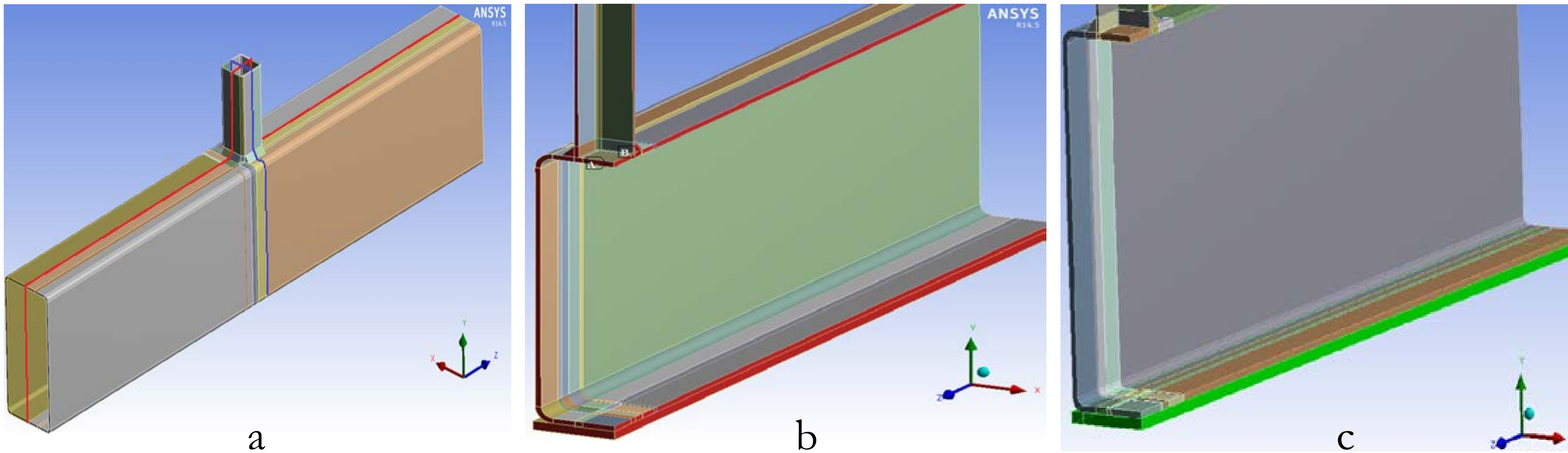
- Failure force is equal to the maximum experimental test force (N_f=$N_{máx}$), if the strain asociated to this force is less than $3\%b_0$.
- If the maximum experimental test force is upper than the force asociated a strain equal to $3\%b_0$, then the failure force is N_f=$N_{3\%b0}$.



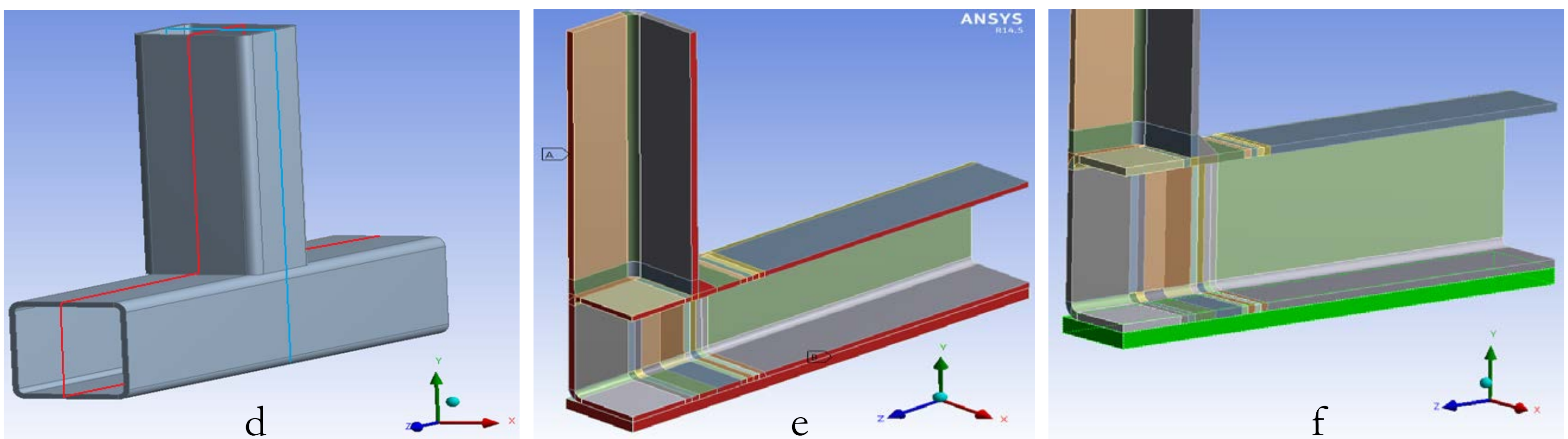


Models and simetry.

Model 1

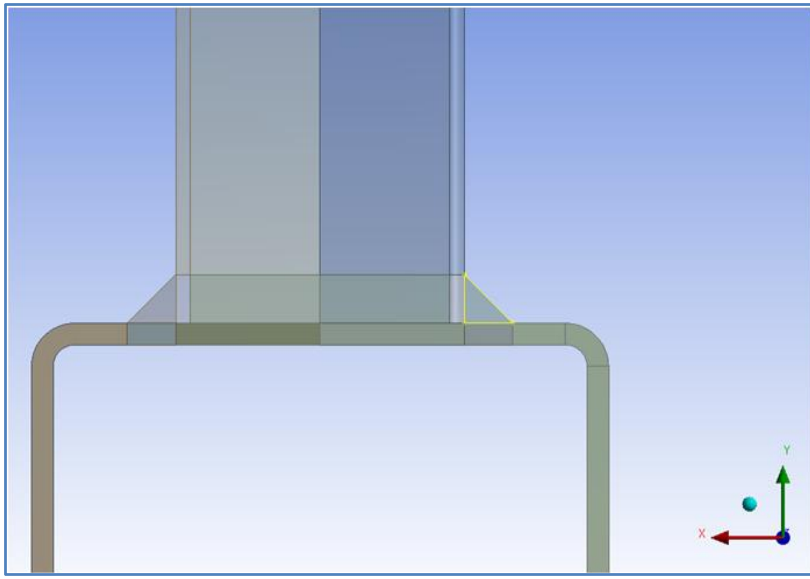


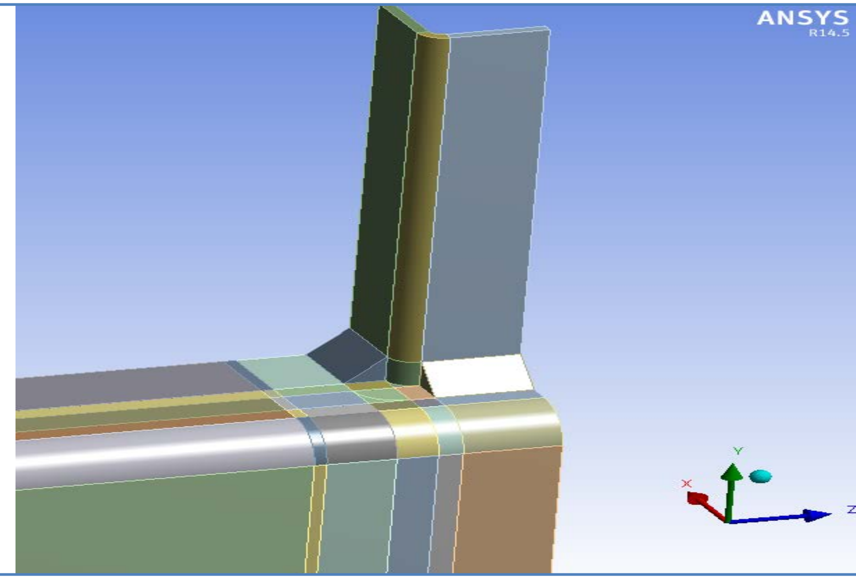
Modelo 2

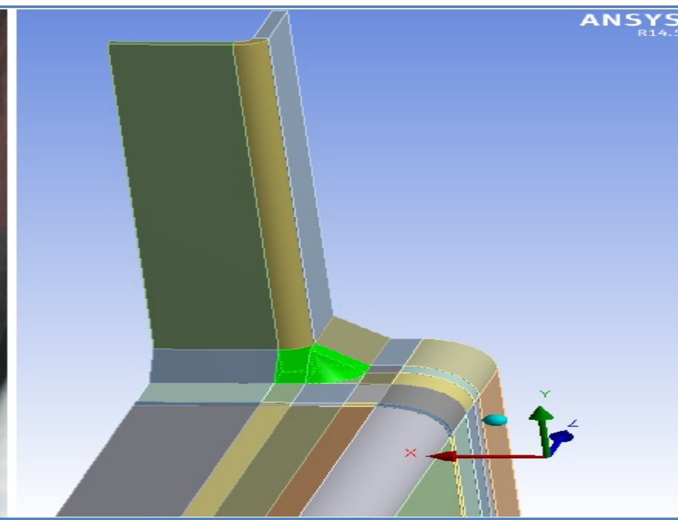


Welds Modelling (Model 1).

Communication Skills II

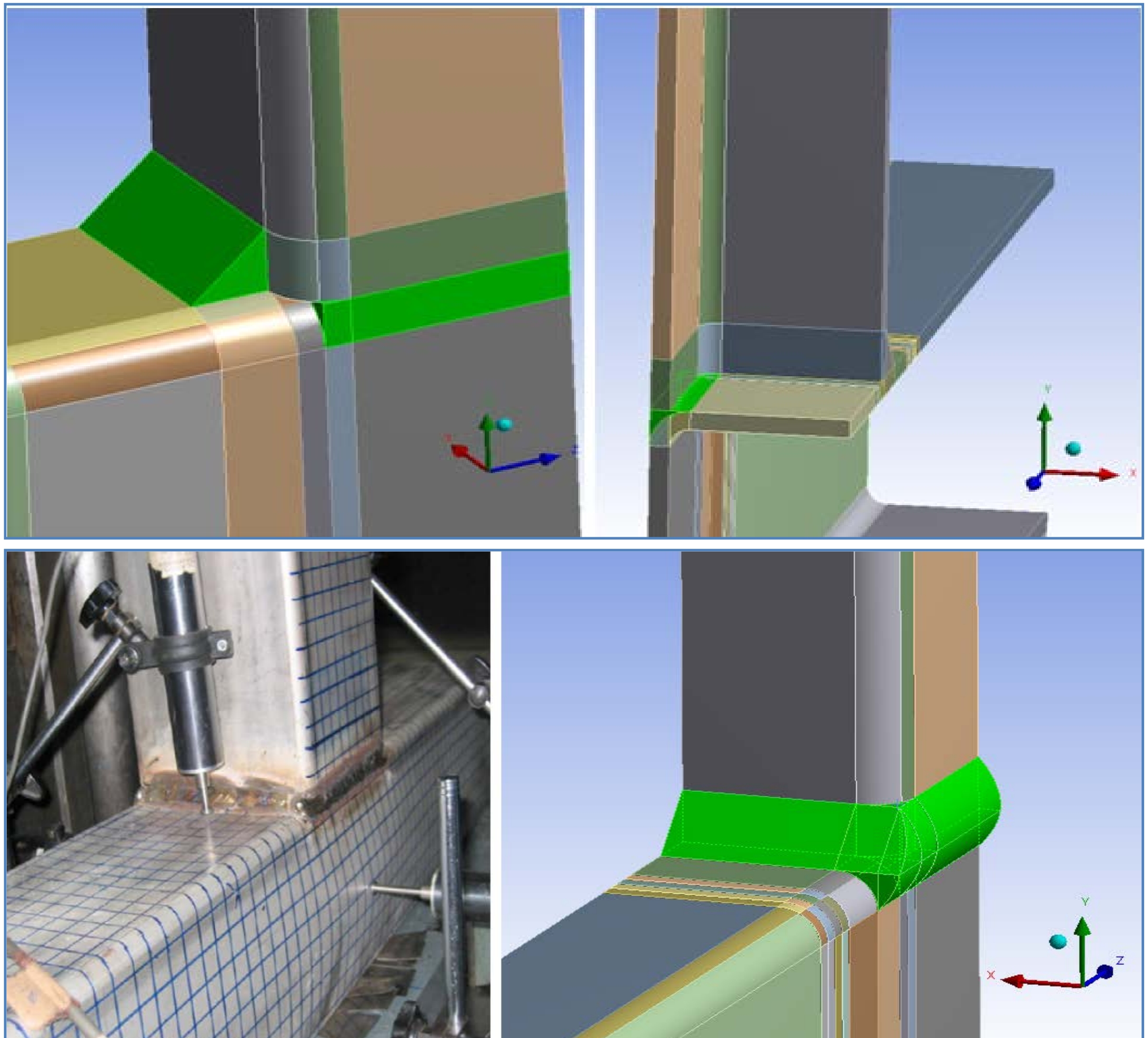






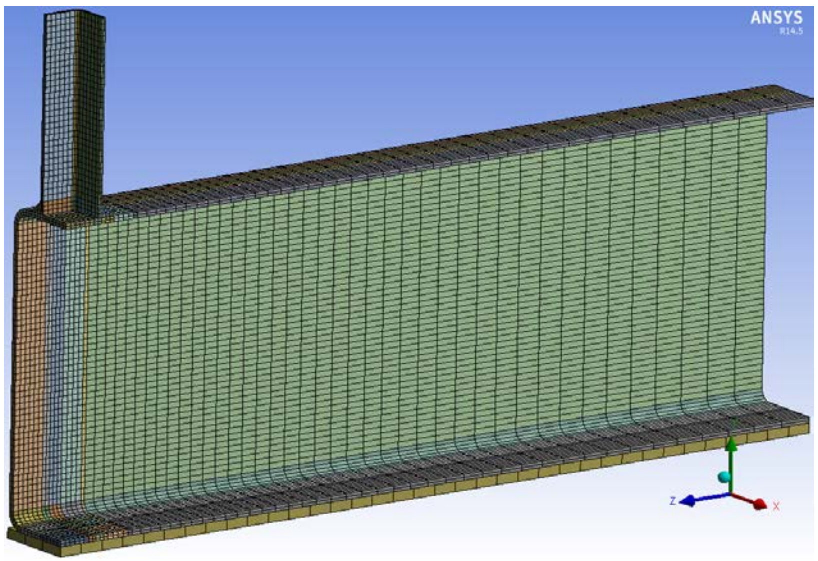
Welds Modelling (Model 2).

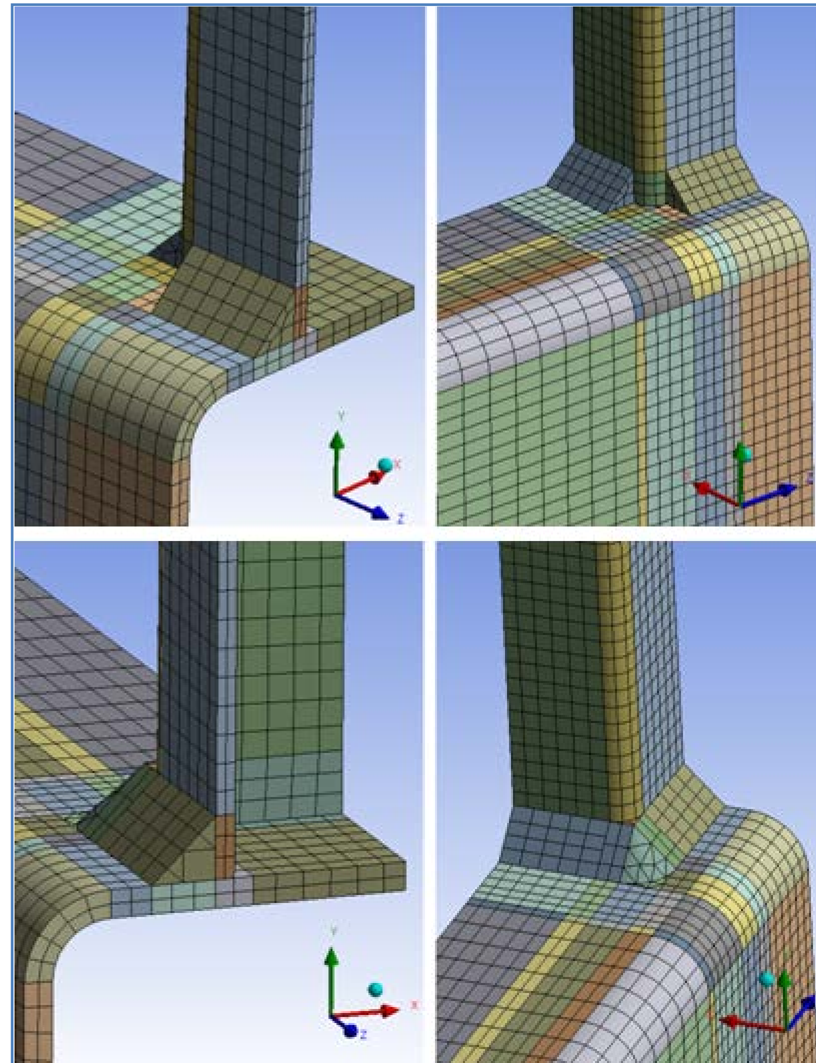
Communication Skills II



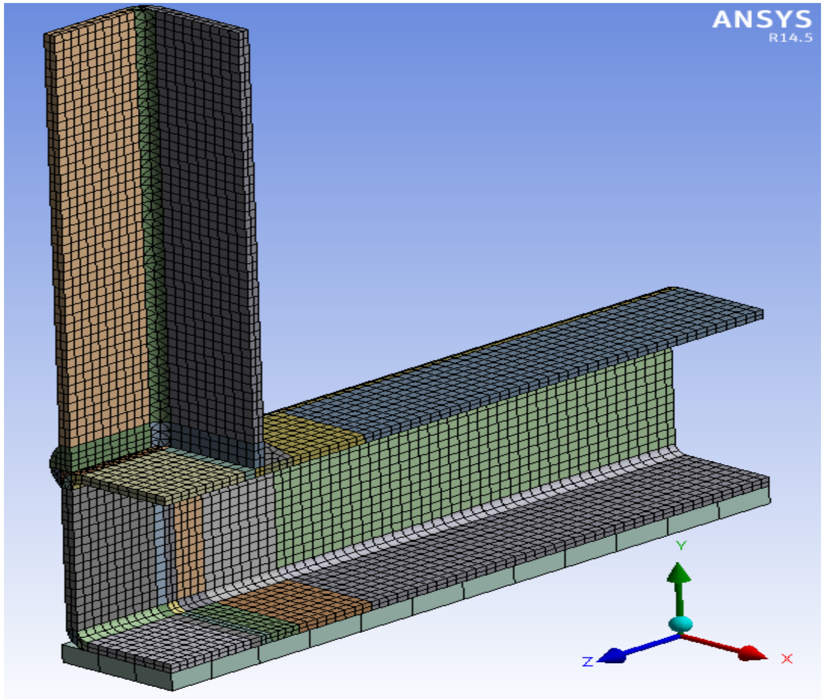
Mesh of Model 1.

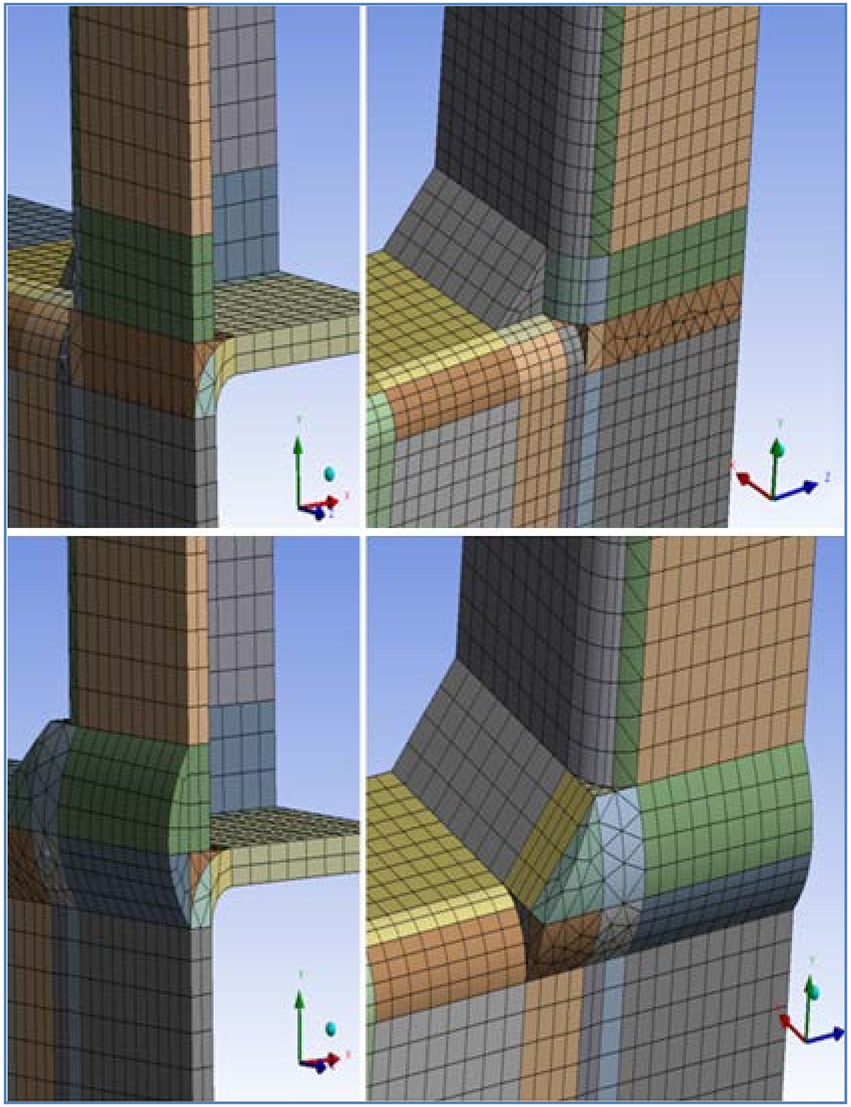
Communication Skills II



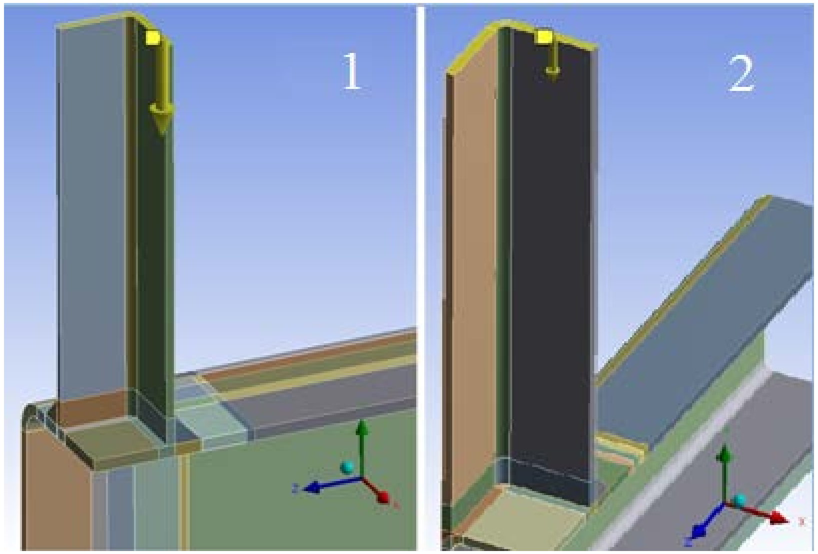


Mesh of Model 2.



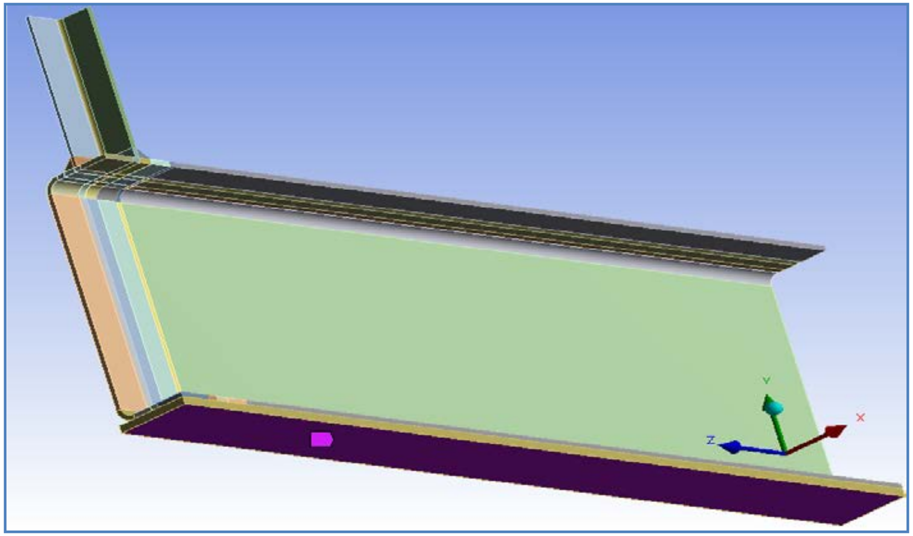


Modelling of loads and boundary conditions.



Loads

- Load by increments of displacement.
- 1= 35 mm.
- 2 = 8 mm.



Boundary conditions

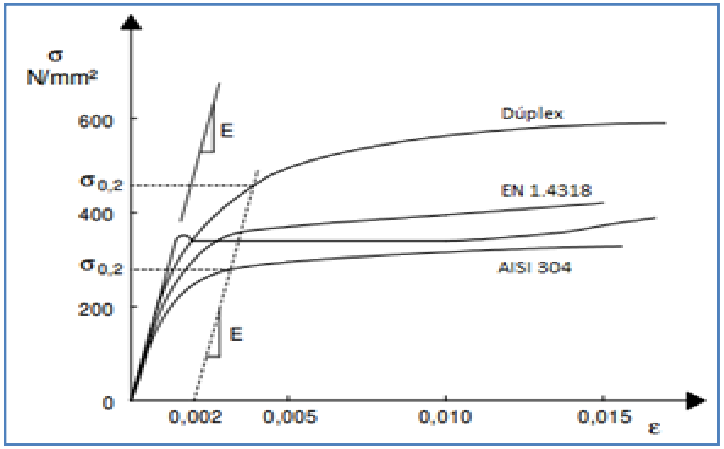
- Only the vertical displacement of the upper section of the brace is allowed.
- Displacement prevented in all axes of the base plate.

Modelling of the material.

Communication Skills II

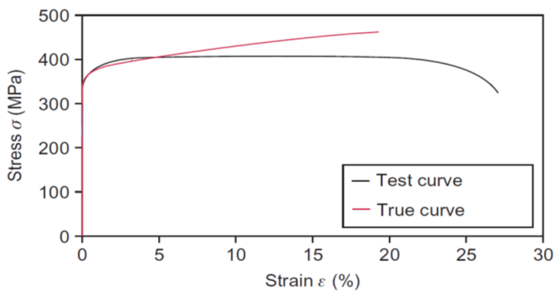
Material Properties

Section ($h \times b \times t$)	Type	E (GPa)	σ_p (MPa)	$\sigma_{0.1}$ (MPa)	$\sigma_{0.2}$ (MPa)	$\sigma_{0.5}$ (MPa)	$\sigma_{1.0}$ (MPa)	σ_u (MPa)	ε_f (%)
40 x 40 x 2	Duplex	216	164	633	707	748	780	827	29
160 x 80 x 3	Duplex	208	167	481	536	570	595	766	40



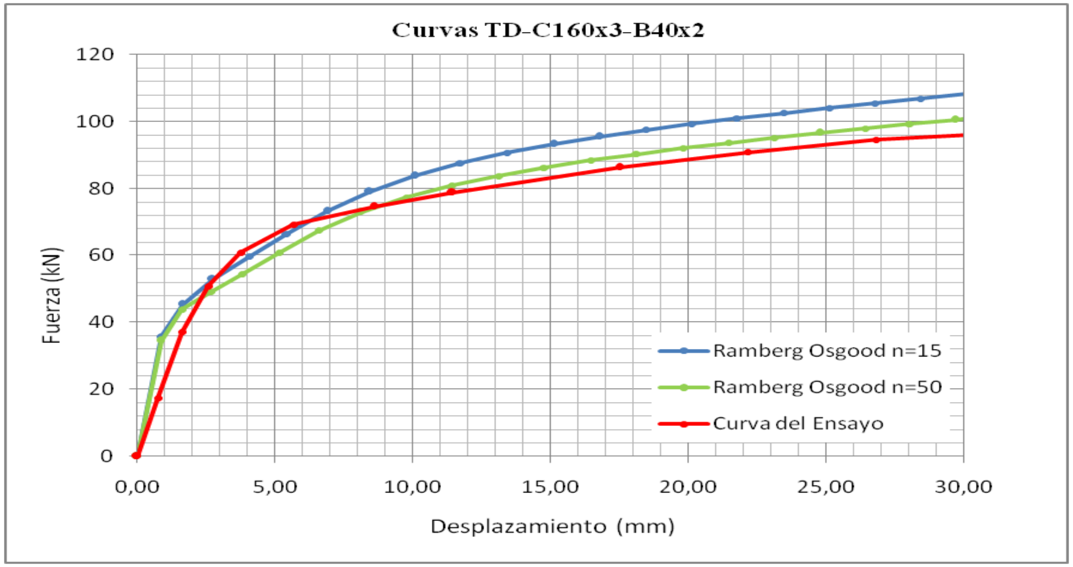
Ramberg y Osgood Model (1943)

$$\varepsilon = \frac{\sigma}{E_0} + K\left(\frac{\sigma}{E_0}\right)^n$$



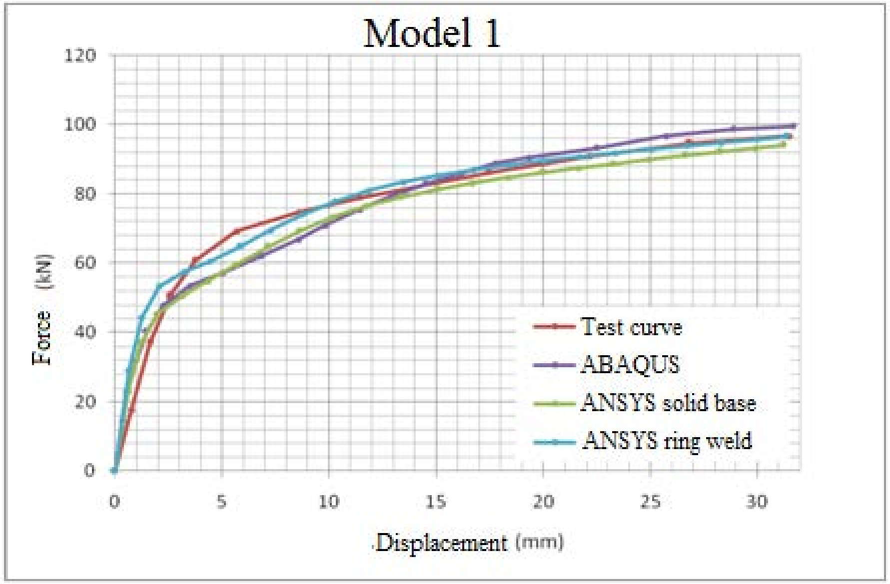
$$\sigma_{true} = \sigma\,(1+\varepsilon)$$

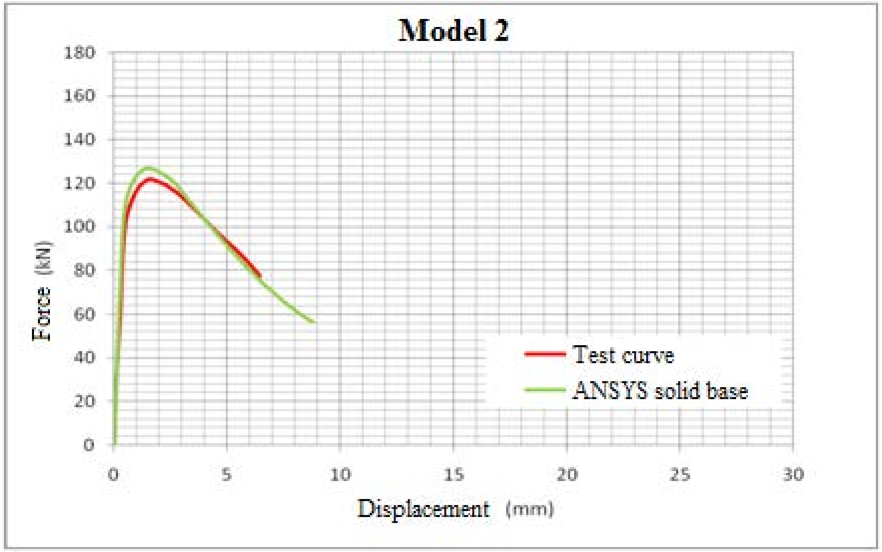
$$\varepsilon_{ln}^{pl} = \ln(1+\varepsilon) - \sigma_{true}/E_0$$



Model Validation.

Communication Skills II





Model 1

•Addition of solid plate improves the Model response.

•Addition of ring weld rises the hardening at the final part of the curve

Model 2

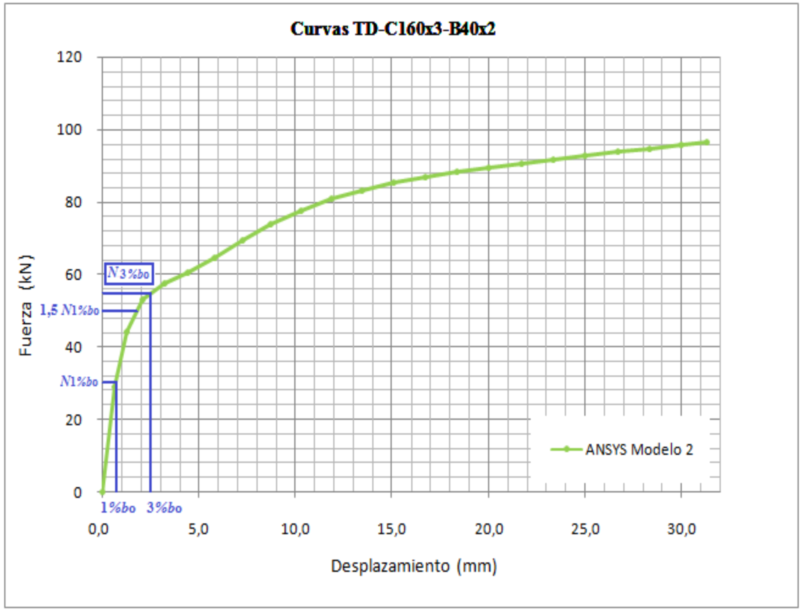
•Once the solid plate has ben validated the simulation in Model 2 is easier.

•The inclusion of the weld and solid plate is is considered too.

Model Verification.

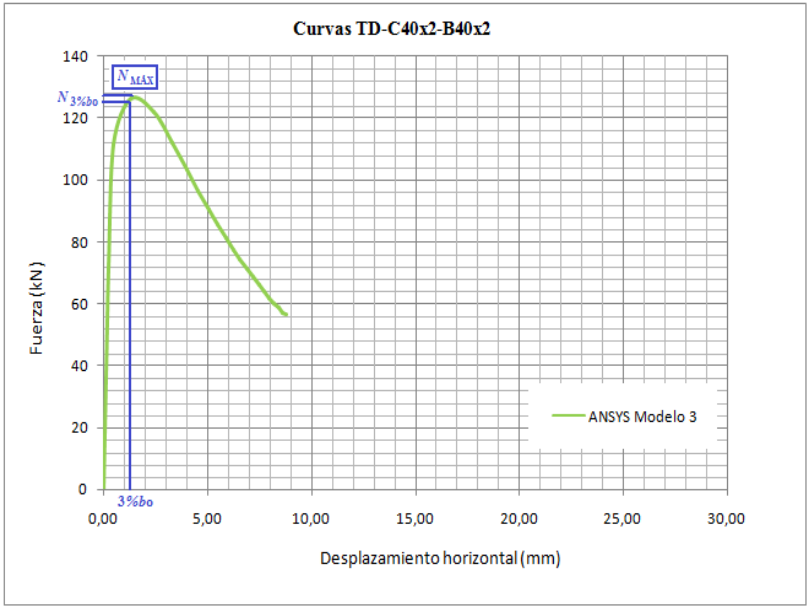
Communication Skills II

Model 1



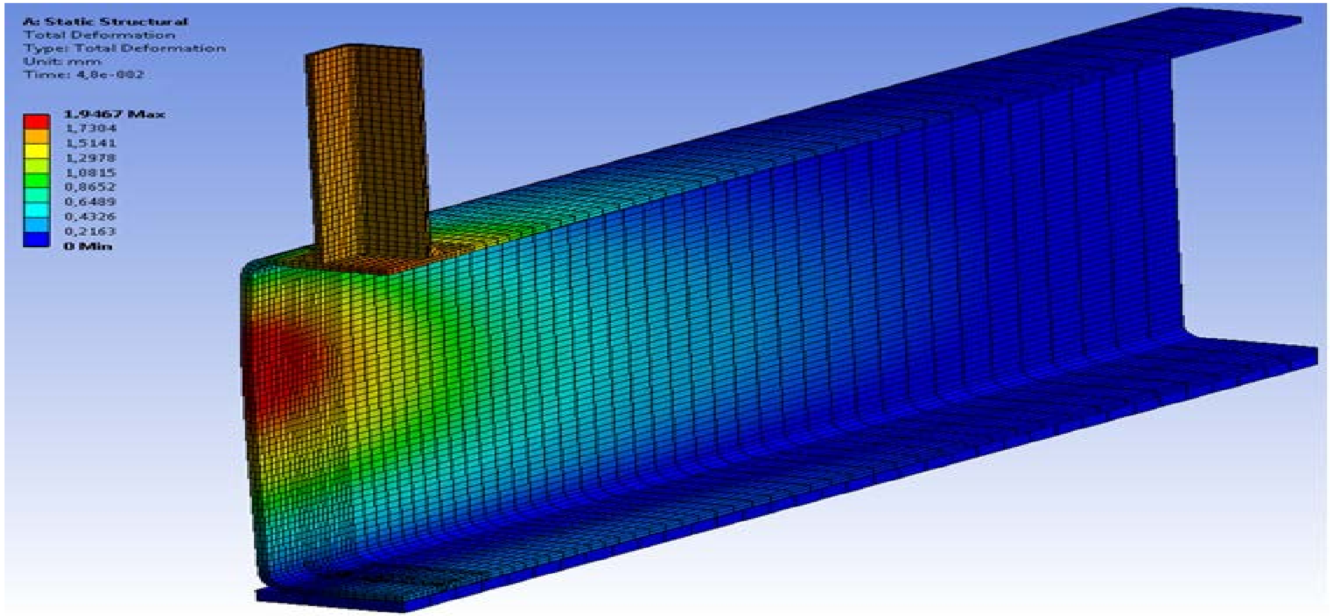
- **Deformation Limit criteria: $N_{f,ANSYS}$ = 46,5 kN.**
- **Standard EC3 value : 39,5 kN.**
- The standards are more conservative.
- $N_{f,ANSYS}$ correspond to a desplacement of 1,7 mm.
- No plastic deformations appear on the chord face or chord side wall face.
- Deformation Limit Criteria obtains the failure force Nf before the critical fail.

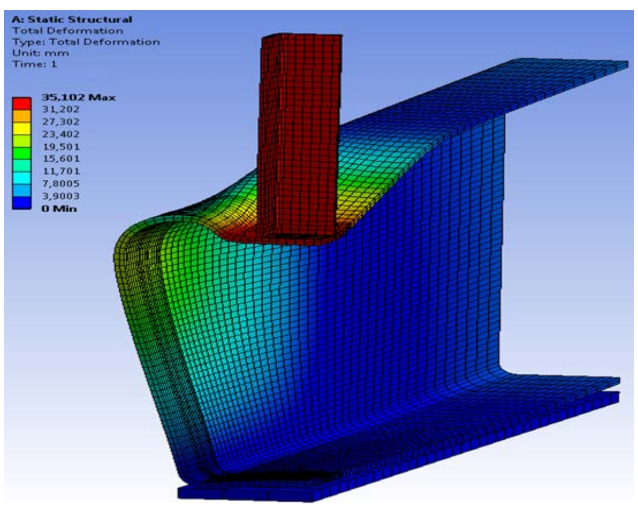
Model 2

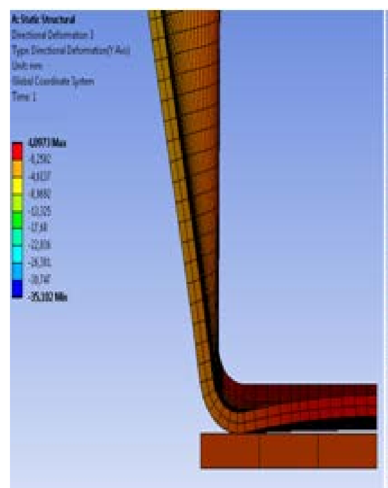


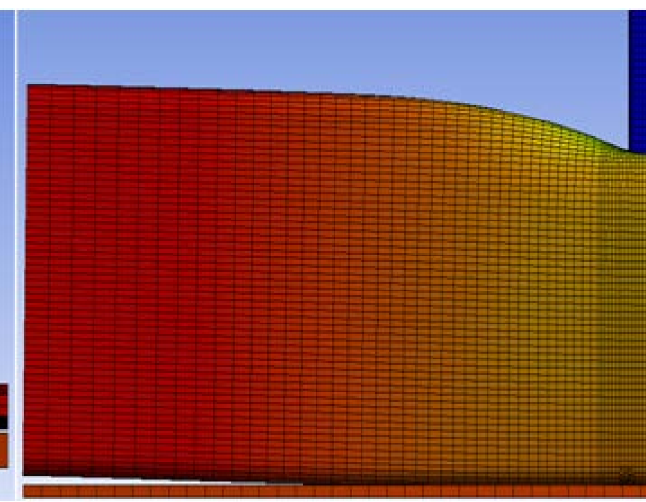
- **Deformation Limit criteria: $N_{f,ANSYS}$ = 122,5 kN**
- **Standard EC3 value = 91,1 kN.**
- The standards are more conservative.
- $N_{f,ANSYS}$ correspond to a desplacement of 0,85 mm.
- No plastic deformations or chord dent.
- Deformation Limit Criteria obtains the failure force Nf before the critical fail.

Model 1 Verification.

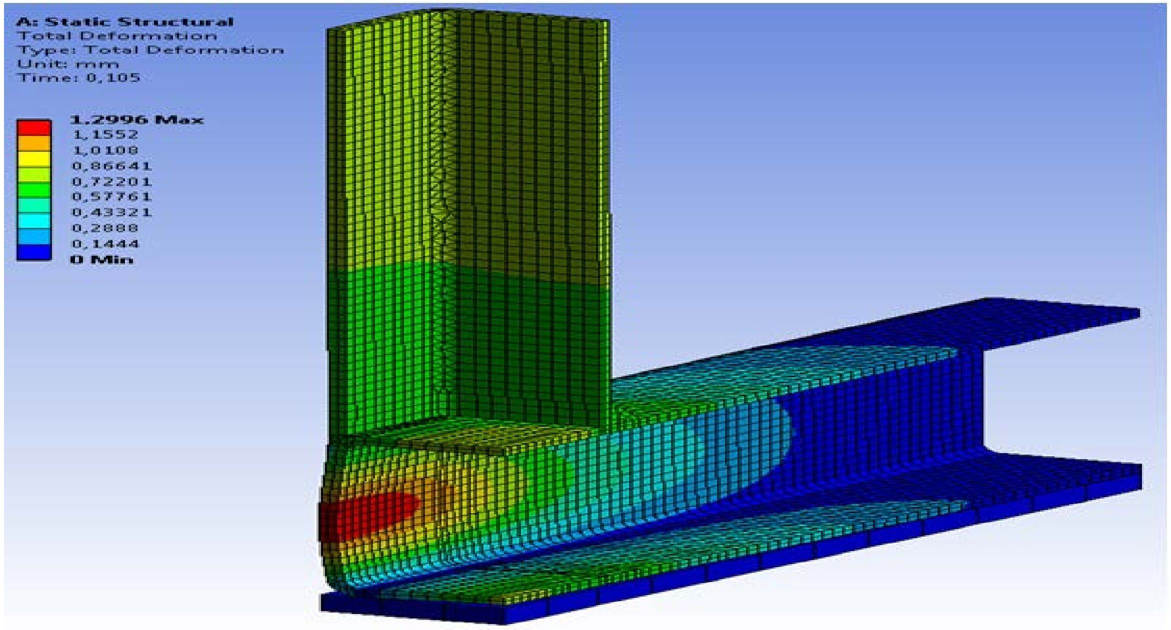


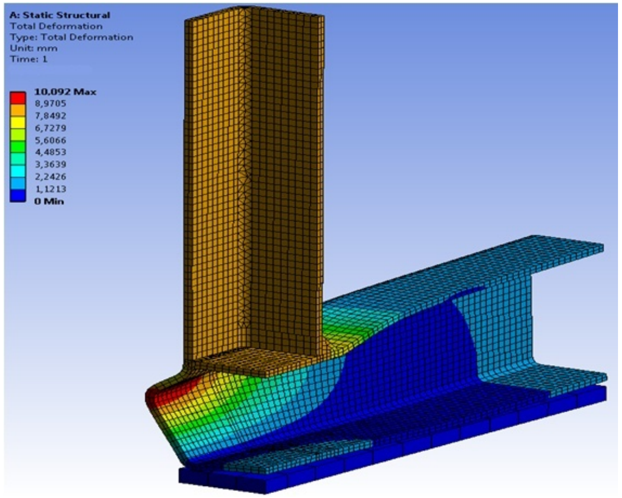


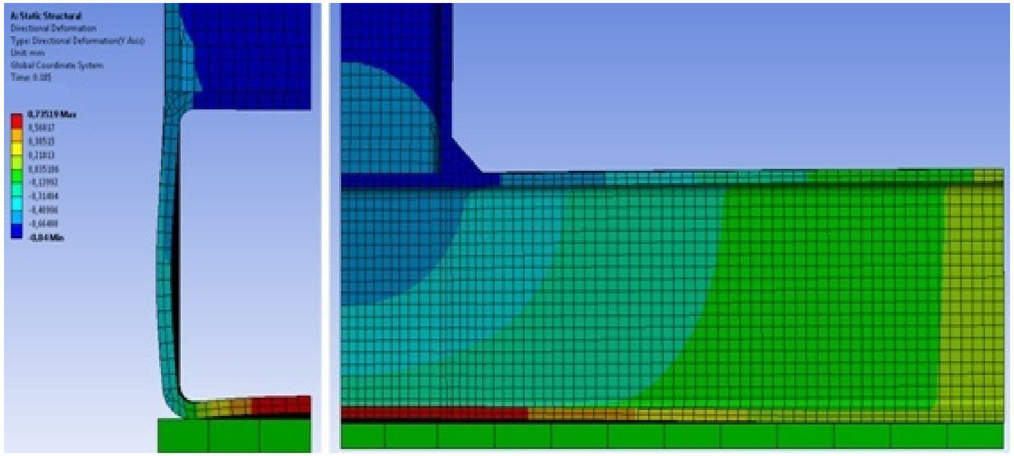




Model 2 Verification.







Conclusions.

- It shows that the finite element simulation is a useful tool for predicting the behavior of T-joints with tubular steel profiles.
- The ring weld proposal improves the model response of this, and the inclusion of rigid elements plate in the base of the T-joint, allows the lifting of the bottom chord plate, providing a realistic simulation.
- The failure modes presented in numerical models correspond to those that occurred in experimental trials and proposed by the standard (EC3 and CIDECT) based in β ratio.
- Deformation Limit Criteria gives an accurate force Nf before the failure occurs in T joint.
- European standards provide more conservative resistance values than the values obtained by finite elements model.
  - Can be used at joints with plate thicknesses of 2 mm, even if they were designed to thicknesses greater than 2.5 mm.
  - This would be significant cost savings in the development of small tubular structures with RHS profiles.